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Connecting Innovators Worldwide

The Product Development and Management Association

Product Development and Management **Body of Knowledge**

A Guidebook for Training and Certification

SECOND EDITION

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The Product Development and Management Association

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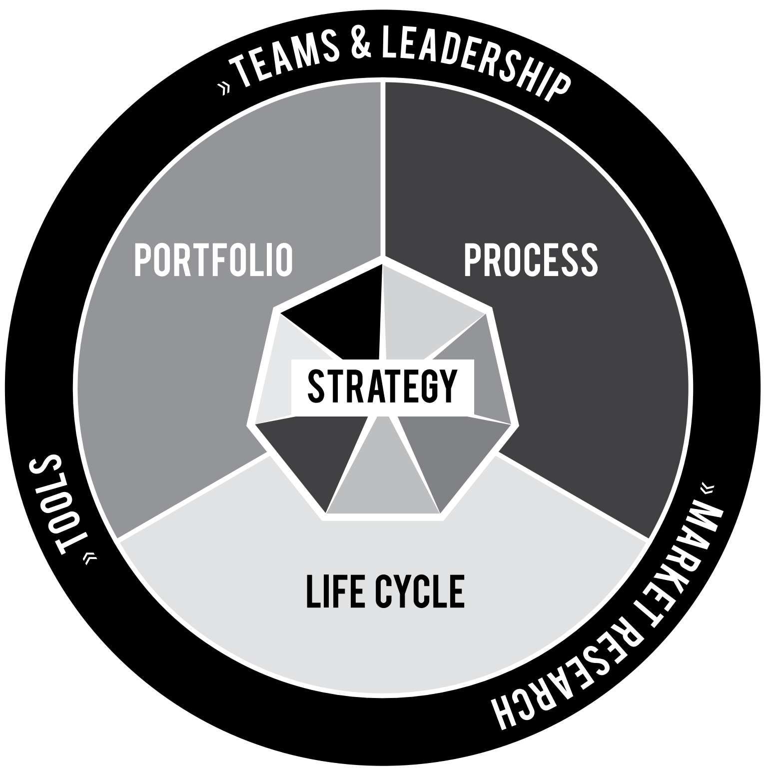

ABOUT THIS BOOK

This book is designed to provide the body of knowledge (BoK) required by candidates studying for PDMA's New Product Development Professional certification examination (NPDP).

It is divided into seven chapters, consistent with the seven topics used as a basis for the NPDP examination. These are:

1. Strategy
2. Portfolio management
3. Product innovation process
4. Product design and development tools
5. Market research in product innovation
6. Culture, teams, and leadership
7. Product innovation management

The book covers the fundamental principles of product innovation and product management, which can be applied to a wide range of product and service industries. It is intended to provide the basis for ongoing learning and continuous improvement, both for individuals and their organizations.

Clearly, there is wide variation across industries. The type of products or services, the markets, organization size and structure all contribute to differences in the approach to product innovation and product management. It is not possible to address the full range of specific practices and processes used in all industries. Instead, this book focuses on the fundamental principles that underpin successful product innovation and product management across a broad range of industries and individual organizations. Throughout the book, we endeavor to provide relevant examples of the specific ways in which these fundamental principles are applied to a range of product and service situations.

The material provided as the basis for the NPDP certification can be applied to the full range of product innovation projects included in most company portfolios:

- New-to-the-company products or services,
- Line extensions,
- Cost reductions,
- Product or service improvements — features, functionality, aesthetics.

CHANGES TO THE FIRST EDITION

The first edition of the Product Development and Management Body of Knowledge — a guidebook for training and certification, was published in 2017 (Anderson, 2017). Following is a summary of content changes made in the second edition:

- The order of the chapters has changed to Strategy; Portfolio management; Product innovation process; Product design and development tools; Market research in product innovation; Culture, teams and leadership; Product innovation management.
- Sustainability has been moved from Chapter 7 to be distributed across chapters 1, 2, 3, and 5 to be aligned with specific focus on strategy, portfolio management, product innovation processes, and product design and development tools.
- Addition of Business Model Canvas (BMC) to Chapter 1.
- Addition of a digital strategy to Chapter 1.
- Extension of the section on Open Innovation in Chapter 1.
- Addition of Agile portfolio and specific portfolio management metrics including cost of delay (COD) to Chapter 2.

- Addition of design thinking and hybrid product innovation processes to Chapter 3.
- Focus on design and development tools in Chapter 4, with the addition of a range of new tools including the Kano method, design for manufacture and assembly, Taguchi methods, design for usability, prototyping, and life cycle analysis (sustainability).
- Greater emphasis on social media and other new generation market research tools in Chapter 5.
- A complete change in emphasis for Chapter 7 with a focus on management of product innovation. Three sections in Chapter 7 cover the role of product innovation management, managing innovation through the product life cycle, and key tools for product innovation management (feasibility assessment, financial analysis, project management, and performance metrics for continuous improvement).
- The glossary has been updated. This provides a quick reference to brief definitions of the key terms used throughout the book.
- Allocation of exam questions across the 7 chapters of the BoK has been changed from the first edition to reflect the change in weighting of the material in the chapters (refer to Figure 3).

WHAT IS PRODUCT INNOVATION?

Innovation is turning a creative idea into a value.

Product innovation is the creation and subsequent introduction of a good or service that is either new, or an improved version of previous goods or services.

In this book, product innovation is used as an all-embracing term to include product development and new product development. It covers all aspects of bringing a product to market from strategy, initial idea through to commercialization, and includes the processes and tools required throughout. It encompasses product improvement, line extensions, cost reductions, and new-to-the-company products.

Although the term product innovation specifically refers to “product,” most of the principles discussed throughout the book are equally applicable to product or service (either where the service is a product in its own right or where service is part of a product offering).

Use of the term organization

The term organization is used throughout to include commercial companies, private companies, not-for profit organizations — in fact, any entity involved in the innovation and marketing of products and/or services.

THE SCOPE OF PRODUCT INNOVATION

The macro view

Put simply, successful product innovation is about choosing the right products to develop (doing the right things) and using the right processes, practices, and tools to develop the products (doing things right). Figure 1 extends this overview of product innovation to include the essential ingredients of people (culture, organization, and teams), and performance metrics used as a basis for continuous improvement.

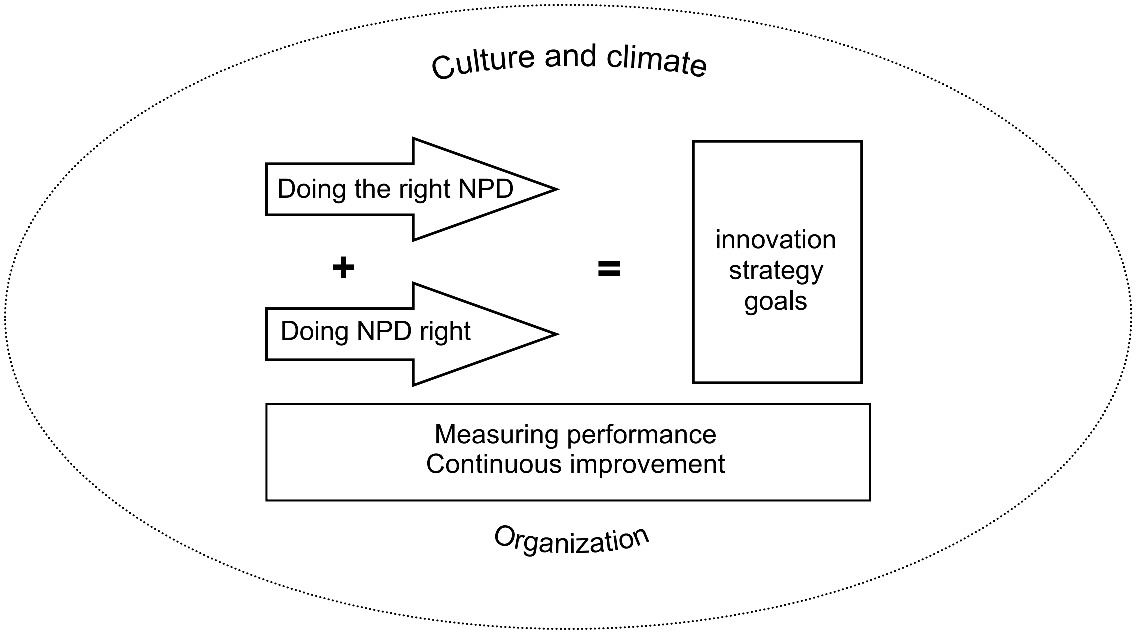

Figure 1 A macro view of product innovation

The individual project view

Figure 2 presents the scope of an individual product innovation project.

1. Start with a problem, challenge, or opportunity. This could be addressing product functionality problems, utilizing under-capacity manufacturing capability, taking advantage of a market trend, etc.
2. Identify the target market. Who are they? What are their characteristics? What need are they seeking to fulfill? What specific features and benefits do they want?
3. Define the core benefits, plus tangible and augmented features of the product. What is it that the target market truly values? What product features are required to deliver this core benefit to the market? What augmented features (e.g., warranty, after sales service) can add value to the product?
4. Identify and understand all the stakeholders. These include internal stakeholders within the organization (senior management, marketing, manufacturing, procurement, technical, etc.), and external including competitors, distribution channels, regulatory bodies, the customer, etc.
5. Use a structured development process: A process that is fit for purpose for the specific product and within the specific organization. A process that is well understood and communicated across the organization.
6. Develop the marketing mix in parallel with product innovation. This includes pricing the product at a point that is acceptable to the target market; designing promotion that reaches the target market and delivers messages consistent with the defined product benefits; using the right distribution channels to reach the target market.
7. Ensure a clearly defined strategy that ensures the new product is aligned with the organization's goals.
8. Develop a culture and climate within an appropriate organizational structure to support and promote innovation.

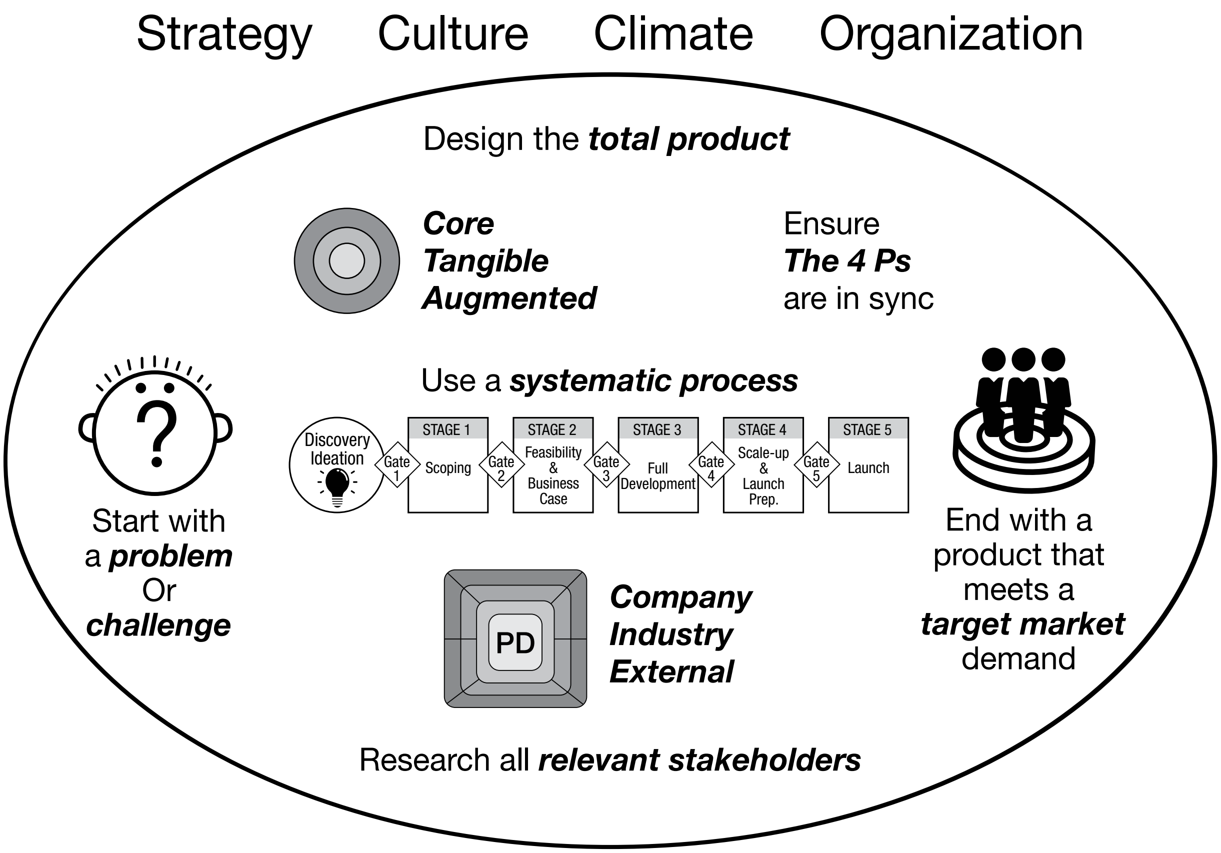

Figure 2 A project view of product innovation

THE ROLE OF PRODUCT INNOVATION IN THE ORGANIZATION

Most organizations rely on their products or services for both sustenance and growth. The ongoing review and refreshing of an organization's product offering, through product improvement and new product innovation, is fundamental to its survival. New products and/or services are frequently referred to as the "lifeblood" of an organization.

Prominent business leaders have provided some interesting insights to the value of product innovation:

"Investing in new product innovation and expanding the product catalog are the most difficult things to do in hard times, and also among the most important." Bill Hewlett and David Packard

"I would rather gamble on our vision than make a 'me too' product." Steve Jobs

"We see our customers as invited guests to a party, and we are the hosts. It's our job to make every important aspect of the customer experience a little better." Jeff Bezos, founder of Amazon

"I think that too often companies tend to have engineers working in individual cubes. They are isolated. They often don't see themselves as part of a larger process with a complex web of interdependencies." Jim Morgan, senior advisor, Lean Enterprise Institute

ABOUT PDMA

The Product Development & Management Association (PDMA) was founded in 1979. Centered in the USA, it has 16 International Affiliates in Europe, South/Central America, and Asia/Pacific. It is the premier association worldwide for product innovation professionals including practitioners, academics, and service providers.

The scope of PDMA
Membership represents a broad cross-section of product and service industries, both "business-to-business" (B2B) and "business-to-consumer" (B2C), including:

- Consumer goods,
- Heavy machinery,
- IT and software,
- Banking,
- Healthcare,
- Consultancy.

The basis of PDMA's body of knowledge
Over a number of years, PDMA has generated a body of knowledge (BoK) from across its spectrum of academic, practitioner, and service provider members. Specifically, this BoK has been generated from:

Academic research: PDMA has academic members worldwide who focus on research into product innovation and product management practice and processes. Much of this research is included in the PDMA's *Journal of Product Innovation Management,* which is published six times per year.

The Outstanding Corporate Innovator Award: PDMA seeks to enable product innovation professionals to learn from the best organizations. For the past 30 years, PDMA has presented its Outstanding Corporate Innovator Award (OCI) to companies that have demonstrated a sustained record of product innovation practice and performance. Companies to win this award include Starbucks, Baker Hughes, Xerox, and DuPont.

Conferences: PDMA's international conference is held annually in the United States. Other regional conferences are held in countries including India, Netherlands, Italy, Indonesia, and Korea.

Global networking: PDMA provides opportunities for global networking through its conferences, an annual research forum, and virtual meetings and webcasts.

What is special about PDMA?

- It offers the network of contacts to connect product innovation professionals worldwide.
- It facilitates the ongoing understanding of best practices in product innovation and product management and the associated BoK through:
  - academic research and publication (e.g., the JPIM and Research Forum),
  - learning from leading companies (e.g., the Outstanding Corporate Innovator Awards), and
  - facilitating exchange of ideas and knowledge across organizations and thought leaders.
- It offers internationally recognized professional certification, the NPDP.

THE NEW PRODUCT INNOVATION PROFESSIONAL CERTIFICATION (NPDP)

Detailed information on the NPDP can be obtained from the Certification section of the PDMA website: www.pdma.org/

The benefits of certification:

For individuals: Confirms mastery of product innovation principles and best practice leading to professional advancement, new job opportunities, and greater remuneration.

For management: Identifies those who have the product innovation skills and knowledge to move into leadership roles.

For organizations: Promotes better product innovation practice, leading to greater new product success.

Requirements for application

Either:

Education
Hold a Bachelor's or higher university degree (or an equivalent degree) from an accredited institution

Experience
Accrued at least two years of professional-level experience working in new product innovation (the candidate must have accumulated the required experience within the prior four years)

Or:

Education
Hold a high school diploma or equivalent

Experience
Accrued at least five years of professional-level experience working in new product innovation (the candidate must have accumulated the required experience within the prior eight years)

About the examination
The exam consists of 200 multiple-choice questions. The distribution of questions across the seven topic categories is shown in Figure 3.

To pass the examination, 150 questions must be answered correctly (75 percent).

Examination content
Figure 3 shows the seven sections of the NPDP examination and the percentage of the 200 examination questions devoted to each section.

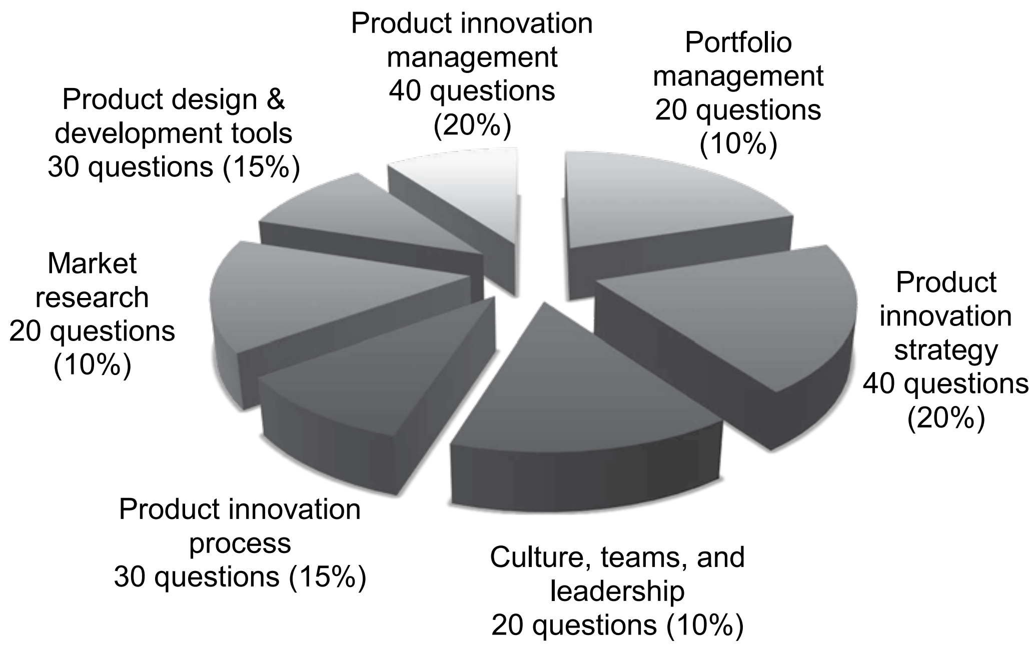

Figure 3 Allocation of NPDP exam questions

PREPARING FOR THE EXAMINATION

This book is designed to provide all the basic information required to pass the examination. Although it is possible to pass the examination through self-learning, it is strongly recommended that candidates attend authorized training courses.

Further references are provided at the end of each chapter for those people who are keen to delve wider or deeper into specific topics. Although these references are not compulsory reading for the examinations, they do provide a resource for a more extensive understanding of examination topics.

THE BOOK STRUCTURE

This book is divided into seven chapters, which align with the specific areas for the examination. A brief outline of each chapter is provided below.

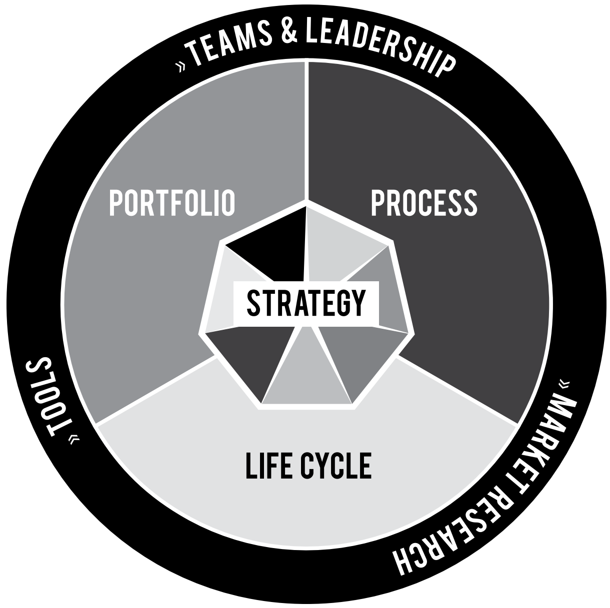

Figure 4 The seven sections of the BoK

Figure 4 presents the seven sections of PDMA's product innovation BoK. At the center of the figure is strategy that defines the direction and goals for product innovation. This provides the basis for the product innovation portfolio, for the process leading to individual new products, and the consequent management of these products through their life cycles. Contributing at all levels of strategy, portfolio, and life cycle management are market research, specific tools, and people (culture, organization, leadership, and teams).

Strategy

The chapter on strategy covers various types of strategy from corporate, through business and functional strategies. An emphasis is placed on the innovation strategy, particularly as it sets out the framework, and provides direction, for product innovation. The benefits and limitations of specific innovation strategic frameworks are discussed. The role of supporting strategies from technology, marketing, platforms, intellectual property, and capability are presented, both as being directed by higher level business strategy and in their mutual contribution to the overall business strategy.

Portfolio management

The portfolio management chapter relates strategy to project selection. A product portfolio is defined as the set of current and potential new products that can form the basis for a program of product innovation including product improvement, cost reductions, line extension, and new-to-the-company products. Methods for project selection are presented, both as a means of assessing project potential and of achieving strategic alignment with regard to individual project prioritization and balance across specific categories of product innovation. Portfolio management is presented as a cross-functional activity that encompasses the development of new products through to launch, and the ongoing review of existing products to ensure optimal alignment with strategy and resource availability.

Product innovation process

Rapid changes in technology, communication, and market demands have placed considerable pressure on companies to become more effective and efficient in their product innovation. Greater understanding of the success factors for new product innovation has resulted in the application of a range of new product processes to specific contexts. This chapter outlines many of these processes — including Stage-Gate®, Concurrent Engineering, Integrated Product Innovation, Lean, Agile, and Lean Startup. The benefits and limitations of each process are discussed and specific contexts for application are recommended. Although not specifically included in this chapter, reference is made to the tools and metrics that are required to underpin a successful new products process.

Product design and development tools
A wide range of tools is required at all levels of product innovation — strategy formation, portfolio management, new product process, design, life cycle management, etc. Some of these tools are applicable across a range of industries and products, while others are more specific in their application. In this chapter, we focus on descriptions of a range of generic product design and development tools applied to ideation, concept development, embodiment, fabrication and assembly, sustainability, service, and post-service. Specific tools for strategy development, portfolio management, market research, and innovation management are included in their respective chapters. The discussion of the various tools is intended to provide their potential application and value to product innovation and product management. It is not possible to provide detailed explanations on how to apply the various tools. Direction is provided to further reference sources for those who seek a more in-depth understanding.

Market research in product innovation
Market research is required to provide market-related information and data to underpin decision-making in all aspects of strategy development, portfolio management, the new products process, and life cycle management. Certain market research techniques are more appropriate for specific purposes; for example, exploratory customer needs analysis, product concept testing, and product sales potential. The application of market research extends across the full cycle of product innovation, from initial idea generation to final product launch and post-launch reviews. This chapter covers a range of market research tools including secondary research, qualitative vs. quantitative, focus groups, customer site visits, ethnography, consumer panels, social media, big data, crowdsourcing, alpha and beta testing, and market testing. The benefits and limitations of each tool are discussed together with their potential application at various stages of the new product process. Specific emphasis is placed on the accuracy and reliability of the various tools, and in turn, their value in decision making at various stages of product innovation.

Culture, teams, and leadership
It is widely recognized that new product innovation cannot be successful through good processes alone. Success is dependent on people, on the culture of the company, and the environment that is created to foster innovation. This chapter outlines the characteristics of an innovative culture. It also focuses on the requirements for a high-performing team and of team structures to support cross-functional teams in an innovative environment and in different project contexts. Management roles and responsibilities at various levels and within different stages of product innovation are also discussed.

Product innovation management
This chapter is divided into three parts. The first part addresses the role of product innovation management. The second part focuses on the product life cycle and how product innovation is managed through this life cycle. It outlines the stages of the product life cycle — introduction, growth, maturity, and decline — and discusses product management and product innovation strategies for each stage. Significant emphasis is placed on a discussion of the introduction stage of the life cycle, with reference to case study examples. The third part describes some of the key tools for managing product innovation including feasibility analysis, sales and demand analysis, financial analysis, and project management. It also presents performance metrics as a basis for continuous improvement in product innovation.

PDMA BOOKS

Over a number of years, PDMA has supported the publication of a range of books related to product innovation. For further information, refer to https://pdma.org/. Although not required reading, these books do provide an excellent background resource for many of the topics included in the NPDP examination.

PDMA ToolBook 1: Practical cross-functional coverage of the entire product innovation process from idea generation through delivery of the final assembled product. Includes sections on benchmarking and changing your new product innovation process and managing your product portfolio. (Belleveau, Griffin, and Somermeyer, 2002).

PDMA ToolBook 2: This book covers all aspects of product innovation, from the creation of the concept through development and design to the final production, marketing, and service. (Belleveau, Griffin, and Somermeyer, 2004).

PDMA ToolBook 3: This book is the third volume covering the best practices of product innovation and is a follow up to the successful PDMA ToolBook 1 published in 2002, and PDMA Toolbook 2 published in 2004. The ToolBooks cover a number of critical aspects of product innovation from the creation of the concept through development and design, to the final production, marketing, and service. (Griffin and Somermeyer, 2007).

Design Thinking: New Product Development Essentials from the PDMA: *Design Thinking* is the Product Development and Management Association's (PDMA) guide to better problem solving and decision-making in product development and beyond. You'll learn how to approach new product development from a fresh perspective, with a focus on systematic, targeted thinking that results in a repeatable, human-centered problem-solving process. (Luch, Swan, and Griffin, 2015).

Open Innovation: New Product Development Essentials from the PDMA: *Open Innovation: New Product Development Essentials from the PDMA* is a comprehensive guide to the theory and practice of Open Innovation. (Noble, Durmusoglu, and Griffin, 2014).

PDMA History, Publications, and Developing a Future Research Agenda: This book describes the many publications that PDMA has created and provides a hint of things that may influence the future of PDMA itself. (Hustad, 2013)

PDMA HandBook Third Edition: The PDMA HandBook of New Product Development, Third Edition provides a comprehensive, updated picture of what managers need to know today for effective new product innovation. (Kahn, 2013)

Product Development and Management Body of Knowledge. A guidebook for training and certification. First edition (Allan M. Anderson, 2017). The first edition of the PDMA's BoK is used as a basis for training and self-learning toward the NPDP certification.

Leveraging Constraints for Innovation: This PDMA *Essentials Book,* the third in this series, provides a framework of individual, organizational, and market and societal constraints that guides managers in identifying specific constraints related to their innovation activities and provides them with corresponding tools and practices to overcome and leverage those constraints. (Griffin, Spanjol, and Gurtner, 2018).

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Product Development and Management
Body of Knowledge, 2nd edition, 2020

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1

STRATEGY

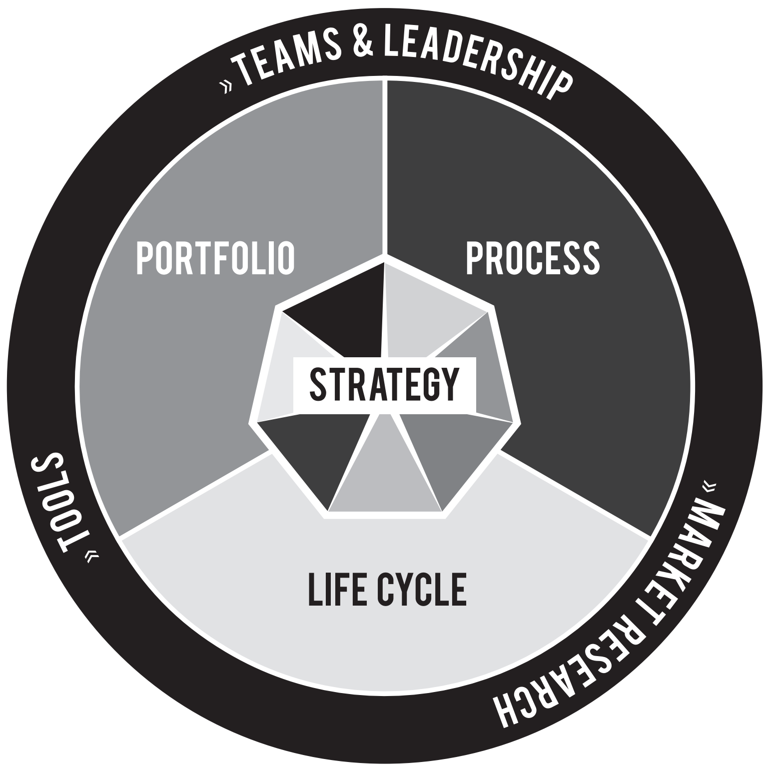
Provides the context, goals, and direction for product innovation and ongoing product management

1. Strategy

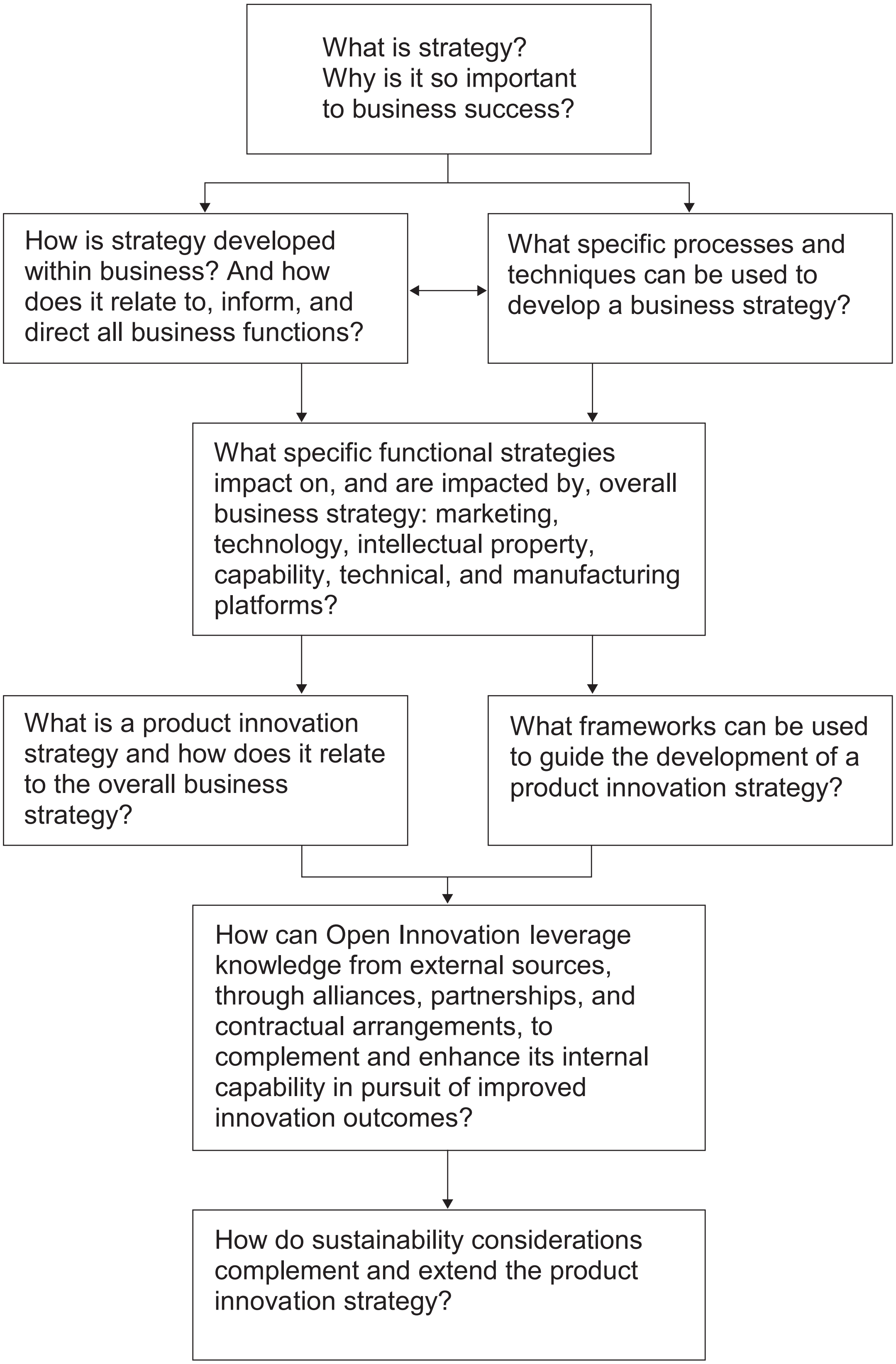
THE CONTENT

What you will learn in this chapter

Strategy lies at the very heart of an organization's sustenance and growth. It lays the foundation, and provides the framework, for all of the organization's functions and activities. In this chapter strategy is defined as it is applied at various levels of the organization. In particular, emphasis is placed on the innovation strategy, providing frameworks for analysis and development of the innovation strategy together with guidance on its implementation throughout the organization.



The Chapter Roadmap



The corporate strategy or business strategy underpins the goals and direction for all of an organization's activities. The overall business strategy provides the foundation for functional strategies including manufacturing, marketing, intellectual property, capability and, most importantly in the context of this book, innovation. Business strategy is informed by, and informs the product innovation strategy. In turn, the product innovation strategy informs the selection and on-going management of the organization's product portfolio, which prioritizes specific innovation projects.

1.1 WHAT IS STRATEGY?

A strategy is broadly defined as: *a method or plan chosen to bring about a desired future, such as achievement of a goal or solution to a problem.*

When applied within the business context:

"It defines and communicates an organization's unique position and says how organizational resources, skills, and competencies should be combined to achieve competitive advantage" (Porter, 2008), or *"An organization's game plan for achieving its long-term objectives in light of its industry position, opportunities, and resources"* (Kotler, 2012).

Key components stand out in the context of product innovation:

1. Unique positioning;
2. Competency and capability utilization;
3. Competitive advantage;
4. The approach chosen in which to integrate and execute on the above.

1.1.1 The importance of strategy to product innovation success

Since 1990, the Product Development and Management Association (PDMA) has carried out regular studies of a cross-section of organizations to better understand the product innovation practices and processes that lead to improvement in new product success. The aim of these studies has been to identify what differentiates the "best" companies from the "rest" in terms of product innovation performance and outcomes.

The most recent study was carried out in 2012 with the results published by Markham and Lee (2013). Results from this survey show that the definition of a clear product innovation strategy contributes significantly to overall new product success. Seventy-eight percent of the best companies had strategies that direct and integrate their entire product innovation programs compared to 54 percent of the rest of companies.

1.1.2 Hierarchy of strategies

An organization should be directed by an overarching strategy that provides goals, priorities, and focus for the whole organization. Where the organization is large and multi-faceted, the organizational strategy may be referred to as a corporate strategy. In smaller companies it may simply be referred to as the business strategy (discussed in greater detail later in this chapter).

Most companies rely on innovation, to some degree, for sustenance and growth. An innovation strategy founded on the business strategy provides the direction and framework for innovation across the organization. Most companies will have a range of functions, each of which will form its own strategy in contributing to the overall organizational strategy and in supporting the innovation strategy. Figures 1.1 and 1.2 show the hierarchy of decision-making strategy within an organization and where innovation fits into this hierarchy.

Figure 1.1 points to the importance of a fully integrated approach to strategic planning led by the overarching mission statement through to individual business goals to achieving this mission, the innovation strategy then underpins achievement of these goals and, finally, the specific functional strategies (marketing, technical, manufacturing, etc.) that contribute to achievement of the goals. It is critically important that all of these aspects are in harmony and are driven in the same direction.

Figure 1.2 provides an extension to Figure 1.1, emphasizing the importance of the overarching organization mission informing product portfolio selection and the overall product innovation strategy. It also emphasizes the importance of alignment of functional strategies through to the development and implementation of the product innovation strategy.

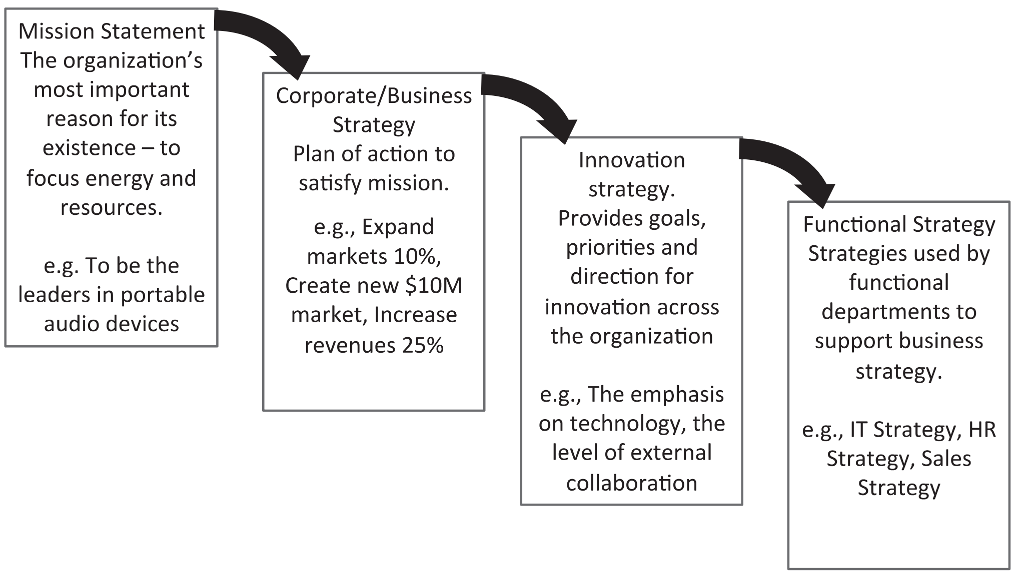


Figure 1.1 The hierarchy of strategies

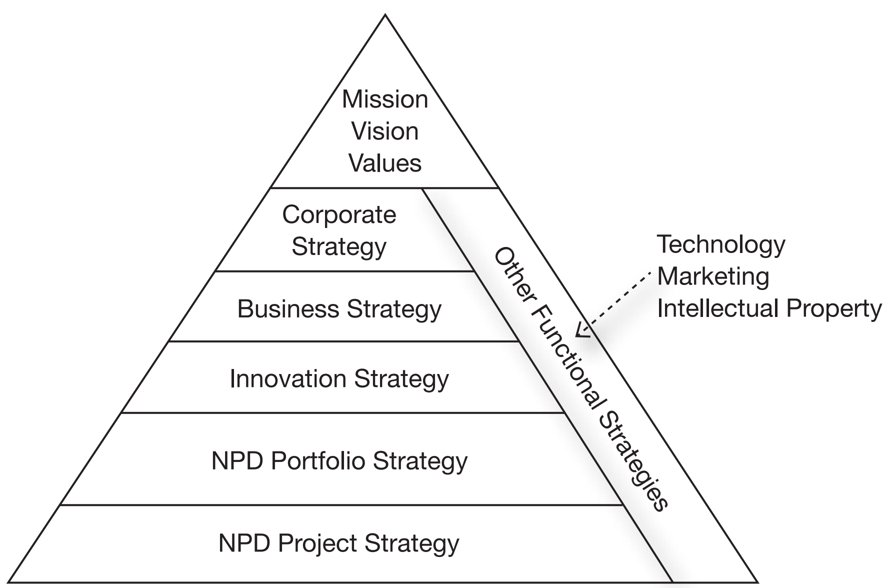


Figure 1.2 Innovation and the strategic decision hierarchy

1.2 ESTABLISHING THE ORGANIZATION'S DIRECTION

1.2.1 Organizational identity

Fundamental to the long-term success of an organization is a clear definition and understanding of what the organization stands for and why it exists, *"Who are we as an organization?"* (Whetten, 2006).

Key attributes of an organization identity are:

Central: If an attribute is changed, the whole nature of the organization would be changed.

Enduring: Attributes that are deeply ingrained in the organization, often explicitly considered sacrosanct or embedded in the organization history.

Distinguishing: Attributes that are used by the organization to separate itself from other similar organizations.

The organizational identity provides the foundation for the definition of an organization's vision, mission, and values. These attributes are manifest in the day-to-day operations of the organization, including in how the product innovation strategies are played out.

1.2.2 Vision

"An act of imagining, guided by both foresight and informed discernment, that reveals the possibilities as well as the practical limits…It depicts the most desirable, future state of…an organization" (Kahn, 2013).

Example: Amazon Vision

"Our vision is to be earth's most customer centric organization; to build a place where people can come to find and discover anything they might want to buy online."

1.2.3 Mission

The statement of an organization's creed, philosophy, purpose, business principles, and corporate beliefs. The purpose of the mission is to focus the energy and resources of the organization.

Example: Starbucks Mission Statement

"To inspire and nurture the human spirit — one person, one cup and one neighborhood at a time."

1.2.4 Values

"Principles to which a person or organization adheres with some degree of emotion" (Kahn, 2013).

Example: Fisher & Paykel (F&P) Healthcare

- *LIFE. We relentlessly focus on improving patients' lives and strive to provide a high quality of life for our employees.*
- *RELATIONSHIPS. We care for our patients, customers, suppliers, shareholders, the environment and each other.*
- *INTERNATIONALISM. We are global in people, in thinking and in behaviors.*
- *COMMITMENT. We value people who are self-motivated and have a desire to make a real contribution.*
- *ORIGINALITY. We encourage original thinking, which leads to the innovative solutions required to create better products, processes and practices.*

1.2.5 Organizational identity and product innovation

The organizational identity forms the foundation on which the organization is built. The mission, vision, and values define not only what the organization is seeking to achieve, it also defines the "personality" of the organization — how it acts and how it feels. The mission, vision, and values have a significant impact on reinforcing how important product innovation is to the organization. They also significantly influence the focus for the product innovation and how it is carried out. Managers should ensure that the mission, vision and values provide the appropriate context and direction for product innovation. They also have responsibility for ensuring the relevance and connection of the mission, vision and values at all levels of the product innovation process. Communication and regular reinforcement of this relevance and connection, across all functions and staff involved in product innovation, is vitally important.

1.3 BUSINESS and CORPORATE STRATEGY

1.3.1 Business strategy

Porter (1996) argues that competitive strategy is *"about being different."* He adds, *"It means deliberately choosing a different set of activities to deliver a unique mix of value."* In short, Porter argues that strategy is about competitive position, about differentiating the organization, and its offerings, in the eyes of the customer, about adding value through a mix of activities different from those used by competitors.

Tregoe and Zimmerman (1980) define business strategy as *"the framework which guides those choices that determine the nature and direction of an organization."* Ultimately, this boils down to selecting products (or services) to offer, and the markets in which to offer them.

In essence, the amalgam of these two definitions leads to the following:
Business strategy is about choosing a "a set of activities to deliver a unique mix of value" where, for most businesses, the unique mix of value is centered on the product and/or services the business offers to specific markets.

In effect, product innovation and product management is central to most business strategies. The business strategy, in turn, provides the context and direction for the innovation strategy and for product innovation. Basically, the key steps of business strategy leading to product innovation implementation are:

1. Define the business goals including specific product categories and markets to focus on, and respective growth targets.

2. Define the role that product innovation will play in achieving these goals. A business could choose between mergers and acquisitions and product innovation as a vehicle for meeting its goals. If product innovation is chosen as the key vehicle, then the business has a number of potential options available including in-house development, external partnering, and licensing for manufacture and/or marketing.

3. Define the key focus or foci on which the product innovation strategy is based. This is often referred to as the "attack plan." In later sections, we present a number of innovation strategy frameworks that direct a business into making decisions among major areas of focus for its product innovation. Broadly speaking, these center on decisions related to how much risk the business is willing to take in its product innovation. Does it want to be a market leader or follower? Does it want its innovation to be technology or market led? Does it want to differentiate its new products on the basis of cost or on specific features? Does it want to target a wide range of product and/or market areas or does it want to pursue a narrow focus?

4. The strategic decisions outlined above, and discussed in more depth later in this chapter, lay the foundation for further steps in new product planning including individual project selection, product portfolio management, and resource allocation. It ultimately also provides a basis from which to select the appropriate PRODUCT INNOVATION methodology for a given product innovation opportunity. These steps are further summarized in Figure 1.3.

Figure 1.3 Business strategy as foundation for product innovation

1.3.2 Corporate strategy

Organizations can vary significantly in size and in the way in which they are structured. Large organizations will often be divided into business units, each centered on specific product categories, brands, services, markets, or regions (see Figure 1.4 on PepsiCo). In these large and multifaceted organizations, it is generally desirable to have an overarching strategy for the whole organization with separate strategies for the individual business units linked to this overall, or corporate, strategy.

A corporate strategy is therefore:

- The overarching strategy of a diversified organization.
- It answers the questions of "in which businesses should we compete?" and "how do these individual businesses create synergy and/or add to the competitive advantage of the organization as a whole?"

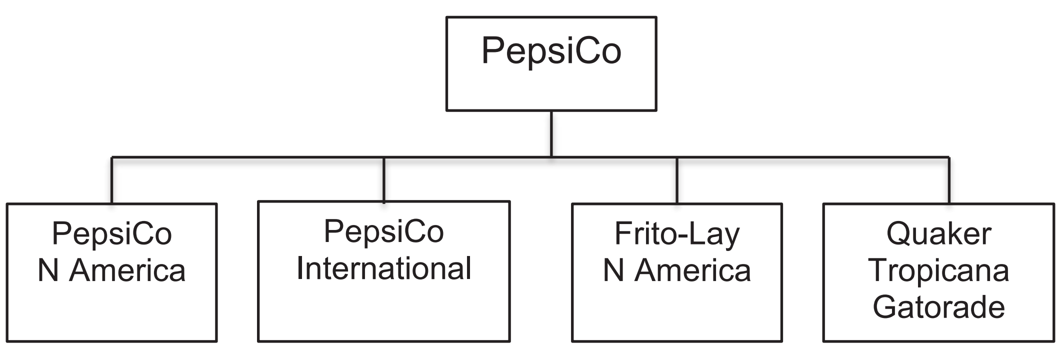


Figure 1.4 An example of a corporate business structure, PepsiCo

The role that product innovation plays within a large corporation will depend on the structure of the organization and particularly the level to which the organization seeks to achieve synergies across its business units, as opposed to maintaining a high degree of business unit autonomy. Most corporations will have a high-level strategy to optimize synergies across its business units. This will impact the mergers and acquisitions (M&A) strategy as well as the internal innovation strategy. Some hypothetical examples:

- A manufacturer of PCs may define a strategic goal of fully integrating its own operating system into its branded PCs. It could do this by developing its own operating system in-house, partnering externally for the development, or acquiring a company that has either the requisite development skills or an operating system that meets the company's needs.
- A global food manufacturing company with business units in 50 countries may decide to have a core platform of technologies that can be applied to a range of products. But the specific taste preferences in different countries may dictate a requirement for slight variations in product formulations. In turn, the company needs to decide whether it is better to have a large central R&D facility, focused facilities in selected regions, or a combination of both.
- A large oilfield service company with over 20 business divisions in 80 countries has a number of R&D facilities around the world. Each of the facilities has different R&D systems and processes. There is very little knowledge transfer across the R&D facilities. Strategically, the company has an important decision to make: do the advantages of standardized R&D and knowledge management practices outweigh the benefits of highly focused, individual facilities with their own "fit for purpose" systems and practices?

1.4 PREPARING A BUSINESS STRATEGY

A comprehensive understanding of the business context is essential to informing the development of business goals and strategy. This includes the organization itself, the industry within which the company operates, and the wider regional and global environment. Refer to Figure 1.5.

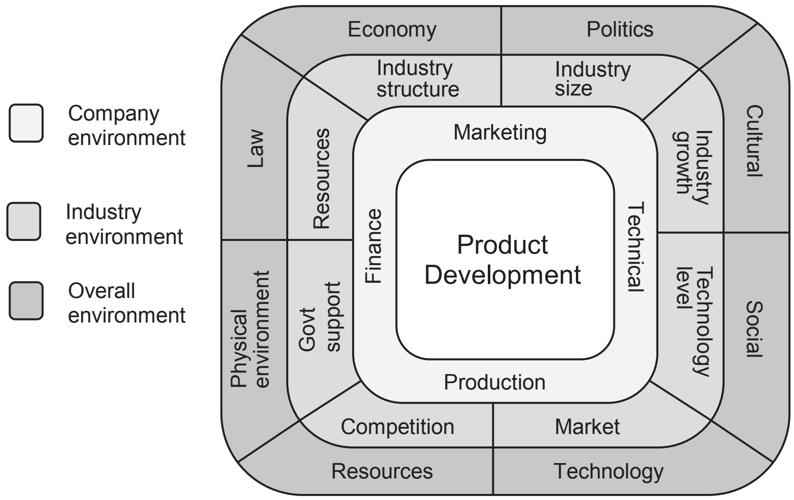


Figure 1.5 The context for product innovation

A number of tools can be used to provide a structured approach to ascertain the requisite knowledge on which to develop business goals and strategy. Following are some of the most commonly used tools. A combination of these tools provides the most comprehensive knowledge to underpin strategic planning.

1.4.1 SWOT analysis

SWOT stands for **Strengths, Weaknesses, Opportunities,** and **Threats**.

Strengths: Characteristics of the business or project that give it an advantage over others.

Weaknesses: Characteristics that place the business or project at a disadvantage relative to others.

Opportunities: Elements that the business or project could exploit to its advantage.

Threats: Elements in the environment that could cause trouble for the business or project.

Advantage can be taken of opportunities and to protect against threats, but they cannot be changed. Examples include competitors, prices of raw materials, and customer lifestyle changes. It is essential that effective and appropriate management processes are used to mitigate against these risks (see Chapter 3).

For a SWOT analysis to be effective, company senior management needs to be deeply involved. This isn't a task that can be delegated to others.

However, organization leadership shouldn't do the work on their own, either. For best results, a group of people who have different perspectives on the company should be involved. People should be selected to represent different aspects of your company, from sales and customer service to marketing and product innovation. Some organizations even look outside their own internal ranks when they perform a SWOT analysis and get input from customers to add their unique voice to the mix.

Examples of specific considerations to take account of in a SWOT analysis are shown in Figure 1.6.

S STRENGTHS	W WEAKNESSES	O OPPORTUNITIES	T THREATS
• What the company does well, e.g., technical development, market research • What separates the company from competitors, e.g., strong brand recognition • Company resources such as specialised manufacturing or skilled staff • Tangible assets such as IP or capital	• What the company lacks, e.g., specific skills or capital • Things that competitors do better, e.g., distribution, consumer relationships • Resource limitations, e.g., specific skills, access to raw materials • Unclear value proposition	• Significant identified gaps in product offerings • Few or weak competition • Market trends supporting need for the company's products • Availability of specialist technical knowledge – through licensing or acquisition	• Emerging competitors • Changing regulatory environment • Potential for disruptive technologies • Trends counter to current product attributes • Potential loss of valuable skills • Potential loss of critical raw materials

Figure 1.6 SWOT analysis

1.4.2 PESTLE analysis

A PESTLE analysis is a structured tool-based, macro-environmental analysis of **P**olitical, **E**conomic, **S**ocial, **T**echnological, **L**egal, and **E**nvironmental factors. It is particularly useful as a strategic framework for seeking a better understanding of trends in factors that will directly influence the future of an organization — such as demographics, political barriers, disruptive technologies and competitive pressures. The tool is especially useful when starting up a new business or entering a new foreign market (refer to Figure 1.7).

P	E	S	T	L	E
• Government policy • Political stability • Foreign trade policy • Tax policy • Labor law • Trade restrictions	• Economic growth • Exchange rates • Interest rates • Inflation rates • Disposable income • Unemployment rates	• Population growth rate • Age distribution • Educational levels • Safety emphasis • Lifestyle attitudes • Cultural barriers	• Technology incentives • Level of innovation • Automation • R&D activity • Technological change • Technological awareness	• Discrimination laws • Antitrust laws • Employment laws • Consumer protection laws • Patent laws • Health and safety laws	• Weather • Environmental politics • Climate change • Pressure from NGOs

Figure 1.7 Example of PESTLE analysis

1.4.3 Delphi technique

Delphi technique is a forecasting **method** based on the results of questionnaires sent to a panel of experts. Several rounds of questionnaires are sent out, and the anonymous responses are aggregated and shared with the group after each round. It is mainly applied to future forecasting or foresighting and longer term strategic planning. The aim of the Delphi process is to clarify and expand on issues, identify areas of agreement or disagreement, and then begin to seek consensus. The Delphi technique consists of seven steps:

Step 1: Choose and appoint a facilitator
The first step is to choose your facilitator, preferably a neutral person familiar with research and data.

Step 2: Identify the subject-matter experts
The Delphi technique relies on a panel of experts. This panel may be members of the project team, including the customer, or other experts from within the organization or industry. An expert is any individual with relevant knowledge and experience of the particular area being investigated.

Step 3: Define the problem
What is the problem or issue where understanding is being sought? The experts need to know what problem they are commenting on. A precise and comprehensive definition is required.

Step 4: Round one questions
Ask general questions to gain a broad understanding of the experts' view on future events. The questions may go out in the form of a questionnaire or survey. Collate and summarize the responses, removing any irrelevant material and looking for common viewpoints.

Step 5: Round two questions
Based on the answers to the first questions, the next questions should delve deeper into the topic to clarify specific issues. These questions may also go out in the form of a questionnaire or survey. Again, collate and summarize the results, removing any irrelevant material, and look for the common ground. The key goal is to achieve consensus among the experts.

Step 6: Round three questions
The final questionnaire aims to focus on supporting decision making. Focus in on the areas of agreement. What is it the experts agree on? In some situations, more than three rounds of questioning are required to reach a closer consensus.

Step 7: Act on your findings
After the third round of questions, the experts should have reached a consensus with a view of future events.

Predicting the future is not an exact science, but the Delphi technique can help in understanding the likelihood of future events and what impact they may have on specific strategies or projects.

1.4.4 Business Model Canvas (BMC)

The Business Model Canvas (BMC), first developed by Osterwalder et al. (2010), is a simple yet effective visual strategy tool that organizations, big and small, use for business model innovation. The BMC provides the basis for the Lean Canvas approach used in Lean start ups with its emphasis on entrepreneur-focused business planning, discussed further in Chapter 3.

The importance of the organization's business model in the context of strategy and innovation is very key. Business models, if incorrectly defined and not supporting the innovation strategy and management, the technology strategy, and the product strategy, will not achieve the goal of value creation — which is ultimately what it's all about for profit-making organizations. The growth of the Internet, the ease of accessibility and globalization (among others) have created the impetus for organizations to incorporate innovation into every facet where value can be captured and translated into profit.

Finally, "technological innovation does not guarantee business success — new *product innovation efforts* should be coupled with a business model defining their 'go to market' and 'capturing value' strategies." (Treece, 2010:183)

The BMC normally addresses customer segments, value propositions, channels, customer relationships, revenue streams, and key activities, resources, partners, and cost structures. A key component of the BMC is the aforementioned aspects of knowledge in a visual form, similar to Figure 1.8. It is designed to depict an entire business model on a single page. The right side of the BMC focuses on the customer, while the left side focuses on the business. The information is derived from asking and answering key questions:

Customer segments
An organization often focuses on a broad range of customers. These can be divided into distinct customer segments, each with its own specific needs and requirements. This allows for tailoring of specific value propositions, customer relationships and channels for each segment.

Value propositions
The **value proposition** defines how an organization distinguishes itself from the competition. This distinction focuses on quantity such as price, service, speed, and delivery conditions on the one hand, and on the other hand it also focuses on quality including design, brand status, and customer experience and satisfaction.

Channels
Which channels are to be focused on to reach the desired customer segments? How are those channels integrated? Which are most cost-effective?

Customer relationships
What type of relationship is required for each customer segment? What are the expectations of these customers? How are they established? What would be the associated costs?

Revenue streams
What are the customers willing to pay and for what value? How would they prefer to pay? How are they currently paying? How does each stream add up to the total revenue?

Key activities
What key activities are required to successfully deliver the value proposition? These include R&D, marketing, manufacturing, and distribution channels.

Key resources
Resources can be categorized as physical, intellectual, financial, or human resources. Physical resources may include assets such as business equipment. Intellectual resources include (among other things) knowledge, brands, and patents.

Key partners
Who are the key partners? Key suppliers? Which key resources are they providing? Which key activities do the partners perform?

Key partners are the external companies or suppliers needed by the business to perform key activities and deliver value to the customers. Buyer-seller relationships are necessary to optimize operations and reduce the risks associated with a business.

Cost structure
What are the most important cost drivers in the organization's business model? Which key resources and activities are most expensive? The business can be either cost-driven or value-driven. A cost-driven organization looks to minimize all costs while a value-driven company is more focused on delivering great customer value in terms of quality or prestige.

<table>
<tr>
<td rowspan="2">Key
Partners

Who are key partners?
Who are key suppliers?
Which key resources are we acquiring from partners?
Which key activities do partners perform?</td>
<td>Key
Activities

What key activities do our value proposition require?
Our distribution channels?
Customer relationships?
Revenue streams?</td>
<td rowspan="2">Value
Propositions

What value do we deliver to the customer?
Which customer problems are we solving?
What products and services are we offering to each customer segment?
Which customer needs are we satisfying?</td>
<td>Customer
Relationships

What type of relationship is expected by each customer segment?
Which ones are established?
How are these integrated into our overall business model?
How costly are they?</td>
<td rowspan="2">Customer
Segments

For who are we creating value?
Who are our most important customers?

Mass market
Niche market
Segmented
Diversified</td>
</tr>
<tr>
<td>Key
Resources

What key resources do our value propositions, distribution channels, customer relationships, revenue streams require?

Physical
Intellectual
Human
Financial</td>
<td>Channels

Through which channels do our customers want to be reached?
How are we now reaching them?
How are our channels integrated?
Which ones are most cost efficient?</td>
</tr>
<tr>
<td colspan="2">Cost structure

What are the most important costs inherent in our business model?
Which key resources are most expensive?
Which key activities are most expensive?</td>
<td colspan="3">Revenue streams

What value are our customers really willing to pay?
What are they currently paying?
What would they prefer to pay?
How much does each revenue stream contribute to total revenue?</td>
</tr>
</table>

Figure 1.8 Business Model Canvas (BMC) framework

1.5 INNOVATION STRATEGY

"An innovation strategy is an essential tool for product innovation and continued growth in difficult times" (Cooper and Edgett, 2009).

"Managers should articulate an innovation strategy that stipulates how their firm's innovation efforts will support the overall business strategy. This will help them make trade-off decisions so that they can choose the most appropriate practices and a set of overarching innovation priorities that align all functions" (Pisano, 2015).

Innovation within an organization should be far more than just a grab bag of good ideas and practices. It should be an integrated and coordinated effort across the organization with clear guidance from, and connection to, the overall business strategy.

An overarching innovation strategy will provide the goals, direction, and framework for innovation across the organization. Individual business units and functions may have their own strategies to achieve specific innovation goals, but it is imperative that these individual strategies are tightly connected with the overarching organizational innovation strategy.

1.5.1 What defines a good innovation strategy?

The innovation strategy should be tailored to the specific organization. There is no standard recipe book that defines what an innovation strategy should be. Above all, the innovation strategy must provide a sound basis for providing alignment across the organization; for establishing priorities; and for evaluating trade-offs.

Characteristics of a good innovation strategy include:

1. Innovation is messy and should be embraced as such (form of art and science). For example, it is most often non-linear in its application as it involves abstract concepts such creativity and perseverance. The journey is as important as the end-goal (which in itself is often unclear).
2. Innovation is about experiential learning and development. It comprises iterations of trying out new things, capturing the lessons, and then reprioritizing efforts.
3. Information that is generated and useful during the innovation processes is key to success.
4. Constant intentional curiosity is required in order to search for the desired designs, outcomes, processes, systems, or products.
5. Innovation boils down to creating value, not necessarily new ideas and or inventions.
6. Being first to market does not guarantee the intended success.
7. Involving customers as best, and as early, as possible is advisable.
8. Innovation requires the ability to integrate seemingly disparate (and unobvious) components into one.
9. Innovation is ongoing, so organizations need to design and implement support structures and systems that enable it to be continual.

Reeves et al. (2017) offer the information-advantaged innovation strategy, which posits the following requirements:

1. Deciding where to compete;
2. How to deal with complexity;
3. Understanding what the competition is doing and offering;
4. Other information pertaining to execution timelines, customer-related insights, and organizational capabilities and gaps, are useful sources of information.

Furthermore, innovation is not always a major breakthrough event or big bang, but can consist of many small adjustments, e.g., to the product innovation process (expediting it and/or making it more cost-effective).

Various other authors propose:

1. Manage uncertainties by planning how to identify and respond to them.
2. Innovation concepts need to be commercialized. Hence, connecting innovators with resources that can be commercialized is key.
3. Embrace the creatives in the organization.

1.5.2 The relationship of innovation strategy to overall business and individual functional strategies

Throughout this book, a number of specific strategies and processes that underpin, and are directly impacted by, the overall innovation strategy are presented, including:

- Technology strategy, marketing strategy, platform strategy, open innovation, intellectual property — all of which are founded on, and contribute to, the overall innovation strategy.
- The role of and contribution of business to environmental sustainability.
- In Chapter 2, the processes for project selection are discussed — again, directed by the innovation strategy priorities.
- In Chapter 3, a range of processes that are appropriate to different innovation strategies are discussed.
- In Chapter 6, organization and teams chapter, the various structures that are appropriate to different innovation strategies are discussed.
- In Chapter 7, the stages of the product life cycle and their strategic importance in defining innovation priorities are discussed.

An example of integrating innovation with business strategy

"Several years ago, Bristol-Myers Squibb (BMS), as part of a broad business strategic positioning, decided to focus on cancer as part of its pharmaceutical business. BMS recognized that biotechnology-derived drugs were likely to provide a sound basis for cancer treatment. As a result, BMS decided to re-focus its technological capabilities from its traditional organic chemistry to biotechnology" (Pisano, 2015).

1.6 INNOVATION STRATEGY FRAMEWORKS

A number of approaches to, and frameworks for, developing an innovation strategy have been presented over the years. Following is a selection of these approaches. No single one of these frameworks may be sufficient to fully develop an innovation strategy for an organization, but they should serve as foundational starting points.

1.6.1 Porter's strategic framework

Michael Porter (2008) argued that an organization's strengths ultimately fall under one of two headings: cost advantage and differentiation. By applying these strengths in a broad or narrow range, he defines three generic strategies: Cost leadership, differentiation, segmentation. Refer to Figure 1.9.

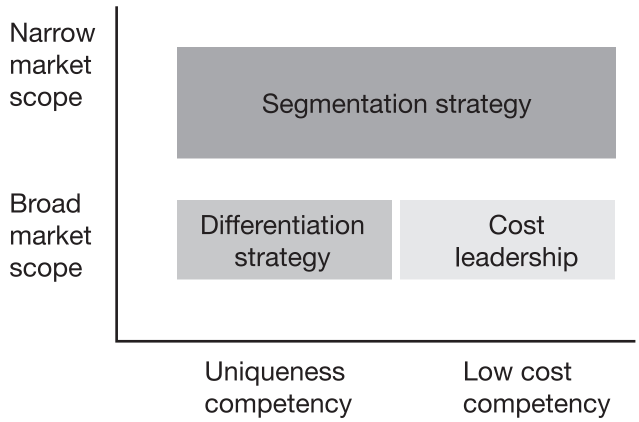


Figure 1.9 Porter's three competitive strategies

Porter's cost leadership strategy

The features of the cost leadership strategy are:

- It grows the organization's market share by appealing to "cost conscious" customers.
- It is often adopted by commodity product companies.
- It can be achieved through:
  - Economies of scale: higher manufacturing throughput to reduce manufacturing cost per unit.
  - Offering "no frills" or "value" products that reduce overall manufacturing cost.
  - Optimizing the supply chain: standardized components/materials and packaging and just-in-time delivery.

An advantage of a cost leadership strategy is that it is often the only way to break into or maintain a market position in a price-competitive market where there is strong competition and customers are less concerned about product differentiation. Disadvantages include the constant drive for cost reduction can lead to a reduced emphasis on quality, to a point where customers switch to a competitor; and generally lower margins that are constantly being squeezed, resulting in limited R&D investment.

A cost leadership strategy focuses product innovation in the following ways:

- The level of product innovation funding is low — often below 0.3% of sales revenue.
- The major emphasis is on minor product changes, often centered on cost reductions through manufacturing process changes and changes in raw materials.
- There is little to no focus on long-term research or development.
- Technology will often play an important role but mainly in improving manufacturing systems — automation, robotics, etc.

Porter's differentiation strategy

The features of differentiation strategy are:

- A focus on a broad product base.
- Gaining market share through delivering unique and superior products and establishing a loyal customer base.
- Customers are generally more concerned with the product's quality and its features.

Advantages of a differentiation strategy include:

- Providing a strong potential for establishing customer loyalty.
- Providing potential for higher profit margins based on differentiated product features.

Disadvantages of a differentiation strategy include:

- Constant innovation is necessary to deliver new product features that continue to be attractive to the customer.
- Failure to deliver the desired features with an appropriate value proposition can lead to a significant reduction in market share.

A differentiation strategy focuses product innovation in the following ways:

- A significantly higher level of investment in product innovation than for cost leadership. It ranges from around 2 percent of revenue for food products to 20 percent for electronic goods (this still depends significantly on the specific nature of the products and their differentiating features that can command a price premium).
- Intimacy with customers, to fully understand current and future needs.
- Sound foresighting to predict short to medium term trends.
- Depending on the specific product category and its margins, a relatively strong emphasis on research and longer-term development.
- Technology often plays an important role, but mainly focused on product features and functionality.

Porter's segmentation strategy

Also called a "focus strategy." Rather than focusing on a broad market as in cost leadership and differentiation strategies, segmentation adopts a narrow market focus. It is based on an intimate knowledge of a key market — often with specialized needs.

Advantages of a segmentation strategy include:

- Providing a strong focus for the organization's marketing and product innovation effort.
- Allowing the organization to drive for an in-depth understanding of, and relationship with, its customers. Therefore, this provides a strong competitive edge against newcomers.
- Providing the opportunity for higher margins and therefore product innovation investment.

Disadvantages of a segmentation strategy include:

- The danger of being dependent on a single, narrow market (putting the eggs in one basket). New technologies lead to your product being outdated. Refer to section 1.6.3 on disruptive technologies, with examples such as Kodak's focus on photography film and the impact of new digital technology.

A segmentation strategy focuses product innovation in the following ways:

- The level of product innovation funding is generally higher than for cost leadership or differentiation. But again, it is highly dependent on the product category and its potential for creating high margins.
- A major emphasis is on customer intimacy: fully understanding the needs of the current target market and predicting future needs.
- Often working with lead user groups in the target market to identify new opportunities and co-develop new products.
- Technology often plays an important role in the development of new product features or functionality.

1.6.2 Miles and Snow strategic framework

Although relatively old, the Miles and Snow framework still provides a useful method to describe a strategic approach to innovation (Miles & Snow, 1973). It is based on four specific strategic approaches: prospector, analyzer, defender, and reactor. Refer to Figure 1.10.

Prospector	First to market Seeks out growth, risk taking
Analyzer	Fast follower, often better products
Defender	Maintain niche in a stable market
Reactor	Responds only under duress

Figure 1.10 Miles and Snow strategic framework

Organizations that adopt a prospector strategy:

- Are risk-tolerant and keen to explore new opportunities;
- Are flexible in developing and applying new technologies;
- Value speed to market in order to capture greater market share.

Organizations that adopt a defender strategy:

- Are risk-averse, focused on a narrow and stable market and product category;
- Are focused on core capabilities, even a single technology;
- Resist radical developments;
- Respond swiftly to competitive threats;
- Cover a full range of product variants within their focus product category;
- Product innovation is focused on product enhancements;
- Are not usually technologically aggressive.

Organizations that adopt an analyzer strategy:

- Balance the priorities of a prospector and a defender strategy;
- Are moderately risk tolerant;
- Often follow prospector companies with imitator products — also called “fast followers”;
- Focus on imitation products having features or functionality that add greater value to the market;
- Have lower funding for product innovation than do prospectors;
- The product innovation capability is based on product and market analysis combined with skills in reverse engineering and design improvements;
- Technology often plays an important part, but mainly in analysis and re-engineering rather than radical change.

Organizations that adopt a reactor strategy:

- Often have no clear strategic goals;
- Respond to market changes with no clear plan for technology development or market entry;
- Are generally regarded as not successful long-term.

1.6.3 Sustaining vs. disruptive product innovation

A key strategic decision for most companies is whether to focus their product innovation efforts on sustaining or disruptive innovation.

The principle of disruptive innovation was first explored by Clayton Christensen (1997). He defined the difference between disruptive and sustaining innovation as follows:

"A disruptive technology or disruptive innovation is an innovation that helps create a new market and value network, and eventually goes on to disrupt an existing market and value network. The concept of disruptive technology is widely used but disruptive innovation seems a more useful concept in many contexts since few technologies are intrinsically disruptive. It is rather the business model than the technology that enables and creates the disruptive effect. In contrast to disruptive innovation, a sustaining innovation does not create new markets or value networks but only develops existing ones with better value, allowing the companies to compete against each other's sustaining improvements." Refer to Figure 1.11.

Although an organization can choose a sustaining or disruptive innovation strategy, often it is a disruptive innovation of a competing organization that has the greatest impact. The trap of disruptive innovation is that it does not happen overnight. It creeps up on companies — often unnoticed or disregarded. A well-documented example is that Kodak was aware of the new digital technology being developed by other companies but simply disregarded it, believing that the quality of film was far better than digital could offer. This was true at the time, until technology developed to the point where the digital deficiencies were overcome. By this stage it was too late for Kodak, as other companies that embraced digital technology took a significant share of Kodak's market.

Features of disruptive innovation

- The new product or service targets specific needs of a segment of an existing product or market.
- Although the new product may be inferior in some ways to the existing product, it offers special features that are truly valued by the small segment of the market with users who are leaders or influential to the market as a whole. This allows the new product to gain a foothold in the market.
- In time, the overall features of the new product are improved to the point where more and more customers are "converted." The value of the new features now significantly outweighs any negative features or under-performance.

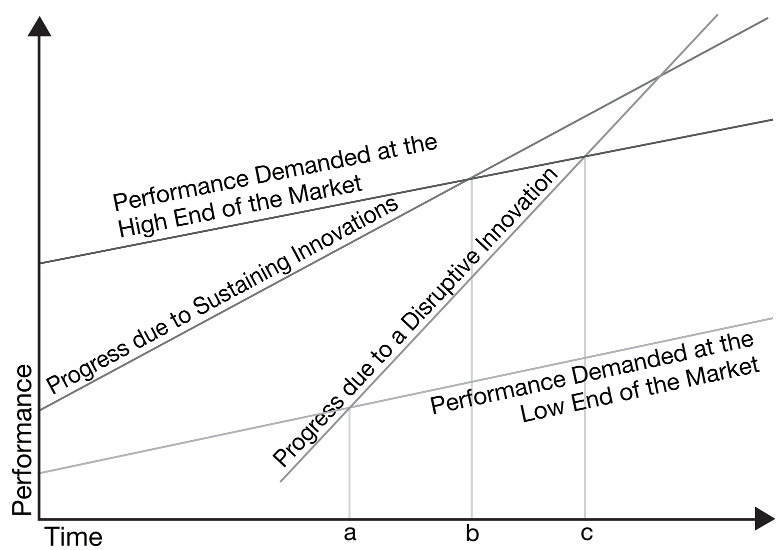


Figure 1.11 Sustaining vs. disruptive innovation

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Examples of disruptive product innovation:
Digital cameras: disrupting traditional film cameras;
Uber: disrupting traditional taxi services (some purists may argue that this does not fully fit the true model of disruptive innovation);
TripAdvisor: disrupting traditional travel agencies;
Mobile phones: disrupting traditional land lines;
3D printing: disrupting traditional manufacturing in the future;
Artificial intelligence: disrupting human-incumbent jobs;
Cryptocurrency: potential to disrupt payment services systems and banking.

1.6.4 The innovation landscape map (Pisano, 2015)

Although new technology is often the source of innovation, this is by no means always the case. In fact, over recent years many leading companies including Amazon, LinkedIn, and Alibaba have mastered the art of business model innovation. A key decision in defining an organization's innovation strategy is the relative effort and resources allocated to technological and business model innovation.

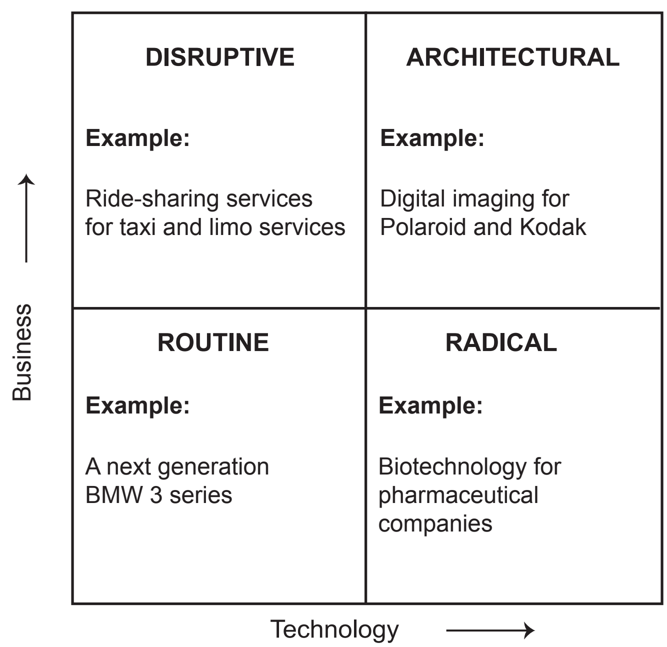

Figure 1.12 The innovation landscape map
Reprinted with permission from "You Need an Innovation Strategy" by Gary P. Pisano. Harvard Business Review, June 2015. Copyright 2015 by Harvard Business Publishing; all rights reserved.

The four quadrants of innovation described by Pisano in Figure 1.12 are:
Routine innovation: Builds on an organization's existing technological competencies and fits with its existing business models. Innovation is focused on feature improvement and new versions or models.
Disruptive innovation: Requires a new business model but not necessarily new technology. So, for example, Google's Android operating system potentially disrupts companies like Apple (refer to section 1.6.3 on sustaining vs. disruptive innovation).
Radical innovation: Here the focus is mainly technological. Genetic engineering and biotechnology have had a significant impact on the pharmaceutical industry.
Architectural innovation: A combined focus on technology and business. A well-quoted example is digital photography, which caused significant disruption for companies such as Kodak and Polaroid.

1.7 STRATEGIES THAT SUPPORT THE INNOVATION STRATEGY

The overarching innovation strategy provides the goals, direction, and framework for innovation across the organization. Individual business units and functions will have their own strategies to achieve specific innovation goals, but it is imperative that these individual strategies are tightly connected with the overarching organization innovation strategy. The following strategies that support the innovation strategy are briefly discussed:

- Platform
- Technology
- Marketing
- Intellectual property
- Capability

1.7.1 Product platform strategy

A product platform strategy is fundamental to the development of new products for most companies. A product platform strategy is defined as a set of subsystems and interfaces that form a common structure from which a stream of derivative products can be efficiently developed and produced.

"A product platform technology is not a product. It is a collection of common elements, especially the underlying core technology, implemented across a range of products. It is the foundation of product strategy, especially in high-tech companies where many products are built from a core technology." (McGrath, 1995).

Benefits of platform strategy

A product platform strategy offers the following benefits to an organization:

- It enables products to be deployed rapidly and consistently.
- It encourages a longer-term view of product strategy.
- It can leverage significant operational efficiencies.
- It ensures that the underlying elements of the product platform are clearly understood by the organization and the market.
- It can provide a significant point of differentiation from competing products.

Example: Platform strategy in the Internet industry

Google, Facebook, Apple, and Amazon are all examples of companies that have evolved from single products to entire ecosystems (Simon, 2011).

In the Internet industry, a platform can be a structure made up of integrated features. For example, Google started with a very good search engine in 1998. By adding Gmail, Maps, Docs, Voice, and YouTube it has developed a true platform.

Example: Platform strategy in the software industry

A software environment that is used to write applications and run them is a product platform. It includes software tools such as GUI builders, compilers, class libraries, and utilities for developing the applications, as well as a runtime engine for executing the applications, because they are not able to run on their own. Sun's Java and Microsoft's NET Framework are examples of major software platforms.

Example: Platform strategy in the automobile industry

Key mechanical components that define an automobile platform include:

- The floor plan, which serves as the foundation for the chassis and other structural and mechanical components.
- Front and rear axles and the distance between them (the wheelbase).

- Steering mechanism and type of power steering.
- Type of front and rear suspension.
- Placement and choice of engine and power train components.

For example, the Audi TT and the VW Golf share many mechanical components but appear entirely different visually.

1.7.2 Technology strategy

A technology strategy is *a plan for the maintenance and development of technologies that supports the future growth of the organization and aids the achievement of its strategic goals.*

Some of the decisions required to develop an organization's technology strategy:

- Does it lead or follow in its adoption and development of new technologies?
  - What are the boundaries that will impact the organization's innovation (the maximum level of risk and uncertainty it has on innovation projects)?
  - If and when it follows, does it acquire or imitate the leaders?
- What level of investment does the organization make in developing and owning new technologies?
- What methods does the organization use to acquire and protect technologies? Patents, trade secrets, standards, speed (refer to section 1.7.3 on intellectual property).
- What comprises the company's technology platform(s) — the technologies shared across products, services, and processes?
- Does the organization make or buy technologies?
  - To what extent does it open its innovation to the outside world?
  - To what extent and in what ways does it engage partners and suppliers in technology development?
- What core competencies does it need to develop in-house? Core competencies are those absolutely critical to the successful development and implementation of the new technologies.

Technology foresighting

Technology foresighting is a process for looking into the future to predict technology trends and the potential impact on the company. A wide range of tools is used for foresighting. These include brainstorming, expert panels, Delphi, SWOT analysis, patent analysis, and trend analysis. Refer to Chapter 7 for further discussion of some of these techniques. A basic framework is shown in Figure 1.13.

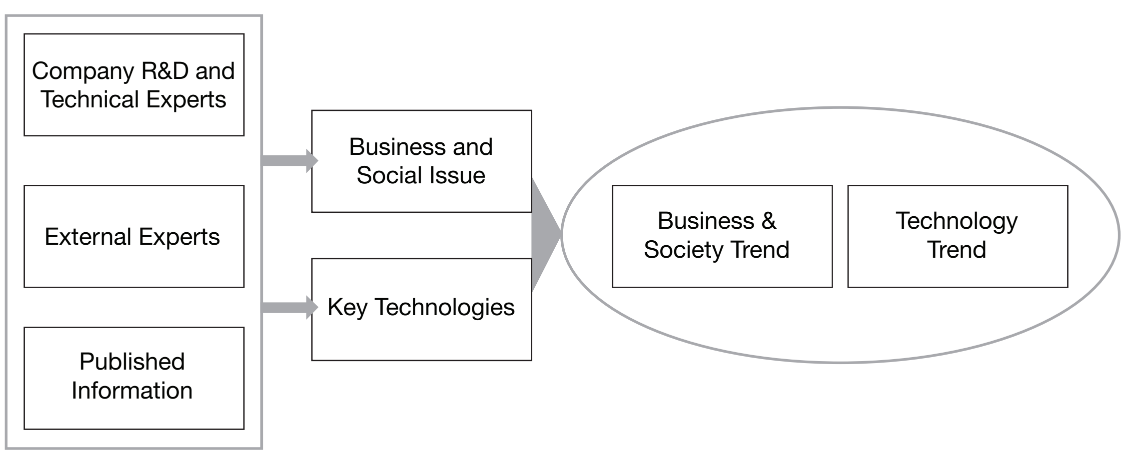

Figure 1.13 A basic technology foresighting framework

Technology strategy: link to the business and innovation strategies

The role and importance of a technology strategy will depend largely on the strategic focus for the organization:

- Technology-driven companies are highly dependent on achieving a competitive edge through new and innovative technologies.
- Market-driven companies are heavily focused on meeting customer needs, where technology may or may not be a significant component.
- Most companies will fall somewhere in the middle ground, with a strong focus on meeting customer needs but where technology is an important consideration in achieving a competitive edge.

In section 1.6.4, Pisano's innovation landscape map was introduced. This presented four quadrants of innovation strategy based on the relative emphasis on business and technology. Architectural innovation was defined as focusing on both business and technology while radical innovation was defined as a more singular focus on technology. Organizations that have strategically positioned themselves in either the architectural or radical quadrants of Pisano's innovation landscape will need to place a strong emphasis on the status and trending of relevant technologies (both current and future). Fundamental to technology development and application is the principle of the technology life cycle or the technology S-Curve.

Technology S-Curve

The technology S-Curve basically shows the life cycle stages that apply to most technologies; refer to Figure 1.14.

The embryonic stage: where the technology is initially applied, often with limited performance. At this stage, there are significant risks for companies applying the technology. These risks, associated with potential product failure and lack of customer satisfaction, may be a significant deterrent to organizations that are employing relatively low-risk innovation strategies. On the other hand, organizations that have committed to higher-risk strategies may see technology at the embryonic stage as an opportunity to gain an early foothold in the market and to become a market leader.

The growth stage: based on significant improvement in the technology and its performance. The more risk-averse organizations will now be more willing to apply the technology. This leads to greater competition for products applying the technology.

The maturity stage: signals the point where the limits of the science required to increase the performance of the technology have been reached. Or possibly the technology has been superseded with a new and more advanced technology. Refer to Figure 1.15.

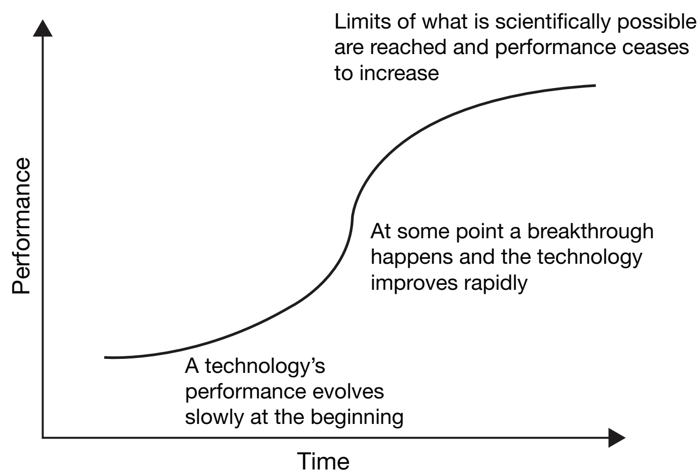

Figure 1.14 The technology S-Curve

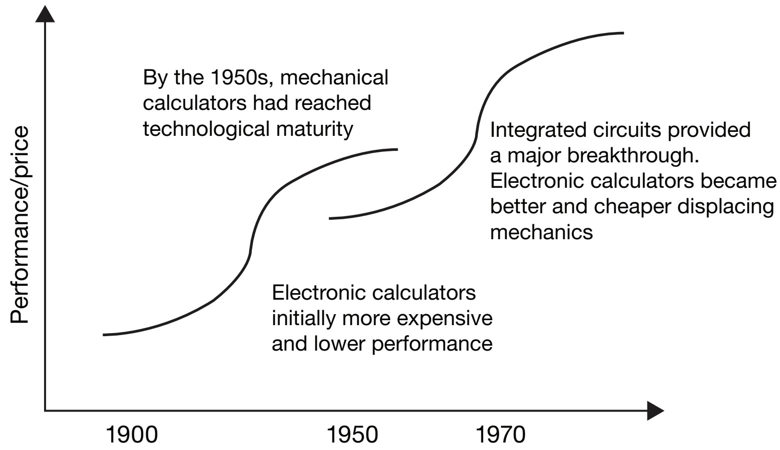

Figure 1.15 Technology disruption example: mechanical calculators

Technology roadmap

Technology roadmaps are an important complement to the product roadmap in aligning technology planning and development to overall planning for the launch of a single product or a range of products. Technology road mapping is particularly important in organizations that have a strong strategic focus on technology in underpinning the innovation strategy and new product innovation. Refer to Chapter 7 for greater detail on technology roadmaps.

1.7.3 Intellectual property strategy

Intellectual property (IP) refers to creations of the mind, such as inventions, literary and artistic works, designs, symbols, names and images used in commerce. Just like other forms of property (land, buildings, etc.), IP can be sold, licensed, exchanged, or given away by its owner.

IP is particularly important in product innovation because it defines the potential for an organization to capture value from new products. This can be done either directly by the organization in its manufacturing and marketing of the new product, by licensing the product to another organization, or by selling the IP rights. Protection of IP ownership is, therefore, an essential component of an organization's business strategy. IP is protected under law in a number of ways that enable the owner to earn recognition or financial reward from what they invent or create.

Types of IP rights

Patent: a government authority or license conferring a right or title for a set period, especially the sole right to exclude others from making, using, or selling an invention.
Copyright: the exclusive and assignable legal right, given to the originator for a fixed number of years, to print, publish, perform, film, or record literary, artistic, or musical material.
Trademarks: a symbol, word, or words legally registered or established by use as representing an organization or product.
Plant variety rights: give exclusive right to produce for sale and sell propagating material of a plant variety.
Trade secrets: information related to IP that is retained confidentially within an organization.

Approaches to IP management

As an organization progresses in its maturity in the application of intellectual property as a business strategy, it moves from a reactive state, where the emphasis is simply on tracking IP developments, to a focus on utilizing IP to drive competitive advantage. The decision on what emphasis is placed on IP as a driver of overall business strategy will depend on overall organization goals and the environment in which it is operating. Figure 1.16 summarizes the management of IP under four specific headings — reactive, proactive, strategic, and optimized.

Figure 1.17 outlines the approach to managing IP in an optimized manner, where IP is front and center in achieving the organization's strategic goals. Here, IP is used:

- to drive competitive advantage;
- as a key criterion in portfolio management;
- as a key driver for company profitability and growth.

Competitive intelligence underpins strategic decisions and mitigates risks.

Approach / Activity	Reactive	Proactive	Strategic	Optimized
Research and product innovation	Patent as an after-thought	Freedom to operate	Aligned with business strategy	IP drives strategic advantage – R&D investment
IP portfolio and management	Simple portfolio tracking	Relate portfolio to business. Build IP awareness	Portfolio management input to R&D and licensing	Portfolio management for competitive advantage
IP acquisition and monetization	Ad hoc response to IP licensing opportunities	Proactively identify licensing partners	IP royalty and revenues goals	Business drives IP monetization & acquisition targets
Competitive intelligence	Ad hoc or situation-driven intelligence	Competitive intelligence on key industry players	Ongoing analysis of complete IP competitive landscape	Competitive intelligence is key to business strategy
Risk management and litigation	Respond to surprise litigation	Risk profile monitoring; defense patenting	Protective licensing	Non-mitigated risks are insured

Figure 1.16 Approaches to IP management

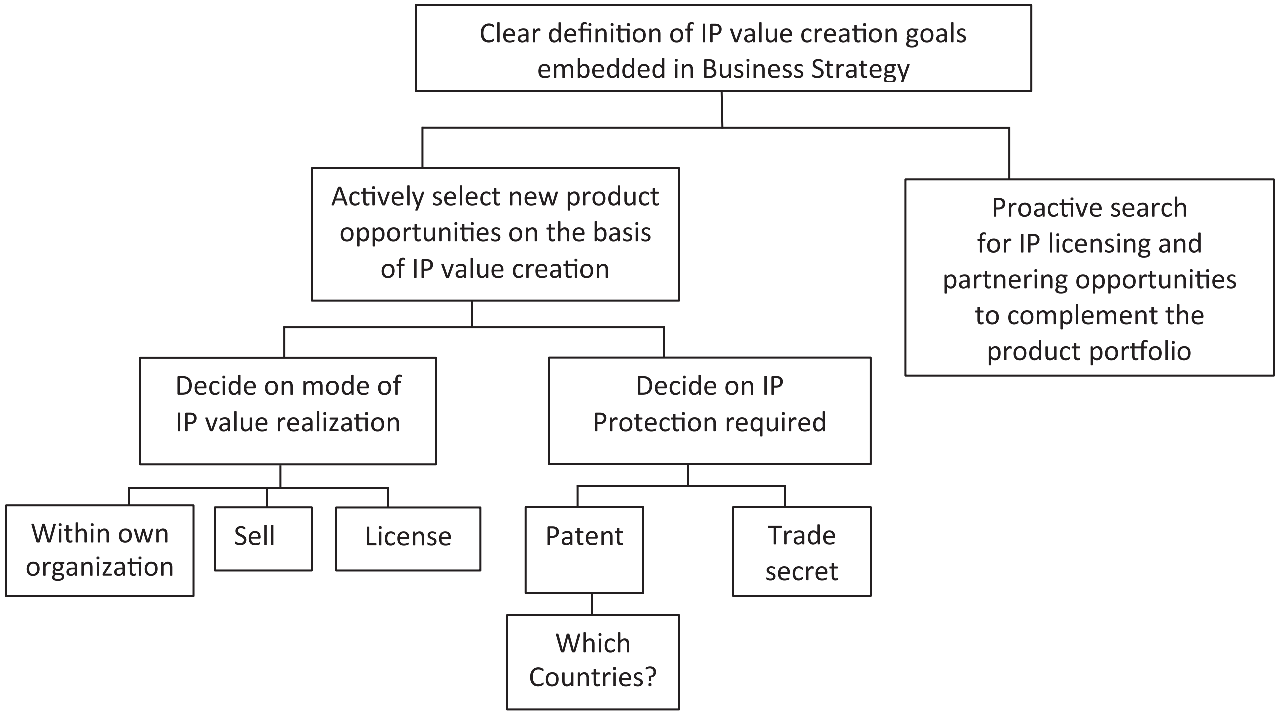

Figure 1.17 An optimized approach to IP strategy

1.7.4 Marketing strategy

A marketing strategy is a process or model to allow an organization to focus limited resources on the best opportunities to increase sales and thereby achieve a unique competitive advantage.

The marketing strategy must be informed by, and be consistent with, the business goals identified in the overall business strategy. It is, therefore, an important contributor to successful development and implementation of the innovation strategy.

The hierarchy of business goals, marketing strategy, and marketing planning is summarized in Figure 1.18.

- Start with business goals, encapsulated in the vision and mission.
- Develop the marketing strategy: high-level direction for the marketing efforts.
- Define the marketing mix: product, price, promotion, place.
- Prepare the marketing plan: specific tasks and activities designed to achieve the marketing strategy and business goals.

Figure 1.18 Business goals to marketing plans

In developing the marketing strategy, the following questions need to be answered:

- What products will be offered? Includes determining the breadth and depth of product line.
- Who are the target customers? Consider market boundaries, segments to be served.
- How will the customers be informed of the product's availability and of its benefits?
- How will the products reach the customers? Specifies the distribution channels to be used.

The marketing mix

The marketing mix comprises the basic tools available to market a product. The market mix is often referred to as the four Ps — product, price, promotion, and place. Elements of the marketing mix are shown in Figure 1.19.

Figure 1.19 The marketing mix

Developing the marketing mix for a product

In developing the marketing mix for a product, the following should be considered:

- All elements of the marketing mix should be synchronized around target market needs and expectations.
- The price should be aligned with customers' expectations of the product worth — evidenced by its functional and aesthetic attributes.
- The promotion should emphasize the core benefits, the tangible and augmented features (see below for a description of core, tangible, and augmented product features).
- The place of sale should be consistent with the product's quality, and features and behaviors of the target market.

Chapter 7 further discusses the application of the marketing mix at various phases of a product's life cycle, with a specific emphasis on the introductory phase.

What is a product?

A product can be described at three levels (refer to Figure 1.20):

Core product: The benefits that the target market will derive from the product.

Tangible product: The physical and aesthetic design features that give the product its appearance and functionality.

Augmented product: These are benefits that may be provided extra to the product, either free of charge or for a higher price.

An example: a luxury automobile

Core benefits: demonstration of wealth, power and prestige to the owner.

Tangible features: sleek styling, powerful engine, heated seats, etc.

Augmented features: 5 year warranty, special payment terms, 2 years free service.

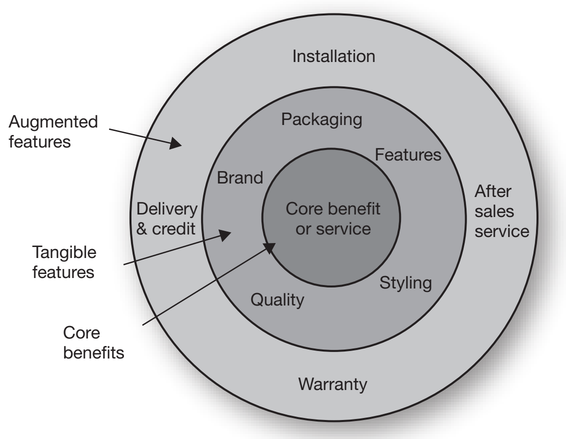

Figure 1.20 The three levels of a product

The value proposition

Value proposition is defined as *"a short, clear and simple statement of how and on what dimensions of a product concept will deliver value to prospective customers. The essence of 'value' is embedded in the trade-off between the benefits a customer receives from a new product and the price the customer pays for it."* (PDMA Glossary, see Chapter 3 of the PDMA ToolBook 1).

Clarity of the value proposition associated with a new product under development is central to its ultimate success in the marketplace. Appropriate market research to establish customer needs lays the foundation for the product's value proposition. This in turn can be developed into a clear concept description and product design specifications. Ongoing market research, throughout the product innovation process, should ensure the product's design continues to be aligned with the value proposition.

Analyzing the current product portfolio
Analysis of an organization's current product portfolio is central to both product management and product innovation planning.

A technique developed by the Boston Consulting Group (BCG) provides a framework for analyzing the current product portfolio on the basis of two dimensions, market share and market growth (refer to Figure 1.20). On the basis of this analysis, current products are placed into one of four categories — stars, question marks, cash cows, and dogs — defined as follows:

Stars are products that command a significant market share in a growing overall market.
Question marks are products that are in a market of high overall growth but as yet have not captured a significant market share.
Cash cows are products that have a high share of a market which has low overall growth.
Dogs are products that have a low share in a market with low overall growth.

The strategies associated with product management and product innovation for each of these product categories are summarized in Figure 1.21.

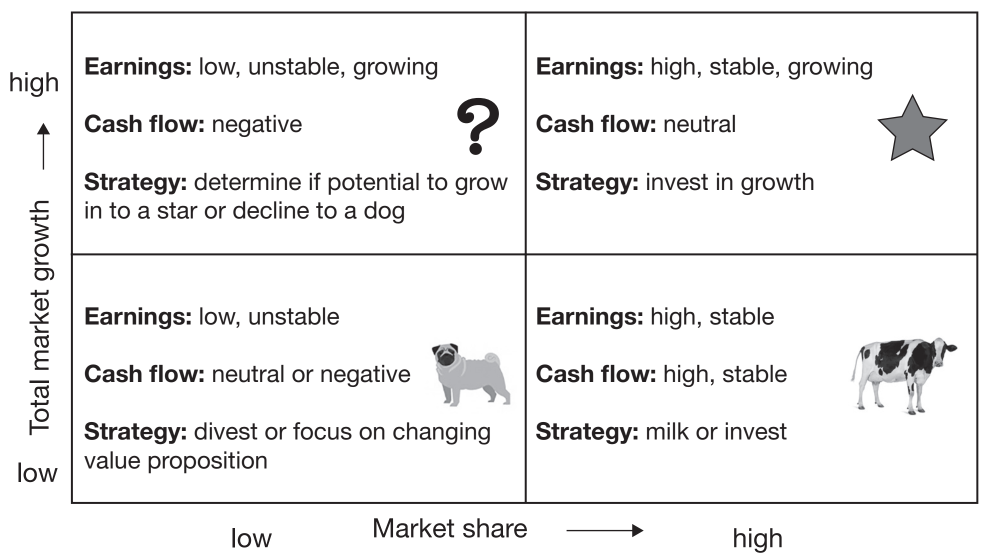

Figure 1.21 Adaptation of the BCG growth-share matrix
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The product roadmap
A product roadmap is a plan that matches short-term and long-term business goals with specific product innovation solutions to help meet those goals.

The purpose of a product roadmap is to communicate direction and progress to internal teams and external stakeholders. It shows the high-level initiatives and the planned steps to get there. Creating a product roadmap should be a continuous process throughout the life cycle of a product. Refer to Chapter 7 for greater detail on product roadmaps.

1.7.5 Capability strategy

Having defined the innovation strategy, it is imperative to establish the right set of capabilities to implement this strategy.

Some key definitions:

Competencies refer to the combination of skills, knowledge, and ability that lead to superior performance in an organization and that allow it to be competitive in the marketplace. There are two main types, commonly referred to as “soft” or “behavioral” competencies and “hard” or “technical” competencies.

Behavioral competencies include cognitive and personality characteristics while technical competencies include learned expertise such as project management. Behavioral competencies involve characteristics such as analytical thinking, interpersonal ability and initiative. Abilities rely on natural or inherent behaviors as opposed to learned. Although abilities can be developed to some extent, the majority of what constitutes ability cannot be learned. Technical competencies involve the knowledge and skills elements which are learned through study and practice. Skills are the application of knowledge in work or leisure, in a trade or profession.

Core competencies are what give an organization one or more competitive advantages in creating and delivering value to customers. Whereas a standard set of competencies allow an organization to compete in the marketplace, core competencies are those that give the organization a truly competitive edge.

Resources are the operational inputs that allow an organization to perform its business activities. Resources are often divided into three categories:

- Physical assets,
- Human resources,
- Organizational capital.

Capabilities are the activities and functions an organization performs to utilize its resources — physical assets, organizational capital and human resources (competencies) — in an integrated way. Capabilities are practiced and developed over time. As they become stronger, the organization enhances its expertise in a particular functional or operational area. This expertise allows the organization to differentiate itself from competitors.

Capability-based strategies, sometimes referred to as the resource-based view of the firm, are determined by those internal resources and capabilities that provide the platform for the organization’s strategy and those resources and capabilities that are the primary source of profit. A key management function is to identify what resource gaps need to be filled in order to maintain a competitive edge where these capabilities are required.

A basic roadmap for developing capability-based strategies for product innovation:

1. Ensure a clear definition of organizational mission, goals, business strategy, and innovation strategy. As discussed in previous sections of this chapter, these underpin all organization decision-making. Refer to Figure 1.22.
2. Carry out a SWOT analysis, specifically focusing on the organization’s capability to take advantage of opportunities and to combat threats. What specific resources — physical assets, organizational capital, and human resources — are required?
3. Carry out a “capability audit” to identify current organizational resources and their strengths.
4. Identify the gaps between required capability and the current capability. Specifically:
   - What new resources need to be added?
   - Where do current resources need to be strengthened?
   - What competencies are required to compete?
   - What core competencies are required to provide a truly competitive edge?

5. How should the organization develop the desired capability and acquire the required resources? Specifically:
   - Develop internally, e.g., train or re-train existing staff
   - New appointments to supplement or complement existing competencies
   - Mergers, acquisitions, joint ventures, open innovation

Figure 1.22 The hierarchy of capability-based strategy

1.7.6 Digital strategy

Digital business **innovation** involves the application of **digital** technology to improve operational efficiency, drive customer engagement, or develop innovative products or services for an organization.

Digital strategy focuses on using technology to improve business performance, whether that means creating new products or reimagining current processes. It specifies the direction an organization will take to create new competitive advantages with technology, as well as the tactics it will use to achieve these changes.

Digital transformation
The Institute for Digital Transformation defines digital transformation as, "The integration of digital technologies into a business resulting in the reshaping of an organization that reorients it around the customer experience, business value, and constant change." This definition recognizes that digital transformation is much more than just a change in IT technology such as hardware, software, or a digital platform. A digital transformation goes to the heart of the business processes and transforms them to leverage digital capabilities that were unavailable during the Industrial Age. Customer demands, including the customer experience, and business value are different in a digital business.

The impact of digital transformation on product and service design
Following are some of the technology aspects of a digital transformation that have a significant impact on the design of new products and services.

- Smart devices are products or appliances that are characterized by sensors or monitors, a user interface, processing capability, and digital communication. As such, these devices are essentially computers embedded in a product that provide additional functionality. Most smart devices can also be customized with a personal profile or programmable functionality that enable the user to create a unique pattern of interaction with the device.
- The Internet of Things (IoT) is a digital technology that has grown rapidly during the past few years. It is characterized by any device or equipment with digital communication capability along with sensors or

monitors. The Internet of Things connects devices digitally across a network and allows either one-way or two-way communication.

- Analytics platforms provide aggregation of data into a dashboard or user interface. This enables a customer to monitor and control a process that has multiple connected devices. The analytics can also be used to troubleshoot and analyze the performance of the different steps in the process being monitored.
- Digital platforms are software applications that operate over the Internet and connect individuals from different user group categories. Through the platform connection, the individuals or corporate entities can exchange information, purchase products or services, and promote a cause or product. Digital platforms can be very complex with many user group categories and extensive sharing capability for presenting and exchanging information. Or the platform can be very simple and focused on a small set of categories or type of information.

The impact of digital transformation on product and service innovation processes

How do the changes in product architecture in the Digital Age impact the process of product innovation? The key change for the product innovation is that a new KPI has jumped to the forefront — relationship management. The customer's perspective of value in the Digital Age is more than the product performance, it is also the level of connectedness and relationship that accompanies a new product. Essentially every product is now more than just a combination of functions and features, it is a service with a relationship. Customers want to connect with the product before they purchase it — either through reviews or forums from other users. Customers want to connect with the manufacturer or seller when they purchase so that they can easily purchase, install, set up, or customize the product to make it personal. Many customers want to connect with others in a community of interest and share experiences of product use. Many customers want the product to connect to platforms or networks so that they can control it remotely. Many customers want the product to track how they are using it so that the product will remember their behaviors and adapt to what they are doing or provide access to other similar or complementary products. All of this is dependent upon the product's ability to create a relationship and very little has to do with the function and efficacy of the product.

Even if the product is not powered and connected, customers will join user groups or provide feedback on the producer's website and/or social media channels. Relationship management is an important aspect of value to customers in the Digital Age. Therefore, the product must be designed to facilitate the establishment and maintenance of a digital relationship.

While that is a fundamental shift in the design of many products, a major transformation also occurs in the process of developing a new product or service. In an Industrial Age business, the designers and developers gathered customer requirements through focus groups. Then they crafted the new product and tested it in a laboratory or test facility to be sure it worked as expected. Once they were confident in the design, they created and set up the production facility so the product could be produced. Finally, the product was launched to the market. In the Digital Age, those steps are transformed by the digital technology capabilities.

The Digital Age development process starts with customer needs, but this information is often collected by direct inquiry with thousands of users or potential users through social media. This is both faster and broader than the focus group approach. The product development step in the process is transformed using rapid prototypes. 3D printing technology and the creation of virtual twins can reduce the time in this phase of the development by an order of magnitude. An idea or concept is formulated one day, and it can be tested the next. This brings us to the test and validation phase of development. Questions concerning user acceptance testing can be easily addressed with an A/B test with actual customers. Testing for extreme conditions and environments can be done virtually once a virtual twin has been calibrated. Again, this dramatically shortens the time and lowers the cost. Additionally, the development of the manufacturing processes can be quickly accomplished because digital manufacturing is using flexible work cells and lot size of one production scheduling. The combination of these effects is one reason that Digital Age companies can bring new products to market in a fraction of the time required for Industrial Age companies.

In Chapter 7, we discuss the principle of "Crossing the Chasm," which describes the difficulty of launching an innovative new product. This is the difference between the early adopters who try everything new just to have the newest product and the acceptance of the product by the mainstream who want to make sure the innovative new product really does provide value before they are willing to buy one. In the Industrial Age, that chasm was often deep and wide. Tremendous pressure was put on marketing to make sure the new product crossed the chasm and business was able to receive a benefit from the investment in the new product.

Digital Age technologies and systems bridge that chasm. The digital attributes of the new product can allow customers to experience the product before purchasing, thus selling them on the benefit. The community of early adopters can provide instant access to success stories that will further convince the mainstream to adopt the product. And if there is a problem with the new product, immediate feedback is obtained, and the developers can correct the problem — demonstrating a strong commitment to customer success and satisfaction.

While that is the upside of developing new products in the Digital Age, there is also a downside, or at least a risk that a Digital Age company must be prepared to address. Because it is much easier for a new product to enter the market, that also means it is much easier for competitors' new products to enter the market and establish a commanding position. An interesting characteristic of Digital Age products is that updates and upgrades are regularly provided for the product. This constant refreshing of the product allows a product line to rapidly respond to new entrants in the market and gives the company a reason to re-engage and strengthen the relationship. In addition, most Digital Age products have interfaces with other third-party software applications such as digital platforms. These are also changing every few months and products must be updated to stay compatible. Due to these factors, the product development process must keep a constant stream of feature enhancements and performance improvements in the pipeline. Industrial Age businesses could launch a new product and see its position in the market grow and remain stable for years with no product changes. Not so with Digital Age products. There must be something new on a regular basis, typically quarterly, to maintain market position.

Product innovation operations and control

The operational control of product development is the aspect of the process that does not need to undergo massive change as a company transitions from Industrial to the Digital Age. Almost all companies are now developing new products using cross-functional teams and managing those teams with a structured control process. This general approach is still used in the Digital Age, but the time spent in each stage can be significantly reduced. In addition, many organizations have been using Agile project management methodologies for IT or software development projects and this is a best practice for digital development. While Agile is not as well suited for hardware development as it is for software, the use of digital technologies like 3D printing and digital twins make the use of Agile possible with any kind of new product.

A digital strategy framework

There is no singular process or best practice when defining and implementing a digital strategy. Whether you're transforming an existing business/portfolio or starting a new enterprise, the single most important part of a digital strategy, like all other strategies, is to have one. Figure 1.23 presents a sample outline of some of the elements that can be included in a digital strategy:

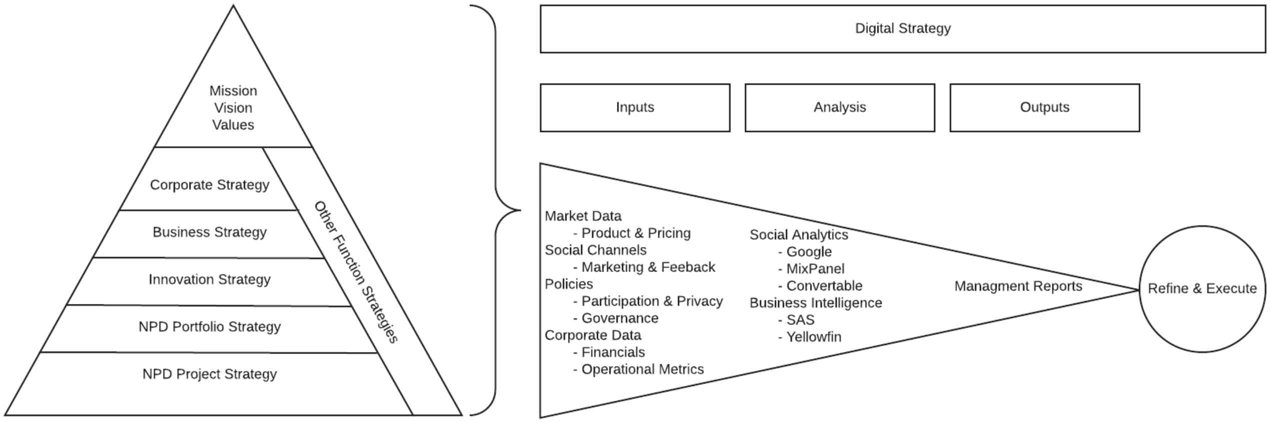

Figure 1.23 Sample digital strategy framework

The digital strategy is an extension of the existing strategy hierarchy as discussed in section 1.1.2. To begin planning a digital strategy, first start by understanding your current mission, vision, and values and the strategies that underpin them. Next, use a structured process to design the digital strategy, as shown in

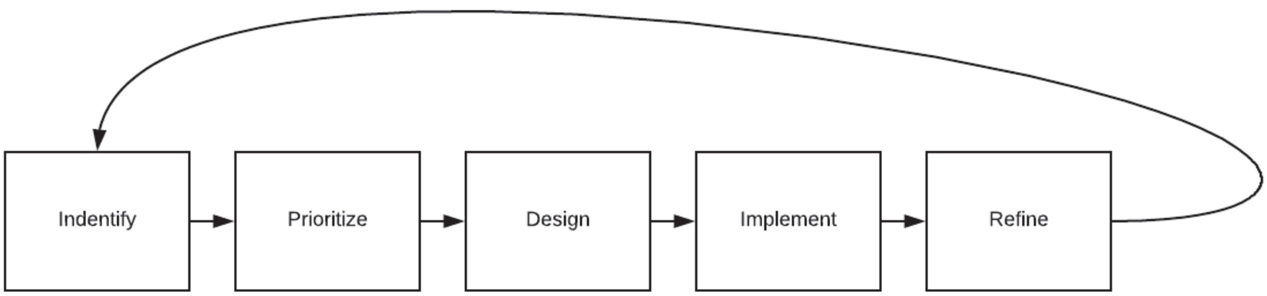

Figure 1.24.

Figure 1.24 Sample digital strategy planning process

Identify: During this phase of the process, you will identify the inputs you have to your digital strategy. Inputs can be current internal assets such as financial data or operational metrics. Inputs should also include things like your current data management policies to include privacy policies, participation policies for consumers (if applicable), and general data governance policies. Another key component will be external inputs such as consumer feedback from surveys, i.e., net promoter scores or social channel feedback like tweets and Facebook posts. Last but not least will be market data related to your product or service offering. Pricing information, market trends, and consumer sentiment are examples of market data.

Prioritize: During the identification phase, you will uncover new sources that you may not have access to today or manually intensive sources that are available but cost/time prohibitive to assemble. Looking back again to your overall strategy hierarchy, you can assign relative priorities to each source. It is important to remember that data analytics is a never-ending process of acquisition, refinement, review, and enhancement of process.

Design: During the design phase, you take the prioritized inputs, map them to their associated goals from the prior strategy review and then design the format of the output. Outputs can be simple management reports or real-time management dashboards. Like data sources, reporting solutions can and should be iterative. Simple tabular reporting can happen quickly, whereas complex data visualization can often take months or even years to perfect. As mentioned earlier in this section, as time compression takes place in each product development and innovation phase, access to timely and actionable data becomes increasingly important.

Implement: Many organizations provide access to data without providing a context for the consumption of those data. The first step in implementing a reporting solution for your digital strategy will be to educate the consumers of those reports on the goals each element is tied to and how to read and interpret the data presented. This is not to say that new insights cannot or should be developed by the individual consumers. If that does happen, it is important that these insights be fed back into the larger digital strategy for broad review, validation, and distribution. If each consumer is not aligned on the meaning of a metric, the organization can easily become inefficient and possibly even ineffective.

Refine: During each design phase, the cadence with which the digital strategy will be enhanced should be pre-determined. This commitment is part of each stakeholder's understanding and each data source's roadmap to deliver outstanding elements. A typical enterprise cadence for feedback, review, refinement, and enhancement of a digital strategy is quarterly. For example, a new strategy is launched in Q1, the process runs and outcomes occur, decisions are made, and feedback is collected. Feedback is reviewed in real time and a new set of reports, tools, etc., is scheduled for release in Q2, and so on. Each company's cadence is informed by market speed, product lifespan, etc. Some companies make changes annually and some, monthly. The important factor is to always align your activities to your larger strategic hierarchy.

1.8 OPEN INNOVATION

1.8.1 Foundations of Open Innovation

Open Innovation (OI) is defined is the strategy adopted by an organization whereby it actively seeks knowledge from external sources through alliances, partnership and contractual arrangements to complement and enhance its internal capability in pursuit of improved innovation outcomes. These innovation outcomes may be commercialized internally, through new business entities, or through external licensing arrangements.

OI can deliver many benefits, but applying it is challenging. Figure 1.25 summarizes some potential benefits as well as challenges of applying OI, organized around the six principles of OI (Tidd and Bessant, 2013).

Principle of OI	Potential benefit	Challenges in OI application
Tap into external knowledge, e.g., through customer contests, university partnerships, and other collaborations	Increase pool of knowledge Reduce reliance on limited internal knowledge	How to search for and identify relevant knowledge sources Breaking down traditional internal views on innovation
Acquire external R&D	Can reduce the cost and uncertainty associated with internal R&D and increase depth and breadth of R&D	Less likely to lead to distinctive capabilities and more difficult to differentiate External R&D may also possibly be competitors
Do not have to originate research in order to profit from it	Reduce cost of internal R&D, more resources applied to external search strategies and relationships	Need sufficient internal R&D capability in order to identify, evaluate and adapt external R&D
Building a better business model is superior to being first to market	Greater long-run profitability and success	First-mover advantages depend on technology and market context and may be difficult to overcome
Best use of internal and external ideas, not generation of ideas	Better balance of resources to search and identify ideas, rather than generate	Many companies are better at generating superficial ideas than finding the long-term winners The cost of evaluation is often high when sifting through potentially thousands of ideas
Profit from others' IP (inbound OI) and others' use of our IP (outbound OI)	Gets intellectual property (IP) in the hands of those companies best equipped to commercialize	Conflicts of commercial interest or strategic direction Negotiation of acceptable forms and terms of IP licenses

Figure 1.25 The benefits and challenges of Open Innovation. Adapted from Tidd, J. and Bessant (2013)

1.8.2 Open Innovation model types

Searching for and then working with external parties (be they customers, suppliers, competitors, or research institutions such as universities) is labelled as "inbound open innovation." Organizations can become different types of "inbound open innovators" depending on the number/types of partners with which they work (aka "partner variety") and the number/types of phases of their innovation process that they "open" to external parties (aka "funnel openness") (Tidd and Bessant, 2013). Figure 1.26 summarizes the four models of OI according to the level of funnel openness and the partner variety. In the bottom left of Figure 1.26 there are closed innovators who have very low funnel openness and a low variety of partners. In the top right is the other extreme of open innovators who have a high level of funnel openness and a high variety of partners.

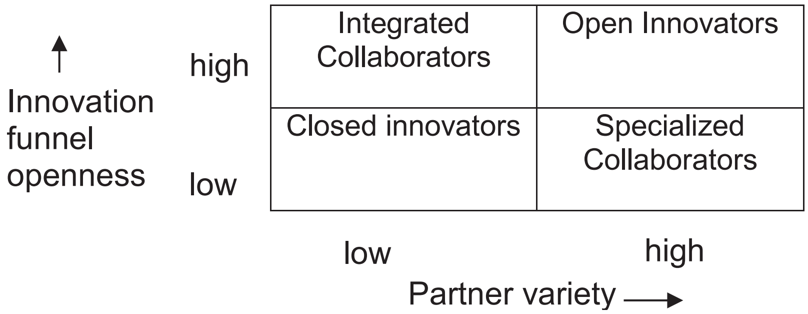

Figure 1.26 Open Innovation model types

Organizations must exercise caution when deploying resources for inbound innovation. Research shows that at low levels of openness (being generally closed to outside ideas) and very high levels of openness (considering ideas from a vast array of sources), innovation performance seems to suffer, while firms with a moderate amount of openness showed superior product and process performance.

The main success factors and appropriate managerial styles differ for these different types of open innovators (Tidd and Bessant, 2013). The main success factors for each of the four OI models summarized in Figure 1.27 and the associated management style are presented in Figure 1.28.

OI Model	Main Success Factors	Managerial Style
Open innovators	Technological leadership	Highly participative
Specialized collaborators	Technological excellence, service, time and others	Participative
Integrated collaborators	Quality, service, time, brand equity and others	Mainly top down
Closed innovators	Quality, service, time, brand, technological excellence and others	Mainly top down

Figure 1.27 Success factors and management styles for OI models

Becoming an open innovator improves innovation performance, but this effect is highly contingent on the number of potential partners, use of pre-screening these partners, and uncertainty of the industry environment for the firm (Lazarotti and Manzini, 2014).

Organizations can participate in OI in various ways: innovation seeker, innovation provider, intermediary, or open innovator (Ellis, Gianiodis and Secchi, 2014). The mechanisms for participation in each are summarized in Figure 1.28.

OI Participation Type	Mechanisms to Participate
Innovation seeker	Leverage user innovation; outsource and form alliances
Innovation provider	Venture capital; licensing and alliances
Intermediary	Auctions; partnerships
Open innovator	Outsource, form alliances, mergers and acquisitions; venture capital licensing

Figure 1.28 Mechanisms for participation in Open Innovation

For further reading on Open Innovation, refer to Noble et al. (2014).

1.8.3 Open Innovation examples

Open Innovation is used by many organizations, including a number of PDMA's Outstanding Corporate Innovation (OCI) award winners. The 2015 OCI award winner, Novozymes, a leader in enzymes and microbial technologies, uses OI in various phases of the innovation process. They are particularly active in crowdsourcing in the idea generation stage: they collect ideas online for two weeks, screen these ideas and then mature the selected ones for one month. These matured ideas are then pitched to management as New Lead Project Proposals.

Offshore Oil Engineering Co., Ltd (COOEC), the OCI winner in 2018, is the world's leading supplier of KIBS marine energy engineering and provides innovative integrated solutions to petroleum and gas field development. COOEC actively uses OI through partnering with university research centers, suppliers, and clients.

A final example is the Smart Village initiative in impoverished rural Indian states. A number of companies, many of them competing against each other in other markets, collaborate to empower villagers so that the villagers can join in the supply chain and create a win-win environment both for themselves and for the participating companies (Darwin and Chesbrough, 2016).

1.9 SUSTAINABLE INNOVATION

1.9.1 What is a sustainable business?

A sustainable business, or a green business, is an enterprise that has minimal negative impact on the global or local environment, community, society, or economy — a business that strives to meet the triple bottom line (defined in section 1.9.2). Often, sustainable businesses have progressive environmental and human rights policies.

Sustainability in business generally addresses two main categories:

- The effect business has on the environment;
- The effect business has on society.

The goal of a sustainable business strategy is to make a positive impact on either of those areas. When companies fail to assume responsibility, the opposite can happen, leading to issues like environmental degradation, inequality, and social injustice.

Beyond helping curb those global challenges, sustainability can drive business success. Several investors today use environmental, social, and governance (ESG) metrics to analyze an organization's ethical impact and sustainability practices. Investors look at factors such as a company's carbon footprint, water usage, community development efforts, and board diversity.

According to McKinsey (https://www.mckinsey.com/business-functions/sustainability/our-insights/sustainabilitys-deepening-imprint), the strongest motivating factors among company employees to adopting a sustainable mindset are to: align with a company's goals, missions, or values; build, maintain, or improve reputation; meet customers' expectations; and develop new growth opportunities.

1.9.2 Sustainability and strategy

Most organizations now have an overarching framework for incorporating sustainability into standard organization operations. This implies that:

- Organizations develop a formal sustainability plan.
- Sustainability is used to drive competitive advantage.
- Sustainability is used as a driver for innovation and developing new products, following the triple bottom line (people, planet, profit) concept.
- Sustainability is included in organization mission statement and values.
- Sustainability metrics are tracked at the executive level.
- Sustainability maturity model is in place and progress is tracked regularly.
- Sustainable innovation is used to be compliant, market driven, engaged, or shaping the future, or compliant, reactive, proactive, purpose.

The triple bottom line

In traditional accounting, the "bottom line" refers to either the profit or loss at the very bottom of the statement of revenue and expenses. It was the key indicator of business performance. Over recent years, businesses have sought to evaluate their performance in a broader perspective, taking into account social and environmental contribution or impact.

The "triple bottom line" reports performance against three dimensions:

- Financial
- Social
- Environmental

These dimensions are often referred to as the three Ps:

- Profit
- People
- Planet

1.9.3 How to create a more sustainable business strategy

Step 1: Assess the problem and define objectives

The first step to driving change is assessing what sustainability means to your team, company, industry, and client. Consider the big problems each of these groups thinks is a priority. This information can be used to create a materiality matrix depicting the relevant sustainability topics relative to the impact on your organization and the importance to your stakeholders. A simple example: https://www.greenbiz.com/article/how-make-your-materiality-assessment-worth-effort.

To guide this process, consider asking questions such as:

- Which societal and environmental topics are most important for the organization's customer segments?
- Where can societal and environmental topics form a risk for the organization or its customers?
- What is the purpose of the organization?
- How much waste is the organization creating?
- Does the organization have a positive culture?
- Are the hiring practices attracting diverse job candidates?
- Are the organization's products targeted to address the main topics in your materiality matrix?
- What impact does the organization have on the local community?

Answering these types of questions will help establish the organization's sustainability objectives and improve the quality of input to a PESTLE analysis (section 1.5.2).

Step 2: Establish the sustainability component of the organization's mission

Decide on specific sustainability objectives and ensure that these are embodied in your company's mission. Ensuring that these objectives are an integral part of the mission is an important part of becoming a more sustainable business. Here are two examples of companies with mission statements that effectively focus on sustainability:

Alignable (https://www.alignable.com): "We believe that local businesses are stronger together. Our goal is to help small business owners make the connections that lead to long-term relationships, generate more word-of-mouth referrals, and unlock access to the collective wisdom of the local business community."

Patagonia (https://www.patagonia.com/home/): "Build the best product, cause no unnecessary harm, use business to inspire, and implement solutions to the environmental crisis."

In each, it is clear what the company values are, and how they are executing against those values.

Step 3: Craft the sustainability strategy

A clearly defined contribution of sustainability to the organization's mission is the starting point for sustainable business strategy.

In crafting a sustainable business strategy, it is important to ensure that the organization remains profitable. This is the number one priority. And as proven in many organizations, sustainability efforts may contribute to greater profitability.

Consider this: Does the organization typically leave the electricity and heat on overnight, even while no employees are on site? Imagine how much savings could be realized, in both cost and energy resources, if the last person in the office simply shut them off.

Or what about the consumers willing to pay more for a sustainably produced product? A 2017 Unilever study found that 33 percent of consumers want to buy from brands "doing social or environmental good," creating an untapped opportunity in the market for sustainable goods. (https://www.unilever.com/news/press-releases/2017/report-shows-a-third-of-consumers-prefer-sustainable-brands.html)

There are several strategies for specific industries that can increase operational efficiency while driving social and internal value. Putting in the work to build a robust sustainability strategy can help both the organization and the environment in the long term.

1.9.4 Introduction to sustainable product innovation

The bio-economy is gaining strength and visibility given that sustainability is part of society's agenda. It is also the responsibility of corporate organizations to promote it and engage society and consumers through a sustainable economy. New product innovation professionals should also embrace this new reality by incorporating sustainability as an integrated part of the new product innovation strategy and process. This section illustrates which elements, when integrated in regular product innovation, will support sustainable innovation.

Sustainable development is defined as "development which meets the needs of current generations without compromising the ability of future generations to meet their own needs." Brundtland Commission (1987), Report of the World Commission on Environment and Development: Our Common Future.

Sustainable innovation is the process in which new products or services are developed and brought to commercialization. Throughout this process the characteristics of sustainable development are respected from the economic, environmental, and social perspectives, in the sourcing, production, use, and end-of-service stage of the product life cycle. It has a global focus, beyond the primary life cycle of the product/service, and takes all stakeholders into account.

The importance of sustainability to product innovation. Over recent years, sustainability has become increasingly important in product innovation. A 2011 Sustainability and Innovation Global Executive Study reported that 70 percent of the organizations surveyed included sustainability permanently on the management agenda and invest in it (Haanaes et al., 2012).

In the 2012 PDMA CPAS, a third of the companies responded that sustainability contributed to their profits (Markham and Lee, 2013).

Figure 1.29 presents an Innovation Maturity Model which shows the characteristics relating to sustainability for organizations moving from what can be described as a "beginner" to a "leader."

Stage 1: Beginning

- Corporate policies do not recognize the triple bottom line (economic, social and environmental)
- Overall strategy for sustainability is focused on compliance with the minimum legal requirements
- Limited sustainability awareness when setting new product goals and specifications.
- Supplier policies do not incorporate sustainability
- Limited sharing and development of sustainability metrics

Stage 2: Improving

- Centralized Sustainability reporting function is in place
- Environmental, Health and Safety policy publicly states metrics and goals
- Carbon, energy and water footprints are established and measured at the plant level
- Regulatory and policy issues are actively communicated throughout the organization
- Business and product strategy anticipates future customer behavior based on sustainability trends
- Supplier assessment includes a review of a supplier's Sustainability policies
- Checklists and other tools used to compare sustainability of new products during the NPD process

Stage 3: Succeeding

- Best practices for improving the triple bottom line are consistently leveraged across the entire enterprise.
- Sustainability metrics are established at the enterprise level and linked to the business success of the company
- NPD processes consider and encourage sustainability throughout the phase-gate review process
- Company has shifted focus from meeting government regulations to exceeding requirements (benign by design)
- Supply chain impacts to the corporate sustainability goals are well understood and improvement activities are implemented.
- Supplier selection is based upon a supplier's environmental and sustainability policies and efforts.

Stage 4: Leading

- Company publishes an annual sustainability report that discusses all aspects of the triple bottom line
- Corporate Sustainability policy is fully integrated into other company policies and viewed as an important lever to drive growth and profitability
- Sustainable ideas and IP are leveraged for broader use by way of the supply chain, licensing, sale of IP, joint ventures, etc.. with the specific intent of broader impact.
- Organization emphasizes R&D Innovation to develop new technologies and design methods that will reduce the overall environmental footprint of new products
- Majority of company's products are "certified" according to industry standards and third party assessments
- Product sustainability metrics shared broadly and seen as competitive edge

Figure 1.29 Sustainability maturity model

Examples: Sustainability and strategy

Companies such as Nike have discovered that integrating sustainability into business operations can be a competitive advantage:

- “Sustainability and business growth are complimentary” (Nike, 2013). By developing innovative sustainable products, Nike has been able to reduce greenhouse emissions by 3 percent while increasing revenues by 26 percent over the same period.
- “Materials matter.” Nike is investing heavily into R&D and launching partnerships with organizations such as NASA to develop the next breakthrough material.
- “From reputation management to innovation opportunity.” Nike has learned that rather than just managing its reputation, it can create opportunities for change through industry collaboration, partnership, and transparency.

Externalities

Externalities are the effects of a product on people or the environment that are not reflected in the market price of the product. Externalities are a consideration for many companies. Government policy or regulation can be used to incorporate externalities into product price. Carbon pricing is an example of a policy that incorporates an externality (i.e., greenhouse gas emissions) into a product (i.e., electricity).

In the absence of regulation or policy, some companies have found profitable value marketing the incorporation of externalities into products. For example, products labelled as having been produced from renewable resources may command a higher price from consumers who value the environment.

The circular economy and innovation

Cradle to cradle (the beginning of a product’s life to the start of a new product’s life) thinking or focus on the circular economy can become a strategic driver. In the circular economy, the aim is to create closed loops in the product life cycle, based on three principles:

Principle 1: Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows.

Principle 2: Optimize resource yields by circulating products, components, and materials at the highest utility at all times in both technical and biological cycles.

Principle 3: Foster system effectivenessby revealing and designing out negative external influences. http://www.ellenmacarthurfoundation.org/ and https://kumu.io/ellenmacarthurfoundation/educational-resources#ce-general-resources-map/key-for-general-resources-map

Figure 1.30 shows examples of products in the circular economy.

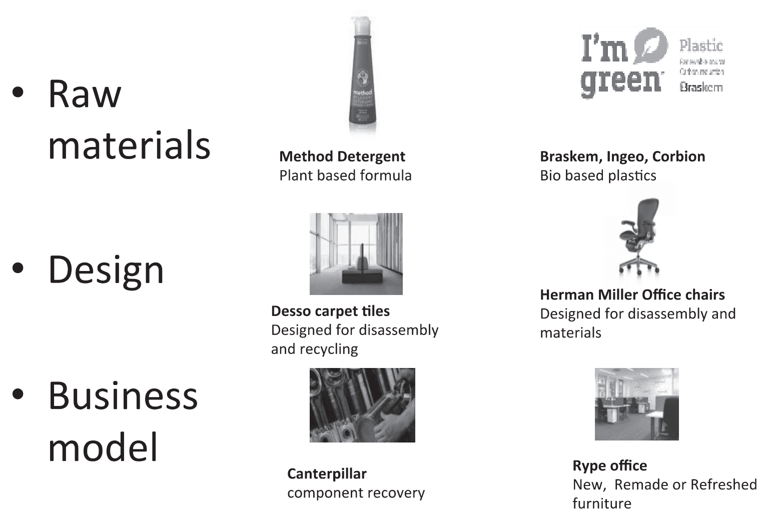

Figure 1.30 Examples of products for the circular economy

1.10 IN SUMMARY

- Strategy lies at the very heart of an organization's sustenance and growth. It lays the foundation and provides the framework for all of the organization's functions and activities.
- Strategy starts from the corporate and business levels of the organization and feeds into (or, can be fed by) the various functional strategies of the organization.
- Laying a strong foundation of knowledge related to the organization, the industry, the wider environment, competitors, and customers is essential to good strategy development. A number of tools can assist in this process including SWOT, Delphi, PESTLE, and Business Model Canvas.
- An innovation strategy is essential to most organizations. It stipulates how the organization's innovation efforts will support the overall business strategy. This provides the basis for trade-off investment decisions across product categories or business units.
- A range of frameworks is available to help with defining an organization's innovation strategy. Examples include those developed by Pisano (2015), Porter (2008), Christensen (2003), and Miles and Snow (1978).
- The innovation strategy is complemented by platform, technology, marketing, intellectual property, and capability strategies. All strategies must be harmonized to achieve common innovation goals.
- Realization of the product strategy (development and launch) can be achieved either using internal or external capabilities — or a combination of both. Increasingly, organizations are adopting an Open Innovation strategy to actively promote innovation with external parties.
- Increasingly, sustainability is becoming an integral part of an organization's overall mission with a specific strategy focused on sustainability. Most organizations are now providing triple bottom line reporting based on the three P's of profit, people, and planet.

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Practice questions: Strategy

1. A platform strategy is defined as _____?
   A. A common marketing plan for a series of products.
   B. A common manufacturing system for a range of products.
   C. A set of systems and interfaces that form a common structure from which a stream of derivative products can be effectively developed and manufactured.
   D. A strategy that connects marketing, technology, and manufacturing.

2. A corporate vision is _____.
   A. An NPD project goal.
   B. A philosophy statement about the beliefs of the company.
   C. A set of values.
   D. A picture of some desired future state that the organization hopes to obtain.

3. Mission statements help organizations to _____.
   A. Focus people and resources.
   B. Initiate ideas.
   C. Plan for product launch.
   D. Borrow capital at a low rate.

4. A strategy can be defined as _____.
   A. An organization's philosophy.
   B. A company's game plan for achieving its long-term objectives.
   C. An organization's new product development plan.
   D. The organization's values statement.

5. You are leading the strategic planning process for a horticultural company that is developing a new apple cultivar. A key element of the company's strategic planning is optimization of revenue from intellectual property. What specific form of intellectual property protection would you follow in this case?
   A. Plant variety rights.
   B. Trademarking.
   C. Patenting.
   D. Copyrighting.

6. Who is responsible for setting the corporate and business strategy?
   A. Process management.
   B. Senior management.
   C. The shareholders.
   D. The board of directors.

7. Your competitors have launched a new product. As you evaluate your response to compete with them, you realize that the technology employed in your current product has reached its limits and cannot be improved to increase the performance to effectively compete and the only option is to consider superseding with newer and advanced technology. What stage on the technology S-Curve are you on?
   A. Growth stage.
   B. Embryonic stage.
   C. Maturity stage.
   D. Laggard.

8. A dairy product manufacturer has discovered a new microorganism that may have significant health benefits (probiotic). The company decides to initiate a significant research program to prove these health benefits. It plans to use the probiotic in a range of products including yogurts, health drinks, and infant formula. This is an example of what type of strategy:
   A. Line extension.
   B. Technology.
   C. Platform.
   D. Marketing.

9. Which of the following strategies is most likely to have a strong emphasis on technology?
   A. Routine.
   B. Architectural.
   C. Radical.
   D. Both B and C.

10. In the BCG Growth-Share matrix a "cash cow" is defined as a product with high market share but low growth potential. What strategy should the company adopt for this type of product?
   A. Take as much profit from the product as possible.
   B. Sell the product while it is still making money.
   C. Carry out a detailed analysis of the product, the competitors, and the market, leading to a clear strategy for the future of the product.
   D. Make significant investment in product improvements.

Answers to practice questions: Strategy

1. C	6. B
2. D	7. C
3. A	8. C
4. B	9. D
5. A	10. C

2

PORTFOLIO MANAGEMENT

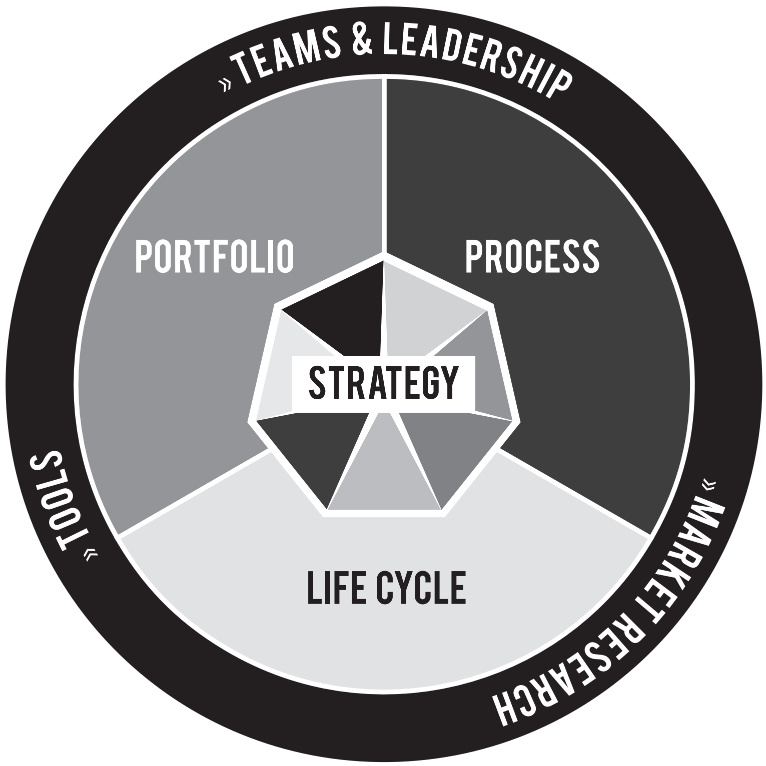
Establishes and maintains an appropriate balance of new and existing product innovation projects aligned with the business and innovation strategies

2. Portfolio Management

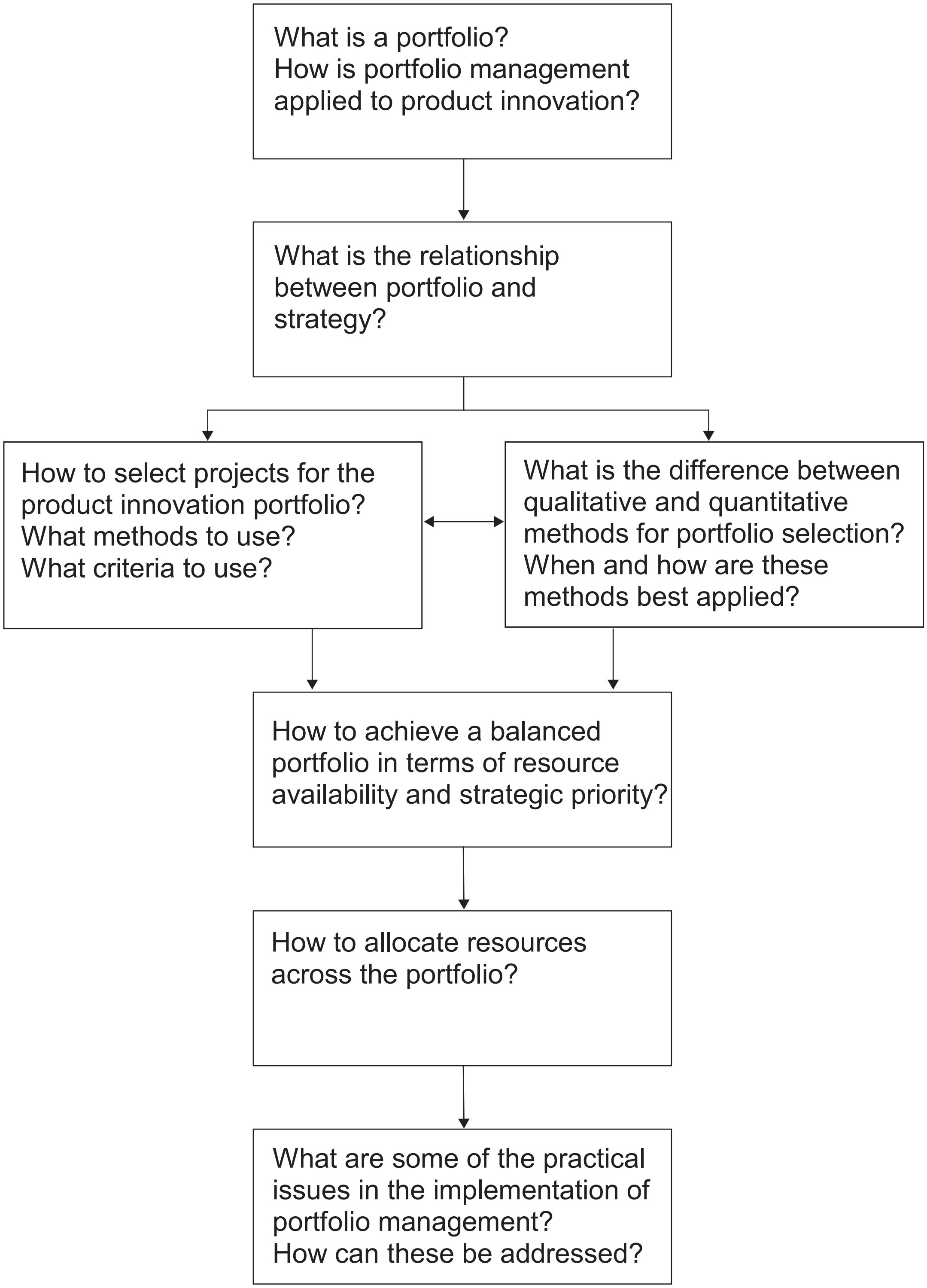
THE CONTENT

What you will learn in this chapter

Portfolio management ensures that the collection of product innovation projects is aligned with strategy and resource availability. In this chapter we further define the relationship of the product innovation portfolio to the overall business strategy. The types of projects that can be included in the portfolio are discussed, together with criteria and methods that are commonly used to select projects to achieve a desired portfolio balance. Some of the practical issues in the implementation of portfolio management are highlighted, together with suggested strategies to address these issues.



The Chapter Roadmap



The corporate strategy or business strategy, and in turn the innovation strategy, are prerequisites of portfolio management. An organization's product portfolio, in both its development and ongoing maintenance, invariably has a set of projects competing for resources and investment. Portfolio management is an essential tool, informed by the innovation strategy, that ensures the right prioritization and balance of product innovation and product management projects.

2.1 WHAT IS A PRODUCT PORTFOLIO?

A product portfolio is defined as *"A set of projects or products that an organization is investing in and making strategic trade-offs against."* (PDMA HandBook, 3rd Edition, 2013)

2.1.1 What is portfolio management?

"A portfolio is a collection of programs, projects and/or operations managed as a group. The components of a portfolio may not necessarily be interdependent or even related—but they are managed together as a group to achieve strategic objectives." (Project Management Institute, PMBoK 2013)

When applied to product innovation and product management, *"There are two ways for a business to succeed at new products: doing projects right and doing the right projects. Portfolio management is about doing the right projects!"* (Belliveau et al., 2002)

Cooper et al. (2015) define the goals of portfolio management:

1. **Value maximization:** Allocation of resources to maximize the value of the portfolio (the sum of the commercial worth of the individual projects).
2. **Balance:** Achieve the right balance of the right projects in terms of some pre-determined criteria such as long vs. short term; high vs. low risk; specific product or market categories.
3. **Business strategic alignment:** Ensure that the overall portfolio continues to reflect the business strategy and the organization's innovation strategy. Ensure that the investment across the portfolio aligns with the organization's strategic priorities.
4. **Pipeline balance:** Ensure that resources and focus are not spread too thinly — most companies include too many projects in their portfolio. Obtain the right number of projects to achieve the best balance between pipeline resource demand and available resources.
5. **Sufficiency:** Ensure that the financial goals set out in the product innovation strategy are achievable through the projects selected in the portfolio.

Portfolio management is often viewed as two separate activities, portfolio selection and portfolio review. In reality there should be no separation between these two activities. New products should always be viewed in competition for resources with current products as well as with other potential new products. Portfolio management should be applied as an ongoing process that is continually evaluating the product portfolio. This may be existing products, new products, product enhancements, maintenance and support, or research and development. It is a process that ensures optimal alignment with the strategic goals and that maximizes the return on investment. Figure 2.1 shows the overarching role that portfolio management plays; the projects that need to be considered; the scope, from ideation to "end-of-life"; the relationship to individual project execution; the reliance on performance metrics; and the critical linkage with financial planning and resource management.

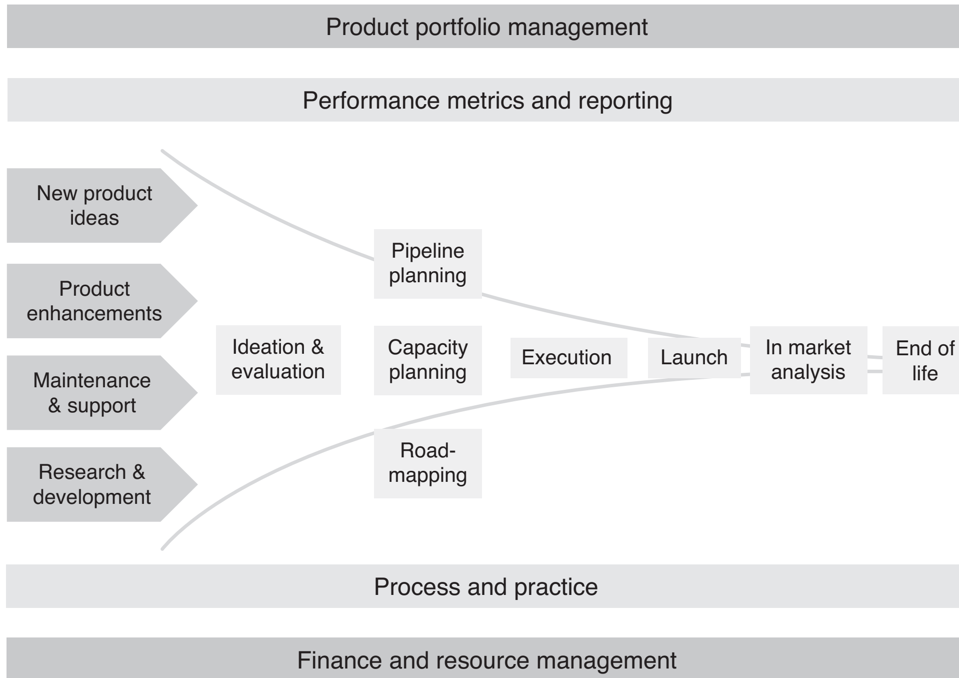


Figure 2.1 Portfolio management

2.1.2 Key characteristics of portfolio management

1. It is a decision-making process within a dynamic environment, requiring ongoing review.
2. Projects are at different stages of completion.
3. It deals with future events. There is no certainty of success. Portfolio management is used to increase the overall odds of success across the full range of projects or products.
4. Resources for product innovation and product management are limited and often shared with other business functions. These resources need to be allocated to achieve the best return to the organization. Alignment with the overall goals of the organization and the innovation strategy is essential to successfully implementing these trade-off decisions.

2.1.3 Types of projects included in a portfolio

In deriving an appropriate balance of projects in the portfolio, a variety of project or product classifications are used. The application of some form of classification system helps with strategic alignment and prioritization. Commonly used project or product types are:

Breakthrough projects (sometimes referred to as radical or disruptive). These projects strive to bring a new product to the market with new technologies, depart significantly from existing organizational practices, and have a high level of risk.

Platform projects produce a set of subsystems and interfaces that form a common structure from which a stream of derivative products can be efficiently developed and produced. They provide the platform for founding derivative products/projects (see below). They generally involve more risk than product enhancements or incremental improvements, but generally not as much as breakthrough.

Derivative projects are spin-offs from other existing products or platforms. They may fill a gap in an existing product line, offer more cost-competitive manufacturing, or offer enhancements and features based on core organization technology. Generally they are relatively low risk.

Support projects can be incremental improvements in existing products or improvements in manufacturing efficiency of an existing product. Generally they are low risk.

2.2 THE RELATIONSHIP OF THE PRODUCT PORTFOLIO TO STRATEGY

"Without a portfolio management method, strategic criteria for project selection are missing, so there is no strategic direction to the projects selected." (Cooper et al., 2001)

2.2.1 Approaches for linking strategy to portfolio

Cooper et al. (2001) suggest three broad objectives for achieving strategic alignment in portfolio management:

Strategic fit: Are the projects consistent with the articulated strategy? For example, if certain technologies or markets are specified as areas of strategic focus, do the projects fit into these areas?

Strategic contribution: What specific goals are defined in the business strategy? For example, "capture a larger share of an existing market," or "break into a new product category." How well will the projects contribute to achieving these goals?

Strategic priorities: Does the breakdown of the investment across the portfolio reflect the strategic priorities? For example, if the organization is seeking technology leadership, then the balance of projects in the portfolio should reflect this focus.

Cooper et al. (2001) suggest three methods of project selection and ongoing review to ensure a clear link between strategy and product portfolio:

- Top-down,
- Bottom-up, and
- A combination of top-down and bottom-up.

All three methods are designed to ensure that the combination of projects in the portfolio optimally achieves the strategic goals subject to resource constraints.

The top-down method

If the senior-most authority of an organization (such as a business's CEO) personally determines all projects, this would be "top-down," but it would not make use of the knowledge and experience of people in the organization. The top-down method recommended here balances high-level direction with input from those lower in the organization. The method is known as the "strategic bucket" method. A "bucket" in this context is a type of project. The size of the bucket represents how much resource is needed to complete the project.

This method involves the following steps:

1. Clear definition of the organization and business strategies, and the strategic goals and priorities relating to innovation.
2. Definition of the level of resourcing available for the entire project portfolio.
3. Prioritization of business units or product categories in strategic importance to the organization as a whole.
4. Identification of "strategic buckets" and allocation of the ideal spend across these various business units or product categories.
    - EXAMPLE: 20% breakthrough, 50% platform, 20% derivative, 10% support
    - EXAMPLE: 60% Business A, 30% Business B, 10% Business C
5. Allocation of projects into the strategic buckets according to their prioritization.

The bottom-up method

As the name implies, the bottom-up method starts first with a list of individual projects and through a process of strict project evaluation and screening ends up with a portfolio of strategically aligned projects:

1. Potential projects are identified.
2. Strategy criteria for evaluating projects are defined.

3. Each potential project is evaluated against the selection criteria.
4. Projects are selected primarily as a result of meeting the selection criteria with no specific consideration of business unit or product category priorities, or for achieving any sense of balance across the projects in the portfolio.

The combination method

Again, as the name implies, this approach combines the benefits of both the bottom-up and top-down methods:

1. Strategic priorities with regard to business unit or product category spend are established.
2. All potential projects are ranked against strategic criteria and spend for each project estimated.
3. The combination of individual project priority and budgeted spend is used to allocate the projects into strategic budgets in line with the business unit or product category priority.

2.3 SELECTION OF NEW PRODUCT OPPORTUNITIES

Organizations should be continually looking for new product opportunities. These new product opportunities can be derived through:
- Analysis of the current product portfolio and identifying areas for product improvement or line extension, and
- Idea generation or creative ideation techniques.

Evaluation of product opportunities
The PDMA Product Innovation and Management Comparative Performance Assessment Study (CPAS), carried out in 2012, identified that the best companies used portfolio management techniques significantly more than others (Markham and Lee, 2013). A summary of the relative usage of various project evaluation tools is shown in Figure 2.2.

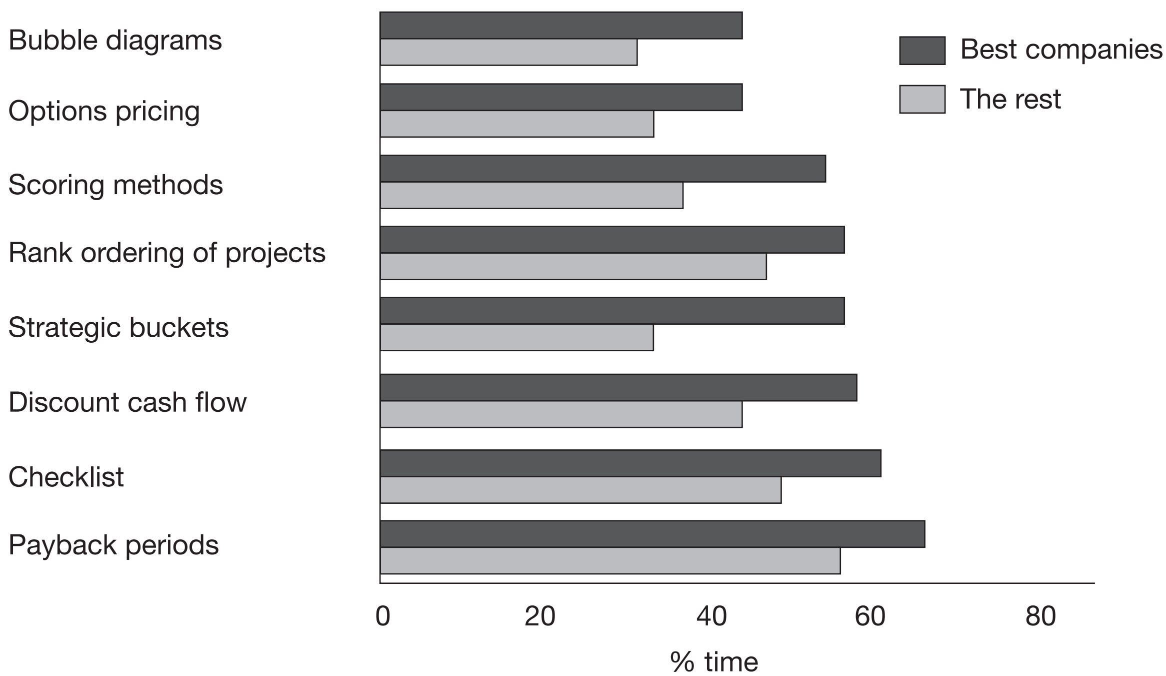


Figure 2.2 Project evaluation tools used by companies

Broadly speaking, techniques for evaluating and screening new product opportunities can be defined under two headings: qualitative and quantitative.

2.3.1 Qualitative evaluation
Qualitative or scoring methods are, by definition, subjective. Nevertheless, there is a sound body of evidence that organizations using scoring methods in portfolio management achieve significant portfolio success. (Markham and Lee, 2013; Cooper et al., 2001).

Over the years, there have been a number of studies into the factors leading to successful new products. Some of the more important success factors are:
1. Having a unique, superior product. One that is differentiated from those of competitors, offers unique benefits, and provides superior value to the customer.
2. Targeting an attractive market — one that is growing, is large, and has good margins, weak competition, and low competitive resistance.

3. Leveraging internal organizational strengths — products and projects that build from organization strengths, competencies, and experience in both marketing and technology. (Cooper et al, 2001)

Most of these success factors are relatively well known and understood by organizations, especially in traditional areas of business. They can be readily applied as criteria to evaluate new product opportunities with a reasonably high level of confidence.

Other criteria that can be used include:
- Strategic alignment,
- Technical feasibility,
- Level of risk,
- Regulatory implications,
- Near-term financial return,
- Long-term financial return,
- R&D expense,
- Break-even time, or time to profitability,
- Breadth of benefit among products or product lines, and
- Availability of investment funding.

Sustainability and the product portfolio
For many companies, sustainability is an integral part of strategy. Sustainability should be considered in project selection. Examples of sustainability criteria are:
- Triple bottom line,
- Carbon emissions,
- ISO compliant Life Cycle Assessment, and
- Resource re-use or recycling.

Figure 2.1 presented a funnel-like process for moving from the very early stages of idea generation through to final product launch. This funnel process is commonly used to show the importance of evaluating a large number of ideas or opportunities to arrive at those product concepts that are truly worthy of significant investment and inclusion in the product innovation portfolio. Where the organization is presented with a large number of new product opportunities, it may be worthwhile to do a simple pass/fail analysis to reduce the list of opportunities to a more manageable size.

Pass/fail
The pass/fail approach is primarily used as a "first pass" evaluation of product ideas. It assesses whether the idea meets some basic criteria. The process requires assigning a pass (P) or a fail (F) to each idea for specific criteria. Ideas have to pass on all criteria to be carried forward. As with most screening methods, it is best to include a cross-section of functional representatives in this evaluation (marketing, technical, manufacturing) so as to represent a broad range of knowledge and experience. A simple example is shown in Figure 2.3.

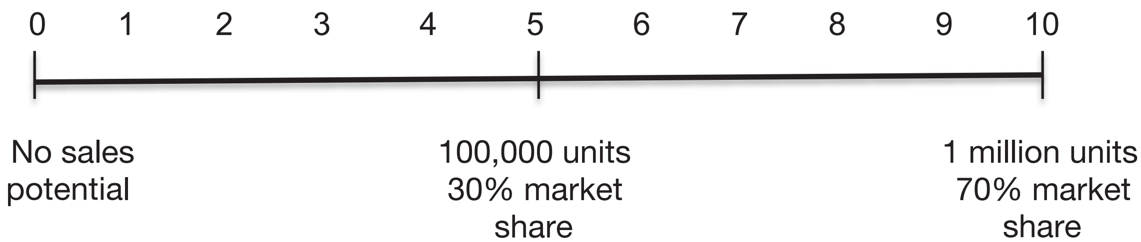
Product idea	Existing Distribution channels	Manufacturing capability	Consistency with range	Overall
One	P	F	P	F
Two	P	P	P	P
Three	P	P	P	P
Four	F	P	P	F
Five	P	F	F	F
Six	P	P	P	P
Seven	F	F	F	F

Figure 2.3 Example of pass/fail evaluation

Scoring

The scoring approach usually implies more detailed analysis and would normally follow a pass/fail screening. More information is required to make better assessments. The process is as follows:

1. Assessment criteria are selected and weightings assigned to each criterion to show its relative importance.
2. Each product idea is scored on a 10-point scale for each criterion and a weighted sum calculated across all criteria. This leads to a ranking of the product ideas.
3. To ensure an objective approach to scoring, especially where a number of people are involved, it is important to provide descriptive reference points on the 10-point scale. For example, the 10-point scale for sales potential as an evaluation criterion in Figure 2.4, could be described as:



	Screening Factors				
	Sales Potential /10	Fit with Strategy /10	Levl of Competition /10	Overall Score /10	Rank
Weighting / Product idea	(10)	(7.5	(5)		
One	8	6	8	165	3
Two	8	9	7	182.5	1
Three	6	6	8	145	4
Four	5	6	5	120	6
Five	4	7	5	117.5	7
Six	8	3	6	132.5	5
Seven	7	8	8	170	2

Figure 2.4 Example of scoring evaluation

In Figure 2.4, the product ideas with higher overall scores would be prioritized higher. Product idea two is the highest priority, and therefore ranks highest in selection for inclusion in the portfolio. The number of product ideas to implement depends on how many resources are available.

2.3.2 Quantitative evaluation

In the context of product portfolio selection and ongoing management, quantitative evaluation is most commonly financially based and can be used either:

- to decide if the new product is financially viable — does it have the potential to deliver a satisfactory return on investment, or,
- to decide on the prioritization of projects as part of the portfolio selection or ongoing portfolio management process.

Figure 2.5 presents a framework for financial analysis of a new product opportunity. This framework clearly demonstrates the information required to carry out a quantified financial analysis, namely:

- Benefits or returns: based on sales volumes and prices,
- Costs: based on cost of manufacturing and marketing, and
- Capital costs: costs associated with purchase of buildings, plant and equipment.

Specific financial indicators are used to determine the cumulative net value (returns less cost) relative to the cost of the project (capital cost). Indicators include:

- Net present value (NPV),
- Internal rate of return (IRR),
- Return on investment (ROI), and
- Payback period.

Some businesses need to also consider net return in the near future to remain financially viable. For example, if a large project has a high ROI but no near-term cash flow and is one of few projects, the business could fail to pay its bills and become insolvent regardless how big the ROI is.

Subjective financial scoring methods and financial analyses using subjective estimates (for example, sales potential) are useful in the early stages of product idea evaluation for screening purposes when data are limited. However, financial analysis becomes a much more valuable and important tool as the development process proceeds to the more expensive stages. Detailed financial analysis, based on sound information and data, becomes an essential portfolio analysis tool. More detail on estimation of sales potential and financial analysis is presented in Chapter 7.

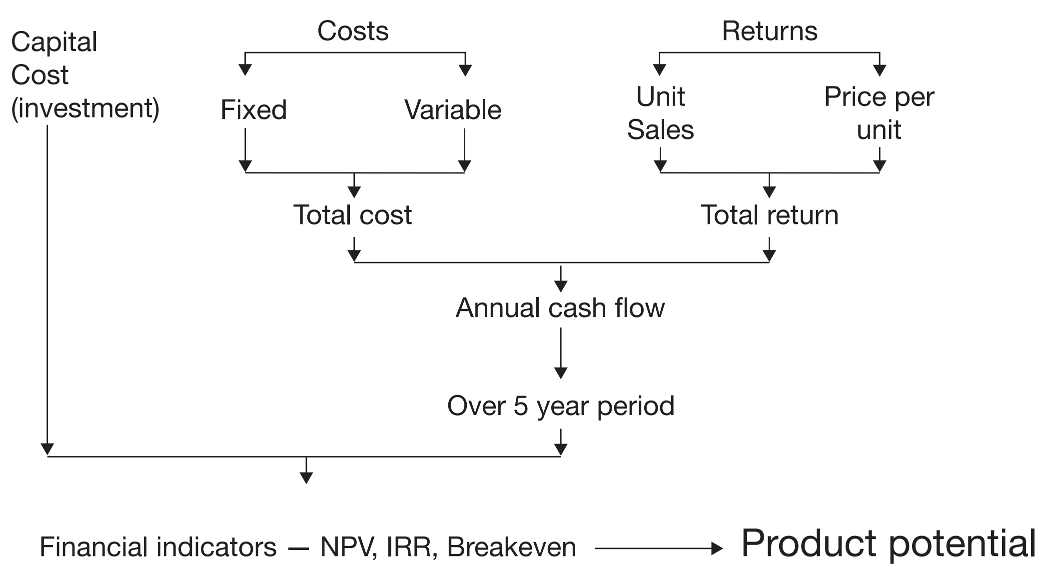


Figure 2.5 A framework for financial analysis

2.4 THE BALANCED PORTFOLIO

Most organizations should seek to have a range of new product opportunities in the portfolio. This helps balance risk with reward. Also, a more diverse portfolio is resilient to the effects of market change. The range and proportional representation of these new product opportunities should be directed by the overall corporate or business strategy, aligned with the innovation strategy. Categorization of the new product opportunities can be by business unit, product category, or target market, or based on the characteristics of the project, for example:

- Breakthrough, derivative, platform, or support,
- Cost of R&D, or of commercialization,
- Potential returns or benefits,
- Level of risk — in development or in commercialization,
- Technical difficulty, to develop or to maintain,
- Time to market from start of development to commercial returns,
- Capital investment in plant and equipment,
- Potential for intellectual property value creation.

2.4.1 Achieving a balanced portfolio

As described earlier, the representation and balance of new product opportunities in the portfolio should be directed by the business and innovation strategies. These strategies should provide management with the basis for:

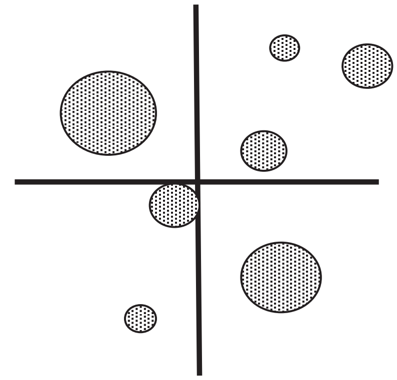
1. Deciding on the key dimensions and criteria of the portfolio. For example, the proportion of the portfolio that can be allocated to high-risk product ideas, or to new product opportunities that target new markets for the organization, or the emphasis on product improvements relative to “new to the organization” opportunities.
2. Allocating product innovation opportunities to the portfolio so as to achieve the optimal balance by applying the key dimensions and criteria, thus ensuring alignment with strategy.
3. Ongoing management of the portfolio to ensure appropriate selection and balance throughout the development pipeline and the products’ life cycles.

Figure 2.6 shows a simple table representing a proportional allocation of projects across product and market newness. This is an example of a way to represent the state of balance in a portfolio with regard to product and market newness.

	Low market newness	High market newness
Low product newness	Improvements to existing products 30%	Additions to existing product lines 15%
Medium product newness	Cost reductions 25%	New product lines 10%
High product newness	Repositioning 15%	New to the world products 5%

Figure 2.6 An example of a product portfolio model

2.4.2 Representing the product portfolio



Visual representations of the portfolio are useful in both the development and presentation of the portfolio. Bubble diagrams are the most commonly used form of visual display.

Typically, a bubble diagram shows projects on a two-dimensional X-Y plot. The X and Y dimensions relate to specific criteria of interest (for example, risk and reward). Bubbles are plotted according to the projects' ratings on the X and Y dimensions. The size of the bubbles represents a third criterion of interest, for example the level of capital investment or the resource requirements.

Figures 2.7, 2.8 and 2.9 show bubble diagrams with different dimensions for representing balance in the portfolio.

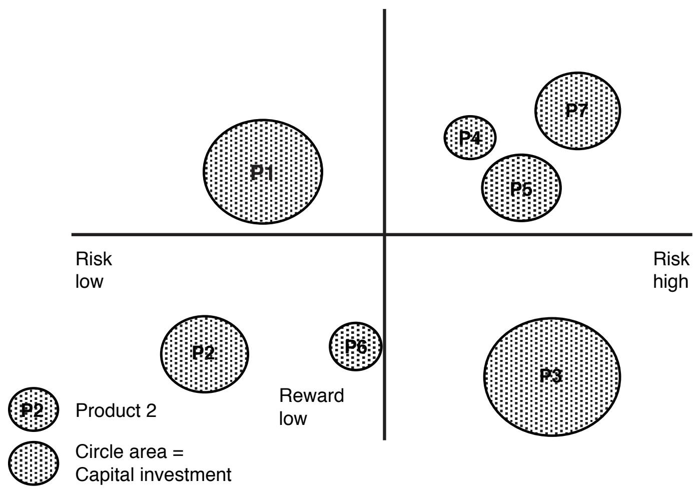


Figure 2.7 Bubble diagram portfolio: risk vs. reward and capital investment

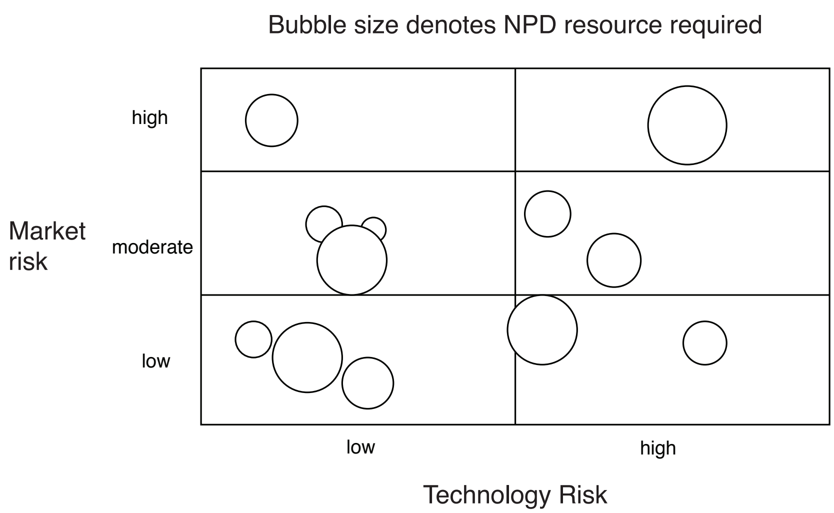


Figure 2.8 Bubble diagram portfolio: market-technology risk

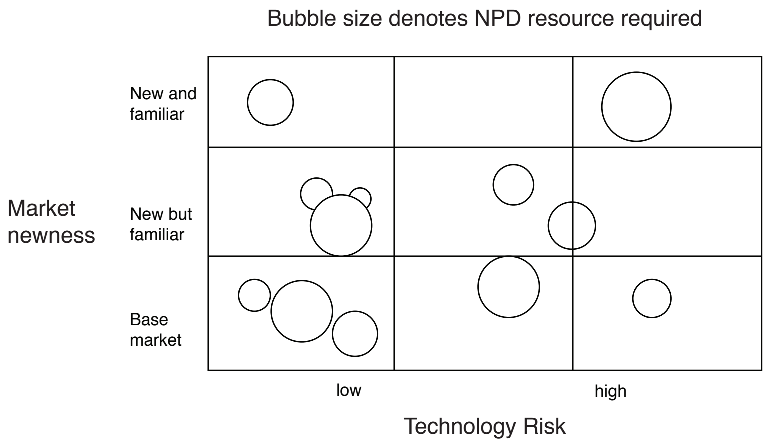


Figure 2.9 Bubble diagram portfolio: market-technology newness

Bubble diagrams and similar charts are particularly useful in senior management presentations to give a relatively simple at-a-glance overview of the state of a portfolio. It is relatively easy to identify gaps in the portfolio or inconsistencies with regard to business strategy and goals. For example, in Figure 2.8, the portfolio has a relatively high emphasis on low to moderate risk projects with respect to both market and technology. Only one project is categorized as high risk for both market and technology, but this project demands a relatively high resource commitment. This relatively quick overview provides management with insight as to the alignment of the portfolio with the organization's overall strategy with respect to risk.

2.5 RESOURCE ALLOCATION

A critical aspect of portfolio management is resource allocation. It is imperative that projects are adequately resourced. Most organizations discover their product innovation success and ongoing product management is impacted by:

- Too many projects at the same time,
- Poor project planning and execution,
- Product innovation projects competing with other business priorities,
- Project delays that require heroic efforts to complete on time,
- Last-minute efforts to complete a task, only for it to sit in a queue downstream,
- Constantly changing priorities that force pulling of resources from one task to another,
- Lack of support (material, vendor, engineering), and
- Managers' time consumed solving routine, urgent problems.

Invariably this results in delayed launches, lost opportunities, and poor product acceptance due to deficiencies in features and functionality.

Resource allocation is a complex process. It is not simply a question of numbers of individuals. It is having the right individuals with the right skills available at the right time.

The benefits of proper resource allocation are:

- Better project flow (fewer delays),
- Higher output (more launches),
- Higher employee satisfaction, and
- More effective portfolio management.

A key element of the innovation strategy is capability planning. That is: the alignment of internal and external capabilities to match the innovation goals and strategy. Application of portfolio selection criteria, based on the innovation strategy, provides a sound basis for resource allocation.

2.5.1 Methods for resource allocation

Cooper et al. (2015) recommend two fundamental bases for resource allocation: project resource demand and new product goals. These are best used in association with the overall portfolio management process.

Based on project resource demand

1. Prioritize the current project list from best to worst (using a scoring model or some form of financial analysis).
2. Develop a detailed plan for each project. Use a project management software package.
3. Allocate resources in the project plan according to specific categories (engineers, designers, manufacturing, etc.).
4. Determine the cumulative resource requirements for each category by time.
5. Match the resource demand for each category and time requirements against resource availability.
6. Identify areas of resource overload.
   i) Re-prioritize projects in timing or delete projects from the portfolio.
   ii) Source additional resources through additional hiring or outsourcing.

Based on new business goals

1. Begin with new product goals. Ask "what returns or profits are desired from new products?"
2. Calculate the potential returns or profits from each potential new product in the portfolio using financial analysis, e.g., EVA or DCF.

3. Prioritize the projects and their potential returns against the business goals and select the projects that deliver the cumulative financial returns required to meet the business goals.
4. Carry out the same exercise in individual project planning outlined in method 1 above to determine the resource requirements by time against resource availability.

2.5.2 Resource allocation as a business process

Without an understanding of the supply (resources) and the demand (projects), deploying a pull-based resource planning process is impossible.

Figure 2.10 shows four significant roles when establishing a resource allocation process. Figure 2.11 illustrates a typical resource allocation process.

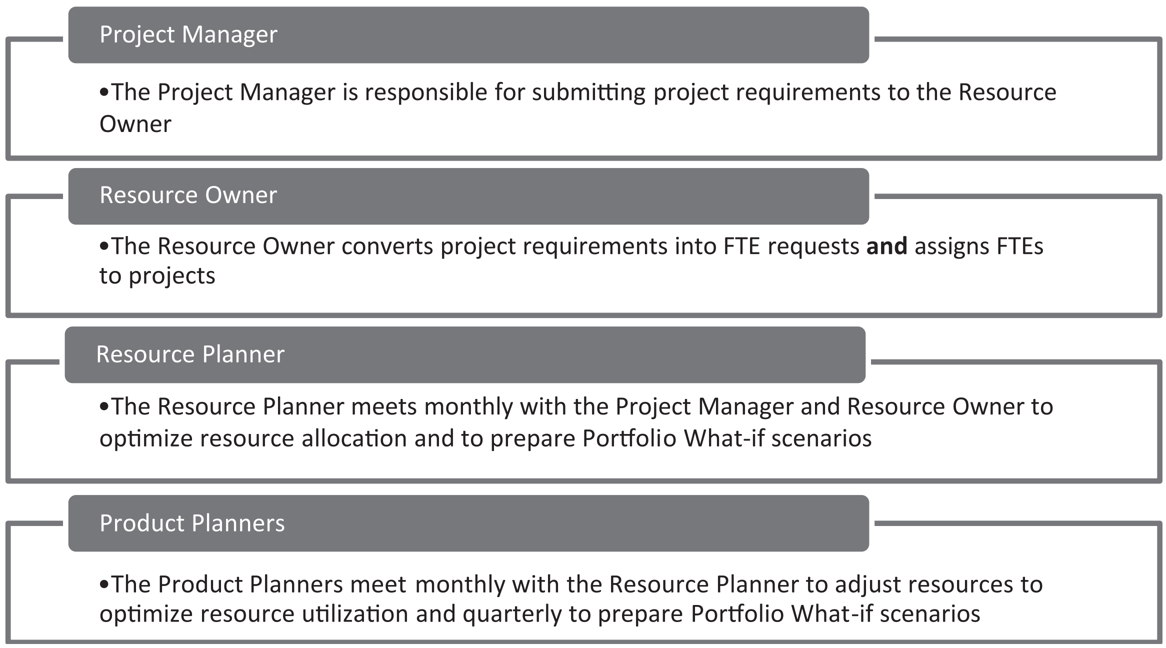


Figure 2.10 Roles and responsibilities for resource planning

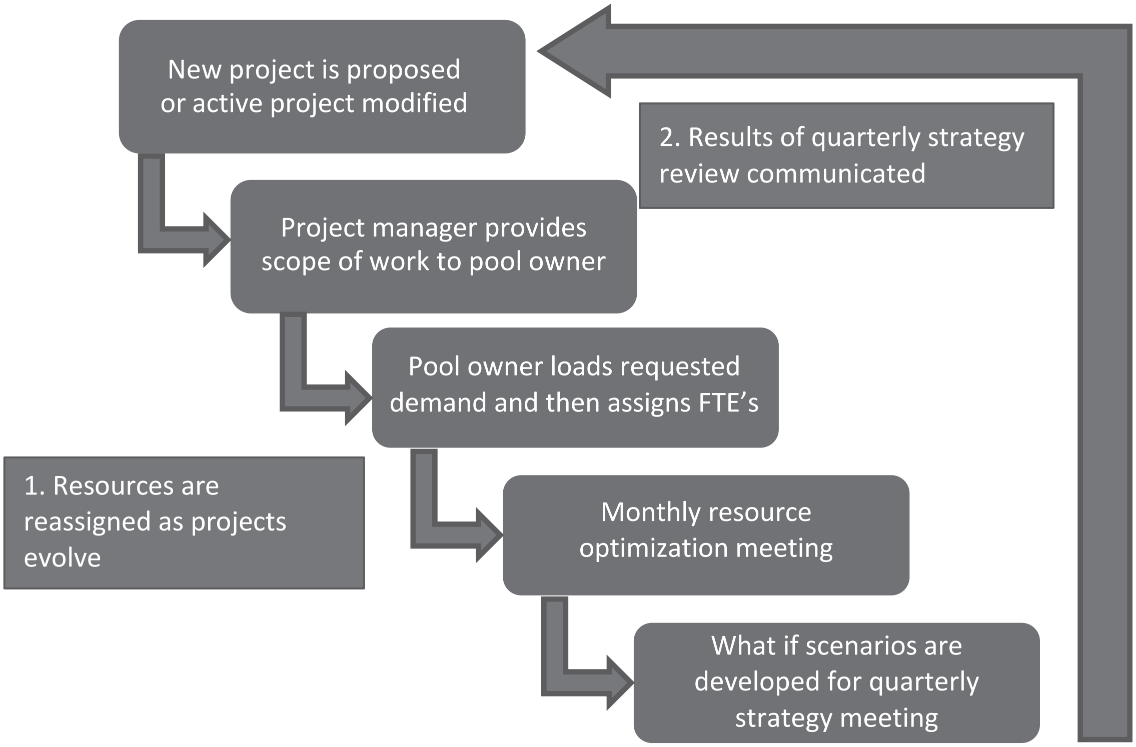


Figure 2.11 Typical resource allocation process

2.5.3 Tools to support resource allocation

In large organizations, it can be difficult to collect information about available resources. Optimizing the allocation of potentially competing resources across a range of projects can be extremely challenging. Figure 2.12 presents a process for collecting resource information based on resources required by individual projects and resources available. Resources required are identified by project managers and resources available are identified by the resource owners — functional or departmental managers.

A requirements input form provides a standard and consistent template to capture the resource demand from all of the project teams. This form contains pre-defined fields requesting specific types and format of information. Consistency in defining the type of resource required is essential to the resource owner. For example, a requirement for three engineers does not necessarily provide the level of detail to the resource owner on the type of engineers required. Are they three process engineers or one structural engineer and two process engineers, etc.

The resource owners use the requirements input forms to consolidate the resources required by the project teams. Inevitably, this will lead to an imbalance of resources available relative to resources required.

In Figure 2.13, the data from the forms have been input into a table to show which types of resources are scarce, or possibly where resources are in over-supply. After assessing the resource gaps, where "percentage utilization" exceeds 100%, action can be taken to address them such as adding resources, shrinking projects, or choosing smaller projects. A clear innovation strategy and goals are critical in providing the basis for cross-functional discussions on allocation of competing resources.

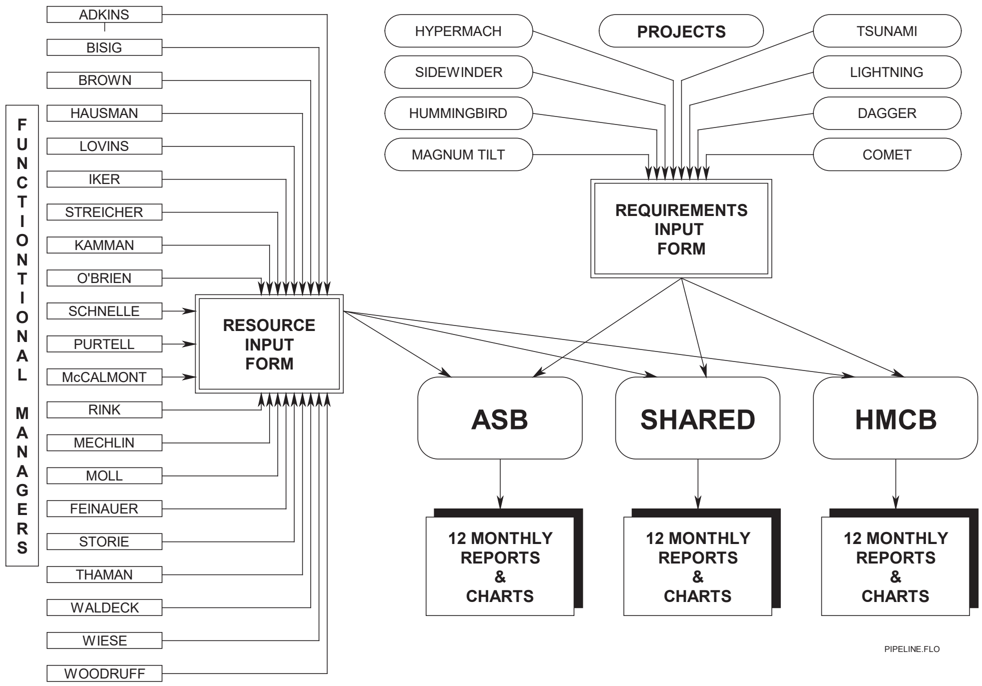


Figure 2.12 Process of collecting resource information

REQUIRED										
ASB				HMCB						
HUMMINGBIRD	HYPERMACH	MAGNUM TILT	SIDEWINDER	COMET	DAGGER	LIGHTNING	TOTAL REQUIRED	CAPACITY	% UTILIZATION	DICIPLINE
160	160	40	160	120	168	80	888	977	91	Product Manager (Killer)
0	0	0	100	128	0	0	228	228	100	Mechanical Engineer - Spindle
40	160	0	0	0	0	0	200	200	100	Finite Element Analysis
40	60	0	0	0	0	0	100	60	167	Structures Simulation
0	20	0	0	0	0	0	20	20	100	Vibrations and Structures
10	0	10	0	0	0	0	20	40	50	Precision Engineering
40	0	80	120	87	0	0	327	680	48	Documentation Group
40	0	0	0	10	0	0	50	50	100	Power Panel Assembly
10	0	0	0	10	0	0	20	20	100	Cable Assembly
0	0	20	100	10	0	0	130	320	41	Spindle Assembly
80	40	0	320	120	0	0	560	590	95	Process Engineer - Manufacturing
0	0	0	50	0	0	0	50	425	12	Tool Designer
20	8	16	8	0	0	0	52	64	81	Financial Analyst
40	0	40	12	0	0	0	92	48	192	Product Cost Specialist
8	16	4	25	30	0	4	87	53	164	Purchasing - Lead
8	30	20	30	20	4	6	118	57	207	Buyer
0	0	2	0	0	42	0	44	60	73	Service Parts Technician
40	0	30	5	2	0	20	97	320	30	Process Engineering Support

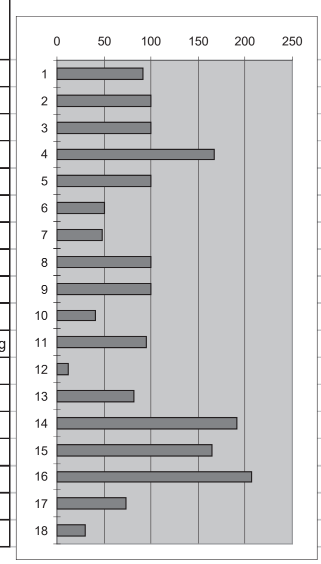


Figure 2.13 Output showing where and when the resource gaps will occur

2.6 IMPLEMENTING PORTFOLIO MANAGEMENT SYSTEMS

2.6.1 The complexities of portfolio management

Portfolio management is complex and challenging. It involves:

1. Choosing criteria for project selection and prioritization that match strategy.
2. Individual projects that often compete for the same resources.
3. The type and quantity of available resources may change over time.
4. Types and quantities of project resource needs will change over time.
5. Projects can be canceled unexpectedly.

Resolving these issues can be both challenging and overwhelming. Best practice for organizations in the early stages of portfolio management development is to adopt a basic approach initially, and gradually move to more complex processes and techniques to support portfolio decision-making. Building cross-functional understanding of and commitment for portfolio management, together with senior management support, is critical.

A regular rhythm of cross-functional dialogue about projects and priorities may be a good place to start in organizations with no existing portfolio management system. More complexity can be added to this rhythm as time progresses. Figure 2.14 shows a prioritization of portfolio management dimensions from simple to complex, in terms of project assessment criteria, resourcing and application of financial criteria with associated probabilities of success. Assessment criteria can start with relatively simple definitions, evolving with more detail and evaluation of projects against these criteria from simple pass-fail to numerical rating scales, as discussed in section 2.3.1. Resourcing can evolve from relatively crude estimates of project demands through to the complexities of resourcing as a function of time. Financial assessment can evolve from relatively basic qualitative estimates to financial modeling based on probabilities and sensitivity analyses.

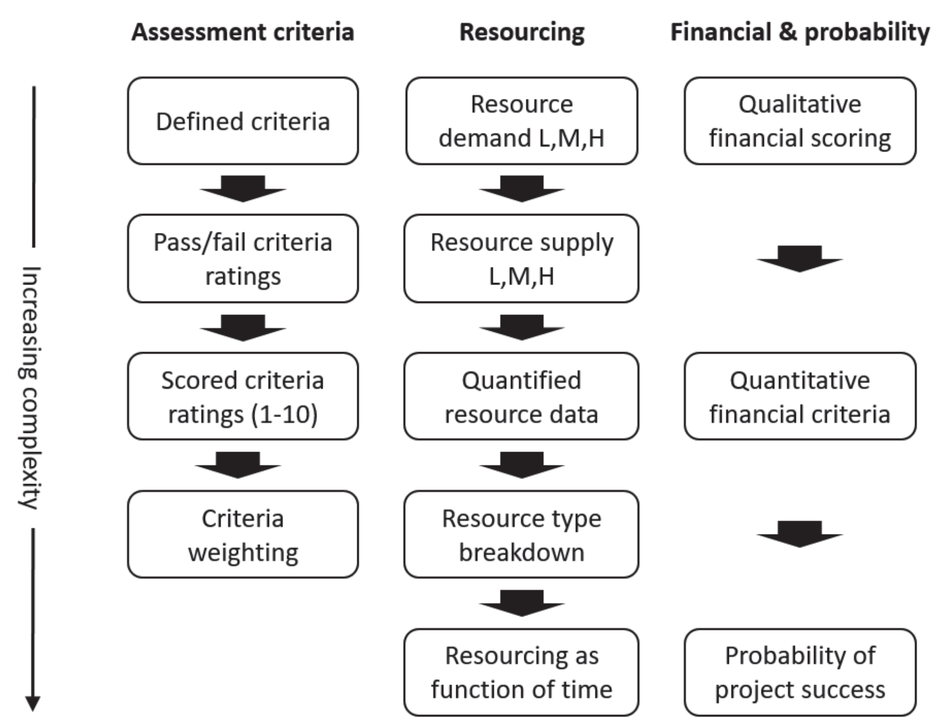


Figure 2.14 Portfolio management dimensions with increasing complexity

2.6.2 Guidelines for portfolio management

Here are some guidelines to help address the complexities in portfolio management:

1. **Surprising results:** It is not uncommon to score projects against criteria and see results indicating that the most popular projects have the least value. Consider whether the criteria are complete or whether popular projects have lost their original value.
2. **Change management:** There can be strong constraints preventing cancelation of projects such as external commitments and senior leadership directives. Projects have momentum resulting from sunk costs and team motivation. The results of portfolio management are a guide that can be overridden by specific project constraints. But it is essential that this is done with clear and objective justification.
3. **Scope of portfolio:** One of the first things to consider when setting up a new portfolio management process is what the portfolio covers. Ideally, everything that competes for resources should be covered. However, this can be impractical because resource data might not be available for everything or getting all this data may take too long. One option is to limit and define what the portfolio covers.
4. **Assessment criteria overlap:** Be careful not to double- or triple-count criteria that are similar. For example, net present value, payback period, and revenue all measure financial return in different ways. Figure 2.15 presents a hypothetical example including three financial assessment criteria — NPV, 5-year revenue and payback period. The sum of the weightings assigned to these financial criteria is 26 out of a total of 44. This results in a contribution of 59% to the overall evaluation, which is higher than the risk and strategic criteria combined. In Figure 2.16, the weightings of the financial criteria have been decreased to give a total of 14 out of a total of 37, or 32%. This brings the sum of the financial criteria in greater alignment with the other assessment criteria.

Risk Financial Strategic

	Probability of development success	Probability market acceptance	NPV	Revenue: next five years	Payback period	Growth potential	Sum of weightings	Percent of total weight
Criteria weighting:	**5**	**8**	**6**	**12**	**8**	**5**	**44**	
Financial			6	12	8		**26**	**59%**
Risk	5	8					**13**	**30%**
Strategic						5	**5**	**11%**

Figure 2.15 Assessment of criteria by criteria type — financial criteria dominate

	Risk		Financial			Strategic		
	Probability of development success	Probability market acceptance	NPV	Revenue: next five years	Payback period	Growth Potential	Sum of weightings	Percent of total weight
Criteria weighting:	**5**	**8**	***4***	***6***	***4***	***10***	**37**	
Financial			**4**	**6**	**4**		**14**	**38%**
Risk	5	8					**13**	**35%**
Strategic						10	**10**	**27%**

Figure 2.16 Assessment of criteria by criteria type — financial criteria balanced with other criteria

5. **Scoring definitions:** Figure 2.4 showed scoring definitions, which can help ensure consistency of scores. An example of a scoring definition is: A sales potential score of 5 out of 10 means 100,000 units sold. Scoring definitions may be difficult to create when starting out. For example, you need to know that 100,000 units sold is about average for your organization in order to define it as 5 on a scale of 1 to 10. But, if you don't know whether 100,000 is high, low, or normal, you don't know what value to assign. Consider starting scoring evaluation without scoring definitions. Later, as you learn what values are normal for your organization, you can add them to the process.

6. **Estimating resources:** Resource demand is never perfectly understood, but is especially uncertain at the beginning of projects. People have different levels of ability and comfort creating estimates.
   - Some may feel that when they provide an estimate, they are committed to deliver results to the value estimated.
   - Others may only be comfortable estimating when they have perfect information.

   As discussed in Chapter 3, projects managed using the Agile method tend to be self-organizing and communicate status in short, frequent, in-person team meetings. While this has many benefits, it can make it more difficult for those facilitating portfolio processes to obtain resource information from Agile teams. The result can be missing or slow resource data, which can stymie the portfolio management process.

   It is important that the leaders of a portfolio management process provide tools and guidance to those providing resource data. The American Society of Professional Estimators (ASPE) publishes estimate classification guidance that can help communicate expectations for the level of accuracy appropriate at different points in a project. For Agile projects, facilitators of the portfolio process may need to take a more active role and invest more time obtaining resource information because imposing requirements to provide resource information can either be ineffective or perturb the natural rhythm of the Agile methodology.

7. **Rhythm of portfolio updates:** Ideally, analysis and discussion of the portfolio should coincide with business decisions. If the portfolio is updated quarterly but the organization is making business decisions weekly or monthly, consider simplifying the portfolio management process. Portfolio management is best used as an integral part of business decisions rather than as a stand-alone analysis exercise.

   For organizations such as software developers that use the Agile process to manage most of their projects, portfolio reviews may need to be performed more frequently because the scope of Agile projects can change rapidly and frequently, even late in development. As a result, not only will priority scores change as result of strategy changes, but also because the definition and scope of the projects themselves may change and no longer align to the business strategy in the same way.

8. **Resource adjustments:** The portfolio management process will result in changes to the priority of potential projects and projects underway. For projects underway, care must be taken to implement project resource increases or decreases resulting from reprioritization. Changing project resources too abruptly or too frequently can impact both the Lean and Agile project methods discussed in Chapter 3. Though the lean methodology benefits from clear prioritization, if new resources are not applied effectively they may introduce process waste and undermine Lean. The Agile project methodology thrives on small, self-organized teams of experienced individuals. Introducing new personnel with less experience has the potential to perturb Agile team dynamics and make Agile teams too large. It is recommended that resource change decisions be closely coordinated with the leaders of project teams, especially where Lean and Agile methods are used.

2.7 PORTFOLIO PERFORMANCE METRICS

The primary focus of portfolio management is the selection of projects to achieve an appropriate balance aligned with strategy. But portfolio management is also concerned with maintaining portfolio balance and effectiveness. Portfolio performance metrics are used to do this.

The same criteria used to assess projects can also be used as performance metrics — but this can be difficult if there are many assessment criteria. For example, it may be helpful to have a technical risk criterion that is provided by the development team and a commercial risk criterion that is provided by the marketing team. To quickly understand level of risk in the portfolio, these assessment criteria may be combined into one performance metric for risk.

Once portfolio performance metrics are selected, the next step is to record the values of those metrics at regular intervals. If your organization is meeting regularly to review the portfolio, a good practice is to record the values of performance metrics at the conclusion of these meetings. Make a note of the organization's strategy at the time the values are recorded.

Performance metrics are then used to evaluate whether the portfolio is changing in response to changes in strategy. The values of portfolio metrics can be trended to see whether, and how quickly, the portfolio changes in response to strategy change. If the portfolio does not change in response to strategy change, this may indicate a strategy implementation problem. If the portfolio changes but requires a much longer time to change than expected, this response time can help guide future decisions on strategy change.

Successful implementation of a change in strategy to reduce portfolio risk could look as shown in Figure 2.17. A quarter is one-fourth of a calendar year or about three months, a period commonly used for business reporting.

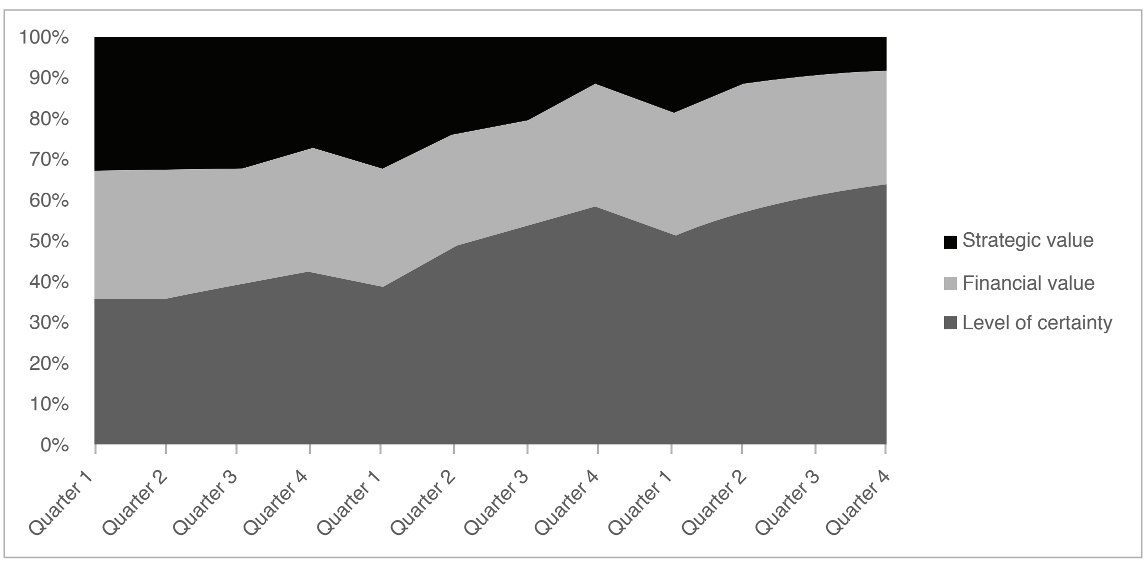


Figure 2.17 Example portfolio performance metric results over time

There is a clear trend of increased certainty (i.e. lower risk). If this trend had not been evident in the first few quarters, more emphasis could have been placed on actions to find additional low-risk projects. It is also noteworthy that:

1. The change required three years to improve from 37% to 62%.
2. The strategic value of the portfolio appears to have been impacted by this strategy change more so than financial value.

These insights can be used in many ways. For example:

1. If the impact to the portfolio's strategic value was higher than expected, consider how much this impacts the business's long-term growth potential. Was the risk reduction strategy too strong, resulting in new problems?
2. If the organization is later challenged to improve financial performance by 30% over the next twelve months, the above information may allow a judgement that a portfolio change is not a realistic strategy to accomplish this because it took three years to shift the balance of the portfolio by 25%. Therefore, other methods of improving financial performance may be needed. Alternatively, the goal of 30% improvement could be revised to be less aggressive.

2.8 IN SUMMARY

- *"A portfolio is a collection of programs, projects, and/or operations managed as a group. The components of a portfolio may not necessarily be interdependent or even related—but they are managed together as a group to achieve strategic objectives."* (Project Management Institute).
- A product portfolio is defined as *"A set of projects or products that an organization is investing in and making strategic trade-offs against"* (PDMA HandBook, 3rd Edition, 2013).
- Product portfolio management is the selection and maintenance of the "right" products, consistent with business and innovation strategies of the organization.
- The overall organization strategy and, in turn, the innovation strategy provide the criteria for product portfolio selection.
- Projects that are included in the portfolio can be from different business units, "new to the organization" products, product improvements, cost reductions, and can be at different stages of the new product pipeline and product life cycle.
- Typically, organizations will work toward a balanced product innovation portfolio based on criteria including risk vs. reward; new to the organization vs. line extensions; new vs. existing markets, etc. It is critical that these criteria are clearly aligned with strategy.
- Alignment of strategy with individual project selection and a balanced portfolio can be achieved through a "top-down" or "bottom-up" approach (or a combination of both).
- Resource allocation is a critical element of portfolio management. Many organizations are plagued by too many projects — resulting in poor execution, delayed launches, and commercial failures. Capability planning, embedded within the innovation strategy, provides a sound basis for resource planning as part of the portfolio management process.
- To avoid becoming overwhelmed when starting a portfolio management system, start a simple portfolio management process and build upon it over time.
- Portfolio performance metrics can be used to help measure and maintain portfolio balance over time and to assess how well the portfolio changes in response to changes in strategy. Portfolio performance metrics are often created by combining the portfolio assessment criteria.

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Practice questions: Portfolio management

1. A weakness of the net present value (NPV) method for assessing projects in portfolio management is that:
   A. Projects cannot be rank ordered.
   B. NPV doesn't allow for resource allocation.
   C. Tools for calculating NPV are not readily available.
   D. It is difficult to determine accurate cash flow data for projects, especially early in the development process.

2. Allocating resources across a set of projects to optimize performance is known as:
   A. Value maximization.
   B. Profit seeking.
   C. Rationalization.
   D. Pruning.

3. "Top-down" and "bottom-up" are ways to think about:
   A. Forecasting.
   B. Leadership.
   C. Connecting customers with the organization.
   D. Linking strategy and the product portfolio.

4. You are the CEO of company A. Your company has grown organically through lots of acquisitions and you now have a wide range of products that have been launched into a variety of markets, and your product teams have ideas to develop new products. You need to optimize the investment across all of these existing and new products. What would you do?
   A. Tell the teams not to develop any new products.
   B. Give each team the same amount of money and ask them to proceed with development.
   C. Establish a portfolio management process.
   D. Approve projects that only cost less than $500K to develop.

5. In evaluating product opportunities, which of the following is a financial method for evaluation?
   A. Strategic alignment.
   B. Return on investment.
   C. Technical feasibility.
   D. Time to market.

6. In evaluating product opportunities, which of the following is a non-financial method for evaluation?
   A. Level of risk.
   B. Net present value.
   C. Payback period.
   D. Internal rate of return.

7. Company A has recently implemented a range of new product development practices. As a first stage, it has used a range of ideation tools to generate a number of potential new product ideas. It is now seeking to evaluate and prioritize the 150 product ideas for further evaluation and development. What technique would you recommend for the first stage of evaluating the 150 new product ideas?
   A. Pass/fail evaluation.
   B. Financial analysis.
   C. Ask the boss to do it.
   D. Detailed scoring of each idea against strategic criteria.

8. Mary is a product manager for ACE Electronics. She has been asked by the senior management executive to prepare a list of criteria as a basis for evaluation of new opportunities to be included in the new products portfolio. She presents the following list:
   Potential market share;
   Potential contribution to company profitability;
   Availability of product development resources.
   Mary has omitted the most important criterion from her list. What is it?
   A. Support from the chief executive.
   B. Alignment with the company's new product strategy.
   C. Sufficient marketing budget.
   D. Sufficient manufacturing capability.

9. Which of the following statements best represents the relationship between the number of projects that engineers are working on and their productivity?
   A. Engineers get more productive the more projects they work on.
   B. Engineers work just as well on five projects as they do on one.
   C. Assigning engineers to more than two projects starts to reduce their productivity.
   D. It is best to have engineers each work on just one project.

10. Jane has been evaluating the state of the innovation portfolio at ACME Bricks and Construction. Several simultaneous projects use the same set of product development experts. Moreover, many of these projects are being delayed and compete with other business priorities. What critical aspect of portfolio management should Jane look at to address these issues?
    A. Resource allocation.
    B. Project flow.
    C. Agile project development.
    D. Strategy execution.

Answers to practice questions: Portfolio management

1.	D	6.	A
2.	A	7.	A
3.	D	8.	B
4.	C	9.	C
5.	B	10.	A

3

PRODUCT INNOVATION PROCESS

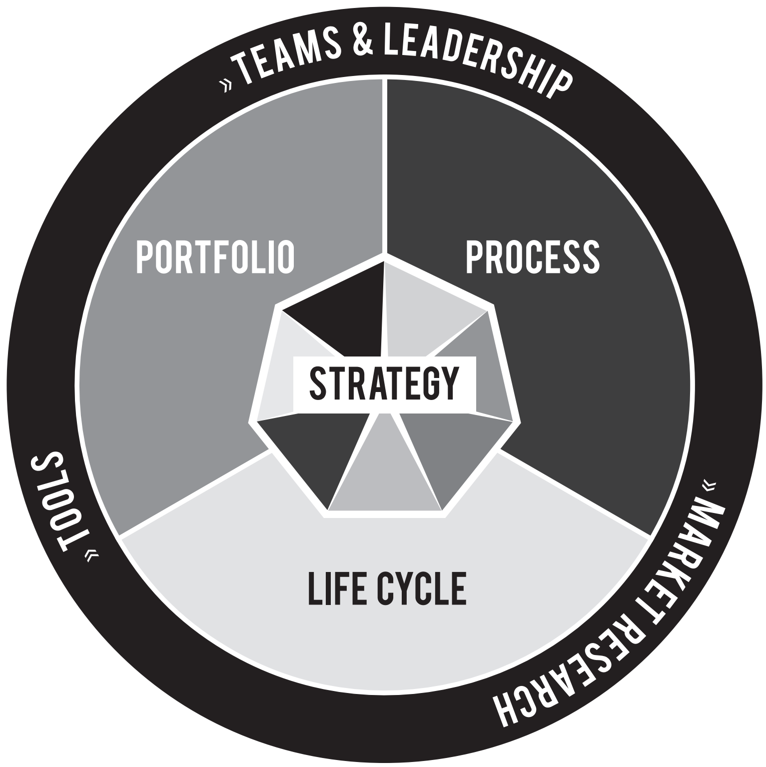
Provides an approach, which is commonly understood and accepted by the whole organization for successfully developing new products or making improvements to existing products

3. Product Innovation Process

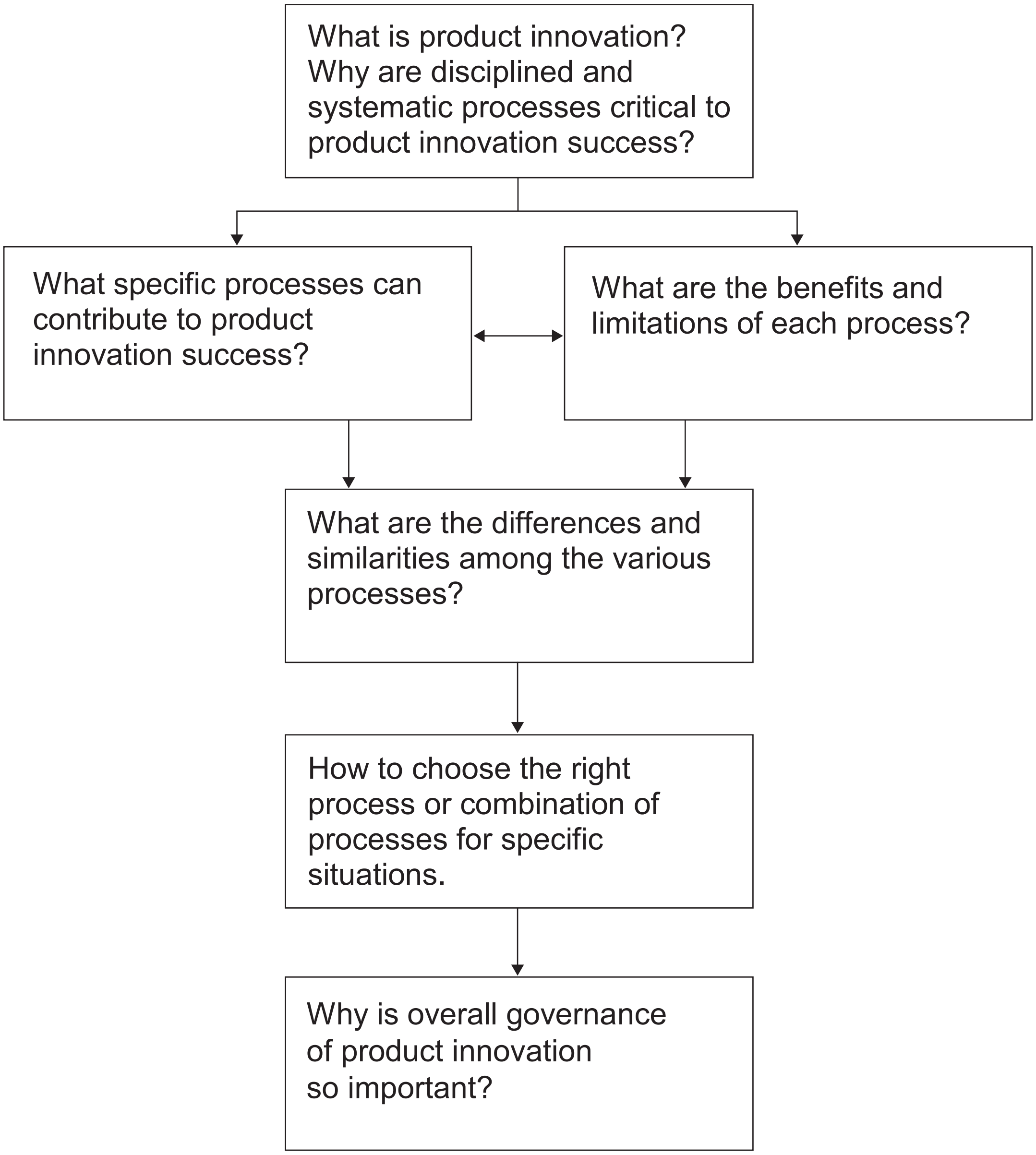
THE CONTENT

What you will learn in this chapter

A structured and disciplined process to product innovation is recognized as a critical factor to achieving successful outcomes. In this chapter, you will be introduced to a number of processes for systematic product innovation. A summary of each process is presented, together with discussions of their benefits and limitations. Overall, you are encouraged to select the best process or combination of processes for the specific organization and product.



The Chapter Roadmap



3.1 INTRODUCTION TO PRODUCT INNOVATION

3.1.1 What is product innovation?

Product innovation is, by definition, a multidisciplinary activity, requiring sound decision-making based on inputs from a wide range of sources. The application of appropriate, structured, and consistent processes, adopted across an organization, has long been recognized as a key contributor to product innovation success. The evolution of new product processes has resulted in a range of models, each with its own special features, suited to different contexts.

The Product innovation process can thus be defined as the activities, tools, and techniques, consisting of product-line planning, strategy development, concept generation, concept screening, and research, to achieve successful outcomes in the form of products for clients (Cooper, 2001:80-81).

Kahn (2013) offers a new products process definition as:
"A disciplined and defined set of tasks and steps that describe the normal [and appropriate] means by which an organization repetitively converts embryonic ideas into salable products or services" (Kahn, 2013).

3.1.2 Product innovation as a "risk vs. reward" process

Robert Cooper presents an interesting analogy of product innovation with the gambling process (Cooper, 2001). Basically, the process of product innovation is one of risk management where the rules are:

1. If the uncertainties are high, keep the stakes low.
2. As the uncertainties decrease, the amount at stake can be increased.

Most organizations are risk averse, simply due to the history of high new product failure. Hence, critical questions for most organizations are: *"is it possible to reduce this failure rate?"* and, if so, *"how?"*

This creates the impression that product innovation is just about managing risk vs. reward — the main objective should be about developing a suitable product/solution for the market, thereby balancing risk/reward with delivering on (and possibly exceeding) customer expectations and requirements. Modern product innovation aims to enlarge the "space of possibilities" within the risk/reward balance, so as to achieve the optimal "solution space."

The 2012 PDMA survey of a broad range of companies showed there was about a 61% success rate for new products (Markham and Lee, 2013). The success rate was found to be highly dependent on the quality of product innovation practices and processes adopted by the companies:

- The best companies had success rates of 82%;
- The rest of the companies had success rates of 59%.

Clearly, it is possible to improve new product success rates, and there are practices and processes that have been proven to underpin this improvement.

3.1.3 Managing the risk of new product failure

The cumulative costs associated with product innovation increase significantly throughout the product innovation process. The challenge for the product developer is to ensure that the risks associated with product failure (the level of uncertainty) are reduced as the costs increase (refer to Figures 3.1 and 3.2). Figure 3.1 illustrates how product innovation costs increase as a product innovation project progresses through the development phases, e.g., due to increased resourcing, effort, materials, and time consumption.

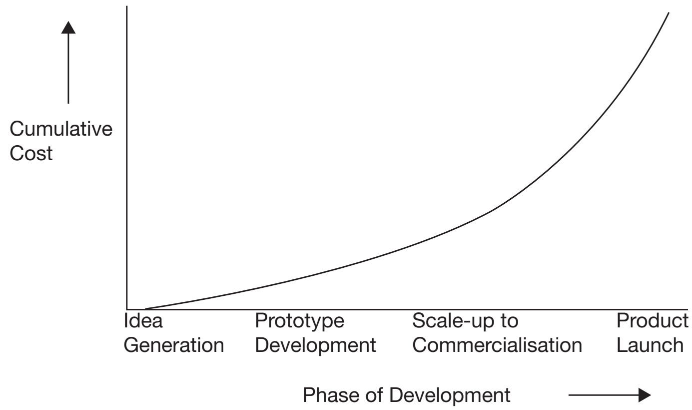


Figure 3.1 The costs of new product innovation

However, while the cumulative costs increase over time, the uncertainty element presents an inverse effect to it (see Figure 3.2) because as the product becomes better defined (the Project Management Institute refers to this as "progressive elaboration"), the uncertainty about project, the product, the market, and other key factors become less ambiguous, and more predictable. The probability for success also increases, e.g., product performance success.

Managing cumulative costs while achieving project success is a fine balancing act for the product innovation team. Product innovation failure is highest in the early stages of the project.

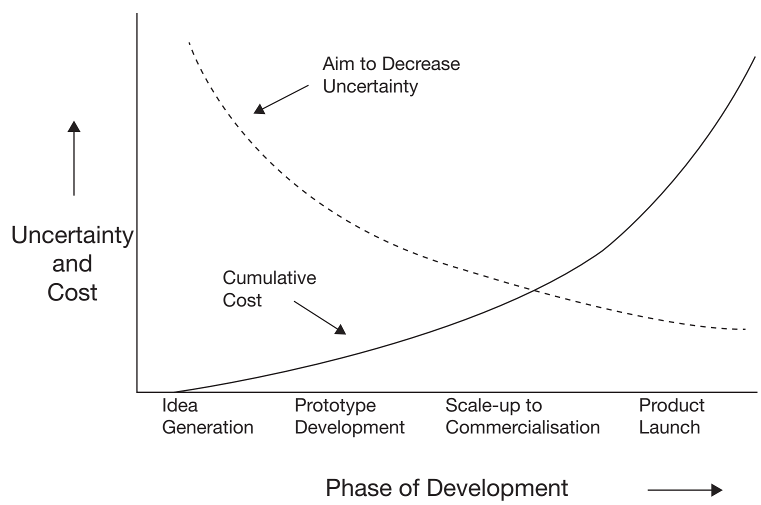


Figure 3.2 Managing uncertainty and costs over the product innovation cycle

3.1.4 Knowledge improves decision making and reduces uncertainty

Figure 3.3 presents a standard decision framework that is used in a wide range of professions. As the different product innovation process models are discussed, it can be observed that the basic fundamentals of this decision framework underpin all of these models. The aim is to reduce uncertainty and increase predictability. The knowledge, information, and data required to make sound decisions come from a wide range of sources:

- Organization records,
- Organization staff ,
- External advisors,
- Published literature,
- Patents,
- Competitors,
- Customers.

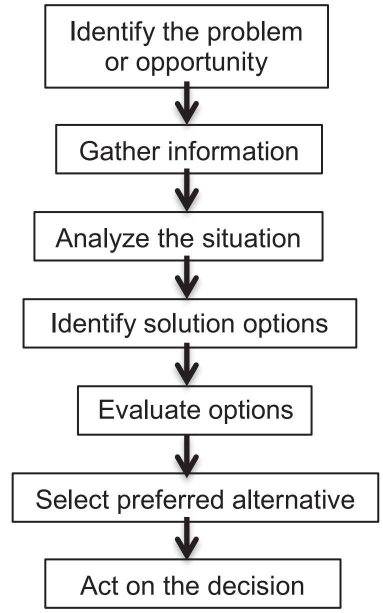


Figure 3.3 A standard decision framework

Techniques for gathering the required knowledge are further discussed in Chapters 4 and 5.

3.1.5 The importance of the "front-end" of the product innovation process

The front-end stages of the product innovation project are critical to success and serve as the starting point of the process where opportunities are identified and concepts are formed prior to entering the formal product innovation process. It includes the stages of idea generation, initial concept development, and high-level intentions of how a product innovation project will contribute to the overall product innovation strategy. Some literature refers to this as the "fuzzy front-end," mainly because it includes the stages of a project that are least well defined, and it specifically relates to the fact that the product/solution concept is still unclear, is still taking shape, and that the value proposition is yet not fully defined. It is commonly referred to as the Front End of Innovation (FEI) and will be addressed as such in this document.

Figure 3.2 shows the cumulative costs throughout the product innovation process. The early stages are relatively inexpensive. Costs then start rising dramatically through the expensive stages of final prototyping and scale-up to commercialization. The FEI (Front End of Innovation) provides the opportunity to seek greater clarification of a new product's potential, at relatively low cost.

Well-informed decision-making at this early stage can significantly reduce uncertainty and provide confidence for ongoing project investment.

It is in these early stages of a product innovation project that constant alignment to the organization's project/product portfolio management process outcomes are sought and assessed (see Chapter 2). These include project review and selection. It is critically important to provide due diligence to the early stages with the aim of decreasing uncertainty, maximizing project/product definition, and applying the appropriate level of planning for the next stages. Failing to do so will impact the project as the portfolio management pipeline process may render an unexpected outcome of/for the project/product's development and continuation.

3.2 THE PRODUCT INNOVATION CHARTER (PIC)

Fundamental to the successful implementation of a product innovation project is clarity of intent and direction founded on the innovation strategy. This clarity of definition is provided in what is called the Product Innovation Charter (PIC).

The PIC is defined as:
“A critical strategic document, the Product Innovation Charter (PIC) is the heart of any organized effort to commercialize a new product. It contains the reasons the project has been started, the goals, objectives, guidelines, and boundaries of the project. It is the “who, what, where, when, and why” of the product innovation project. In the discovery phase, the charter may contain assumptions about market preferences, customer needs, and sales and profit potential. As the project enters the development phase, these assumptions are challenged through prototype development and in-market testing. While business needs and market conditions can and will change as the project progresses, one must resist the strong tendency for projects to wander off as the development work takes place. The PIC must be constantly referenced during the development phase to make sure it is still valid, that the project is still within the defined arena, and that the opportunity envisioned in the discovery phase still exists.” (From the PDMA Glossary.)

3.2.1 Content of the PIC

The PIC is normally a relatively short summary document with other documents, such as the project plan, appended. It contains specific sections:

- Background;
- Focus arena;
- Goals and objectives;
- Special guidelines.

The content of these sections is detailed as follows:

PIC — Background

- Validation of the project: its purpose and relationship to the business and innovation strategy. Why is the organization pursuing the project?
- Scope of the project: how wide or narrow is the project’s focus?
- The role of the project team in achieving the project’s goals.
- Project constraints: resources, funding, manufacturing, marketing, etc.; anything that is likely to impact a successful project outcome.
- The current and future state of any key technologies.
- Environment, industry, and market analysis that shows the context for the new product, its customers, competitors, regulations, etc.
- The benefits of the project (i.e., the product) will be determined, planned for, tracked, controlled, and realized.

PIC — Focus arena

The term arena is mainly applied in sporting or theatrical terms — denoting the area where the play takes place. This definition has been extended to business to denote the “playing field” for a business activity. The PIC should contain:

- The target market (where the game is being played).
- The key technologies and marketing (how the game is played).
- Key technology and market dimensions that underpin project success.
- The strengths and weaknesses of competitors (the other players in the arena). Their technology, marketing, brand, market share, manufacturing, etc.
- The approach taken to identify and incorporate all (other) project/product stakeholders impacted by the product, e.g., society, supply chain.

PIC — Goals and objectives

- Specific goals related to contribution to the business strategy — percentage share of a new market, increase in share of current market.
- Sustainability strategy goals need to be determined and managed besides the market customer segment, socio-economic impacts, etc.
- Business operation goals including profit, sales volume, cost reduction, increased throughput, and sustainability goals.
- Project-related objectives including financial budget, time to launch, benefits tracking and realization, and effective stakeholder expectations management.
- Each goal or objective should have specific and measurable success criteria. These are referred to as performance metrics (refer to Chapter 7 for a more detailed discussion on performance metrics).
- Decrease negative impacts on planet and people, e.g., plan for the use/re-use of materials and uplift society.

PIC — Special guidelines

- Working relationships of the project team — how and when meetings are held.
- Project reporting — frequency, format, specific stakeholders.
- Budget expenditure responsibilities.
- Involvement of external agencies, e.g., regulatory bodies.
- Specific aspects relating to time of launch or product quality.
- Project governance and leadership.

PIC — Additional sustainability considerations

- During the product innovation processes, a culture of re-using materials and or recycling should be top of mind. The aim should be to reduce the use of raw materials, reduce the negative impacts on society and the planet's environment, and address climate change.
- Consider the notion of creating shared value for all stakeholders that are impacted by the new product and the socio-economic effects. For example, companies operating in particular communities should develop a shared value framework that goes beyond only meeting the shareholder requirements, but all other stakeholders as well.
- Alternate notions relate to the circular economy which emphasizes the reduce, re-use, and recycle factors.
- Sustainability strategies also need to include evaluating the supply chain "ecosystem" and support the twelve Sustainability Development Goals (SDG), which include:
    - No poverty;
    - Zero hunger;
    - Good health and well-being;
    - Quality education;
    - Clean water and sanitation;
    - Affordable and clean energy;
    - Decent work and economic growth;
    - Industry, innovation, and infrastructure.
- Fair trade, human rights, and favorable employment conditions (e.g., fair labor practices) should be key components in product innovation, and its management life cycle.
- The sustainability factors should be intentionally planned for, monitored, managed, and reported on as part of the benefits realization management processes. Stakeholder expectations planning and management are thus part of the process.

3.3 SPECIFIC PRODUCT INNOVATION PROCESSES

Over the past 50 years there has been a dramatic increase in the research into, and application of, product innovation processes. This has resulted in a wide range of processes — many of which have been designed for specific industry, product, or market contexts.

It must be emphasized that the new product process is not a uniformly defined process that can be applied in the same way to all organizations or products. It should be designed to meet the specific needs of the organization and its customers, products, or services.

Historically, defined processes for product innovation date back to an eight-phase process for development of chemical products in the 1940s. In the 1960s, NASA practiced the concept of phased development — the phase review process, which divided the development project into phases with reviews following each phase.

In the mid-1960s Booz, Allen and Hamilton (Booz and Co., 1982) designed a process that was divided into six basic stages which has laid the foundation for many of the processes developed over recent years. These stages are:

- Exploration;
- Screening;
- Business evaluation;
- Development;
- Testing;
- Commercialization.

Since then, and perhaps the most defining step in the formalization of the new products process and its application across a wide range of industries, came in the early 1980s with Cooper's Stage-Gate® process (http://www.prod-dev.com/).

Subsequently, over the past three decades, the evolution of a number of processes, designed to meet the needs of specific organizations with different product and market contexts, is evidenced. The remainder of this chapter describes a selection of these modern product processes and outlines their advantages and disadvantages in applications within specific contexts. These processes include:

- Stage-Gate®;
- Integrated Product Development (IPD);
- Systems engineering;
- Agile;
- Lean;
- Lean startup;
- Design thinking.

We have chosen to use the term "process" in this book although it may well be argued that Agile, Lean, design thinking, and IPD might best be described as philosophies or sets of principles.

3.3.1 The Stage-Gate® Process

This process was first developed by Cooper and Edgett in the early 1980s and has been continuously updated over the years in response to changing industry needs (Product Innovation Institute Inc® http://www.prod-dev.com/) in the early days (see www.stage-gate.com for current information). Figure 3.4 illustrates the basic model of the Stage-Gate® Process.

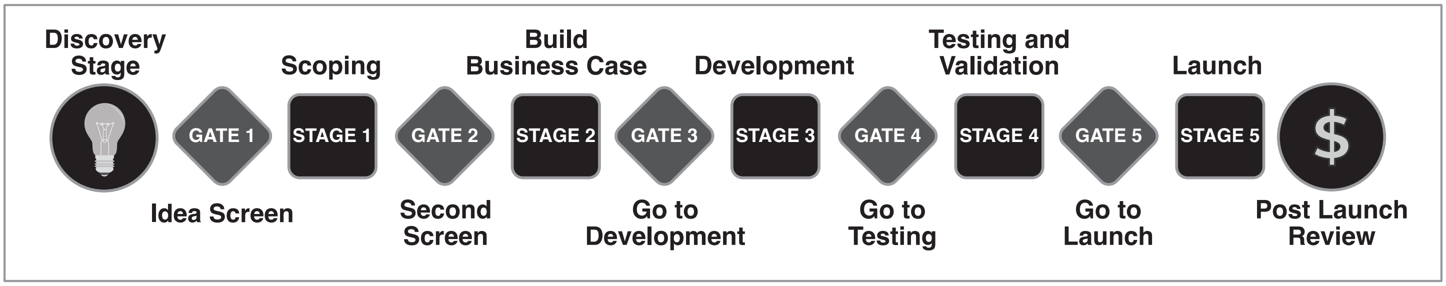


Figure 3.4 The Stage-Gate® Process. Reprinted with permission from the Product Innovation Institute, Inc® http://www.prod-dev.com/

Following is a brief description of the main stages for Stage-Gate®:

- **Discovery:** looking for new opportunities and new product ideas.
- **Scoping:** a quick look at the market opportunity, technical requirements, and capabilities available.
- **Business case:** a critical stage that builds on the scoping stage with a more in-depth technical, marketing, and business feasibility analysis.
- **Development:** the product design, prototyping, design for manufacture, preparation of manufacturing, and launch plans.
- **Testing and validation:** testing all aspects of the product and its commercialization plans to validate all assumptions and conclusions.
- **Launch:** full commercialization of the product, including full-scale manufacturing and commercial launch into the market.

The number of stages should be adapted according to specific context and will depend on:

- The urgency for new product launch. Greater urgency leads to a more compressed process with fewer stages.
- The current knowledge about the technology and market related to the new product — the level of uncertainty or risk. The greater the basis of knowledge, the lower the risk, resulting in fewer stages required.
- The level of uncertainty. Higher levels of uncertainty demand greater information by applying the appropriate risk response strategy — leading to a longer process.

An example of how a company adapted the Stage-Gate process to its unique requirements is General Electric (GE). Although the stages differed in the number of phases (several phases could make up a stage) and descriptors, the model shares the five common basic stages — General Electric introduced 10 phases across the basic stages shown in Figure 3.5 (see Phillips et al., 1993):

Stage 1 **Preliminary concept development**	Customer needs
	Concept definition
	Initial feasibility
Stage 2 **Design and development**	Preliminary design
	Final design
Stage 3 **Validation**	Critical productivity
	Market/field test
	Manufacturing feasibility
Stage 4 **In-service product and support**	Market readiness
	Market introduction follow-up

Figure 3.5 Example of Stage-Gate process adaptation (Philips et al., 1993)

At the time, GE's choice of this Stage-Gate process and its 10 phases drove cross-functional focus on early market needs prior to full market production. An additional reason was to instill "discipline in [its] project management techniques" (Phillips et al., 1993:292).

What is a stage?
A stage is a defined set of processes, and activities in a section of the overall product innovation process, including: Activities such as project-related work that the product innovation leader and his/her team must do, according to the project plan/schedule. An organization would typically have a predefined "way" (methodology) that it utilizes resources and time in executing on the project. The activities are mostly cross-functionally integrated and strong-matrix structured teams. Working together on a common stage objective(s) should be the norm.

During any and all stages, the project leader and their team need to assess and analyze project and/or product progress and issues, and resolve them accordingly. The results and metrics gathered during the stage enable the team to decide on the appropriate course of action. Ultimately, all the stage's deliverables should be submitted to the decision-making body/forum for assessment against the specific gate criteria.

What is a gate?
A gate is a defined point in the product innovation process where key decisions are made on the future of the project, including:

The deliverables that were developed during the previous stage serve as inputs into the next Stage-Gate process. As stated above, these were defined and agreed in the preceding stage(s) and are part of the evaluation criteria for that particular gate. The gate criteria can be technical, financial, and/or qualitative in nature. The output of the gate event will be decisions taken (go/kill/hold/rework) as well as go-forward plans that include the next-stage deliverables, schedules, and expected product outcomes.

The gate event is part of the product innovation control and management (governance) processes and implies that certain conditions need to be met in order to proceed.

Benefits and limitations of the Stage-Gate® Process

Benefits:

- Adds discipline and constraints into product innovation.
- Places an emphasis on quality decision-making.
- Is transparent to all involved.
- Can be adapted to a wide range of organizations.

Limitations:

- Has the potential to become over-bureaucratic.
- Where it is not fully understood, it can be seen as too rigid and costly.
- The discipline and constraints can be perceived as stifling creativity.

Evolution and application of the Stage-Gate® process
The Stage-Gate® process, at least in its early iterations, appeared quite linear and sequential. This has never been the intention of its originators. Over recent years, Cooper has written a number of articles demonstrating new evolutions of the Stage-Gate® process and its adaptation to different product innovation contexts and organizational requirements. Cooper emphasizes that, although the basic principles of the process may remain the same, its application should be modified to be fit for specific situations. (Cooper, 2014, Cooper et al., 2018).

Evolutions and applications of Cooper's Stage-Gate® process include:

1. **Parallel processing:** The traditional Stage-Gate activities are "compressed" into parallel (concurrent) streams of activities (as opposed to linear and sequential), with the aim of expediting the activities within each stage. They then converge at strategic decision gates to allow for progression. The parallel processing requires the organization to allocate more resources to activities in the same time period.

2. **Circular design and product management:** Here, the focus is on sustainability. This involves incorporating the customer and product users early on in the product innovation design stage, with the aim of re-using materials, designs, reducing waste in the product's development and life, and the ability of recycling the product at the end of its use.

3. **Fast Stage-Gate:** Also known as Agile-Stage-Gate (Cooper et al., 2016), the aim is to incorporate principles of IT's (Information Technology) Agile approaches (e.g., scrum, sprints, backlogs) into the product manufacturing environments. It required modifications to the Agile application as known in IT, to cater to the differences in the manufacturing environments. This hybrid approach aims to foster innovation, minimize risk, speed up decision-making, and speed up product innovation and launch to market.

   The benefits and limitations of the Agile-Stage-Gate-Hybrid model:
   The benefits and limitations relate to how manufacturing companies have adopted Agile principles (that are typically applied in software development companies), and the outcomes this has delivered. Hence, the Agile-Stage-Gate-Hybrid approach to leverage the strengths of both methods by "[linking] focus, structure, and control [of Stage-Gate], with the benefits of an Agile approach and *mindset*, namely *speed, agility,* and *productivity"* (Cooper et al., 2018:17). The benefits and limitations were extracted from research recently published by Cooper and Friis Sommer in 2018:

Benefits:

- Flexibility of product design;
- Quicker time to market of the manufactured product;
- Increased productivity;
- Improved ability to respond to market changes;
- Improved ability to proactively respond to customer needs;
- Improved team morale due to better communication and coordination;
- Increased project outcomes due to intentional and intensified focus.

Limitations:

- Management's skepticism because they do not understand Agile and/or the required mindsets that it demands;
- Resource assignments and participation intensity increase (note: this can be a positive and negative);
- Managing fluid product definitions and or designs ("ambiguity") can be difficult;
- Managing ever-changing development plans;
- Agile teams tend to be become insular, thus disconnected from the rest of the organization;
- Clashes with bureaucratic organizational processes and/or performance reward systems, e.g. the degree to which the organization fosters and allows for experimentation and failure, or the drive for absolute quality perfection. Another example relates to short-term vs. long-term planning.

  Subsequently, Cooper et al. (2018) propose that the company that wants to implement Agile-Stage-Gate-Hybrid processes do so cautiously and with much thought. Every organizational environment and project will be different so a "one-size-fits-all" expectation will not work. They suggest that initially a small task force is constituted to streamline current processes, and then identify and manage the challenges along the journey. Recognizing that this concept is still new will require all practitioners to assess, experiment, and continually improve on the possibilities it offers.

4. **Product innovation for Internet of Things (IoT):**
   Lee et al. (2018) critically examined whether traditional product innovation processes (such as Stage-Gate) are still relevant when it comes to contemporary IoT products. They include NSD (new service development) in the discussion. It should be noted that digital technologies and products differ from other products due to their characteristics. They are reprogrammable, they homogenize data, and are self-referential (Lee et al., 2018:2286, citing Yoo et al., 2010). So, while digital products are differentiated from each other in relation to customer experience/utility, they share the same data and are connected, i.e., interacting with other devices, in a physical virtual context ("digital materiality"). Hence, "unlike traditional products which have a fixed, discrete set of boundaries and features, distinctive characteristics of IoT products are malleable, editable, open, transferable" (ibid, 2018:2287).

   Applying a product innovation process to digital products (physical and virtual) requires it to be never-ending and non-linear (see Figure 3.6), and primarily consists of short discovery-, definition-, and development phases. The artifacts are thus continually fed back into the "product innovation system" so as to ensure continuous evolution of/for the digital products.

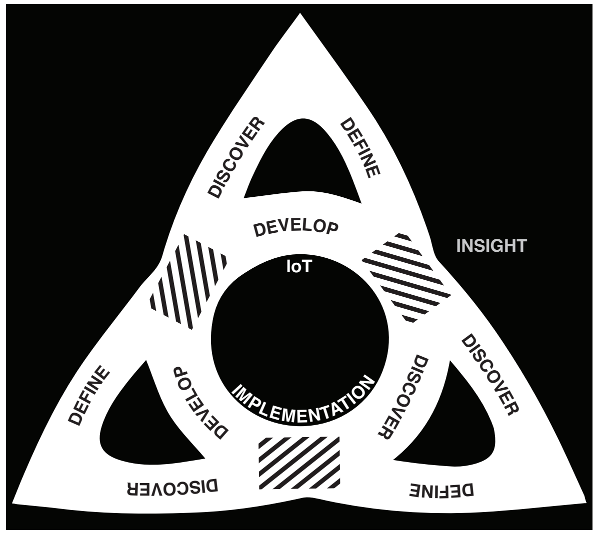


Figure 3.6 Product innovation process suitable for IoT/digital technologies and products. Source: Jacobs and Cooper, 2018 (cited by Lee et al., 2018).

Examples of how the Stage-Gate® process can be modified to specific situations:

1. The development of a simple line extension for a novelty ice cream range where the company has a long history in the market, sound technical expertise, and existing manufacturing capability. In this case, the development complexity is very low, with a relatively high certainty of success, and low risks associated with failure. A short process focusing on an initial business case followed by iterative formulation (or design) stages, informed by product testing, leading to final product launch, is probably all that is required. The development cycle time could be expected to be from one to three months.
2. The development of a model car that can be driven off-road by 10- to 12-year-old children, where the company has some experience with the target market but has limited expertise with the technology involved. There is also significant uncertainty surrounding the product features desired by the target market and of the potential demand. In this case, there is a high level of uncertainty associated with not only the product concept and design specifications, but also with the potential complexity in design and manufacture. Here, one would expect more stages in the process with a greater emphasis on gates to ensuring informed decision-making to reduce uncertainty. Specific focus should be placed on the FEI stages of concept development and initial business analysis. More activity at the end of the process (focusing on design for manufacture, market testing, final feasibility analysis, and scale up for launch) could be expected. The development cycle time could be expected to be from six months to two years.

3.3.2 Integrated Product Development (IPD)

Integrated product development is defined as: *"A philosophy that systematically employs an integrated team effort from multifunctional disciplines to [effectively and efficiently] develop… new products that satisfy customer needs."* (Kahn, 2013)

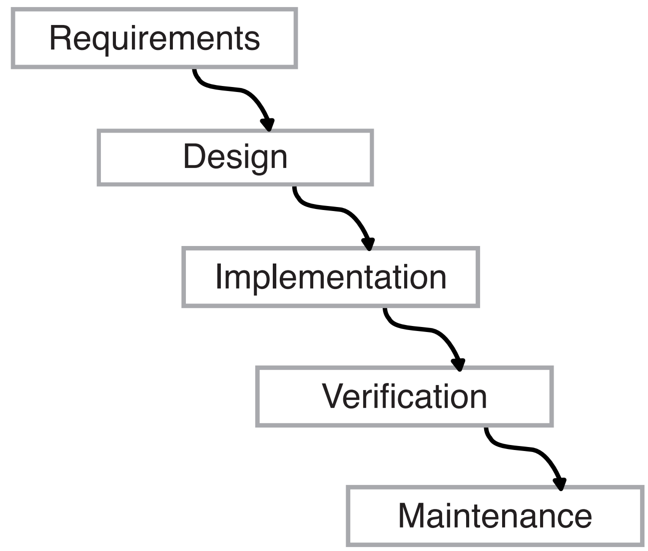
Integrated product development has evolved from "concurrent engineering," which was widely used in the aerospace industry in the 1990s. "Concurrent engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacturing and support. This approach is intended to cause the developers from the very outset to consider all elements of the product life cycle, from conception to disposal, including quality, cost, schedule, and user requirements." (Winner et al., 1988).

The basic premise for concurrent engineering is founded on two concepts. The first is the idea that all elements of a product's life cycle, from functionality, producibility, assembly, testability, maintenance issues, environmental impact, and finally, disposal and recycling, should be taken into careful consideration in the early design phases. The second concept is that the preceding design activities should all be occurring at the same time, i.e., concurrently. The idea is that the concurrent nature of these processes significantly increases productivity and product quality. This way, errors and redesigns can be discovered early in the design process when the project is still flexible. By locating and fixing these issues early, the design team can avoid what often become costly errors as the project moves to more complicated computational models and eventually into the actual manufacturing of hardware.

Concurrent engineering was seen as a replacement for the more traditional sequential "waterfall model." The first development of the waterfall process is generally attributed to Winston Royce in 1970 (Royce, 1970). During the early 2000s it was widely applied within the software industry.

The five phases of the classical waterfall process include:

1. **Requirements gathering:** Understanding what is required to design the product: function, purpose, user needs, etc.
2. **Design:** The attributes and features of the product are designed so as to meet customer needs in the execution stage. It also includes planning and feasibility assessments.
3. **Implementation:** The product's design plan is enacted and mainly entails production activities.
4. **Verification:** Ensuring that the product is meeting customer expectations.
5. **Maintenance:** Use of the customer to identify shortfalls or mistakes in the product design that require change.



Over recent years, the waterfall model lost popularity in the software industry and became a foundation for the integrated product development model.

Figure 3.7 is an example of the IPD model and its phases. Its construct is similar to the approaches of waterfall project management and Stage-Gate processes, due to the decision points that interlink the preceding stages/phases to the next. It thus follows a sequential and logical order of events during the project's life cycle.

In recent times, it has been frowned upon in terms of being "too slow" for a product/project's completion. Some organizations have applied a hybridized approach to the overall framework. This provides the basis of an overall structure, while providing an iterative approach with greater flexibility, which speeds up development. The teams that perform these projects would typically be smaller in size and are normally co-located.

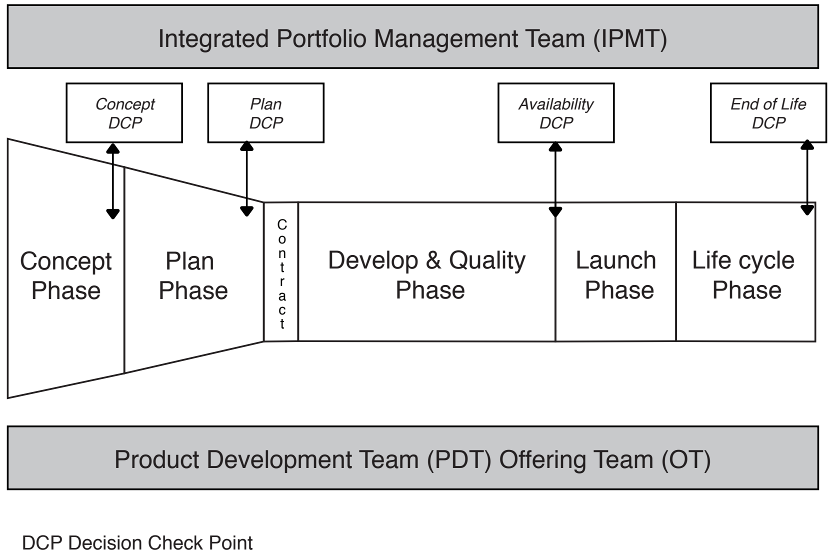


Figure 3.7 An example of the Integrated Product Development Framework

Over recent years, some organizations have focused on a step-wise approach to improving the overall product innovation system, centered on IPD principles (see Figure 3.8).

The aim was to progress from a focus on the application of basic tools for product innovation, through to the application of project management, voice of the customer, linkage to strategy and, at the highest level, a learning culture founded on knowledge capture and management, as illustrated in Figure 3.8.

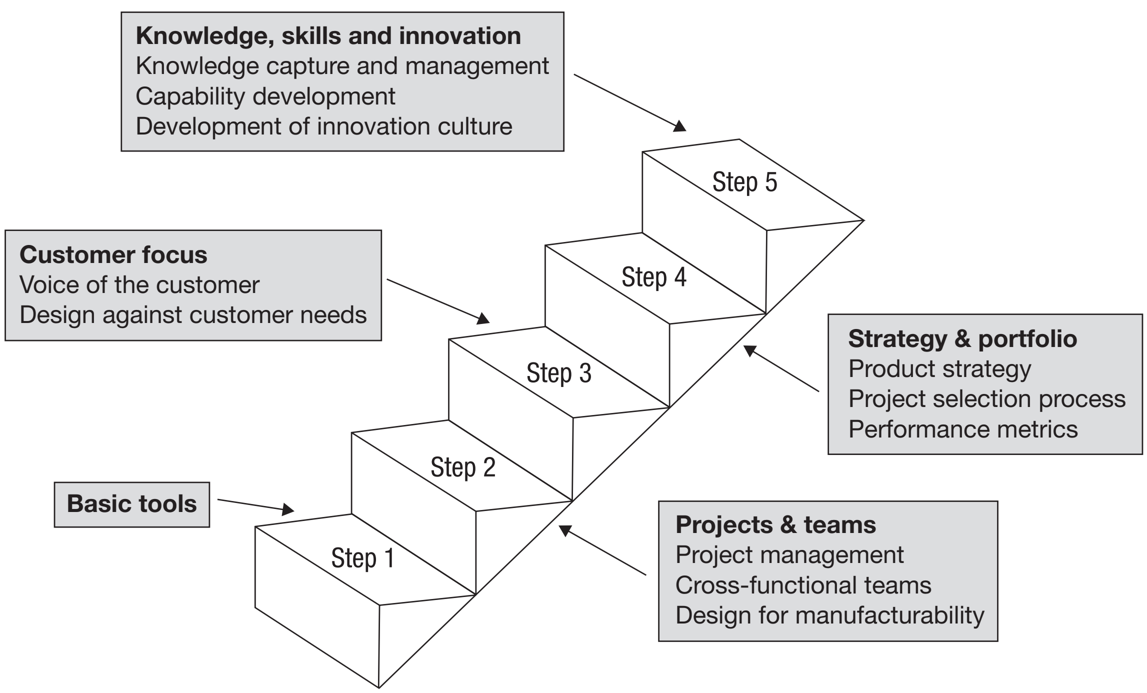


Figure 3.8 Levels of organizational practice based on the IPD System

Figure 3.8 shows IPD more as a framework for evolutionary and capability maturity improvement in product innovation, rather than simply a specific model or process. This framework captures many of the fundamental principles that underpin most commonly used product innovation processes with an emphasis on learning and continuous improvement.

The benefits and limitations of IPD

Benefits:

- As the organization develops its capabilities and matures through the IPD steps, product innovation and delivery should become more efficient.
- Increased efficiencies translate into improved cost management and increased profitability.
- Due to the strong emphasis on design principles in the FEI stages (in relation to defining the product/project goals), and thus clearer product definition, the risks are managed sooner in the product innovation life cycle.
- Quality, proactive risk management, and a focus on customer requirements ensure precise delivery of value.
- Multi-functional teams (internal and external) that effectively collaborate in a product innovation project can pool their skills and capabilities toward common goals.
- In relation to the notions of sustainability and the circular economy, IPD offers the means whereby multi-stakeholder engagement and participation strongly and intentionally encourage the incorporation of said notions into product innovation and the product life cycle.

Limitations:

- Customer requirements need to be clear early on in the development cycle so as to meaningfully contribute to the downstream creation and achievement of value. This requires active stakeholder engagement.
- The latest tools and methods are needed.
- IPD requires the right competencies (people and skills) to be deployed in the process.
- Multi-stakeholder collaboration can be problematic and complex if the teams are unable to effectively collaborate and co-create.
- The appropriate balance of front-end innovation and design controls is paramount to project success, otherwise inefficiencies will ultimately delay product delivery (Naveh, 2004).

IPD and sustainability integration — an example

An example of a company that successfully implemented IPD with a focus of integrating sustainability is Nestlé. Espinoza-Orias et al. (2018) describe how Nestlé, “Guided by values rooted in respect, [it] works alongside partners and stakeholders to create shared value (CSV) across all the activities of the company, which contribute to society while ensuring the long-term success of our business”. Its commitments go so far as to continually align to the SDGs (sustainable development goals) in terms of scope and timelines.

3.3.3 Lean product innovation

Lean product innovation is founded on the fundamental Lean methodology initially developed by Toyota (Toyota Production System, or TPS). TPS is based on the Japanese term Muda, meaning “futility” — uselessness, idleness, waste. Fundamentally, TPS was designed to remove Muda or waste from manufacturing processes. These principles have been incorporated into various product innovation processes.

The core concepts/principles of Lean product innovation consist of removing waste, gathering as much information and knowledge upfront, but importantly, require constant (and relentless) learning, and seeking opportunities for improvements along the entire life cycle of the product’s development (See Figure 3.9). Key components of/for Lean development thus relate to gathering and increasing product knowledge and having the team fully engaged early on in the product innovation process.

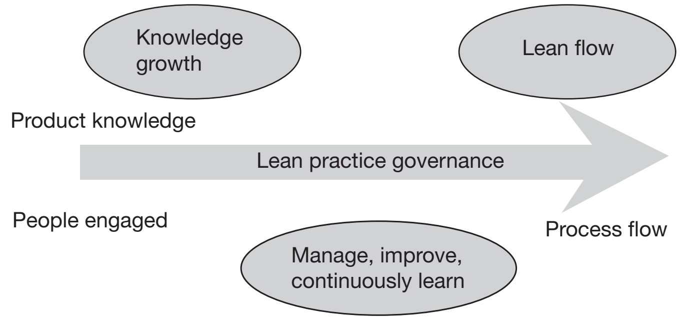


Figure 3.9 The concepts of Lean development

Lean product innovation is a contributor to organizational "productivity" endeavors (Mascitelli, 2011), and among others, is measured as:

- Profit generated per hour (or unit) of time.
- Efficient utilization of designers/developers.
- Faster time to market.
- More projects completed per unit time.
- More customers satisfied more of the time.
- Fewer wasteful activities.

Potential sources of waste include:

- Chaotic work environment.
- Lack of available resources.
- Lack of clear prioritization.
- Poor communication across functional barriers.
- Poorly defined product requirements.
- Lack of early consideration of manufacturability.
- Over-designing.
- Too many unproductive meetings.
- Email overload.

James M. Morgan and Jeffrey K. Liker, authors of *The Toyota Product Innovation System, Integrating People, Process and Technology* (2006, Productivity Press), offer the following product innovation guidelines:

1. Establish customer-defined value to separate value-added from waste.
2. Front-load the product innovation process to explore thoroughly alternative solutions while there is maximum design space.
3. Create a level product innovation process flow.
4. Utilize rigorous standardization to reduce variation, and create flexibility and predictable outcomes.
5. Develop a chief engineer system to integrate development from start to finish.
6. Organize to balance functional expertise and cross-functional integration.
7. Develop towering competence in all engineers.
8. Fully integrate suppliers into the product innovation system.
9. Build in learning and continuous improvement.
10. Build a culture to support excellence and relentless improvement.
11. Adapt technologies to fit the organization's people and processes.
12. Align the organization through simple visual communication.
13. Use powerful tools for standardization and organizational learning.

Benefits and limitations of Lean product innovation

Benefits:

- Focus of process is on transformation of information, not on heavy-handed governance.
- An even-driven approach simplifies collaboration and enables design optimization.
- Emphasis on proactively managing risks to schedule cost, performance, and quality.
- Can be scaled to any size project.
- Simple, often visual tools are used to capture learning, track progress, set priorities, and solve problems.

Limitations:

- Requires dedicated and experienced workers, both to suggest system improvements and to positively respond to system changes.
- Requires a change in organizational structure and culture. A unified and committed project culture is necessary with an appropriate and supporting organizational structure.
- Requires strong supplier management. The focus of Lean product innovation or "just in time" delivery requires good communication and coordination of suppliers.
- Requires a willingness and ability across the organization to accept changes in project goals and direction.

3.3.4 Agile product innovation

The Agile methodology is an iterative approach that can be incorporated into product innovation that is performed in a collaborative environment by self-organizing teams. It helps teams respond to unpredictability through incremental, iterative work cadences. These are known as sprints. Agile has overwhelmingly been accepted in the software industry, but has also been included in a hybridized Agile-Stage-Gate approach (see section 3.3.1, "Fast Stage-Gate") for the manufacturing of tangible products environments. Unlike hardware, software is continuously and infinitely changeable. Recommended further reading on Agile in product innovation includes Pichler (2013) and Cooper et al. (2016).

Manifesto for Agile software development

In February 2001, 17 software developers met in Utah to discuss lightweight development methods. They published the *Manifesto for Agile Software Development.* The manifesto states:
"[They] are uncovering better ways of developing software by doing it and helping others do it. Through this work [they] have come to value:
Individuals and interactions over processes and tools,
Working software [or product] over comprehensive documentation,
Customer collaboration over contract negotiation,
Responding to change over following a plan.
That is, while there is value in the items on the right, [they] value the items on the left more." (http://www.agilemanifesto.org/)

This means that while processes, tools, documentation, contracts, and plans are important and of value, Agile practitioners prioritize the interactions of individuals, a working product, customer collaboration and active inputs, and the ability to adjust to moving plans (change) as the guiding principles by which product design, development, and its launch are realized.

Key elements of most Agile product innovation processes

Although the specific application of Agile product innovation may vary across organizations and context (that is, beyond just software development), the basic elements usually remain the same. These are:

- The product backlog,
- The scrum,
- The sprint,
- The demo,
- The retrospective meeting,
- The product owner role,
- The scrum master role,
- The scrum team role.

The product backlog

The product backlog contains the requirements for a system, expressed as a prioritized list of product backlog items. These include both functional and non-functional customer requirements, as well as technical team-generated requirements. While there are multiple inputs to the product backlog, it is the sole responsibility of the product owner to prioritize the product backlog. A product backlog item is a unit of work small enough to be completed by the team in one sprint iteration.

The scrum

The scrum is a process created by Jeff Sutherland in 1993 based on an analogy with the "scrum" formation used by rugby teams (Sutherland, 2014).

Arguably it is the most popular framework for implementing Agile. With a scrum, the product is built in a series of fixed-length iterations giving teams a framework for shipping software on a regular cadence.

The sprint

The sprint is a set period of time during which specific work has to be completed and made ready for review.

The demo

At the completion of each sprint, the product (in incremental state) and/or new features that were developed in the previous sprint(s) are reviewed by project stakeholders, such as the customer or the company's management. This entails demonstrating the "product" up to this point in time. The aim is to achieve validation, and to continue with the next sprint.

The retrospective meeting

The retrospective meeting aims to identify and record "lessons learned" from the previous sprint(s), and takes place at the end of every sprint. The team evaluates its performance with the aim to continuously improve. Typically, they would discuss aspects such as:

- What went well and why (to keep doing what worked and/or identify new items to incorporate into the working practices);
- What did not go well, why;
- How to address the items that did not go well, which provides a basis from which to sprint planning.

Figure 3.10 illustrates the events, roles, and outcomes that are expected during and after a sprint planning session. Inputs into the meeting and hence the planning outcomes include:

- Product backlog,
- Team capabilities,
- Business conditions,
- Technology,
- Current product.

Ultimately, the team will want to establish and agree on the next sprint's goals, and the sprint backlog is addressed and/or updated.

Each sprint starts with a planning meeting, during which the **product owner** (the person requesting the work) and the development team agree what will be accomplished during the sprint. The duration of the sprint is determined by the **scrum master**. After the sprint begins, the **product owner** steps back to allow the team to do its work. At the end of the sprint, the team presents its completed work to the **product owner** who uses the criteria established in the sprint meeting to accept or reject the work.

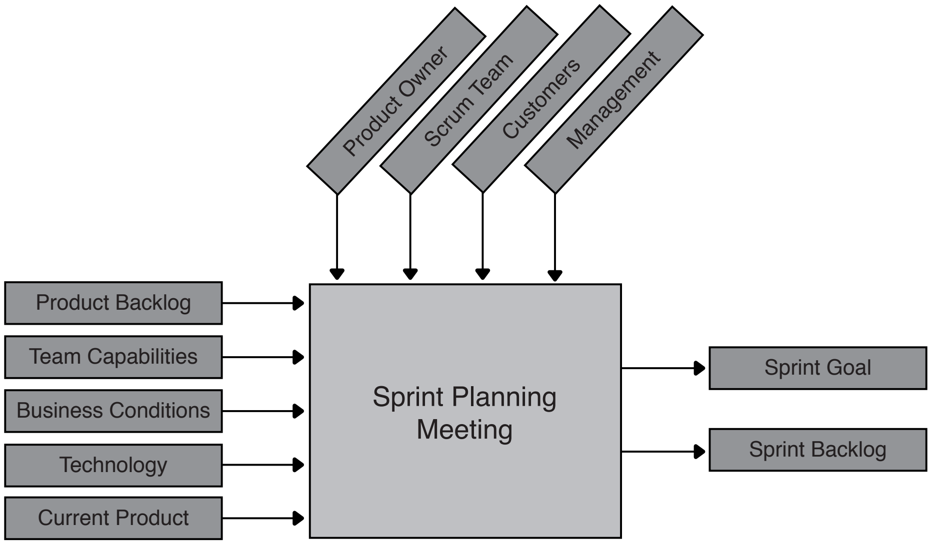


Figure 3.10 Sprint planning meeting

The product owner
The product owner is the single person who must have final authority representing the customer's interests in backlog prioritization and requirements questions. This person must be available to the team at any time, but especially during the sprint planning meeting. The product owner should not manage the team and should resist the temptation to change the work required after the sprint has started. A key responsibility of the product owner is to balance the interests of competing stakeholders.

The scrum master
The scrum master is the facilitator for the team and product owner. Rather than manage the team, the scrum master works to assist both the team and the product owner through:

- Removing barriers between the team and the product owner.
- Facilitating creativity and empowerment in the team.
- Improving team productivity.
- Improving engineering tools and practices.
- Ensuring that information on team progress is up to date and visible to all parties.

The scrum team
The scrum team is usually made up of seven, plus or minus two, members. The team usually comprises a mix of functions or disciplines required to successfully complete the sprint goals (cross-functional team). In software development projects, the team could comprise software engineers, architects, programmers, analysts, quality experts, testers, UI designers, etc. During the sprint, the team self-organizes to meet the sprint goals. The team has autonomy to choose how best to meet these goals and is held responsible

for them. Figure 3.11 illustrates the cycle that the scrum team applies in order to meet product and sprint backlogs. Scrum teams meet as often as daily (or as appropriate), with the aim of consolidating information and agreeing on:

- What was achieved,
- What was not achieved,
- What is needed to progress.

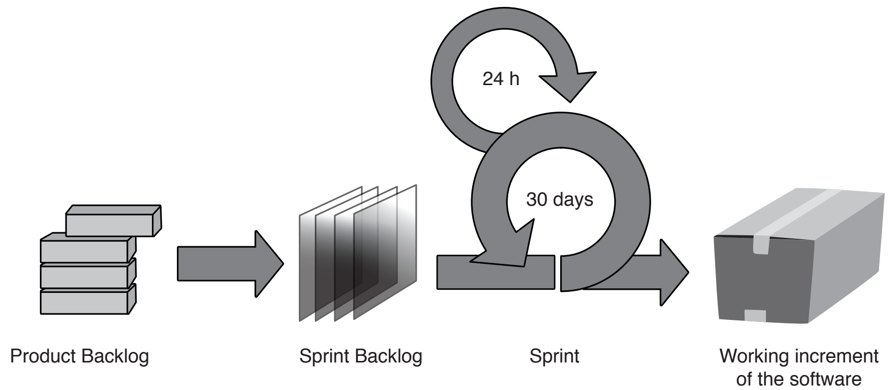


Figure 3.11 How scrum works

Sprint events typically have durations of no more than 30 days and in the process the product and the sprint backlogs are continually addressed, to the point whereby incremental development, or enhancements, can be achieved to/for the product. Typically, a working version of the product is achieved, often referred to as the minimum viable product (MVP). It is a functional product, but may not have all the product features included yet; hence the product backlog serves as the record for future development to be performed.

Key principles of Agile product innovation

Following is a summary of the key principles of Agile product innovation. http://agilemanifesto.org/principles.html

1. [Their] highest priority is to satisfy the customer through early and continuous delivery of valuable software.
2. Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.
3. Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.
4. Businesspeople and developers must work together daily throughout the project.
5. Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.
6. The most efficient and effective method of conveying information to and within a development team is face-to-face conversation.
7. Working software is the primary measure of progress.
8. Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
9. Continuous attention to technical excellence and good design enhances agility.
10. Simplicity — the art of maximizing the amount of work not done — is essential.
11. The best architectures, requirements, and designs emerge from self-organizing teams.
12. At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly.

The benefits and limitations of Agile product innovation:

Benefits:

- Scrum methodology enables projects where the business requirements documentation is hard to quantify or to be successfully developed.
- Fast-moving, cutting-edge developments can be quickly coded and tested using this method, as a mistake can be easily rectified.
- It is a lightly controlled method which insists on frequent updating of the progress in work through regular meetings. Thus, there is clear visibility of the project's development and progress.
- Like any other Agile methodology, this is also iterative in nature. It requires continuous feedback from the user.
- Due to short sprints and constant feedback, it becomes easier to cope with the changes.
- Daily meetings make it possible to measure individual productivity. This leads to improvement in the productivity of each of the team members.
- Issues are identified well in advance through the daily meetings and hence can be resolved speedily.
- Agile scrum can work with any technology/programming language but is particularly useful for fast-moving web 2.0 or new media projects.
- The overhead cost in terms of process and management is minimal, thus leading to a quicker, cheaper result.

Limitations:

- Agile scrum is one of the leading causes of scope creep — because unless there is a definite end date, the project management stakeholders will be tempted to keep demanding that new functionality be delivered.
- If a task is not well defined, estimating project costs and time will not be accurate. In such a case, the task can be spread over several sprints.
- If the team members are not committed, the project will either never be completed or will fail.
- It is good for small, fast-moving projects as it works well only with a small team.
- This methodology needs experienced team members only. If the team consists of people who are novices, the project may not be completed in time.
- Scrum works well for project management when the scrum master trusts the team being managed. If they practice too strict control over the team members, it can be extremely frustrating, leading to lack of motivation and failure of the project.
- If any of the team members leave during a development, it can have a huge adverse effect on the project development.
- Project quality management is hard to implement and quantify unless the test team is able to conduct regression testing after each sprint.

3.3.5 Systems engineering

There appears to be a preference for different product innovation models according to geographical region; for example, IPD is popular in the Asia-Pacific region. Some regions utilize systems engineering. Others, such as in Africa, utilize various models.

Systems engineering (SE) principles combine the concepts of systems thinking and SE process models to take a *problem* through a systematic and integrated process of design and project management tools and methods into a *solution.* All systems comprise *parts/elements* (building blocks), that have *properties/functions,* and the elements are linked to each other through relations. Multiple *systems* (that is, multiple elements in a boundary of one system that relate to another system) can also be called a system or environment. Systems complexity is determined by structure, dynamics in the system/sub-systems(s), changeability, variety, multiplicity, and size.

Hence, systems engineering overlaps and systematically integrates numerous technical and human-centered disciplines. The aim is to combine and integrate elements of industrial-, mechanical-, manufacturing-, control-, software-, electrical-, and civil engineering, as well as cybernetics, organizational studies, and project management into a systems life cycle. The systems user requirements are thus assuredly encapsulated and delivered by means of technical and management processes.

Following are the steps in the systems engineering design framework (extracted from Pahl et al., 2007):

1. Product planning and task selection;
2. Clarifying the task(s) and compiling a requirements list;
3. Abstracting to identify essential problems to solve;
4. Establishing functional structures;
5. Exploring and adopting working principles;
6. Selecting suitable combinations;
7. Firming up into principle solutions;
8. Evaluating principle solutions.

Various methods are applied to each step such as selection methods, trend studies, tests and measurements, brainstorming, design catalogues, quality assurance, and costing methods.

Features of systems engineering include:

- Upfront, intentional, and intensive design thinking;
- Framing a “problem” from a general broad perspective to detail, through analyses;
- Being interdisciplinary;
- Complexity management;
- Cost reductions;
- Risk reduction;
- Shorter project scheduling;
- Optimizations;
- Product quality improvement.

Systems engineering ensures that all likely aspects of a project or system are considered and integrated into a whole.

The systems engineering process is a discovery process that is quite unlike a manufacturing process. A manufacturing process is focused on repetitive activities that achieve high-quality outputs with minimum cost and time. The systems engineering process must begin by discovering the real problems that need to be resolved, and identifying the most probable or highest impact failures that can occur — systems engineering involves finding solutions to these problems.

Benefits and limitations of systems engineering

Benefits:

- The benefit of multiple systems’ strengths become evident and useable.
- Design-related decisions are fairly detailed and made upfront due to intense customer involvement.
- Learning opportunities (increased know-how as the project progresses) start early on in the project and are conveyable to all parties.
- Impending changes are easily identified and managed.

Limitations:

- Over-analyses of the problem and too much detail upfront may cause the risk of delay and a focus on the incorrect elements for solutioning.
- As the project progresses over time, the initial requirements may become outdated because they were based on knowledge that was generated at a historical point in time, and may no longer be appropriate or relevant.
- The same applies to the planning elements, as prolonged planning and or development risk making the solution irrelevant.
- Exerting influence and the ability to effect change become increasingly difficult as the product innovation progresses toward the final phases due to "operational and resource commitments" to the project.

Haberfellner et al. (2019) offer the following useful advice to behaviorally manage some of the limitations:

1. *Beware of super-integrated solutions* that are too large and take several years to carry out, especially when they are located within a dynamic environment and are subject to uncertain conditions. In case of doubt, it is preferable to lean toward smaller solutions that facilitate a quicker benefit.
2. *Implement flexibility* in overall concepts, pursue "Agile systems": Keep options open regarding later adaptations, expansions, dismantling, etc. Plan for modular building blocks that can later be replaced with better or more efficient ones. Be open to or plan for opportunities for expansion or reduction.
3. Consciously plan for flexibility or possibilities of multiple use, even though this may require somewhat increased investment.
4. Consciously make partial introductions to provide interim benefits.
5. Dispense with optimizing unproductive details.
6. Postpone decisions based on uncertain premises for as long as possible — as long as this is compatible with the logical process.

An important aspect relating to items 2 and 3 above is known as *designing for changeability (DFC),* which is a set of principles that enable changes in systems throughout their life cycle. This has especially become relevant in the product platforming environment related to the automobile manufacturing industry. See Fricke et al. (2005) in the Additional Reading section.

3.3.6 Design thinking

"Design thinking is a creative problem-solving approach — or more completely, a systematic and collaborative approach to identify and creatively solve problems." (Luchs et al., 2015)

Is it a product innovation process? Possibly not, in the strictest sense of the definition. But design thinking certainly embodies many of the key principles that underpin the processes discussed earlier in this chapter. It also uses many of the tools discussed throughout this book.

Tim Brown, CEO of IDEO, defined design thinking as "a human-centered approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success."

It is a non-linear approach to problem-solving where designers iterate toward a final solution — through generation of possible solutions, simple prototyping, obtaining customer feedback, and re-designing, re-prototyping, etc. Design thinking is also known as D-Thinking (Stanford University D-School). It is based on IDEO's original "Deep Dive" methodology. Refer to the YouTube video of IDEO's shopping cart: http://www.youtube.com/watch?v=M66ZU2PCIcM

The mission of design thinking

To translate observation into insights, and insights into products and services that will improve lives.

A framework for design thinking

A framework for design thinking is presented by Luchs et al. (2015). Refer to Figure 3.12.

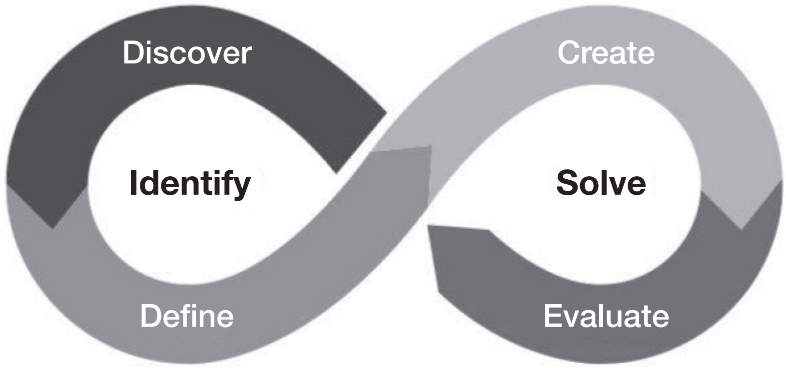


Figure 3.12 Design thinking framework

Identify:

- *Discover:* uncover opportunities through customer insights. The principles of design thinking demand that the discovery process is iterative with building of information from a range of sources.
  Customer empathy is the key to design thinking:
  - Know about users, and care about their lives.
  - Observe them, how they interact with their environment, what they think and feel.
  - Understand the way they do things and why, their physical and emotional needs, how they think about the world, and what is truly meaningful to them.
- *Define:* development of an expanded understanding of the customer needs associated with the product — distilling customer insights. This, in turn, leads to some form of product design specification.

Solve:

- *Create:* develop a concept(s) that can be shared with the target market, which, through several iterations, can evolve to prototyping.
- *Evaluate:* additional feedback on the prototype(s) that is synthesized and used as a basis for more iterations of improvement.

3.3.7 Lean startup

Lean startup is an approach to building new businesses based on the belief that entrepreneurs must investigate, experiment, test, and iterate as they develop products. The concept of Lean startup originated in the early 2000s and evolved into a methodology around 2010. It was developed by Silicon Valley entrepreneurs Blank (2011) and Ries (2012).

Proponents of the methodology say Lean startup principles ensure that entrepreneurs develop products that customers actually want, rather than attempting to build businesses based upon untested ideas. Proponents also describe this mentality as “fail fast, fail cheap” because the Lean startup process is designed to limit the time and money invested in product ideas when entrepreneurs test and prove their potential value.

The Lean startup methodology calls for entrepreneurs to start their business ventures by searching for a business model and then testing their ideas. Feedback from potential customers is then used to adjust their ideas as they move forward. The Lean startup methodology also advocates for entrepreneurs to continually engage in this activity loop — exploring and developing hypotheses that they then test among customers to elicit feedback, something known as validated learning. Entrepreneurs use that customer feedback to re-engineer their products.

Lean startup also advocates for iterative, or Agile, development concepts adapted from the world of software development. A Lean startup will build a prototype quickly, get it to market to gauge success of the product without expending unnecessary resources, and use the data generated by early marketing tests to influence the next build phase. In Lean production, this approach is called Kaizen. In programming, the approach is called Agile.

There are six critical elements for proper execution of the Lean startup methodology:

1. **Build-measure-learn:** Build-measure-learn, as shown in Figure 3.13, is a cycle of creating and testing hypotheses by building something for targeted customers to use, measuring their reactions, and then learning from the results. It should be thought of as a continuous improvement tool, used throughout the product innovation process. Some techniques used in performing build-measure-learn can be:
    - Desk research,
    - Interviews,
    - Observation,
    - Co-creation,
    - Impersonation,
    - Test an MVP,
    - Online surveys,
    - Mock-ups,
    - Networking.

    Refer to Chapter 5 for more information on ideation techniques and design tools.

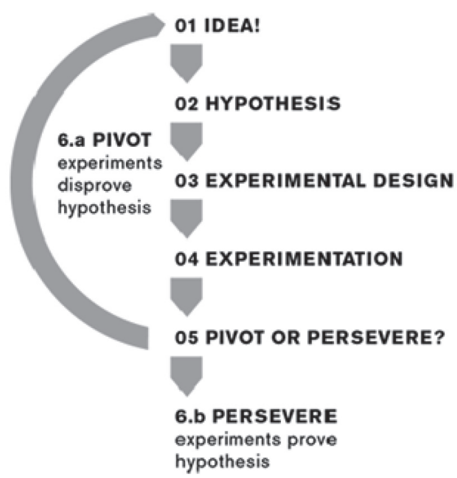


Figure 3.13 The build-measure-learn cycle. Source: Cowan, Alex. Your Lean Startup. Accessed from https://www.alexandercowan.com/creating-a-lean-statup-style-assumption-set

2. **The Business Model Canvas:** The Business Model Canvas (BMC) first developed by Osterwalder et al. (2010), is a simple, yet effective visual strategy tool that organizations big and small use for business model innovation. The BMC is an important tool used by Lean startup businesses with its emphasis on entrepreneur-focused business planning.
    The importance of the organization's business model in the context of strategy and innovation is very key. Business models, if incorrectly defined and/or do not support the innovation strategy and management, the technology strategy, and the product strategy, will not achieve the goal of value creation — which is ultimately what it's all about for profit-making firms. The growth of the Internet, the ease of accessibility, and globalization, among others, have created the impetus for firms to incorporate innovation into every facet where value can be captured and translated into profit. Refer to Chapter 1, section 1.4.4, for more detail on the Business Model Canvas.

3. **Learning plans: One turn of the crank:** As Ries (2012), the author of *The Lean Startup,* wrote, "Validated learning is the process of demonstrating empirically that a team has discovered valuable truths about a startup's present and future business prospects." A learning plan describes how key hypotheses are to be tested. Completing a learning plan is "one turn of the crank," shown in Figure 3.14. The plan is categorized by these four quadrants:
   - Market – patient, consumer;
   - Organization – staffing, budgeting, structure;
   - Commercial – investment, profitability;
   - Technology – technical, innovations/platforms;

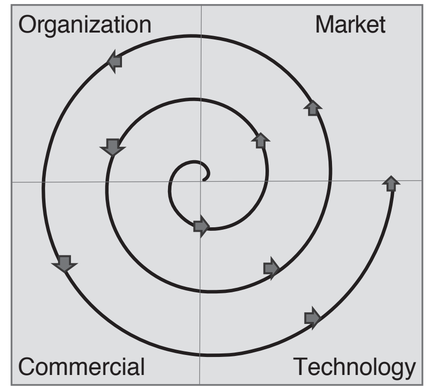


Figure 3.14 The learning plan — "one turn of the crank" Source: Ries (2012). The Lean Statup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Different Successful Businesses. Crown Business, New York.

All quadrants are not required for each learning plan. Only cover those areas that are critical to project success or failure. A typical learning plan may be formatted as illustrated in Figure 3.15. Some attributes of a good learning plan are:

- Good plans fail fast/learn quickly; probability should generally rise as phases progress.
- Are there ways to bring proof forward? Can you learn about low-probability events earlier?
- Design periodic proof or pivot points on problematic issues.

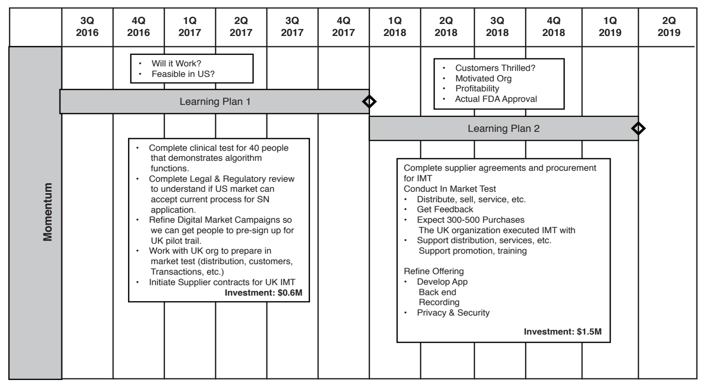


Figure 3.15 Example of a learning plan

4. **Three stages of a startup: Problem/solution fit, product/market/fit & scale.** Figure 3.16 presents the three stages of a startup:
   i. Problem/solution fit: *Is there a clear pain (or gain) worth solving for a customer?* It is fundamental that there be a real "pain or gain" for the target customer. Too many early stage ideas fail because the project team or leadership are enamored with a new technology or the elegance of the solution.
   ii. Product/market fit: *Does the product meet the market need?* Not only is this stage critical to validating the product features and how attractive it will be in the market, it is important to decide on the business model that will be used in "go-to-market."
   iii. Scale: *Accelerating growth to achieve economies of scale.* Are the right production, sales, service, and support structures in place? Is the business model becoming profitable?

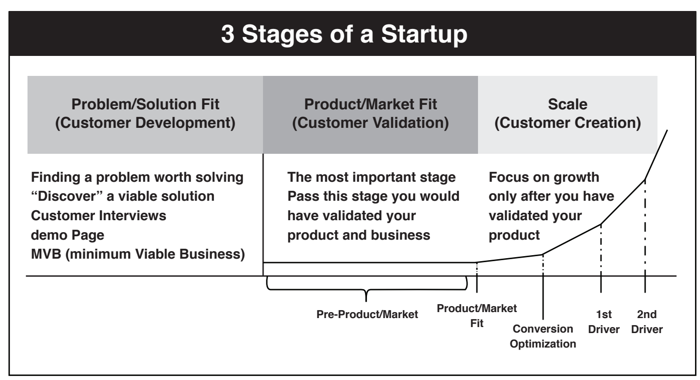


Figure 3.16 Three stages of a startup. Source: StartitUp. Becoming a Lean Startup Guru. http://startitup.co/guides/294/becoming-a-lean-startup-guru

5. **Minimum viable product:** A minimum viable product (MVP) is a product with just enough features to satisfy early customers, and to provide feedback for future product development. "The lesson of the MVP is that any additional work beyond what was required to start learning is waste, no matter how important it might have seemed at the time." (Ries, 2012).

   Gathering insights from an MVP is often less expensive than developing a product with more features, which increases costs and risk if the product fails — for example, due to incorrect assumptions. The term was coined and defined by Frank Robinson in 2001 and then popularized by Blank (2012 and 2016). It may also involve carrying out market analysis beforehand.

   A solution experiment can be a very simple landing page or a paper mock-up to test your idea for a solution with potential customers. No need to really build anything; you just want to validate your assumptions before you can continue to build a prototype or your first version of a working product.

   First versions of your product usually only include the bare minimum needed to solve your customer's problem. Just develop what is needed. People say, "if you're not embarrassed about your first version, you launched too late." We see a lot of entrepreneurs who are afraid to launch. But launch as fast as possible so you can start learning from your mistakes and more important, to start iterating to something that works.

6. **Pivoting.** Entrepreneurs have found that the extreme uncertainty of a new product or service usually requires many course corrections, or "pivots," to find a successful formula. Eric Ries suggests 10 forms of pivoting:
   - **Zoom-in pivot.** In this case, what previously was considered a single feature in a product becomes the whole product. This highlights the value of both focus and an MVP, delivered quickly and efficiently.
   - **Zoom-out pivot.** In the reverse situation, sometimes a single feature is insufficient to support a customer set. In this pivot, what was considered the whole product becomes a single feature of a much larger product.
   - **Customer segment pivot.** Your product may attract real customers, but not the ones in the original vision. In other words, it solves a real problem, but needs to be positioned for a more appreciative segment.
   - **Customer need pivot.** Early customer feedback indicates that the problem solved is not very important, or money isn't available to buy. This requires repositioning, or a completely new product, to find a problem worth solving.
   - **Platform pivot.** This refers to a change from an application to a platform, or vice versa. Many founders envision their solution as a platform for future products, but don't have a single killer application just yet.
   - **Business architecture pivot.** Geoffrey Moore, many years ago, observed that there are two major business architectures: high margin/low volume or low margin/high volume. You can't do both at the same time.
   - **Value capture pivot.** Changes to the way a startup captures value can have far-reaching consequences for business, product, and marketing strategies. The "free" model doesn't capture much value.
   - **Engine of growth pivot.** Most startups these days use one of three primary growth engines: the viral, sticky, and paid growth models. Picking the right model can dramatically affect the speed and profitability of growth.
   - **Channel pivot.** The mechanism by which a company delivers its product to customers is called the sales or distribution channel. Channel pivots usually require unique pricing, feature, and competitive positioning adjustments.
   - **Technology pivot.** Using a completely different technology to solve the problem. This is most relevant if the new technology can provide superior price and/or performance to improve.

3.4 COMPARING PRODUCT INNOVATION PROCESS MODELS

An increase in the understanding of what underpins successful product innovation has led organizations to evolve and adapt process methods to meet the needs of specific organizational contexts and product categories. Researchers and practitioners have recognized that the “one-size-fits-all” approach to product innovation processes does not work. In the preceding sections we have overviewed a number of the key models that have been developed and applied over recent years. Each model has specific benefits and limitations. Although an application of one of these models in its purest form may be appropriate in some situations, in most cases a blend of elements from a number of models is most appropriate. Following is a comparison of selected processes.

3.4.1 Agile vs. Lean

The difference between Agile and Lean is simple to understand, but most people feel they are somehow equivalent. They are not.

Lean is designed to reduce waste and improve operational efficiency, especially related to repetitive tasks as often in seen in manufacturing. The real value in the Lean approach to product innovation is its focus on a core set of principles or guidelines that underpin the process of developing new products. It is not a defined process focused on the specific activities and tasks required to successfully develop a new product. Section 3.3.3 summarizes 13 guidelines for Lean product innovation, as initially applied by Toyota.

Agile is designed to execute tasks over a short time frame, with frequent customer involvement, and to be able to make changes quickly. The structure, process, and roles are all well defined as they are applied to the development of a product or product component. In a nutshell, Agile is a time-focused, iterative philosophy to build a product step by step (incrementally), delivering it in smaller pieces. One of its main benefits is the ability to adapt and change at any step (depending on feedback, market conditions, corporate obstacles, etc.) and to supply only relevant products to the market.

As can be noted, they have nothing to do with each other per se — you do not need to innovate new products to be Lean, and you don’t have to be operationally efficient to be Agile.

3.4.2 Agile vs. Stage-Gate®

Stage-Gate® is not a project management or micro-planning model. Rather, it is a comprehensive and holistic idea-to-launch system and a macro-planning process. It is cross-functional (i.e., involves technical product developers, as well as marketing, sales, and operations). It places significant emphasis on “gates” that form the basis of an investment decision model, asking key questions: is the organization doing the right project? and is the project being done right?

By contrast, Agile was originally designed specifically to rapidly develop working software. In practice, the development stage consists of a number of sprints, where each sprint or iteration produces a working product (executable code or software that works) that can be demonstrated to stakeholders (i.e., customers). An iteration may not add enough functionality to warrant a market release, but the goal is to have a potentially available release at the end of each iteration. Multiple iterations are usually required to release a product or new features; a sprint typically lasts 3-5 weeks.

Robert Cooper has provided a good explanation of the features of both Stage-Gate® and Agile (refer to Figure 3.17). He refers to the commonly-held belief that Stage-Gate® is appropriate for “hardware” products while Agile is appropriate for software, leading to the conclusion that the two methods are mutually exclusive. Cooper claims, “Agile and Stage-Gate® are not substitutes for each other. Rather, Agile is a useful micro-planning tool or project management tool that can be used within the Stage-Gate® process to accelerate certain stages — probably stages 3 and 4.” (Cooper, 2015). Figure 3.18 indicates how constant customer/user engagement works in a typical Stage-Gate process.

Characteristic	Stage-gate	Agile
Type of model	Macro-planning	Macro-planning, project management
Scope	Idea to launch, end to end	Development and testing stages only
Organizational breadth	Cross-functional – technical, marketing, manufacturing	Technical (software code writers, engineers, IT staff
End point	A launched new product in the market place	Developed and tested software product
Decision model	Investment model: go/kill model involves senior management governance	Largely tactical: actions needed for the next sprint

Figure 3.17 Stage-Gate vs. Agile

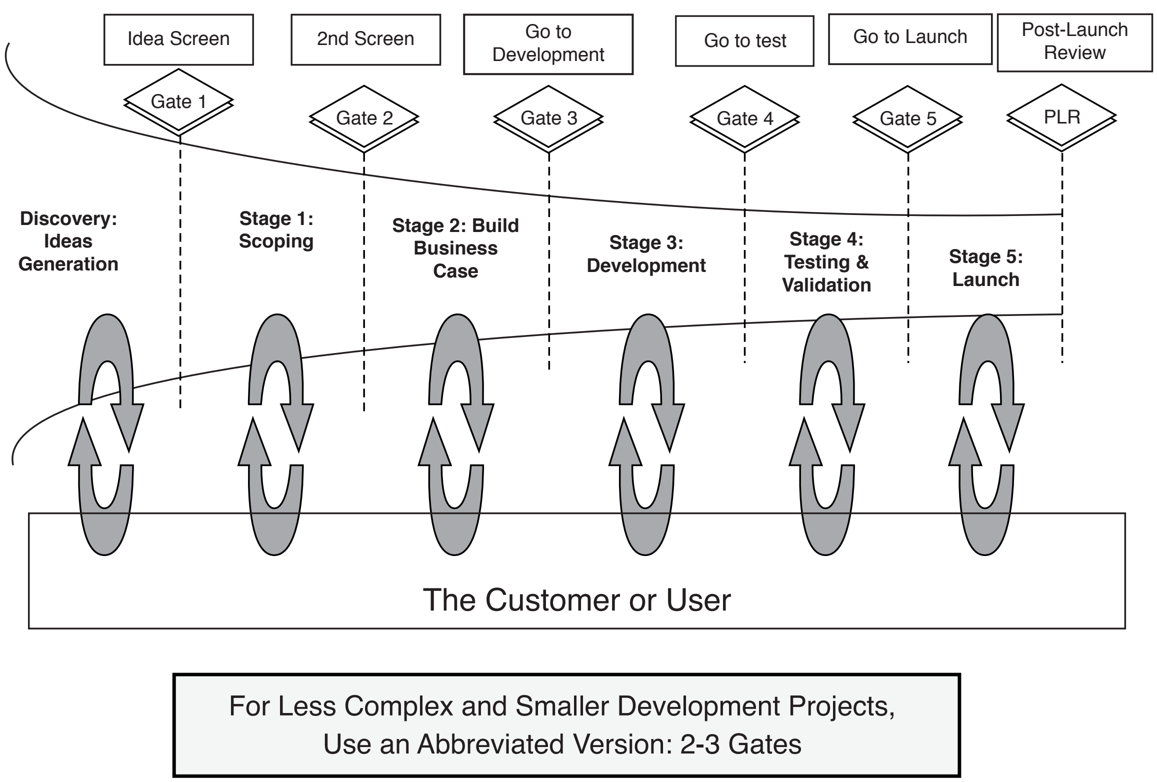


Figure 3.18 The role of Agile within Stage-Gate for software development (reprinted with permission, Cooper, 2015)

3.4.3 Integrated product development (IPD) vs. other process models

IPD, as the name implies, provides a framework that is designed to emphasize the integration of functions, roles, and activities involved in product innovation. It has been defined as “A philosophy that systematically employs an integrated team effort from multifunctional disciplines to [effectively and efficiently] develop …new products that satisfy customer needs” (Kahn, 2013).

One of the features that has evolved into the IPD model is “learning and continuous improvement.” Figure 3.8 presents a form of product innovation maturity model that shows the potential evolution of an organization for a focus on product innovation process and techniques to a knowledge-based learning organization.

It is logical that the macro-planning features and decision-making basis of the Stage-Gate® model; the micro-planning and flexibility of the Agile model; the focus on reduction in wasted time and effort associated with Lean; and the overall integration of product innovation as a learning company are potentially complementary and not mutually exclusive. Merging elements of each model into a true fit-for-purpose product innovation process model, with an overall focus on learning and continuous improvement, is a sign of advanced product innovation practice.

3.5 PRODUCT INNOVATION PROCESS CONTROL AND MANAGEMENT

Each of the product innovation processes discussed in this chapter has significant strengths in basic structure and underlying principles. But each can also take on a life of its own where process takes precedence over outcomes. For example, delivery teams will often produce required artifacts, such as requirements documents or architecture documents, solely to pass through the process gate. A well-defined control and management (governance) responsibility, vested in a senior manager or a management team, is an excellent vehicle for ensuring the overall effectiveness of the product innovation process. That is, the right process, efficiently and effectively focused on delivering the right outcomes.

The Project Management Institute (PMI) defines governance as applied to program management as (emphasis and applicability to product innovation in bold):

"[that which] covers the **systems and methods** by which a program and its strategy are **defined, authorized, monitored,** and **supported** by its sponsoring organization. Program Governance refers to the practices and processes conducted by a sponsoring organization to **ensure** that its programs are **managed effectively and consistently** (to the extent feasible). Program Governance is achieved through the actions of a **review** and **decision-making** body that is charged with endorsing or approving recommendations made regarding a program under its authority." (PMI Standard for Program Management 3rd Edition, 2013:51)

From a product innovation governance perspective, the following questions need to be adequately answered:

1. Is the product innovation process tailored to the specific needs of the organization and its products or services? Is the process well communicated, understood, and accepted across the whole organization?
2. Have measurable targets for new product or service outcomes been determined and agreed upon? Are these communicated and commonly understood across all people involved in the product innovation process?
3. Are there specific metrics designed for each stage in the product innovation process (for example, actual spend vs. budget, milestones on time, overall development cycle time)? Are these used as a basis for learning and continuous improvement?
4. Is the appropriate balance of management authority and individual responsibility defined and in place?
5. Do the decision protocols and processes enable effective and timely decision making? Do any significant and unnecessary "roadblocks" exist that add to frustration and delays?
6. Is the product innovation process reviewed regularly, based on inputs from a cross-section of the organization and from the output and process metrics?
7. Are specific processes and instances in place to resolve potential disagreements among team members, especially when cross-functional teams participate in the same projects?

3.6 IN SUMMARY

- Structured and consistent processes adopted across an organization contribute significantly to product innovation success.
- Product innovation is basically a risk vs. reward process. The application of disciplined processes and practices is designed to reduce the level of uncertainty and improve the likelihood of product success.
- Costs associated with new product innovation generally increase dramatically throughout the product innovation process — especially during final design, prototyping, and scale-up to commercialization. It is vitally important to put significant effort into the early stages of product innovation (FEI, front end of innovation) to ensure that an informed decision is made about the project's likelihood of success.
- This chapter has described a range of new product models. Each has its strengths and is generally more applicable at certain stages of the full product innovation process. The Stage-Gate® provides an idea-to-launch process, while most other models focus on specific stages throughout this overall process.
- Stage-Gate®, IPD, waterfall, Agile, Lean, systems engineering and design thinking all have merits in application to specific organization and product situations. It is important to fully understand the principles of each model and apply the most appropriate model to the specific organizational context. This often requires a blend of two or more models.
- All process models have the following principles in common:
  - A focus on strategic alignment;
  - Knowledge-based decision making to reduce risk of product failure;
  - An emphasis on stakeholder input to design decisions;
  - The use of cross-functional teams;
  - A structured framework, understood and applied across the organization.
- Organizations that are truly successful in product innovation understand the fundamental principles of new product success. They learn from others and are constantly striving for continuous improvement.
- Fundamental to the successful implementation of product innovation is clarity of definition around the intent of the innovation strategy and of specific product innovation projects. This clarity of definition is provided in what is called the product innovation charter (PIC).
- A business sustainability strategy and principles need to be built into every product innovation project. These factors relate to the reduction of waste, recycling where/when possible, and the re-use of materials. Furthermore, it includes operating within the widely accepted triple constraint of people, planet, and profit.

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Practice questions: Product innovation process

1. Mary works as a product development engineer at an automotive parts supplier. Her boss has been complaining about the long lead time in getting new products to market. He believes that the iterative changes, inherent in most of the new products, could be carried out much more efficiently. What type of product development process would you suggest that Mary recommend to her boss to reduce time to market?
   A. Waterfall
   B. Integrated
   C. Agile
   D. Stage-Gate

2. In the early stages of the new products process there is a lot of uncertainty. These stages are often referred to as _______________
   A. Concept generation.
   B. The fuzzy front end.
   C. Business case development.
   D. Concept evaluation.

3. The sign of a mature product development process within an organization is the ability of the organization to:
   A. Include and integrate stakeholders and senior management throughout the development process.
   B. Use iterative and risk-limiting steps to facilitate effective and efficient new product development.
   C. Continuously fill the pipeline with new products.
   D. Develop its own best practices from the various models and experiences.

4. The first step in the classic waterfall process is requirements. The last step is known as:
   A. Development.
   B. Maintenance.
   C. Verification.
   D. Implementation.

5. Key elements of Agile new product process includes the scrum, the scrum master, the scrum team, the sprint, the product backlog, and:
   A. Stakeholders.
   B. Project manager.
   C. Product owner.
   D. Product champion.

6. A company is developing a product that is basically a relatively simple line extension of existing products. It knows the market well and the risks associated with product failure are low. What type of Stage-Gate process would be most likely appropriate for this development?
   A. A 5-stage process with heavy emphasis on initial business analysis.
   B. A 5-stage process with significant market research built into the decision-making.
   C. A relatively short 3-stage process focusing on speed to market.
   D. A 3-stage process with a strong emphasis on pre-launch test marketing.

7. The process designed to build a product through a series of fixed-length iterations giving teams a framework for shipping software on a regular cadence is called:
   A. Sprint.
   B. Lean.
   C. Scrum.
   D. Agile.

8. Gates are defined as decision points based on deliverables, criteria, and outputs. Outputs include:
   A. Financial statements.
   B. Yes or no decisions.
   C. The highs and lows of impact and probability.
   D. Go, kill, hold, recycle decisions.

9. Lean processes are focused primarily on:
   A. Putting more discipline into processes.
   B. Making processes more Agile.
   C. Removing waste.
   D. Encouraging cross-functional integration.

10. The framework, functions, and processes that guide activities in project, program, and portfolio management and provide guidance, decision making, and oversight is called…
    A. Governance.
    B. Project management.
    C. Team leadership.
    D. General management.

Answers to practice questions: Product innovation process

1.	C	6.	C
2.	B	7.	C
3.	D	8.	D
4.	B	9.	C
5.	C	10.	A

4

PRODUCT DESIGN AND DEVELOPMENT TOOLS

Required to facilitate efficient and effective evolution of a product from initial idea through to a manufacture and "market-ready" form

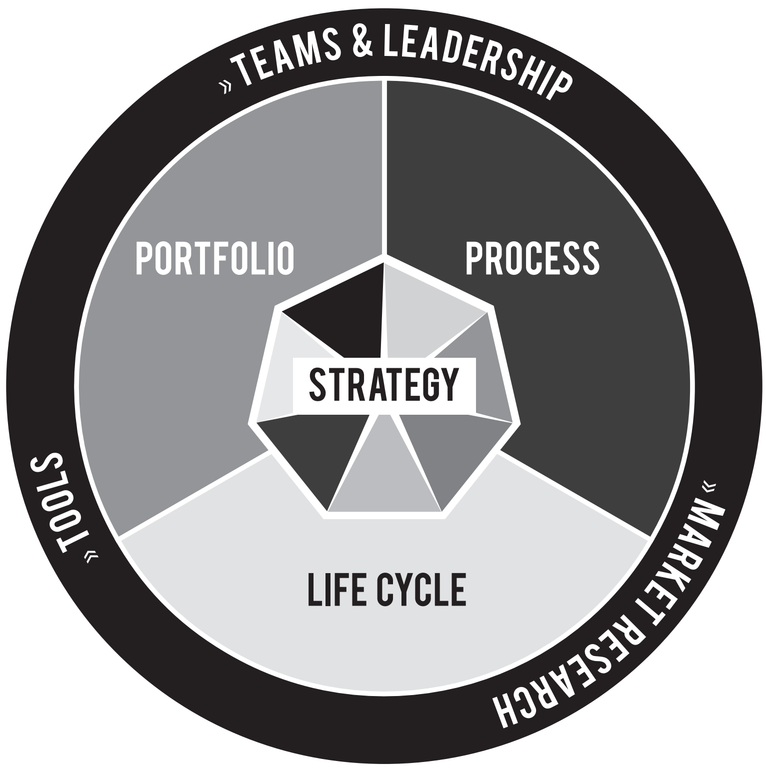
4. Product Design and Development Tools

THE CONTENT

What you will learn in this chapter

Product innovation makes use of specific tools and methods as products move through the different phases of design and development: ideation, concept development, embodiment design, and detail design. Each of these phases benefits significantly from the application of particular tools to reduce uncertainty and ambiguity and to assure conformance with the customer requirements and technical specifications of the design. In this chapter we describe a number of the most commonly used tools, and where they can be applied at the various phases of the product design process.

The 2012 PDMA CPAS showed that the best companies are 30-50% more likely to use R&D and design tools than the rest (Markham & Lee, 2013).



The Chapter Roadmap

The tools described in this chapter are broadly grouped under the sequential stages of the design and development process of product innovation. Some tools may be used during multiple stages of design and development.

Ideation. What tools can be used to solve problems, identify opportunities, or generate new product ideas?	*Scamper; brainstorming; mind-mapping; storyboarding; brain-writing; six-thinking-hats; Delphi; ethnography; a day in the life; empathy analysis; personas; journey maps.*
Concept design. What tools can be used to further develop the initial idea into a more detailed concept description?	*Concept engineering; Kano method; morphological analysis; TRIZ method.*
Embodiment. What tools can be used to provide even greater detail to the concept in terms of aesthetics, form, and	*Conjoint analysis; function analysis; FAST diagram; reverse engineering.*
Initial design specifications. What tools can be used to add quantitative specifications to the qualitative design concept?	*Design for functionality; design for assembly; design for recycling.*
Detail design specifications. What tools can be used to add greater detail to the initial design specifications?	*QFD; house of quality; Taguchi methods; LCA; Kansei engineering; neural networks; reaction cards; emergent emotions.*
Fabrication and assembly. What tools can be used to provide further specifications in preparation for scale-up to manufacturing and launch?	*Prototyping; design for Six Sigma; design for sustainability; design for production.*

4.1 INTRODUCTION TO THE DESIGN PROCESS

For the purposes of this book, we are defining the design process as the section of overall product innovation that focuses on the evolution of a product from initial idea through to final form for manufacture and launch. This evolutionary process requires consideration of a range of factors including:

- Consumer needs and wants:
  - Aesthetics,
  - Functionality.
- Material and component availability.
- Cost vs. what price the consumer is willing or able to pay.
- Capital cost and return on investment.
- Competition.
- Manufacturability.
- Environmental impact.

The design process progresses on the basis of increasing information on these factors, and the application of appropriate design tools. Complementing these design tools are marketing research tools that provide consumer input to the design and inform the evolution of the product (refer to Chapter 5 for market research tools).

The remainder of this chapter follows the stages involved in the design evolution to a final product, and describes some of the most commonly used tools at each stage.

4.2 IDEATION

4.2.1 What is ideation?

Ideation is the creative process of generating, developing, and communicating new ideas. It is an essential part of the design process. Specifically applied to product development, "Ideation includes all those activities and processes that lead to creating broad sets of solutions to consumer problems. These techniques may be used in the early stages of product development to generate initial product concepts, in the intermediate stages for overcoming implementation issues, in the later stages for planning launch, and in the post-mortem stage to better understand success and failure in the marketplace." (Kahn et al., 2013, pp. 453)

There are two types of thinking processes involved in ideation:
Divergent thinking is the process of coming up with new ideas and possibilities without judgement, without analysis, and without discussion. It is the type of thinking that allows for free-association, "stretching the boundaries," and thinking of new ways to solve difficult challenges that have no single, right, or known answer.

Convergent thinking is associated with analysis, judgement, and decision-making. It is the process of taking a lot of ideas and sorting, evaluating, analyzing the pros and cons, and making decisions.

4.2.2 Ideation tools

Following is a selection of ideation tools available to managers.

SCAMPER

Utilizes action verbs as stimuli for idea generation. It is particularly useful in helping to come up with ideas to modify existing products or for making a new product. SCAMPER is an acronym for the following action verbs:

- S – Substitute
- C – Combine
- A – Adapt
- M – Modify
- P – Put to another use
- E – Eliminate
- R – Reverse

Brainstorming

A commonly used technique involving a group of people (typically 6-10) encouraged to generate a large number of ideas where people can speak freely without fear of criticism. Frequently ideas are blended or built on to create another good idea (1+1=3). The design firm IDEO has specific rules for its brainstorming sessions. These are: defer judgement, encourage wild ideas, build on the ideas of others, stay focused on one topic, have one conversation at a time, be visual, and provoke quantity of ideas vs. quality.

Mind-mapping

A graphical technique for imagining connections between various pieces of information, ideas, or concepts. The participant starts with a key phrase or word in the middle of a page, then works out from this point (branches) to connect to new ideas in multiple directions — building a web of relationships.

Storyboarding

Focuses on the development of a story about the consumer's use and experience with a product, with the purpose of understanding the problems or issues that might lead to specific product design attributes or new requirements.

Brainwriting
Instead of asking participants to verbalize ideas, they are asked to write down ideas pertaining to a specific problem or question. Each participant then passes their ideas over to someone else. This person then adds to the list and so the process continues. After about 15 minutes, the lists are collected for group focused discussion. An extension of this technique involves using graphic designs instead of writing ideas and then allowing all group members to enrich the designs of others.

Six thinking hats
A tool developed by Edward de Bono, which encourages team members to separate thinking into six clear functions and roles. Each role is identified with a color-symbolic "thinking hats":
White: Focus on facts.
Yellow: Look for positive values and benefits.
Black: The devil's advocate. Look for problems or pitfalls.
Red: Expresses emotions — likes, dislikes, fears, etc.
Green: Creativity — look for new ideas, possibilities, alternatives.
Blue: Controlling — ensure that an appropriate process occurs.

Delphi technique
A forecasting method based on the results of questionnaires sent to a panel of experts. Several rounds of questionnaires are sent out and the anonymous responses are aggregated and shared with the group after each round. It is mainly applied to future technical and consumer trends, forecasting, and foresighting (further described in Chapter 1 as a strategic planning tool).

Ethnographic approaches
This is a research approach based on observing users in their natural environment such as a kitchen, a camp location, a construction site, etc. This method allows for a "deep dive" to understand the complexities, dimensions, and factors that determine behaviors, beliefs, attitudes, and preferences.

A day in the life
This method uncovers the routines, behaviors, and circumstances faced by users when experiencing products and services. It allows for the identification of the individuals' activities, challenges, and emotions in the course of a day.

Empathy analysis
Involves the capacity to connect with and understand customers deeply and have a direct emotional connection with them. The designer needs to be immersed in the user's world, understand his/her problems and propose solutions from their perspective.

Personas
These are fictional characters built based on objective and direct observations of groups of users. These characters become "typical" users or archetypes, enabling developers to envision specific attitudes and behaviors toward product features. These personas are described using demographic, behavioral, attitudinal, lifestyle, and preference data. Later these characteristics are used to identify possible user segments or possible targets and the interaction persona-product is analyzed with the purpose of adjusting design.

Journey maps
A journey map is a representation as a flowchart of all the actions and behaviors consumers take when interacting with the product or service. The interaction moments are referred as "touch points." The map includes the emotions triggered as the experience evolves and attempts to identify gaps which provide value-creating opportunities.

4.3 CONCEPT DESIGN TOOLS

The ideation stage usually results in a relatively brief description of the product idea with very little detail on its form, function, benefits, features, etc. A detailed description of the product concept is required for two reasons. First, it provides clarity and alignment for all members of the development team, and those associated with the project. Second, it provides a vital means of explaining the proposed product to potential customers, both to seek their views on product benefits and features, and their advice on possible changes or improvements.

The evolution and clarity of the concept from initial idea through to final commercialization is key to new product success. As the development process progresses, so should the detail in the product's specification: from a relatively simple idea, through greater detail of the product concept, and finally to the level of quantitative detail that is required for scale-up to manufacture and commercialization. Figure 4.1 shows a schematic of the design process.

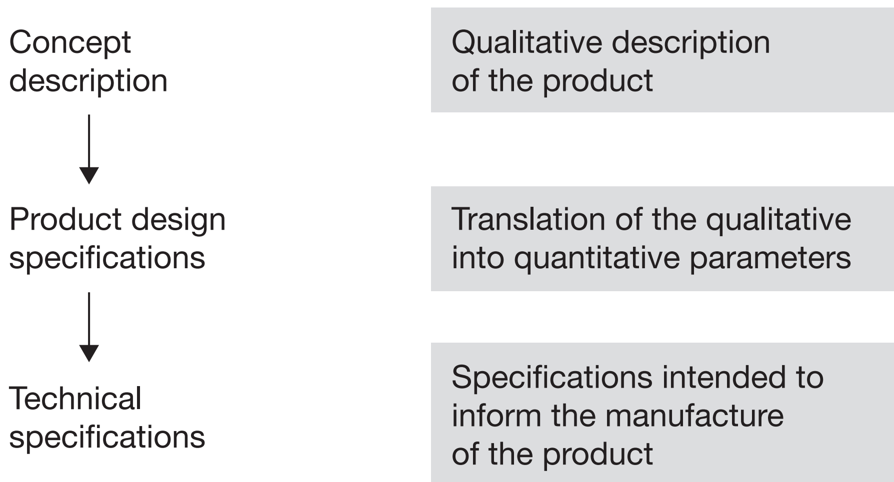


Figure 4.1 From concept to design specification to technical specification.

Every good product starts from a good and clear concept description. Several methods have been suggested to identify possible concepts and evaluate them. Two of these methods are described below: Concept engineering and the Kano method.

4.3.1 Concept engineering (CE) method

This method was developed in collaboration between the Center for Quality Management (CQM), CQM member companies, and MIT. Concept Engineering is a customer-centered process that clarifies the "fuzzy front end" of the product development process with the purpose of developing product concepts. The method determines the customer's key requirements to be included in the design and proposes several alternative product concepts that satisfy these requirements. The method involves the following steps and specific actions:

Stage I: **Understanding of the customer's environment**
This involves understanding the scope of the project and developing a roadmap that will guide the exploration activities, the method of collecting the voice of the customer, and the development of a common image of the customer environment and use of the product. It requires being immersed into the customer's use context through customer visits and the application of contextual inquiry. The voices collected from the customers

will be translated into requirements which identify the expected features to be included in the product design. This stage requires a triangulation of perspectives in the design team toward developing a common image of the customer's environment.

Stage II: **Converting understanding into customer requirements**
Involves converting the customers' voices into requirement statements. The method of priority marking is used to identify the most critical requirements. Generally, a set of 24 customer requirements is collected, from which 8 become critical to be selected in the next stage. Finally, all requirements are clustered around "themes" which will guide the creative inquiry.

Stage III: **Operationalizing what you have learned**
This stage involves the development of a quality chart and operational definitions for all the customer requirements previously identified. The quality chart shows the relationship matrix between customer and technical requirements (metrics). The requirements need to be prioritized using any of the following methods: The Kano questionnaire, self-stated importance questionnaire, or the critical requirements questionnaires.

In addition, this stage involves the creation of general metrics for the requirements. An attempt to minimize the number of metrics per requirement is made with usually two metrics per requirement. The reason is that if a metric is correlated with many requirements (e.g., four), it suggests that this metric is too abstract and thus difficult to interpret. Validity and easiness of use of the metric are the two main criteria to evaluate. Finally, a quality chart is designed as a mechanism to relate the customer requirements with the metrics used to assess those. This chart is very similar to the relationship matrix of a typical House of Quality (HoQ). Both the Kano methods and the House of Quality are discussed later in the chapter.

Stage IV: **Generating concepts**
This stage becomes the transition from the requirements to the "solution" space. It is desirable to generate as many diverse concepts as possible. For this, decomposing the design problem into sub-problems is imperative, as this facilitates providing solutions to specific components of the product or system. There are several methods for decomposition — such as functional analysis, Fast diagrams, process flows, and metrics tree diagrams. This stage ends with clear concept description sheets for the concepts to be carried forward.

Stage V: **Selecting the final concept**
This stage involves the numerical analysis and scoring of the most viable concepts already envisioned. These analyses can be done using the Kano method assessments, alone or in conjunction with the metric importance weights, to determine the overall performance of the product from the perspective of the customer. The final step of Concept engineering is to reflect on the overall process. This includes reviewing how intuitive the convergence about the customer requirements is, the resources and capabilities the firm possesses, and the complete documentation of the process followed by the design team.

4.3.2 Kano method

Widely used in industry, the Kano method has proved to be useful at identifying customer needs and latent demands, determining functional requirements, developing concepts as candidates for further product definition, and analyzing competitive product or services within a product category.

The Kano method classifies the product requirements into three broad categories: Basic requirements, performance requirements, and excitement requirements. Basic requirements fulfill basic functions in each product in the category; these are essential — without them, there is user dissatisfaction. Performance requirements provide real benefits and enhance the utility of the product. These reflect functional performance attributes and are needed for differentiation. Excitement requirements (generally referred to as the WoW! effect) are generally unexpected. They delight the customer and provide superior satisfaction. Their presence increases the overall experience and do not provide dissatisfaction if not present.

The Kano method is operationalized by identifying the set of user requirements, known as customer requirements (CRs), that users look for in products or services. In addition to the above classification, Kano describes four critical categories:

A: **Attractive quality elements** – Customers are satisfied when present but no dissatisfaction when these requirements are not present.
O: **One-dimension quality elements** – These elements show a proportional relationship between functionality and satisfaction. More functionality implies higher levels of satisfaction.
M: **Must-be quality elements** – These are the elements that the user expects at a minimum. They do not lead to satisfaction when fulfilled. However, they cause dissatisfaction when not fulfilled.
I: **Indifferent quality elements** – These elements provide neither satisfaction nor dissatisfaction regardless if they are fulfilled.

Succinctly, the Kano method provides several types of analysis to narrow the set of requirements that will make the product competitive in the market within a specific product category. The analyses are:

- Design of the Kano questionnaire. For further detail, the reader is referred to http://www.kanosurvey.com.
- Kano evaluation table used to categorize the customer requirements as must-be, one-dimension, indifferent, or attractive.
- Frequency analysis to determine customer requirements' priority and relative importance. This also can be achieved through a self-state importance questionnaire.
- Measures of robustness in CRs categorization are: classification agreement, category strength, total strength, and validation through t-test hypothesis testing to assess CRs ranking.
- Calculation of the customer satisfaction/dissatisfaction coefficients for each CR.
- Mapping of the satisfaction vs. the dissatisfaction score to visualize clusters of requirements that provide insights on functional themes that the team should consider through the design and prototyping phases.

4.3.3 Morphological analysis

This technique is useful when the designer is attempting to build possible concepts with the information gathered through previous exploration. The approach generates a system level solution that meets the needs and expectations of potential users. It aims to identify possible "elements" common to several possible "solutions" known as design parameters.

A typical morphological analysis has the following steps:

- Identify user-centered categories or dimensions critical to the product design.
- Use these categories to organize possible concept-ideas. These ideas are branched from each category.
- Create a morphological chart with categories/dimensions on the horizontal, and below each category a series of concept-ideas (see Figure 4.2).
- Combine possible ideas from each category into possible solutions to enter the product design stage.
- Identify specific criteria to allow for a comparison of the adequacy of the solutions found.
- The possible solutions are to be discussed among the NPD team for final assessment.

Figure 4.2 shows the design of a morphological analysis in the creation of concepts for a hotel using five critical design dimensions, and critical dimensions in the design of a hotel. Each bulb represents a possible idea within the category (adaptability, community, etc.). The links between bulbs represent possible conceptual connections. A possible solution/concept (1, 2, etc.) is the concatenation of ideas (bulbs).

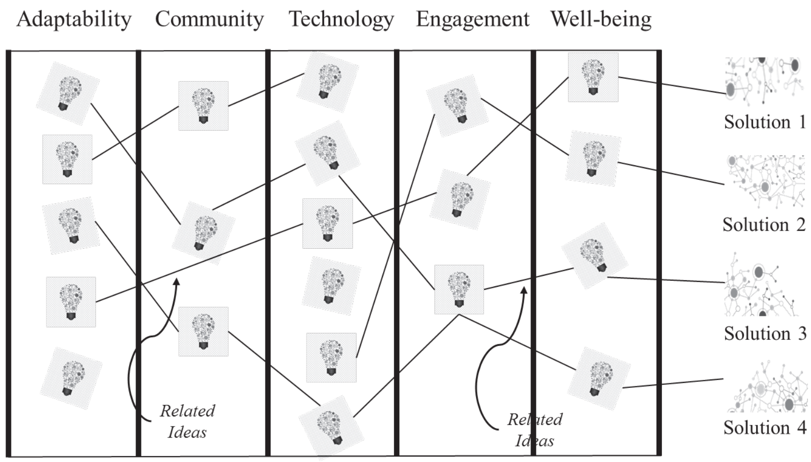


Figure 4.2 Example of morphological analysis

4.3.4 Concept scenarios

This technique generates scenarios as a way to learn how potential concepts would work in real-life situations. Product design teams will collect sketches, illustrations, photos, and descriptions of activities to help develop a customer journey. Scenarios detail the actual actor, description of the context and actor's goal, and a description of how the actor achieves the goal. The purpose of the technique is to elaborate a sketch scenario for every concept that is considered. Every concept scenario implies the following steps:

- Identify possible concepts generally developed with other methods such as the Kano or morphological analysis.
- Create and identify a scenario around each possible concept: actor, context, process to achieve goal.
- Evaluate and reformulate the concept as you go through the scenario.
- Illustrate the scenarios by reflecting on all activities, users, and other participants involved in real-life situations where the concept is being used.
- Discuss the added value of the concept within the imagined situations and user context.

This technique streamlines the product development life cycle by reducing the time to identify critical customer requirements, describe the product functionality within the user experience in mind, communicate new product features, and provide guidance for concept testing.

4.3.5 TRIZ method

TRIZ is a problem-solving method based on logic and data, not intuition, which accelerates the project team's ability to solve problems creatively. TRIZ also provides repeatability, predictability, and reliability due to its structure and algorithmic approach. TRIZ is the Russian acronym for the "Theory of Inventive Problem Solving" (TIPS). G.S. Altshuller and his colleagues in the former U.S.S.R. developed the method between 1946 and 1985. TRIZ is an international science of creativity that relies on the study of the patterns of problems and solutions, not on the spontaneous and intuitive creativity of individuals or groups. TRIZ is explained in greater detail in Ladewig (2007).

In summary, TRIZ is a large-scale innovation process. It contains sets of activities, which can be used for creative right-brained thinking, and analytical left-brained thinking. The basic TRIZ activities are:

- **Functionality:** What causes what to change (how, what, why, when, and how).
- **Resources:** Everything is a resource that can be used.
- **Ideality:** Only look for benefits, which have benefits and less harm.
- **Contradictions:** In looking for improvements in one aspect, what other aspects are affected?
- **Trends:** How many degrees of freedom are available for free, simply through use of a little extra complexity in single features?

The primary research that lays the foundation for TRIZ is:

- Problems and solutions are repeated across industries and sciences. By classifying the "contradictions" in each problem, you can predict good creative solutions to a problem.
- Patterns of technical evolution tend to be repeated across industries and sciences.
- Creative innovations often use scientific effects outside the field where they were developed.

The application of TRIZ

Much of the practice of TRIZ consists of learning the repeating patterns of problems-solutions. These general TRIZ patterns can then be applied to the specific situation. The TRIZ problem solving matrix is shown in Figure 4.3.

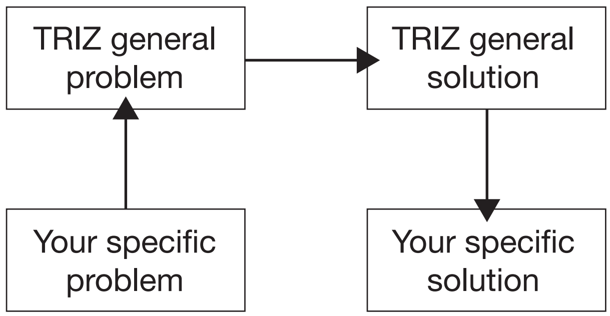


Figure 4.3 TRIZ problem solving matrix

Tools used in TRIZ

The "General TRIZ Solutions" have been developed over the course of the 65 years of TRIZ research, and have been organized in many ways. Some of these are analytic methods such as:

- The ideal final result and ideality.
- Functional modeling, analysis, and trimming.
- Locating the zones of conflict. (This is more familiar to Six Sigma problem solvers as Root Cause Analysis.)

Some are more prescriptive, such as:

- The 40 Inventive Principles of Problem Solving.
- The Separation Principles.
- Laws of Technical Evolution and Technology Forecasting.
- 76 Standard Solutions.

The 40 most commonly used principles of Problem Solving are shown in Figure 4.4.

1. Segmentation 2. Taking out 3. Local quality 4. Asymmetry 5. Merging 6. Universality 7. “Nested doll” 8. Anti-weight 9. Preliminary anti-action 10. Preliminary action 11. Beforehand cushioning 12. Equipotentiality 13. ‘The other way round 14. Spheroidality - Curvature 15. Dynamics 16. Partial or excessive actions 17. Another dimension 18. Mechanical vibration 19. Periodic action 20. Continuity of useful action 21. Skipping	22. “Blessing in disguise” or “Turn Lemons into Lemonade” 23. Feedback 24. ‘Intermediary’ 25. Self-service 26. Copying 27. Cheap short living objects 28. Mechanics substitution 29. Pneumatics and hydraulics 30. Flexible shells and thin films 31. Porous materials 32. Color changes 33. Homogeneity 34. Discarding and recovering 35. Parameter changes 36. Phase transitions 37. Thermal expansion 38. Strong oxidants 39. Inert atmosphere 40. Composite materials

Figure 4.4 Altshuller’s 40 Principles

TRIZ applied to product development

In product development, TRIZ has primarily been applied at the idea generation stage — for new products and for product improvement. An example is presented in the PDMA ToolBook (Ladewig, 2007). Other examples are illustrated in Figure 4.5.

Principle	Solution
Segmentation (Divide an object into independent parts)	Individually wrapped cheese slices
Local quality (Provide different packaging for different uses)	"Adult" editions of Harry Potter books
Universality (make an object perform multiple functions)	Chocolate spread sold in glasses (with a lid) that can be used for drinking afterwards
Nested Doll	Store within store (coffee shops in bookstores)
Another dimension (Tilt or re-orient object)	Squeezable ketchup bottles that sit on their lids

Figure 4.5 Examples of application of Altshuller’s 40 principles to product creation. Source: https://www.mindtools.com/pages/article/newCT_92.html

4.3.6 Concept description examples

Example 1

IDEO, the global design company, is recognized for its human-centered product design. Here is an example of a concept description that IDEO created for a new shopping cart concept, considering issues such as maneuverability, shopping behavior, child safety, and maintenance cost.

"The nestable steel frame lacks sides and a bottom to deter theft, and holds removable plastic baskets to increase shopper flexibility, help protect goods, and provide a method to promote brand awareness. A dual child seat uses a swing-up tray for a play surface, and a hole provides a secure spot for a cup of coffee or a bunch of carnations.

"One of the unique—and potentially patentable—features of the cart is the design of its steerable back wheels. Normally fixed straight for stability and familiarity, an easy sideways effort allows the wheels to turn left or right. Pushing the cart forward puts the wheels straight again."

Example 2

A good framework for preparation and presentation of the product concept description is the core, tangible, and augmented model described in Chapter 1. This is demonstrated in the following example based on the development of a product called the Stingray to address a number of the current problems faced by emergency services workers (specifically firefighters). It comprises an earpiece (or Bluetooth receiver to work with firefighters' headsets) and a main radio unit, which can be repositioned on uniforms for optimal accessibility. Specific product requirements were derived from a range of consumer research techniques including focus groups and observation.

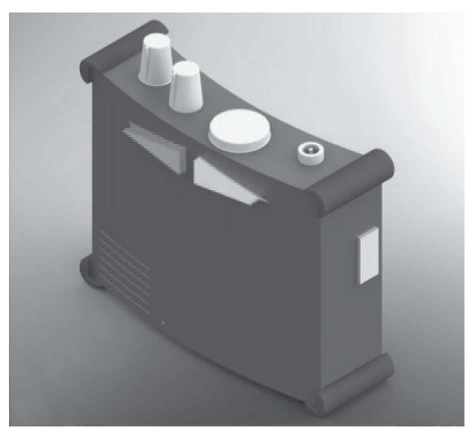
The core product

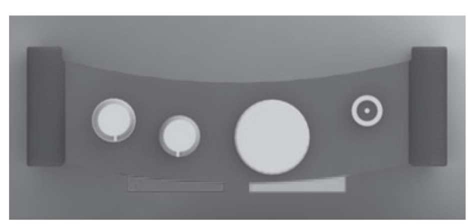
The Stingray enables firefighters to communicate with other emergency services over large distances with clarity, ease, and reliability. This communication will be secure, safe, and reliable. The movement of the user will not be impeded, nor will the radio pose a safety risk.

The tangible product

The Stingray has two pieces, the main radio unit and the earpiece.

The radio



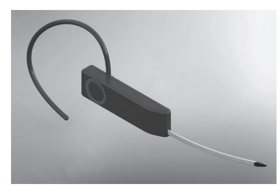


- The radio is housed in a smaller and more compact unit than the older models. A curved profile helps mold the unit to the wearer and a lower, flatter design will stop any twisting motion on the hip while moving.
- A clip on the back of the radio unit allows the radio to be attached directly to a belt. This clip can be removed so the radio can be placed in the pockets of uniforms.
- The upgrade to a digital network will ensure improved audio quality.
- The case will be constructed from a high-strength plastic polymer, polyether ether ketone (PEEK). This helps protect internal componentry from damage due to rough treatment, heat, or water. The corners will also be surrounded by a soft rubber edge that helps prevent damage if the unit is dropped.
- A GPS will provide real-time tracking of personnel.
- The gyroscope and accelerometer can detect if an officer has fallen and is no longer moving. If this happens, the radio will send an emergency signal with their name or ID and geographic position.

- A sheet of copper wire will be placed in the officers' vests to act as an aerial. For emergency personnel who do not wear these vests, a smaller aerial will be provided to plug into the unit, similar to the current screw-in aerials. These plug into the coaxial connector on top of the radio.
- An encrypted Bluetooth signal will connect the radio with the wireless earpiece. The volume and channel control dials located at the top of the radio will be kept the same as on previous radios. This was a feature that the emergency services requested as it is easy to use in all situations. However, the dials now have an added lock-in feature to prevent accidental changes, which can be activated by pressing down on the top of either dial.
- A speaker and microphone are built into the radio unit for use if the earpiece fails to work for any reason. The speaker is activated when the Bluetooth connection to the earpiece is lost. The microphone can be activated by pressing the large "talk button" on the top of the radio.
- An emergency panic button is located on the side of the unit. If this button is pressed, the location and name or ID of the user will be sent to the operator at the base station, and emergency procedures will be followed.
- A chip (SD memory card) will have to be inserted into the radio to make it operational. This is an added security feature, and the chip will also retain information about the user to be sent out with GPS locations so operators know which person is using the radio unit. It will also store voice commands to activate or disable audio transmission through the earpiece.
- A removable lithium ion (Li-ion) battery will be used in place of the old nickel metal hydride battery. This decreases weight and increases battery life.
- The radio can be docked and charged through a mini-USB port located on the bottom of the unit. This port can also be used to program the unit (such as setting the channels) with a provided USB cable.

The earpiece

- Using a wireless earpiece is a completely new concept and piece of equipment for the firefighters. It replaces the old wired speaker that was a large hindrance to firefighting personnel.



- A power button is used to turn the earpiece on or off.
- The earpiece will connect to the main radio unit via an encrypted Bluetooth signal.
- The ear grip will be removable so each individual can attach a fitted ear grip. This will ensure a snug fit on each user to prevent the earpiece falling off.
- A large "talk button" is located on the side of the earpiece to activate the microphone. Voice activation will also be available to the user for situations where both hands are occupied.
- An extended microphone comes down the side of the user's face to get the best possible audio quality through proximity to their mouth.
- Audio quality is improved by placing the audio source close to the ear, and by using a small surface transducer.
- A large battery indicator around the edge of the "talk button" will indicate how much battery life is left.
- The earpiece can be charged via a mini-USB connection on the underside. A USB cable is provided with every earpiece for this purpose. This connection can also be used to update the earpiece's firmware.

Augmented product features

The Stingray will be offered with the following augmented products:

- A deployment service including technical training provided to users.
- Ongoing support services including a 24/7 service desk and online service portal.
- A USB cable.
- A pocket to hold the chip (which can then be kept in a personal storage space such as a locker).
- For every 10 units purchased, a 10-port docking station will be provided.

The translation of the concept description to design specifications is outlined in Figures 4.6 and 4.7.

Step 1: Define the user needs and their relative importance. This was derived from user research including focus groups and observational studies. The list of user needs is shown in Figure 4.6.

#	Needs		Importance
1	case	Must be strong	5
2	case	Must be waterproof, shockproof and heat resistant	5
3	volume and channel knobs	Need to be lockable	2
4	earpiece	Must have a personally fitted ear grip	4
5	radio	Must be lightweight and small	4
6	radio	Needs to have longer battery life	3
7	radio	Needs to be digital	5
8	radio	Must display battery levels for both parts	3
9	radio	Must be personalized so the user can be identified	1
10	radio	Must have GPS	3
11	radio	Must have a kinetic energy charger	1
12	radio	Needs an emergency microphone and speaker	4
13	radio	Transmission range > current product	5

Figure 4.6 The user needs and priorities

Step 2: Translate the consumer needs into engineering design specifications with specific units and target values. These target values were derived from a combination of user research and competitor benchmarking and are shown in Figure 4.7. Further examples of design specifications and their development are provided in Ulrich and Eppinger (2016).

Metric #	Needs #	Metric	Imp.	Units	Target value
1	1,2,6	High strength polymer casing	5	Nm2 or Pascal	>1000
2	6	Total mass	4	G	<700
3	7,12	Battery life	3	mAh	>2500
4	14	Effective transmission range	5	Km	>1.5
5	3,4	Easy to use buttons	4	subjective	>4 (on 1-5 scale)
6	6	Size of radio unit	4	Cm3	<400
7	2	Water resistance	5	x-bar	>5
8	2,3	Effective life of unit	5	Years	>6

Figure 4.7 The design metrics, units, and targets

4.4 EMBODIMENT DESIGN

Embodiment design is the stage of the design process that starts from the concept definition and continues to develop the design based on technical and economic criteria to reach the detail design stage which leads to manufacturability. The list of product design tools used during embodiment is both long and varied. In this section we have chosen just four tools to discuss: conjoint analysis, function analysis, FAST technical diagrams, and reverse engineering.

4.4.1 Conjoint analysis

This method has been successfully used in product conceptualization, product design, and new product strategies. Conjoint analysis belongs to the category of compensatory models. Compensatory models are models of consumer behavior in which consumers are willing to sacrifice the degree of an attribute or benefit present in a product to the increase of another attribute. The method assesses the degree of preference as a function of a linear weighted combination of the critical attributes of the product. For example, a consumer is shopping for yogurt. He takes into consideration the calories, sugar content, and natural/organic benefits of the product. Even though the price of the yogurt is higher than he wanted to spend, the idea is that the good characteristics outweigh the bad characteristic of a higher price, and he will select the yogurt product despite the higher cost.

Conjoint analysis can be also used in combination with a non-compensatory model. In this situation, the product designer will initially rule out certain combinations of attributes that are simply not part of the consideration set followed by the compensatory approach as indicated above. An example of non-compensatory approach follows.

In purchasing a digital camera, the consumer considers the following brands: Canon, Kodak, Nikon, Sony, and Vivitar. In addition, the consumer selects certain features: Brand name, price, resolution, LCD screen size, and zoom. Further, the consumer has a rating for these features, for all the brands being considered. Say the consumer is using a 10-point scale, and as a rule will not consider any brand that scores below a 6 on any attribute. If the brand Sony scores a 9 or 10 on the first four attributes and a 5 on Zoom, the consumer will rule out Sony. In a non-compensatory model, the brand has to comply with all the minimum evaluation scores to be considered a buying option.

Conjoint analysis entails a set of different techniques such as Adaptive Conjoint Analysis (ACA), Conjoint Value Analysis (CVA), Choice Based Conjoint (CBC), Adaptive Choice Based Conjoint (ACBC), and Hierarchical Bayes Conjoint (HBC). All these techniques apply to specific cases of configuration of attributes in product design and evaluation.

Steps in a typical conjoint analysis study

- Identify all possible product attributes considered by the user. These attributes can be physical attributes, performance attributes, and product benefits.
- Specify the number of levels for each attribute. The levels refer to the degree or intensity of the attribute present in the product. Attribute levels should be mutually exclusive (should not overlap).
- Formulate the basic preference model which denotes the mathematical relationship between the individual preference for a product/concept and the utility levels for each attribute that is present in the product. This composition rule can be simply additive or multiplicative.
- Determine how attributes are modeled: part-worths, linear, or curvilinear.
- Determine the estimation procedures to determine part-worths (ordinary least squares OLS, ratings, probability, etc.).

A further discussion of conjoint analysis is provided in Chapter 5.

4.4.2 Functional analysis

Functional analysis is the foundational method when applying value analysis methodology. The central objective of value analysis is to provide performance at the lowest cost. This is done by moving from the concrete world of actions and operations of a product to the abstract world that favors creativity and design. Functional analysis considers that a product is represented by a system composed of several functions interrelated under an operational logic. A function is defined as a relation verb-noun, i.e., stack plates. The active verb “stack” has an “action” over the noun “plates.” The assumption behind functional analysis is that the customer purchases a product because of the functions it performs.

According to functional analysis, functions can be classified as basic and secondary, intrinsic or extrinsic, and use or aesthetic.

A basic function answers “no” to the following question: If I didn’t have to perform this function, would I still have to perform any of the other functions listed? Once the basic function has been identified, all other functions become secondary. Being a secondary function does not imply being irrelevant. On the contrary, secondary functions support the basic function so the product can achieve its purpose.

Intrinsic functions are those that happened inside the boundaries of the product, while extrinsic functions refer to those that occur while the user interacts with the product, for example:

- User pushes channel change button: extrinsic function.
- As a result, several operations occur within the television set (intrinsic functions).

Another classification of functions is use and aesthetic. Use functions refer to something that needs to be accomplished for the product to perform while aesthetic functions require that something is accomplished through any of the five senses: sight, smell, taste, touch, and sound.

4.4.3 FAST technical diagram

FAST is a technique that builds on the results of a functional analysis. The purpose of FAST is to illustrate and provide insights on how the product system works in order to identify malfunctions, incoherence in the sequencing of operations, or operational flaws. The technique allows visualization of the cause-effect relationship among the functions in a product to enhance understanding of how it works.

The diagram is built following How-Why logic. This logic requires functions to be ordered from left to right. From left to right, we answer the question: How is this function carried out? The response is by several functions. When the analysis is done from right to left, we answer the question: Why do we need this function? The approach from both ends — left to right (How) and right to left (Why) — allows for a robust diagram and configuration of functions and enhances posterior analysis and opportunities for re-design and product improvement.

Beyond the boundaries and to the left, FAST allows us to identify a highest-order function. This function is only one and allows for a more abstract definition of why the basic function should exist. Generally, the identification of the highest-order function is the source of a more deep and creative solution space.

Functional analysis and FAST diagrams are extremely useful either when the problem has been structured or a clear identification is needed as it facilitates the communication and rationale provided inside and outside the product development team.

4.4.4 Reverse engineering

Reverse engineering is the implementation of value analysis (VA) tear-down processes to formulate ideas for product improvement. This method has as its purpose to dissemble products, systems, components, and data to identify the functions embedded that allow for comparison of competitors' products and production processes.

The purpose of reverse engineering is to stimulate the creative process by focusing on the identification of the functions starting with the identification of the components of a system and their understanding at a deep level. New conceptualizations are possible, approaching RE as an imitation-type thinking where part and components are copied with few variations to accomplish the expected performance. Another RE approach is the research-type thinking used to identify the language through "signals" (creativity clues) that the embodiment emits, and regroup these signals into new abstractions or components reconfiguration.

4.5 INITIAL PRODUCT DESIGN SPECIFICATIONS

Where the concept description provides a qualitative presentation of the product concept's benefits and features, the product design specifications provide the quantitative requirements. So, for example, where the concept description may describe the size of a new product as "being able to fit into a man's coat pocket," the product design specifications would specify the actual physical dimensions required.

Product design specifications are intended to clarify the product design and to provide quantification and objectivity. They enable the communication of the product design requirements to other members of the design team and to progress the product's development from design through to manufacture.

4.5.1 Design for functionality (DFF)

Functionality determines the final performance of a product. It allows for the intended behavior of the elements of design or their combination. DFF implies considerations such as design for safety (coffeemakers), design for simplicity (platform design), and design for redesign (product variants or derivatives).

4.5.2 Design for production (DFP)

Design for production aims to minimize product costs and manufacture times while maintaining specified quality standards. A successful manufacturing process depends on the following factors:

- Rate: flow of materials, parts, components through the system.
- Cost: materials, labor, machines, equipment, tooling.
- Time: supply times, inventory flows, processing times, machine set-up times.
- Quality: Lost functions and deviations from the target.

Manufacturing processes and the relative costs are impacted by the technology adopted. Several technologies — such as automation, automated material handling, CAD computer aided design software, robotics, flexible manufacturing systems, modular manufacturing, and computer integrated manufacturing (CIM) — determine production process selection and allow the potential for innovation in product design.

4.5.3 Design for assembly (DFA)

Designers influence the cost and quality of the assembly and production of components. Design for assembly (DFA) simplifies the product design to reduce the cost of assembly in the manufacturing process. An assembly is defined as a combination of parts and components needed to manufacture a product. This view includes all the working activities during and after production. These activities depend on the final layout design of the product.

DFA involves evaluating the components and parts of the product as well as the whole design (system view) and the method of assembly used (manual, automatic, fixed automation, and robotic assembly). Therefore, design for assembly seeks to simplify the structure, functions, and related parts and components of products so that the cost of assembly is reduced and inefficiencies due to sequence of partial assemblies, just-in-time processes, product line feeding, and material inventory are minimized. As a consequence, reliability specifications, assembly times, and quality are achieved.

Today, we have different methods of assembly, each requiring specific guidelines. Manual assembly, automatic assembly, fixed automation, and robotic assembly follow general guidelines. These are: a) storing parts in a systematic manner, b) handling parts and assessing their movement along the assembly line, c) positioning parts and components to place them correctly for assembly, d) and joining parts providing the necessary connections. Overall, operations in the assembly line should be structured, reduced as needed, standardized, and simplified.

Several considerations in DFA are:

- Similarity of elements in groups of components,
- Minimization of material variability,
- Grouping of harmful material for final disposal,
- Easiness to identity, extract, or build in risky or harmful parts,
- Handling and separation of parts during manufacturing process.

Three specific techniques are applied in industry: The Hitachi assembly evaluation method, The Lucas DFA method, and the Boothroyd-Dewhurst DFA method. The reader is referred to the suggested readings for a more in-depth treatment of these techniques.

4.5.4 Design for maintenance (DFM)

Maintenance of a product implies monitoring its actual condition, maintaining it, and allowing for recovery of the system as changes occur (such as wear and tear, corrosion, useful life deterioration, and other changes over its operating lifetime). Inadequate maintenance affects functionality of the product, economy, and safety of the entire system. Overall, DFM focuses on safety, ergonomics, and assembly of the product.

Products should be designed to be maintained, repaired, and/or replaced with parts or components. Decisions regarding the selection of materials, assemblies, parts, devices, and components determine the maintainability or the capacity of the system to be inspected, restored, and serviced when components fail as they reach their operational life. During the design stages, design for maintenance should facilitate executing corrective and preventive maintenance. This involves a design review at the following levels:

- Design specifications (technical and customer requirements),
- System level design review (subsystems, functions and FAST diagrams),
- Accessibility and ease of assembly and disassembly,
- Manufacturing sequence and equipment review,
- Component and subassembly analysis.

Overall, design for maintenance applies service measures (refilling, lubricating, conserving, and cleaning), inspection measures (inclusion of safety techniques in the embodiment), and technical measures (simplification of parts, standardization, application of modular principles, simplified tooling for service and inspection, and easy access to parts and components).

Several suggestions take into consideration DFM during the design process:

- Build simplicity when identifying parts and components for the system and its variants,
- Use standard components,
- Allow for easy access to parts when designing for disassembly,
- Apply modular architectures, and
- Allow for system properties that permit self-adjustment.

4.5.5 Design for recycling (DFR)

The notion of DFR is included in the perspective of design for sustainability. DFR implies the use of materials that allow for reusing or reprocessing production waste, products, and parts of products. The methods for DFR center on reusing products and reprocessing products. Several guidelines are followed during DFR, such as: ease of disassembly, material compatibility, material separation, and opportunities to reprocess parts and components.

4.5.6 Design for usability (DFU)

When designing products, it is important to consider the activities of potential users, their perceptions, cognitions, emotions, and actions surrounding the need to work with a product toward their goals. It is critical to understand how consumers interact (interface) with products and how the operation with the product and its behavior, the site or environment where the product is used, and the image/impression impact its functionality, performance, and customer satisfaction. Design for usability evaluates the functionality, serviceability, maintainability, ease of operation, reliability, safety, aesthetics, operating context and environment, and customizability of the concept system. Overall, DFU should be intrinsically connected to the product and manufacture design process.

4.5.7 Design for serviceability (DFS)

Design for serviceability focuses on the ability to diagnose, remove, or replace any part, component, assembly, or subassembly of a product while performing service repairs and troubleshooting. Serviceability facilitates the manipulation and operation while bringing the product to its original working specifications, putting it in operation quickly, and avoiding downtime.

Nowadays, products are designed with instrumentation that alerts when service is required in advance of possible system failures. Intelligent capabilities alert systems of possible failures and even have self-corrective mechanisms to maintain full operation as the user waits for the unit to be serviced.

The lack of serviceability generates unnecessary costs, i.e., machine downtimes, inventory breaks, delays in returning products to customers, interruption of sales delivery, and consequent financial costs.

When implementing DFS, designers and product developers should:

1. Identify the functional requirements for serviceability as determined in a QFD and Kano method. These functional requirements are associated with specific design parameters for each type of service needed (standard operation, scheduled maintenance, and repair).
2. Predict, on the basis of operation information and performance, how design parameters will behave and impact functionality.
3. Develop a prioritization list of all problematic service areas (using a Pareto analysis) to eliminate causes and timing of possible failures based on a lifetime analysis of parts, subassemblies, and components.
4. Estimate the total cost of serviceability considering that its delivery includes cost of diagnostics, logistics and transportation, and the actual service time. Cost of serviceability is mainly determined by actual labor costs.

4.6 DETAILED DESIGN AND SPECIFICATION

4.6.1 Quality function deployment

Quality function deployment (QFD) is a structured method employing matrix analysis for linking "what the market requires" to "how it will be accomplished in the development effort" (Hauser and Clausing, 1988). This method is most valuable during the stage of development when a multifunctional team agrees on how customer needs translate into product specifications and features that will address these needs. The most commonly used example of QFD is the House of Quality shown in Figure 4.8.

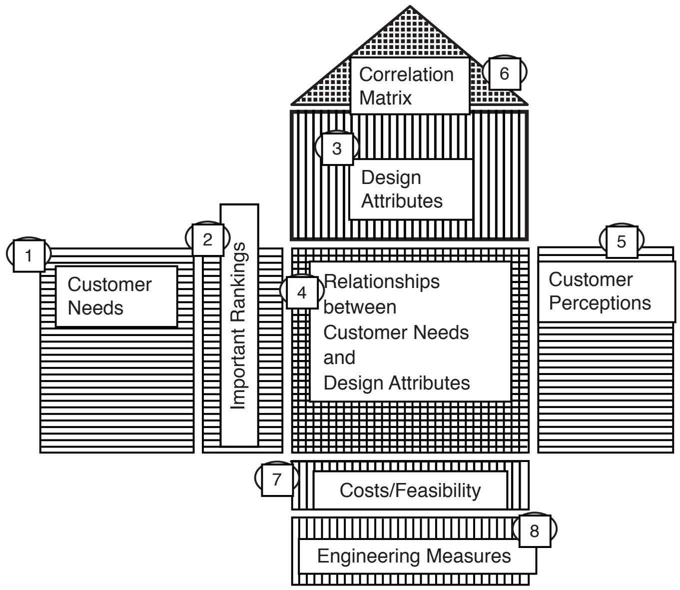


Figure 4.8 The House of Quality

Application of QFD in different environments

QFD can be applied in a range of environments including manufacturing, software, and service as shown in Figure 4.9.

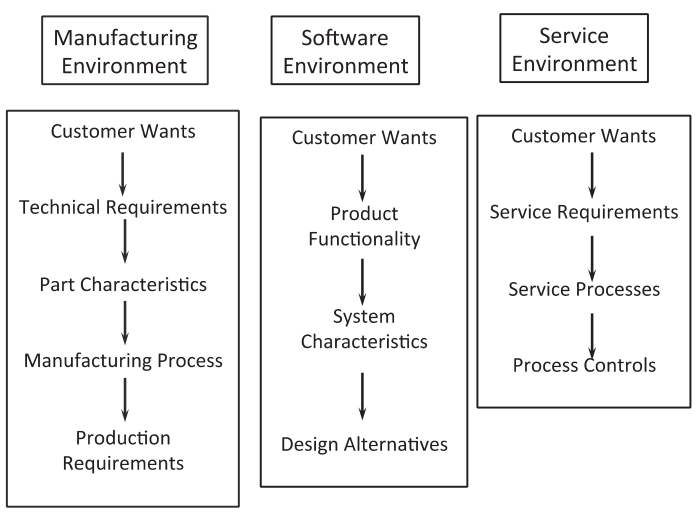


Figure 4.9 QFD application in different environments

Building the House of Quality

The House of Quality is built in six steps:

1. Identify customer needs and wants.
2. Identify design attributes/requirements.
3. Relate the customer attributes to the design attributes.
4. Conduct an evaluation of competing products.
5. Evaluate design attributes and develop targets.
6. Determine which design attributes to deploy in the remainder of the process.

Step 1. Identify customer needs and wants

- These are product or service requirements in the customer's terms from:
  - Market research,
  - Surveys,
  - Focus groups.
- "What does the customer expect from the product?"
- "Why does the customer buy the product?"
- Salespeople and technicians can be important sources of information — both in terms of these two questions and in terms of product failure and repair.
- Often these are expanded into secondary and tertiary needs/requirements. Customer requirements are shown in Figure 4.10.

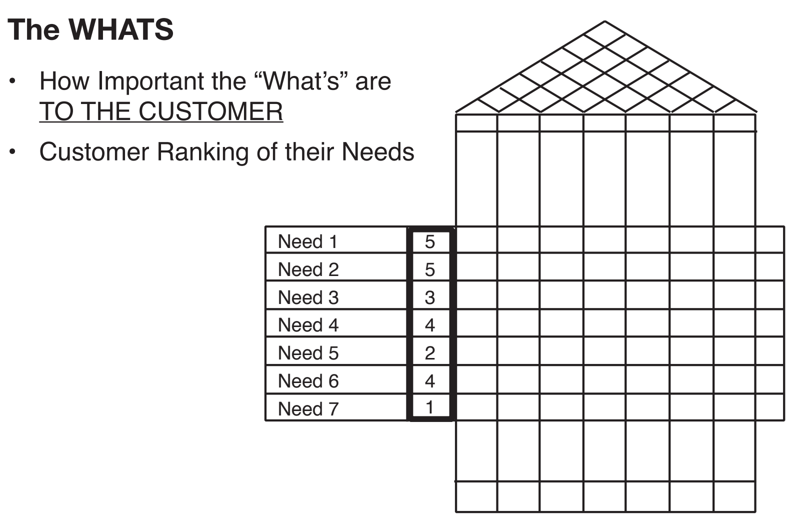


Figure 4.10 Key elements: Customer requirements

Step 2. Identify design attributes/requirements

- Design attributes are expressed in the language of the designer/engineer and represent the technical characteristics (attributes) that must be deployed throughout the design, manufacturing, and service processes. These are illustrated in Figure 4.11.
- These must be measurable because the output will be controlled and compared to objective targets.
- The roof of the House of Quality shows, symbolically, the interrelationships between design attributes. It can show areas where there are conflicting targets of attributes and compromise might be required. These interrelationships are shown in Figure 4.12.

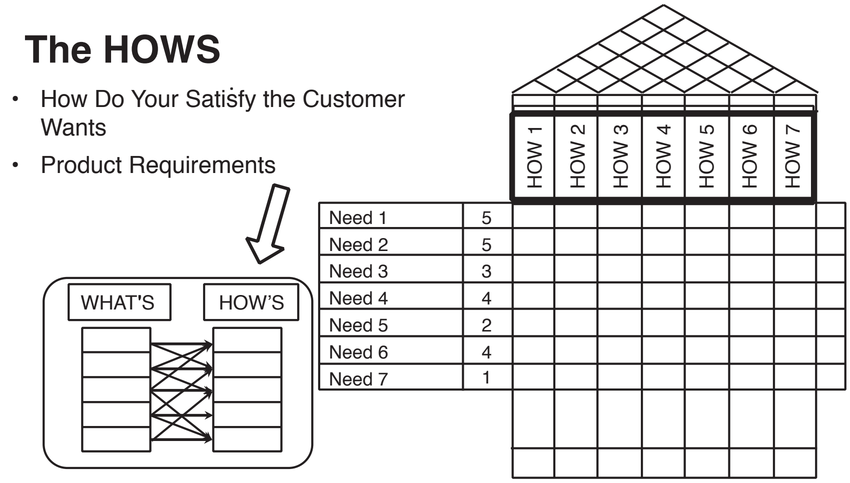


Figure 4.11 Key elements: "Hows" satisfying customer wants

Step 3. Relate the customer attributes to the design attributes

- Symbolically we determine whether there is no relationship, a weak one, moderate one, or strong relationship between each customer attribute and each design attribute.
- The purpose is to determine whether the final design attributes adequately cover customer attributes.
- Lack of a strong relationship between a customer attribute and any design attribute shows that the customer attribute is not adequately addressed or that the final product will have difficulty in meeting the expressed customer need.
- Similarly, if a design attribute does not affect any customer need, then it may be redundant, unnecessary, or the designers may have missed some important customer need. The relationship matrix is shown in Figure 4.12.

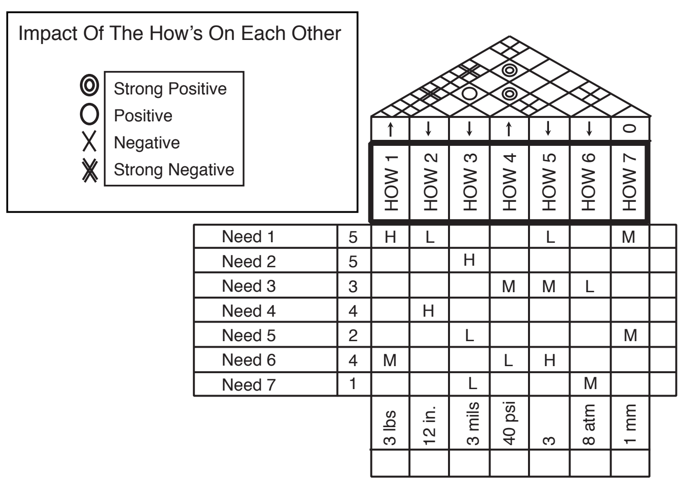


Figure 4.12 The correlation matrix and relationships

Step 4. Conduct an evaluation of competing products

- This step includes identifying importance ratings for each customer attribute and evaluating existing products/services for each of the attributes.
- Customer importance ratings represent the areas of greatest interest and highest expectations as expressed by the customer.
- Competitive evaluation helps to highlight the absolute strengths and weaknesses in competing products.
- This is usually accomplished through in-house testing and then translated into measurable terms.

- The evaluations are compared with the competitive evaluation of customer attributes to determine inconsistency between customer evaluations and technical evaluations.
- For example, if a competing product is found to best satisfy a customer attribute, but the evaluation of the related design attribute indicates otherwise, then either the measures used are faulty or the product has an image difference that is affecting customer perceptions.
- On the basis of customer importance ratings and existing product strengths and weaknesses, targets and directions for each design attribute are set.

Step 5. Evaluate design attributes and develop targets

- This must be accomplished through in-house testing and then translated into measurable terms.
- The evaluations are compared with the competitive evaluation of customer attributes to determine inconsistency between customer evaluations and technical evaluations.
- For example, if a competing product is found to best satisfy a customer attribute, but the evaluation of the related design attribute indicates otherwise, then either the measures used are faulty or the product has an image difference that is affecting customer perceptions.
- On the basis of customer importance ratings and existing product strengths and weaknesses, targets and directions for each design attribute are set. These are shown in Figure 4.13.

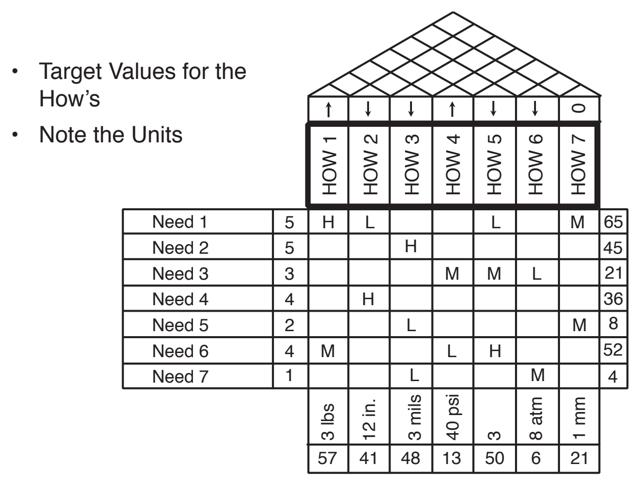


Figure 4.13 Establishing targets for customer needs and design attributes

Step 6. Determine which design attributes to deploy in the remainder of the process

This means identifying the design attributes that:

- have a strong relationship to customer needs,
- have poor competitive performance,
- or are strong selling points.

These attributes will need to be deployed or translated into the language of each function in the design and production process so that proper actions and controls are taken to ensure that the Voice of the Customer is maintained. Those attributes not identified as critical do not need such rigorous attention.

Benefits and limitations of QFD

Benefits include:

- It involves a team approach leading to consensus and promotes cross-functional discussion.
- It focuses the NPD team on customer requirements.
- It provides a structured basis for defining product design specifications and engineering design requirements from customer requirements.

- As development unfolds, and changes in the design are suggested given appropriate feedback from market testing, QFD prevents losing sight of the original concept design and customer requirements.

Limitations include:

- It can be cumbersome (large numbers of needs and hows create large tables) and slow to go through the complete QFD process.
- It can be tedious and often people lose sight of what they are seeking to achieve in the product design.
- As consumer needs evolve swiftly, effort must be focused on identification of the correct design specifications. This is critical when new technologies appear to support the product category where the product is competing.

4.6.2 Robust design

As the product design progresses to the prototype phase, each attribute and function should perform according to the technical specifications and their target values that resulted from the House of Quality, HoQ. Robust product design is a concept from the teachings of Dr. Genichi Taguchi, a Japanese quality guru. It is defined as reducing variation in a product without eliminating the causes of the variation. In other words, making the product or process insensitive to variation. This variation (sometimes called noise) can come from a variety of factors and can be classified into three main types: internal variation, external variation, and unit to unit variation. Internal variation is due to deterioration such as the wear of a machine and aging of materials. External variation is from factors relating to environmental conditions such as temperature, humidity, and dust. Application of Taguchi methods focuses on the product concept selection and design parameters optimization and searches to minimize the effects of sources of variability.

Taguchi developed a quality loss function (QFL) which has a quadratic form. This equation relates the deviation of any design parameter from its target value to the loss in dollars connecting quality with its related cost. A measure of robustness is the signal to noise ratio (S/N) which is used to determine the optimal levels of the design parameters through a design of experiment optimization process.

4.6.3 Emotional design

Consumers build mental representations of products as soon as they start interacting with them. The sensory information that consumers perceive allows the identification of the product's functions which contribute to the creation of meaning and an affective connection with the design in the consumer's mind. Designers rely on emotional design to elicit moods and feelings that allow for creating positive emotional associations and a feeling of trust in the product, and thus improve its usability.

Emotions can be classified according to the level at which users process them. The levels of information processing are: visceral, behavioral, and reflective. The visceral level describes a low processing and basic motor reaction associated with the user's physical senses, i.e., aesthetics, color. The behavioral level is a midlevel processing that involves memory and learning associated with the product usage, i.e., functionality, usability. The reflective level entails feeling, emotions, and cognition that determine understanding, interpretation, and reasoning. At this level, the product connects with the sense of self and identity.

Several methods have been developed to help designers assess the impact of emotional design on the user's preference and intention to purchase. These methods include Kansei engineering, PrEmo2, Geneva Emotional Wheel (GEW), as well as more analytical methods such as sentiment analysis, neural networks, and emergent emotions, among others. A brief description of the most important methods follows.

Kansei engineering

This method is used to identify the relevant design elements (color, size, and shape) embedded in a product as determinant of user preference. The method requires the identification of Kansei words. The methods used are think-aloud laddering, Quantification Theory I (QTI), PLS analysis, and Genetic and Fuzzy logic for estimation purposes.

Sentiment analysis
This technique is used to classify and understand people's opinions in product review blogs or social networks. It allows for the identification of opinion polarities (positive, neutral, or negative) expressed on product features through automated processing. The method makes use of naïve Bayes and deep learning algorithms.

Neural networks
This approach uses back propagation methods to establish possible relationships between product/form parameters and adjective image words. The goal is to change the configuration parameters until the product shape is acceptable. Neural networks make use of back propagation and grey relational analysis as optimization algorithms.

Microsoft reaction card
This method assesses the emotional response and desirability (visual appeal) of a design or product. Participants describe a design based on 118 product-reaction words by selecting cards that are relevant to the product or design. The method concludes with an explanation of why the card is attached to the design. The method uses cluster and frequency analysis and word clouds processing.

Emergent emotions
This method considers that emotions are dynamic, emergent, and recursive processes. The user's pattern of response to a design is driven by the appraisal results. These include emotional responses and desirability of product features resulting from emotional impact and differentiation. The method uses neural network and non-linear dynamic modeling within the context of artificial intelligence to explain the emotional processes consumers go through as illustrated in the Geneva Expert System on Emotions (GENESE).

4.7 FABRICATION AND ASSEMBLY

4.7.1 Prototyping

Prototyping is a design method that builds a physical representation of a product concept. Its main purpose is to assess how well the product features satisfy user expectations. As such, prototyping is an example of a problem-solving approach to design. A prototype approximates the original form of a design idea that allows the product development team to verify the product operations and functions, its components, layout, functionality, appearance, and behavior. Prototypes range from concept sketches to fully functional artifacts.

Prototyping fidelity is the degree to which the design allows for a reasonable understanding of the product in use. Fidelity is differently required if the design team is in the initial stages of product conceptualization (low fidelity prototypes) or in latest stage (high fidelity prototypes). In addition, medium fidelity prototypes allow for evaluating the interactive aspect of consumer experience with design to expose possible failures beforehand.

There are several types of prototypes based on the level of comprehensiveness or expected focus, as well as the stage of the product innovation process (see Figure 4.14).

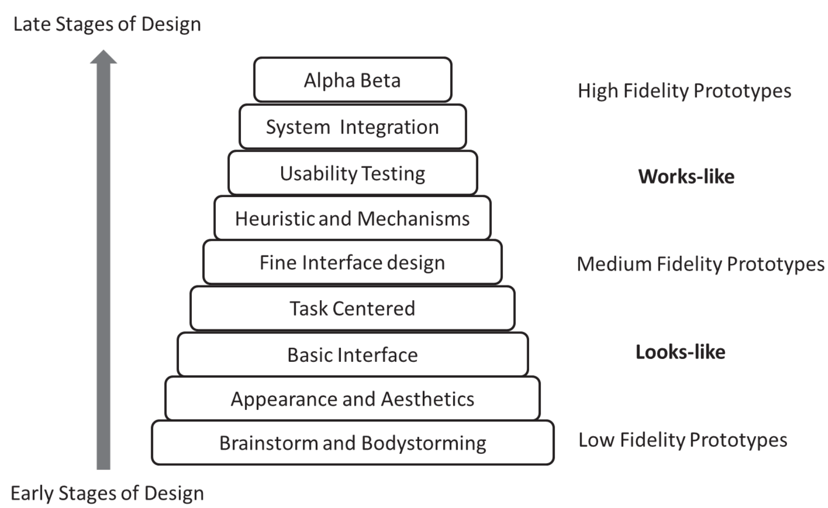


Figure 4.14 Testing objectives and types of prototypes according to the design process. Source: Rodriguez, C.M. (2017)

Prototypes can be classified based on two dimensions: physical-analytical and focused-comprehensive. A clay mock-up is a physical prototype while a simulation model is analytical in essence. Focused prototypes allow for the evaluation of few attributes (e.g., paper prototypes) while comprehensive ones allow for greater scrutiny and analysis of several variables simultaneously (e.g., automobile prototype). A classification of prototypes based on these two dimensions is shown in Figure 4.15. A brief description of the most important types follows.

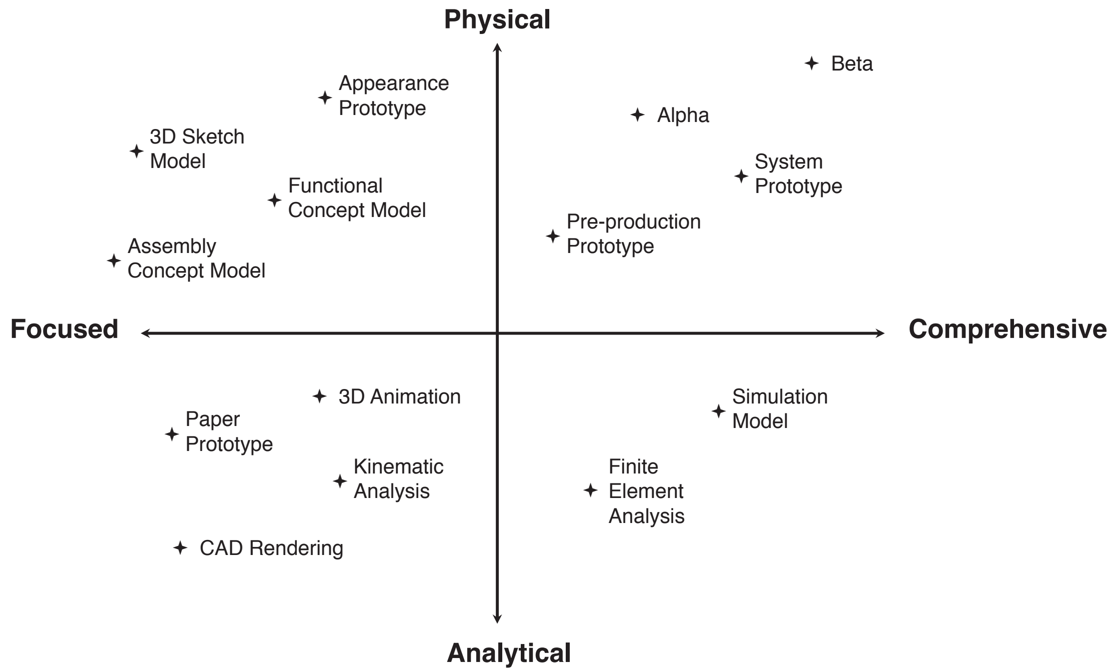


Figure 4.15 Classification of prototypes based on design objective. Source: Rodriguez, C.M. (2017)

Paper prototyping

This is the most common basic form to represent concepts and ideas. The purpose is to evaluate the look, feel, functionality, and interface of the design based on the requirements from the consumer. This prototype does not represent the technical characteristics of the design. Mainly, this prototype is used to explore idea generation and brainstorm possible solutions using sketching as graphical support. Several options for paper prototyping include: storyboards that represent through a series of frames the consumer interface. Additionally, a plastic interface in conjunction with paper can be used to identify the location of features and sequence of interactions. In addition to using paper as creative material, other materials such as foam core, polystyrene foam, wood, thermoplastic sheets, polyurethane, clay, and plastic are generally applied.

Functional prototyping

The purpose of these prototypes is to test how the product works and delivers the expected functions. Usability testing allows identification of possible design errors at early stages when all functions have not yet been finalized. This method favors identifying specific tasks for the user, completion of the task by the user, identifying areas for improvement and modifying the prototype as needed. Overall, experimentation allows for evaluating user-centered design requirements which include ergonomic and cognitive considerations along the user's experience.

Experience prototyping

This type of prototyping applies to the design of product or service experiences. The method requires description in a structural manner of the different stages of product/service delivery and the critical interactions between the object and the user. In the service industry, service maps or blueprints are created to identify the "critical moments" or moments of truth that may create an imbalance or misspecification of the value delivery. In the case of products, this method studies the dynamic relationship between the user and the usage setting that generates functional and emotional concerns. Experience prototyping allows users, designers, and others involved in the creation, innovation, and design process to be active participants within the "experiential setting" and social context, as they discover and generate rich interpretations.

Alpha prototype
This prototype is not entirely functional and is used for testing purposes. During testing all features, functions, and subsystems are scrutinized and an assessment of how the product works is intended. Additionally, a systems integration is verified as well as how the technology performs. This design is close to the production version and simplified production processes are used (e.g., machine instead of molding).

Beta prototype
Beta prototypes represent a full functional version of the product and are evaluated before the preproduction stage. This prototype is used to test the product in its actual usage environment with customers, assemblers, parts manufacturers, and component suppliers. A main purpose is to assess reliability, and products are made using actual production manufacturing facilities. This prototype allows a side analysis of the requirements and adjustments needed during the actual production process.

Preproduction prototype
This prototype is the final type of physical model that specifies all the elements of the design in addition to specifications of part production and components before entering the manufacturing phase of the design process. A particular interest is to confirm the necessary technical requirements and specifications of the design. Design for assembly and manufacturing is validated at this stage with careful attention to production processes, assembly times, parts integration and outsourcing, balance lines, and other manufacturing adjustments.

Virtual prototyping
This method combines the virtual environment with engineering design, allowing the designer to assess design sensitivity and optimization process. Before the final product is built, virtual objects provide the ability to test "what-if" scenarios. Thus, it reduces development time and time to deliver products to markets.

This type of prototyping involves the creation of 3D CAD (computer assisted design) models. These models allow for the analysis of the form and shape, how parts and components fit, rendering, and assembly. In addition, this method requires input devices to sense user interaction and motion, output devices to replace users' sensory input with computer-generated input, and software to handle real-time processing, rendering capabilities, and simulation tests.

Virtual prototyping is mainly used by industrial designers as they aim to visualize their concepts. Several providers of 3D CAD software include AutoDesk (AutoCAD, AutoCad LT), Solidworks, TurboCAD, Solidthinking (Inspiron and Evolve), PTCreo (Direct Modeling, Direct Drafting, and Direct Model Manager).

Rapid prototyping
Rapid prototyping (RP), also known as Solid Freeform Fabrication (SFF), has become critical in efforts to reduce product development cycles and time to market without compromising quality and profitability. Rapid prototyping is the physical modeling of a design using machine technology. In contrast to traditional prototyping, rapid prototyping is sustained on a layer-by-layer material (e.g., sheets of polyvinyl chloride, PVC) deposition process as parts and components are being built. A wide range of materials (such as liquid plastics, resins, and paper/metal sheets) are used as horizontal cross-sections of a computer model driving the RP equipment. This process is known as Additive Manufacturing (AM) within the manufacturing industry, or 3D printing among regular users.

The rapid prototyping process involves: a) construction of a CAD model, b) conversion of the CAD model to a STL format file (STereoLithography). STL files translate the geometry part from a CAD system to the RP machine. The RP input is the electronic information required to specify the physical object with #D data, c) verify that the STL file grants the generation of the support structure, d) slice model into layers, e) produce the physical model, f) remove supporting structures, and g) post-process and refine the physical model.

4.7.2 Design for Six Sigma (DFSS)

Six Sigma aims at reducing variations in a business and manufacturing process via dedicated improvements in the various processes. This requires a sustained commitment from all members of the team. Applications of Six Sigma that focus on the design or redesign of products and services and their enabling processes to meet customer needs and expectations are known as Design for Six Sigma or DFSS.

Six Sigma – DFSS and DMAIC

The aim of DFSS is to create designs that are resource efficient, capable of exceptionally high yields, and are robust to process variations. The process of DFSS and DMAIC is shown in Figure 4.16.

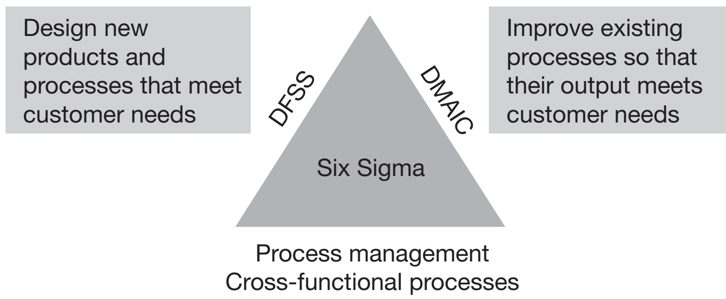


Figure 4.16 Design for Six Sigma (DFSS)

DMAIC is a data-driven quality strategy used to improve processes. It is an integral part of a Six Sigma initiative, but in general can be implemented as a standalone quality improvement procedure or as part of other process improvement initiatives such as Lean.

DMAIC is an acronym for the five phases that make up the process shown in Figure 4.17.

- Define the problem, improvement activity, opportunity for improvement, the project goals, and customer (internal and external) requirements.
- Measure process performance.
- Analyze the process to determine root causes of variation, poor performance (defects).
- Improve process performance by addressing and eliminating the root causes.
- Control the improved process and future process performance.

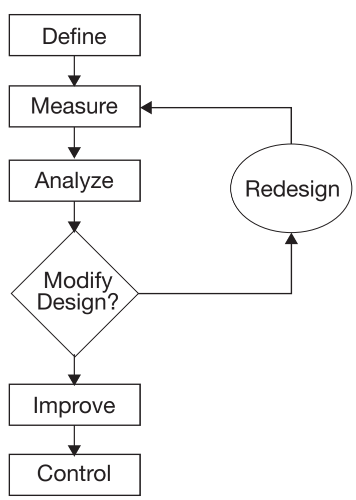


Figure 4.17 Design for Six Sigma (DFSS)

DFSS (IDOV) methodology

The DMAIC approach can improve existing products and services to a level which they are capable of, but the overall product or service performance may be limited by design. In order to overcome this limitation, the Design for Six Sigma (DFSS) approach is recommended as it covers a full range of product and service design starting with the Voice of the customer (VOC) and ending with product or service launch.

IDOV is a specific methodology for designing new products and services to meet Six Sigma standards. The DFSS (IDOV) is a four-phase process:

- Identify: Identify customer needs and strategic intent.
- Design: Deliver the detailed design by evaluating various design alternatives.
- Optimize: Optimize the design from a productivity (business requirements) and quality point of view (customer requirements), and realize it.
- Validate: Pilot the design, update as needed, and prepare to launch the new design.

4.7.3 Design for sustainability (DFS)

The concept of design for sustainability requires that a combination of environmental, social, and economic priorities and considerations be taken into account as the design cycle progresses and over the product life cycle. Product conceptualization and creation, being the first step in the design process, has a major role in defining how sustainability is incorporated in contrast to final stages of the product development process. Design for sustainability is design with the intention of achieving sustainable outputs of the product or service and requires a holistic view and systems perspective. The three pillars of sustainability — known as the triple bottom line (TBL) — stand for: people (social equity), profit (economy), and planet (environment) (see Chapter 1). Sustainability occurs when firms are committed to design projects that reflect the notion that a healthy economy depends on a healthy society and both are sustained in a healthy environment.

In order to identify the appropriate tools used to incorporate the notion of sustainability in product development, an extended definition of product life cycle is needed. Product life cycle (PLC) is defined as the sequence of interrelated stages during the design and management of a product system from the extraction of raw materials and natural resources to manufacturing, distribution, packaging, use, disposal, and reuse of materials, parts, and components in the end of cycle. The product life cycle embraces the notion of the Product System Service (PSS) paradigm that considers products from a systemic perspective and includes the services needed to maintain the product, seeking to maximize an extended version of “quality” eliminating negative impacts on the environment. As such, the tools used under sustainability should incorporate the assessment of TBL aspects in the product design.

The principles of sustainable product design are:

- Use non-toxic, sustainably produced, or recycled materials with low environmental impact.
- Use manufacturing processes and produce products which are energy efficient.
- Build longer-lasting and better-functioning products.
- Design products for reuse, easy disassemble, and recycling.
- Use life cycle analysis tools to help you design more sustainable products.
- Shift the consumption mode from personal ownership of products to provision of services which provide similar functions. Some examples are Interface Carpets (carpet tiles do not require much trimming during installation and create less waste), Xerox (copier leasing rather than purchase), and Zipcar (car sharing).
- Materials should come from sustainably managed renewable sources that can be composted when their usefulness is exhausted.

Sustainability methods

During the PLC, guidelines and tools have been suggested. Guidelines are specific listings of specific issues to take into account during the development process. They suggest aspects to take into account and are considered a checklist that grants awareness of sustainability issues in the development process. Some of these guidelines are:

SPSD framework

SPSD stands for sustainable product and service development. The approach implements sustainable product and service development through the PLC. It focuses on transforming the offering of products into services to reduce manufacturing.

ARPI framework

ARPI stands for analysis, report, prioritize, and improve. The approach grants the implementation of eco designs and includes an assessment of the environment, reporting on these, ranking the considerations, and suggesting actions for improvement.

MDE framework

This framework is a guide to material, design, and ecology (MDE). It emphasizes the selection of materials and their impact in product methods, function design, market requirements, price, and environmental impact.

Product Sustainability Index (ProdSI)

The ProdSI represents the level of sustainability built in a product. It considers the triple bottom line (TBL) indexes. Each cluster includes several factors assessed through specific metrics. A possible list of clusters and factors is shown in Figure 4.18. Clusters are given a weight (from 0 to 100) and factors within each cluster are evaluated on a scale of 1 to 10, where numerals closer to 10 represent a higher level of compliance with the criteria.

Clusters	Factors
Product's environmental impact	▪ Life cycle (useful life span) ▪ Environmental effect (toxicity, emissions) ▪ Residues ▪ Ecological balance and efficiency ▪ Regional and global impact (CO_2, ozone depletion)
Product's social impact	▪ Operational safety ▪ Health and wellness effects ▪ Ethical responsibility ▪ Social well-being (quality of life, peace of mind, life satisfaction) ▪ Employee safety and health ▪ Education
Product's functionality	▪ Service life – durability ▪ Modularity ▪ Ease of use ▪ Maintainability/serviceability ▪ Upgradability ▪ Ergonomics ▪ Reliability ▪ Safety ▪ Functional effectiveness
Resource utilization	▪ Energy efficiency and power consumption ▪ Use of renewable source of energy ▪ Material utilization and efficiency (content and hazardous material) ▪ Water use and efficiency ▪ Installation and training costs ▪ Operational cost (labor cost, energy, capital, etc.)
Product's manufacturability	▪ Manufacturing methods ▪ Assembly ▪ Packaging ▪ Transportation ▪ Storage
Products' recyclability/ remanufacturability	▪ Disassembly ▪ Recyclability and recovery ▪ Disposability ▪ Remanufacturing/reusability

Figure 4.18 Clusters and factors to calculate Product Sustainability Index (PSI). Source: Adapted from Jawahir, I.S., Wanigarathne, P.C., & Wang, X. (2015). Product Design and Manufacturing Processes for Sustainability. In M. Kutz (Ed.), Mechanical Engineers' Handbook. Hoboken, New Jersey: John Wiley & Sons.

4.7.4 Analytical tools for sustainability

Life Cycle assessment (LCA)

This method is used for eco-design and has been used by industry for more than 30 years. LCA provides quantitative data on the product's environmental impact from cradle (extraction of materials) to grave (end of life). The method has four phases: Determination of goals and scope of the LCA; inventory of energy and material inputs across all stages of the PLC; evaluation of the environmental impact associated with inputs and outputs during the life cycle; and interpretation of results to reach corrective decisions. The LCA process is shown in Figure 4.19.

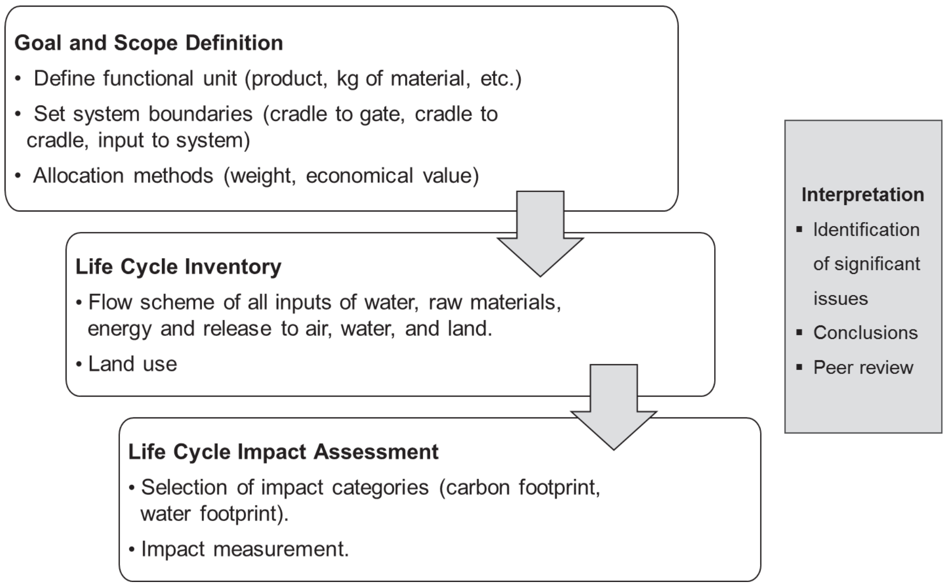


Figure 4.19 Outline of the process for life cycle assessment (LCA)

Simplified life cycle assessment (SLCA)

This method is a simplification of the LCA. Specific information and parameters during the evaluation of the environmental impact phase (i.e., inventory data) are not examined in order to reduce the amount of data gathered.

Quality function deployment for environment (QFDE)

This method integrates notions of QFD, benchmarking, and LCA to conduct environmental impact studies of products and their components. The QFDE follows the logic of axiomatic design which considers that every design should follow four domains in sequence: customer domain, functional domain, physical domain, and process domain. The QFDE method starts by connecting the typical customer requirements of the QFD with sustainable requirements to identify functional requirements. Later these functional requirements assist in identifying key design parameters. Typically, the method has four phases: association of customer requirements (CRs) to engineering metrics (EM), known as technical or functional requirements; relationship of EMs to the product components; estimation of design changes in components or subsystems after benchmarking process; and evaluation of the impact of changes in EMs into environmental quality requirements. The framework for sustainable design using QFDE is shown in Figure 4.20.

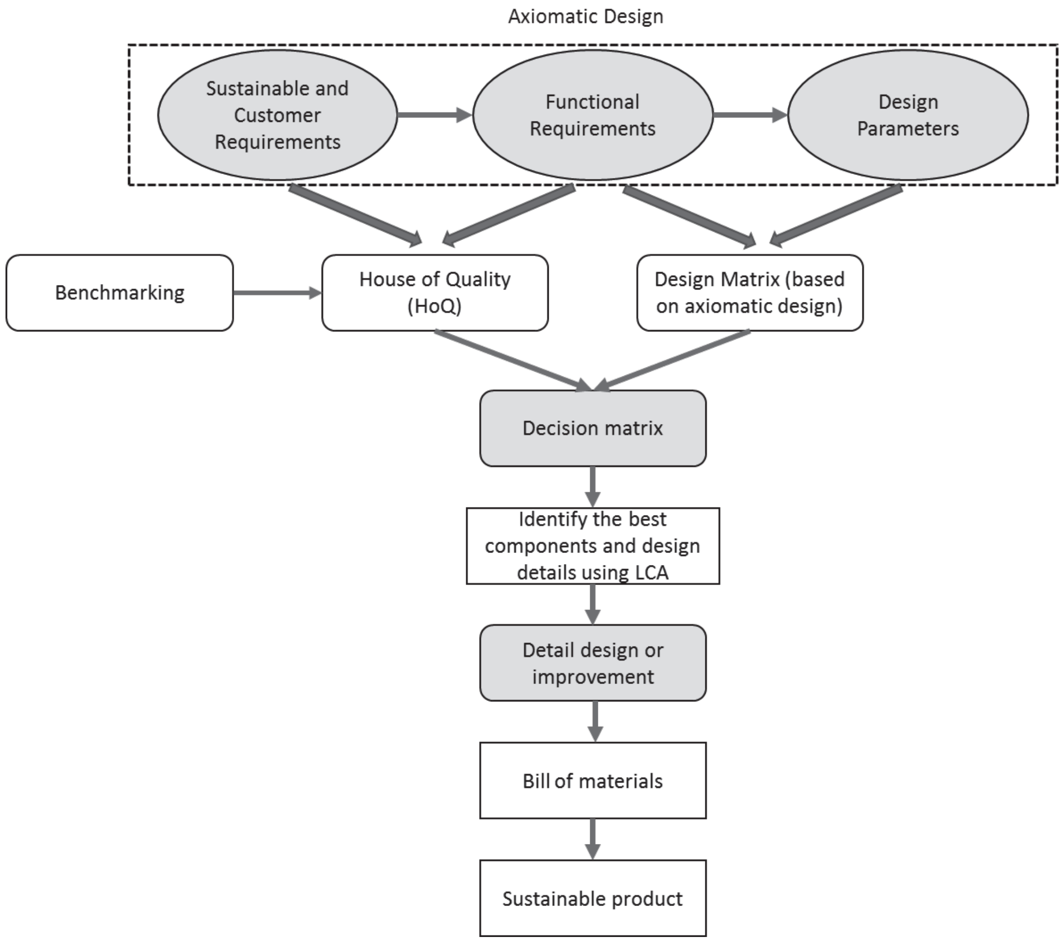


Figure 4.20 Framework for sustainable design using QFDE. Source: Hosseinpour, A., Peng, Q., & Gu, P. (2015).

Life cycle costing (LCC)

This method involves the analysis of all the costs associated to product, process, and/or activities within the life cycle of a product system generated by all the actors in the product life cycle (supplier, manufacturer, and consumer). External costs and end-of-cycle costs are neglected in the conventional LCC method. As such, the method is a cradle-to-grave cost analysis. All costs are used to estimate the net present value (NPV) through a discounted cashflow. Furthermore, the annual cost of owning, operating, and maintaining assets over their entire life — known as Equivalent Annual Cost (EAC) — is calculated.

Life cycle costing can be estimated in three forms: conventional LCC, environmental LCC, and societal LCC. As expected, the environmental LCC considers externalities and related money cashflows. Overall, LCA (focus on environmental) and LCC (focus on economics) are two standard pillars of sustainability. The social component is still under development.

4.8 IN SUMMARY

- Using appropriate methodologies and tools is key to product innovation success. This chapter focused on those tools applied during the design and development phase of product innovation. The design and development phase is defined as the evolution of a product from initial idea through to final design specification, ready for manufacture and launch. Associated market research tools are discussed in Chapter 5.
- Employing appropriate tools is essential to ensuring sound decision-making throughout the new products process. The tools available to product developers are many and varied. Some have generic application across a range of industries and products, while others are appropriate to specific applications. In this chapter, we have discussed a selection of the generic tools.
- Idea generation (ideation) lays the platform for successful new products. Several techniques were discussed — from mind-mapping, storyboarding, personas, ethnographic methods, to a day in the life of the customer. All these techniques allow for in-depth dives into the consumption experience.
- Although not discussed in detail in these notes, the application of product-specific design tools such as conjoint analysis, functional analysis, reverse engineering, CAD, prototyping, simulation, modeling, and experimental design are essential components of the product developer's toolbox.
- Development of sound and well-defined product design specifications from the initial product idea and concept is essential to ensuring that the new product remains on target throughout the development process to manufacture and final product launch. Design specifications are presented through the House of Quality and Taguchi methodology.
- Several considerations during the design process are imperative. Design for production, design for functionality, and design for service, assembly, and maintenance provide the product designer with critical perspectives that support cost minimization, product robustness, reliability, and reaching quality targets.
- The increasing emphasis on sustainability considerations in product design necessitates the application of tools and methodologies including life cycle assessment, QFD for environment, and life cycle costing.

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Practice questions: Product design and development tools

1. Product design specifications are primarily intended to:
   A. Translate qualitative design features into quantitative parameters.
   B. Identify the core benefits of a product.
   C. Identify customer needs.
   D. List the tangible features of a product.

2. The House of Quality relates the voice of the customer to the voice of:
   A. Marketing.
   B. Advertising.
   C. Engineering.
   D. Manufacturing.

3. Which ideation tool used in new product development generates a graphical output linking various pieces of information, ideas, and thoughts?
   A. Mind-mapping.
   B. Brainstorming.
   C. Brainwriting.
   D. Delphi technique.

4. The creative process of generating and communicating new ideas where an idea is a basic element of thought that can be visual, concrete, or abstract is termed:
   A. Market research.
   B. Ideation.
   C. Concept development.
   D. Mind-mapping.

5. Target product design specifications must use a set of metrics to ensure they are met during the design work. Suppose you are designing a new automobile. Which of the following is an acceptable product design metric?
   A. The seats are comfortable.
   B. The car accelerates from 0 to 60 miles per hour in less than 6 seconds.
   C. The towing capacity is adequate for most people to use a boat trailer.
   D. There are a wide range of colors and fabrics available for the interior.

6. SCAMPER is an ideation technique that uses word stimuli including:
   A. Adapt, put to another use.
   B. Substitute, combine, modify.
   C. Reverse, eliminate.
   D. All of the above.

7. The product concept description should include which three elements?
   A. Customer needs, environmental factors, customer use reports.
   B. Qualitative description, quantitative parameters, and technical deliverables.
   C. Core benefits, tangible attributes, and augmented features.
   D. Competitive benchmarks, concept description, qualitative measures.

8. What is the pattern in TRIZ problem-solving matrix?
    A. Identify the specific problem first, then the general problem, and identify a general solution before a specific solution.
    B. Identify the specific problem first, test a solution with a targeted customer group, generate more prototypes, select specific solution.
    C. First use a general problem with general solution, then select the specific problem to solve.
    D. Identify a cross-functional team that can test various product solutions with customers and select the highest rated solution.

9. Jack is a consultant to a manufacturing company. He has been asked to evaluate the components and parts of the product as well as the whole design (system view) and the method of assembly used (manual, automatic, fixed automation, and robotic assembly). What specific design tool should Jack use?

A. Design for manufacturing.
B. Design for assembly.
C. Design for functionality.
D. Design for life.

10. What specific design tool uses the following methods: Think-aloud laddering, Quantification Theory I (QTI), PLS analysis, and Genetic and Fuzzy logic?

A. Taguchi.
B. Six Sigma.
C. Kansei.
D. TRIZ.

Answers to practice questions: Product design and development tools

1. A	6. D
2. C	7. C
3. A	8. A
4. B	9. B
5. B	10. C

5

MARKET RESEARCH IN PRODUCT INNOVATION

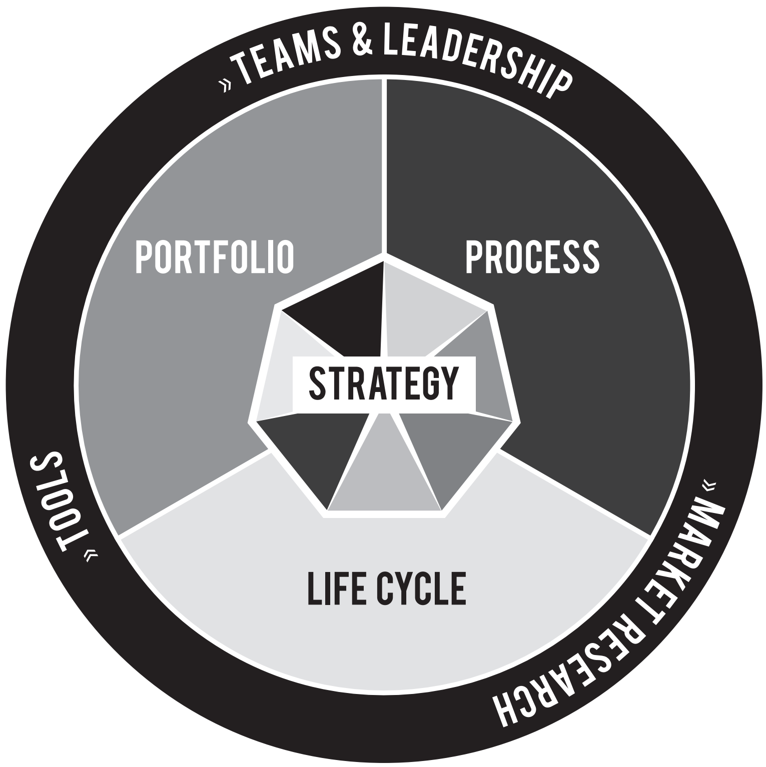
Required to provide market-related information and data to underpin decision-making in all aspects of strategy development, portfolio management, the product innovation process, and life cycle management

5. Market Research in Product Innovation

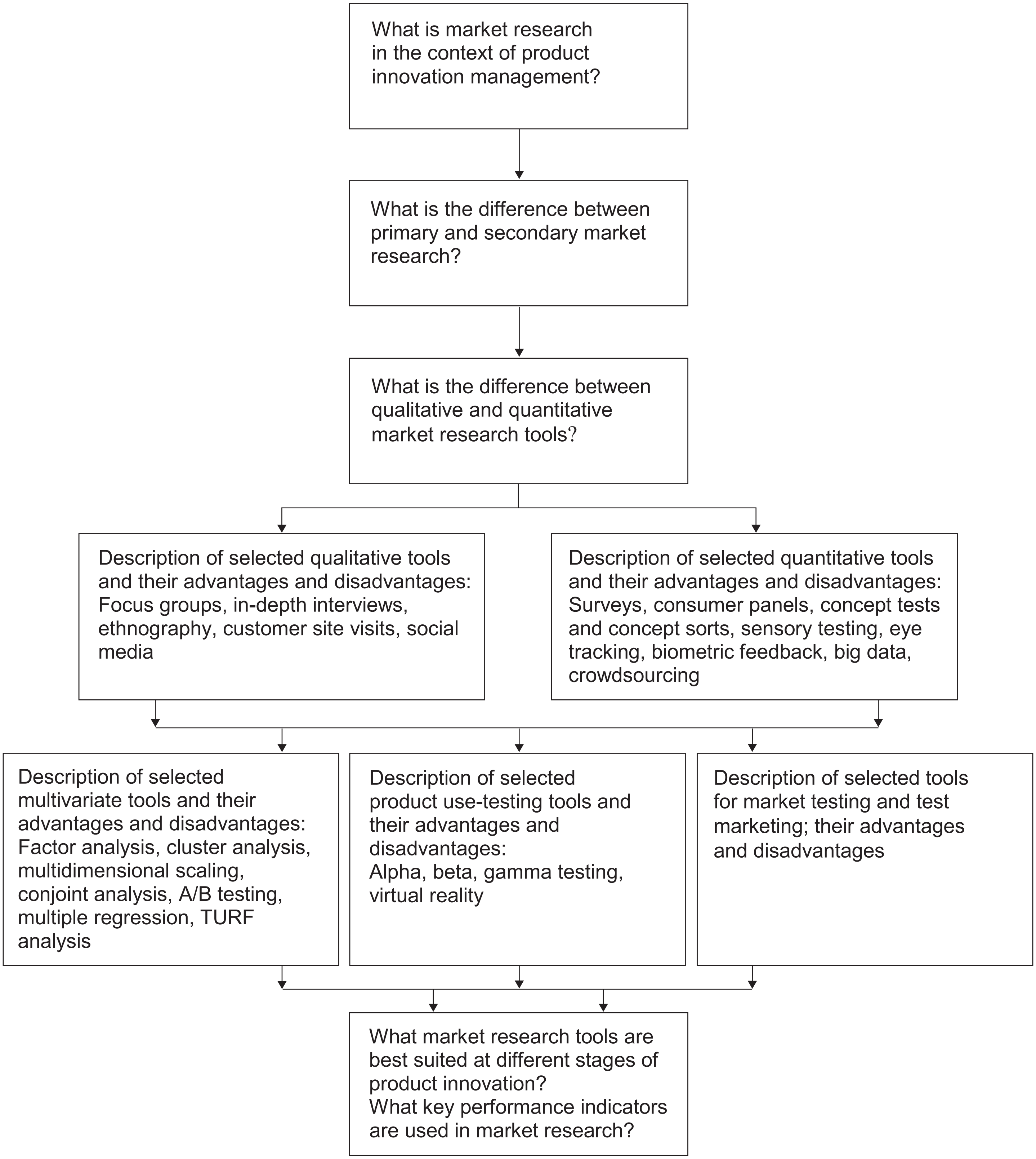
THE CONTENT

What you will learn in this chapter

Market research is critical to informed decision making at all levels of product innovation management. This chapter presents a range of market research tools. The strengths and weaknesses of each tool are discussed, together with how each tool contributes to specific innovation management decisions throughout the innovation process.



The Chapter Roadmap



5.1 INTRODUCTION

Understanding and addressing stakeholder and customer needs is essential to developing successful new products and improving existing products. A wide range of market research techniques is available to inform decision-making in all aspects of product innovation during all points of the process. In particular, market research provides critical information that helps reduce uncertainty throughout the new product innovation process and, thereby, increases the probability of new product success.

This book emphasizes product innovation as a risk vs. reward decision process founded on sound information, data, and knowledge. Market research provides key information that ensures the right decisions are made throughout the new product innovation process, and in turn, reduces uncertainty and minimizes risk. In this chapter, a number of common market research methodologies are presented. Methodologies are the process by which answers to questions that guide decisions are researched. Some methods are appropriate to sourcing specific types of information while others can be used to source a wide range of information. Some methods explore and discover; others confirm and validate. Types of market research, often called studies or testing, are commonly referred to by either their data collection technique or their data analysis technique; for example, surveys, focus groups, conjoint analysis, and cluster analysis. The tools used in market research are the devices, forms, questionnaires, software applications, observation forms, interview schedules, facilities for testing, sensors, and other process enablers. Analysis, often statistical, is the examinataion and inspection of the data collected, translated into findings and conclusions.

In product innovation, the cost of potential failure from wrong or bad decisions increases significantly as the new product innovation progresses toward product launch. The need for high quality, reliable information is consequently higher the further a project advances through the new product innovation process. This is a major factor in the selection of the market research methods that are applied at various stages of the new product innovation process. Market research is a way to find the information needed for product innovation decision-making:

- What opportunities are out there — now and in the future?
- What do customers want or need — articulated vs. unarticulated needs?
- What drives customers to purchase and re-purchase a product?
- What value proposition should be built into the new product?
- What refinements should be made to make the product a more acceptable and desirable solution?
- Will the customer buy the product, how often, where, and at what price?
- Are there other product solutions that already exist in the market?
- What is the advantage of our product solution?
- Can the product solution be protected, and advantage be secured by establishing intellectual property rights?
- Is the product solution sustainable?

Therefore, common areas for market research in new product innovation and product management include voice of the customer, the competitive landscape, voice of the competition, existing intellectual property, and impact of sustainability factors. Common areas of testing include concept testing, product testing, and market testing.

5.1.1 Voice of the Customer

One of, if not the most important area of research for product innovation, is voice of the customer (VOC), a market research term applied to the range of techniques used to capture the requirements and/or feedback of the customer (internal or external). VOC is defined as “a process for eliciting needs from consumers that uses structured in-depth interviews to lead interviewees through a series of situations in which they have experienced and found solutions to the set of problems being investigated. Needs are obtained through indirect questioning by coming to understand how the consumers found ways to meet their needs, and, more important, why they chose the particular solutions they found." (Belliveau, Griffin, Somermeyer, 2002, PDMA ToolBook, Chapter 11).

Many of the methods described in this chapter can be categorized as VOC techniques. For a good review of VOC techniques as a source of new product ideas, see Cooper and Dreher (2015).

In addition to researching the final customer or consumer, when developing a new product or service, it is also essential to consider other key stakeholders in the final purchase decision. For example, most food products have traditionally been sold through supermarkets. Supermarkets are not the final consumers of the products, but they play an extremely important role in determining if the product is made available to consumers. Their views are as important as the final consumer. In the case of medical devices for personal use, it has generally been the medical professional who advises the end-user on what device to use. They are critical stakeholders in the purchase decision and their views must be included and respected by the product developer.

VOC research is not only used in the development stage of the new product innovation process, it is often used to develop customer or market segmentation schemes using demographic, psychographic, behavioral, and lifestyle data to create customer personas for launch and marketing communications.

5.1.2 Six key steps when conducting market research

The following six steps underpin most market research (Naresh, 2009):

1. Define the problem: A clear statement of what information is being sought and what questions need answers.
2. Define the level of accuracy for results: What level of general reliability or specific statistical confidence and experimental error is acceptable.
3. Collect the data: Select and apply a suitable methodology for collecting the results that address the problem with the required level of accuracy.
4. Analyze and interpret data: Apply an analysis, appropriate to the methodology used, so as to provide a summary of the results in such a way as to address the stated problem.
5. Reach a conclusion: Relate the interpretation of results to draw specific conclusions.
6. Implement: Apply the findings and conclusions to the defined problem.

A market research example using the six steps:

1. Define the problem: What is the projected sales potential for a newly developed tracking device for hikers?
2. Define the level of accuracy for results: What is the required accuracy for final launch decision? Statistical accuracy desired is experimental error within 2% with 95% confidence.
3. Collect the data: Statistically-selected sample to represent the target market.
4. Analyze and interpret data: Calculate the mean and variance of the data related to the likelihood to purchase.
5. Reach a conclusion: Is the projected sales potential sufficient to justify launch?
6. Implement: Go or no-go launch decision is made.

5.2 PRIMARY VS. SECONDARY MARKET RESEARCH

There are two basic research sources, primary and secondary, based on the source of data used in the analysis.

5.2.1 Primary research

The collection of information directly and specifically for an organization's own needs. This may involve focus groups, surveys, personal interviews, observation, etc.

Primary research, collected directly and specifically for an organization's own needs, can be divided into two categories based on the statistical reliability of the findings. To a large degree, the level of statistical reliability determines the appropriateness of a market research technique at specific stages of the new product innovation process. In particular, more reliable information is sought as the development proceeds through the new product innovation process and project costs and risks associated with ill-informed decisions increase.

Primary market research methods fall into two broad categories, qualitative and quantitative, based on the nature of the underlying data.

- **Qualitative:** implying that the data is not at a sufficient level to apply statistical analyses resulting in determination of the reliability of the results. Refer to Belk (2006).
- **Quantitative:** implying that the data can be statistically analyzed, providing determination of the level of confidence of the results.

5.2.2 Secondary research

The collection of information from studies previously performed and published by other individuals, groups, or agencies.

Secondary market research involves searching for sources of existing data that were previously collected by someone else and can include:

- Government statistics,
- Syndicated data,
- Industry or trade publications,
- Trade fairs and conferences,
- Newspapers and magazines,
- Organization annual reports,
- Research publications,
- Scientific journals,
- Scholarly articles,
- Patent and trademark (intellectual property) databases,
- Open source databases, wikis,
- Internet websites, white papers, blogs, and discussion forums.

Advantages of secondary research include:

- Low cost and short time required to collect information.
- Wide range of data sources available.
- Provides a sound basis for further and focused primary research.

Disadvantages of secondary research include:

- A lack of specific focus.
- Uncertainty over data accuracy and reliability.
- Data can often be out of date.
- Information may be copyrighted and can't be used without permission.

Secondary research is valuable throughout the new product innovation process, especially during the early stages of a project where general background information is being sought to better inform the project focus and direction. It is also useful post-launch for product life cycle management in terms of tracking the competitive landscape and emerging changes to the marketplace.

Secondary research:
- Provides information on trends including market, technology, demographic, political, regulatory, competitive analysis, patents, and more.
- Is an excellent way to lay the groundwork for primary research.
- Is appropriate where the information is not being applied to high-risk or high-cost decisions.

5.3 MARKET RESEARCH METHODS

Market research methods can be categorized according to the level of statistical reliability that can be attributed to their data and results and are described as either qualitative or quantitative.

5.3.1 Qualitative vs. quantitative data and methods

Qualitative market research: "Research conducted with a small number of respondents, either in groups or individually, to gain an impression of their beliefs, motivations, perceptions, and opinions. Frequently used to gather initial consumer needs and obtain initial reactions to ideas and concepts. Results are not representative of the market in general or projectable. Qualitative market research is used to show why people buy a particular product, whereas quantitative marketing research reveals how many people buy it." (Castellion, Griffin, Kahn, 2004. *The PDMA HandBook* 2nd Edition, Chapters 14-16)

Qualitative market research also provides insight to the language and context consumers use to describe the product, its usage, and the market. This is useful as input in the creation of packaging, manuals, marketing, and advertising materials at launch and throughout the product's life cycle.

Quantitative market research: "Consumer research, often surveys, conducted with a large enough sample of consumers to produce statistically reliable results that can be used to project outcomes to the general consumer population. Used to determine importance levels of different customer needs, performance ratings of and satisfaction with current products, probability of trial, repurchase rate, and product preferences. These techniques are used to reduce the uncertainty associated with many other aspects of product innovation." (Castellion, Griffin, Kahn, 2004. *The PDMA HandBook* 2nd Edition, Chapter 18).

5.3.2 Sample size and the statistical basis of quantitative methods

Statistical formulas, tables, or easy-to-use online calculators are used to determine a sample size sufficient to establish the statistical reliability of research results.

The following information is needed for sample size calculation:

Margin of error (confidence interval): What range around the calculated survey result can be tolerated, e.g., survey result +/- 5%.

Confidence level: What is the confidence that the actual results fall within the confidence interval required?

Variance: What variance is expected in the results? This is often estimated from population statistics or past studies.

General sample size relationships:
- The lower the required confidence interval, the larger the sample size required.
- The higher the required level of confidence, the larger the sample size required.
- The higher the variance in the population with regard to what is being surveyed, the larger the sample size required.

Selecting a sample size that is too small will lead to lower accuracy and confidence in the results.

5.3.3 Sampling methods

There are several approaches to sampling for market research in product innovation. This section focuses on probability sampling, which uses randomization where the odds of inclusion for each selection are known. Probability sampling is the statistical basis for quantitative research. Quantitative research is not possible without using probability sampling. Note: there is a role for nonprobability sampling, sometimes called judgement sampling, and qualitative research in product innovation — however, the projectability of results obtained using this type of sampling is not reliable for reducing risk.

Types of probability sampling for quantitative research:
Random sampling: The simplest method of sampling for quantitative surveys is random sampling. A random sample is defined as a subset of a statistical population in which each member of the subset has an equal probability of being chosen. A simple random sample is meant to be an unbiased representation of a group.

Advantages of random sampling include representation of the target population and elimination of sampling bias. Disadvantages include extreme difficulty to achieve in practice, and the cost and time involved.

In order to overcome some of the disadvantages of simple random sampling, a number of other sampling methods can be applied to maintain a high level of precision but at significantly reduced time and cost.

Three other common sampling methods are systemic, stratified, and cluster sampling.

- **Systemic sampling:** Samples are chosen at a regular interval depending on the size of the population and how large a sample is needed. Be sure there isn't a pattern in the original population that creates a bias in the sample selection.
- **Stratified sampling:** The population is divided into strata according to some variables that are thought to be related to the variables of interest. A sample is taken from each stratum. This is intended to reduce sampling error because if the strata really are related to the variables of interest, then each stratum is more homogeneous, and it has less variation in the target variables.
- **Cluster sampling:** The population is divided into clusters and a sample of clusters is taken. This tends to increase sampling error because clusters tend to be similar; if they were identical, there would be no point in taking more than one observation within the cluster because they would all be identical. The loss of precision is related to the variability within the clusters, which is only known after the sample is taken. In single-stage cluster sampling, the whole cluster is the sample. In multistage cluster sampling, random sampling is done within the cluster in one or more stages.

Understanding the fundamental principles of sample size and relationship of sample selection to the reliability of the research results is important when applying market research to product innovation and management. The key focus of market research in product innovation is to provide stakeholder or market-related information to inform decision-making at various stages of the process in order to reduce risk. The need to gather more reliable information, as the costs and risks associated with development and launch increase, drive a shift from qualitative to quantitative methods. Qualitative techniques such as focus groups are extremely valuable at the start of the process where costs and risks are low, as a frontend to conducting quantitative studies, or following quantitative methods to help give context to results, but quantitative techniques should be applied, where possible, as project costs and risks increase. To get reliable statistical results, it is important to survey a sample of people in a statistically based manner. This chapter only introduces the fundamental principles of sampling and does not go deeper into the statistical basis and calculations used when conducting quantitative market research.

5.4 QUALITATIVE MARKET RESEARCH METHODS

While qualitative research produces data that are not at a sufficient level to apply statistical analyses and reliable, projectable results, it very useful in exploration, discovery, creating context, and learning the why behind quantitative research results. There are a number of commonly used qualitative research techniques in all phases of product innovation — and especially early in the development process, where risk is still comparatively low.

5.4.1 Focus groups

A focus group is defined as a qualitative market research technique where 8 to 12 market participants are gathered in one room for a discussion under the leadership of a trained moderator. Discussion focuses on a consumer problem, product, or potential solution to a problem. The results of these discussions are not projectable to the general market.

Typical characteristics of a focus group:

- Screening questions are used to select 8-12 participants.
- It is conducted in a specialized facility with a trained moderator.
- The research room is set up with a table and chairs, a one-way mirror, and the capacity to audio- and videotape the group.
- Observers can view proceedings from an adjacent room through a one-way mirror.

Focus group advantages:

- Interaction among the group provokes discussion and can provide fresh insights and in-depth understanding.
- Comments come directly from representatives of the market — unfiltered through questionnaires or analysis.
- Questions can be changed quickly in response to participants' comments.
- Behavior of participants can be observed, especially in usage studies.

Focus group disadvantages:

- Group dynamics can suppress some individuals' contribution or lead to dominance by others.
- Comments by participants can be open to interpretation.
- Conclusions do not apply directly to people outside of focus group — results are not projectable.
- Quality of results is heavily influenced by the skill of the moderator.
- Subject to participant availability at a set time and place.

Considerations in applying focus groups:

- Avoid conducting a single focus group. Three or more is best; though not statistically reliable, multiple groups do provide greater confidence in the findings.
- Ensure the moderator has the necessary background and training to handle the topic.
- Conduct with proper planning and preparation — avoid bringing a random group of people together for an unstructured chat.
- Screen out focus group veterans — people who regularly participate in focus groups.
- A focus group is not a quantitative technique — statistical conclusions cannot be made.

The value of focus groups in product innovation decision-making is that when run well, focus groups can provide great insights throughout the new product innovation process:

- What opportunities are out there and customers' ideas on gaps in the market.
- What customers want or need, especially articulated needs. Focus groups are not as good at identifying those needs that the customer has yet to recognize or which they are unable to articulate. Results are likely to be within the current product or market paradigm.

- What value proposition should be built into the new product. Focus groups are used to gain a better understanding of the features that drive value and should be built into the product.
- What refinements should be made to make the product more acceptable. Focus groups are used on an ongoing basis to provide direction for product refinement. Lead user groups or customer panels, comprising customers who have an active interest in the product category and who lead the market in purchasing, are particularly useful. (Thomke and Von Hippel, 2002).

5.4.2 In-depth interviews

This qualitative research method involves conducting longer intensive interviews probing and exploring a specific topic, one on one, with individual participants. The research gathers detailed insights, perspectives, attitudes, thoughts, behaviors, and viewpoints on a problem, idea, program, situation, etc.

In-depth interview advantages:

- Provides more detail, context, language, emotions, and relationships for each area explored.
- Designed to be more open-ended, provide emergent information and insight, reveal hidden relationships, connections, complexity, and help explain quantitative findings.
- Can be a more relaxed, personal, private, safe, and individual-based conversation that provides richer, deeper insight.

In-depth interview disadvantages:

- Time consuming and costly.
- Subject to participant availability at a set time and place.
- Must be conducted by a professional trained in interviewing techniques and subject.
- Can be biased and subject to interpretation.
- Not projectable or generalizable.
- Typically conducted with a smaller number of participants than other types of research due to increased time, effort, and expense.

The value of in-depth interviews in product innovation is that they can provide great insights throughout the new product innovation process:

- What opportunities are out there and customers' ideas on gaps in the market.
- What customers want or need, especially unarticulated needs. Focus groups are not as good at identifying those needs that the customer has yet to recognize or which they are unable to articulate. Results are likely to be within the current product or market paradigm.
- The value proposition to be built into the new product. Focus groups are used to gain a better understanding of the features that drive value and should be built into the product.
- What refinements should be made to make the product more acceptable. Interviews are used on an ongoing basis to provide direction for product refinement.

In-depth interviews are valuable prior to quantitative studies to provide initial framework for the quantitative research purpose and questions. It also provides richer, authentic language for use in quantitative studies. In-depth interviews are also valuable when investigating or exploring the reasons behind quantitative research results.

They work especially well in business-to-business (B2B) research where individuals with specific knowledge or experts are needed, or in business-to-consumer (B2C) when the scenario is sensitive or private. If appropriate to the study design, conducting over the phone or video conference can offer flexibility and lower costs.

5.4.3 Ethnography

Ethnography is defined as a descriptive, qualitative market research methodology for studying the customer in relation to their environment. Ethnographic market research (EMR) refers to a type of research that helps organizations understand the customer in terms of cultural trends, lifestyle factors, attitudes, and how social context influences product selection and usage. Researchers spend time in the field observing customers and their environment to acquire a deep understanding of their lifestyles and cultures as a basis for better understanding their needs and problems.

Unlike focus groups, ethnography utilizes a variety of techniques and forums to present a complete picture of consumers and how products and services fit into their daily lives. Further reference and explanation of the application of EMR to product innovation are provided by Miller et al. (2004) and Katz (2010).

Ethnographic market research can be applied on-site or in-home. On-site EMR takes place wherever the consumer is utilizing the product or service; for example, in a restaurant, store, office, or even the car. Conducting place-based research allows the researcher to interview and observe as the behavior is carried out and provides an opportunity for follow-up questions as needed. Immersion tours of markets can be conducted on location to research entire markets vs. individual consumers. This is especially helpful in geographic expansion.

In-home EMR is similar to on-site and is conducted in the participant's home environment. The research can include one or multiple family members, and often lasts for several hours. The researcher is immersed in the home environment and observes, asks questions, and listens to obtain insight into consumer trends, reactions, and problems. Consumers go about solving those product or service-based issues. In-home sessions provide insight into how to improve products, what new items are needed, and how changing needs affect usage.

Advantages of ethnographic market research:

- It provides a unique opportunity to identify attributes, situations, and states that are truly valued by customers and reveal unidentified dissatisfiers or hidden problems.
- It can be a very useful means of identifying unarticulated needs that participants may be unwilling or unable to identify during a traditional interview, focus group, or survey, especially if the new product is unfamiliar, the situation private or sensitive. The discovery of unarticulated needs can form the basis for radically new products.

Disadvantages of ethnographic market research:

- It takes a long time to carry out, especially if the researcher is seeking a broad representation of the target market.
- It relies on the researcher's interpretation of what is observed.
- It has no basis in statistical reliability.

The value of ethnographic market research to product innovation decision-making is derived from its usefulness in understanding customer needs and product usage.

- What opportunities are out there, particularly new product opportunities? Ethnographic research seeks to get the researchers to walk in the customers' shoes — to really understand the issues and problems that get to needs that new products can satisfy.
- What do customers want or need? Ethnography is an excellent technique for really getting to know the customer and getting to the heart of their needs, which they may be unable or unwilling to articulate.
- What refinements should be made to make the product more acceptable? Ethnographic research can be used to test a product prototype, observe customer reaction to, and watch application of the prototype. Is it used in the intended way? What problems does the customer have in using the product? Ethnography can be used with products already launched in the market for new and improved versions or line extensions.

5.4.4 Customer site visits

Customer site visits are defined as "a qualitative market research technique for uncovering customer needs. The method involves going to a customer's work site, watching as a person performs functions associated with the customer needs a firm wants to solve, and then debriefing that person about what they did, why they did those things, the problems encountered as they were trying to perform the function, and what worked well." (Castellion, Griffin, Kahn, 2004. *The PDMA HandBook* 2nd Edition, Chapters 15-16)

Similar to in-depth interviews, customer site visits are one of the market research method used most commonly by business-to-business (B2B) organizations. It involves one or more associates from a vendor directly interviewing, observing, and interacting with one or more customers (or potential customers) of that vendor at the site of product use.

Advantages of customer site visits:

- Face-to-face communication on customer's premises can provide a large amount of contextual information.
- Site visits often provide the opportunity to see the product in use, observe firsthand its strengths and weaknesses and discuss, directly with the user, what improvements might be made or desired.
- Visits are useful for technical staff involved in product innovation to better understand the customer's needs and how these can best be translated into product design specifications.
- Visits by product innovation team members promote better communication and understanding of requirements leading to greater team cohesion.
- Can often help build stronger customer relationships.

Disadvantages of customer site visits:

- Site visits can be expensive and time-consuming, especially if travel is involved.
- Where the organization is supplying a number of customers, comments and suggestions from one or two of these may not represent the views of the majority. Sample size is important to get a more reliable view.
- The quality of the information gathered is highly dependent on asking the right questions of the right people. So, for example, an interview with a marketing representative of the customer organization may provide limited, or unreliable, technical information.
- Sending an unqualified representative from the organization with limited product knowledge can have a detrimental impact on customer relationships and lead to unreliable information.

Considerations in applying customer site visits:

- Be sure to inform sales representatives of the visit and enlist their support.
- Make sure the customer representatives who host the visit are decision-makers or influencers and have the requisite knowledge to provide the information sought.
- Build in a tour beyond the meeting room to see firsthand where and how the product will be used, if possible.
- Ask customers to identify problems. If they suggest solutions, listen, acknowledge, and accept their input.
- Take samples, visual aids, and anything that can enable a clearer connection with the customer.

The value of customer site visits to product innovation decision-making is the ability to gather in-depth market and technical information:

- What opportunities are out there, particularly with B2B companies, where there may be levels of buyers, users, and influencers in the customer organization who can provide insights into new technologies or competitor products.

- What customers want or need, often focusing on current needs, problems, and required improvements. These are specific issues that the customer is best placed to articulate. Visits can also reveal unidentified needs that the customer is either unable or unwilling to articulate and requires lines of questioning and observation to identify customer's needs — beyond the current product(s).
- What refinements should be made to make the product more acceptable, especially where detailed concepts or prototypes form the basis for the refinement discussion. This is, again, especially helpful in the B2B context.

5.4.5 Social media

Social media has matured and has opened up new ways of interacting with and sourcing information from the marketplace. Media such as Facebook, Twitter, YouTube, Pinterest, Instagram, Tumblr, WhatsApp, LinkedIn, SnapChat, Reddit, blogs and various discussion forums all offer a medium for engaging with and listening to customers. In 2018, Facebook alone reported over 2 billion users worldwide. Social media marketing usage rate for marketing purposes among U.S. companies has risen from 86% in 2014 to 91% in 2019. (Statista, 2019).

Social media is regularly used for co-creation in the ideation and design phases, and driving awareness and promotion in the commercialization and launch phases of product innovation.

Social listening, a type of VOC market research that monitors digital conversations and analyzes what customers are saying about specific topics, is a growing trend. According to the Data & Marketing Association (2018), 59% of marketers list social media as the most effective channel for collecting marketing data, a number that continues to increase. A well-reported example of how social media listening supports the new product innovation process is how after analyzing social media conversations, McDonald's began offering its all-day breakfast menu in key markets.

Clorox brand Brita reports using social listening to learn that millennials regularly complained about a roommate or partner who drank the last of the Brita water and did not refill the pitcher. They launched a new product, Brita Stream, targeted at millennials. It filters as it pours, eliminating waiting for the water to filter when the user finds it empty.

In addition to social listening, companies worldwide apply integrated social media programs to their marketing and product management. Nike, for example, uses Twitter, Facebook, and Pinterest. It also has its own platform, Nike+. In 2018, Nike+ and its apps like Nike Training Club had more than 100 million users; it leads its users through 1.8 million workouts per month with a plan to triple in five years. The Nike app works on smart phones and watches and competes directly with Fitbit® and native watch apps.

When using social media for market research, it is important to recognize and use the appropriate platforms in the target market. For example, restrictions on access to Facebook, Twitter, YouTube, etc., in China have resulted in a range of home-grown platforms and networks like WeChat, Weibo, and Tencent that boast user bases exceeding a billion active accounts in 2019. Access to the Chinese market through these platforms is essential, not only for Chinese companies, but also for companies in other parts of the world that are seeking a better understanding of the Chinese market.

Advantages of social media for market research:

- It can provide direct and immediate contact with current and potential markets.
- If selected carefully, specific social media allows targeting to a very narrow audience.
- It provides the opportunity to engage with a loyal following of supporters or lead users, either as a basis for ongoing idea generation or for input during the product design process (refer to crowdsourcing later in this chapter).

Disadvantages of social media for market research:

- It can be subject to a high degree of bias based on the composition of people using a specific social medium and those who actively engage in this medium.
- It is difficult to maintain control and achieve a clear focus on the problem or question.
- Although it may be possible to receive a large response to a survey through social media, true statistical confidence still may not be assigned to the results.
- Social media reciprocity (the practice of automatically liking and sharing within a network of friends and followers) and customer turbulence, creating rapid changes in attention such as the viral effect, may bias or cloud results.

The value of social media in product innovation decision-making is its facility to reach large numbers of targeted customers quickly and easily. This makes it an excellent market research tool for product innovation:

- What opportunities are out there? Social media provides an excellent source of information on what people are doing and thinking, both individuals and organizations, in real time. This can lead to new opportunities directly or by inference.
- What do customers want or need? Social provides the product developer with a broad canvas of information related to the general market — and in some cases, even to specific market segments. Note that social media is largely unstructured, and as such, needs caution in interpretation.
- What refinements should be made to make the product more acceptable? Specific and targeted social media groups form an excellent basis as online lead users to provide ongoing testing and input to a product's design and use.

There are multiple opportunities for innovation using social media analytics. Social media can serve as a source of consumer insights, complementing traditional market research methods, and the speed with which social media data are generated and analyzed offers opportunities to be proactive in how the data are leveraged. (Moe and Schweidel, 2017).

Social media analytics in product innovation: sustainability example

There is value in using social media analytics in product innovation. Among other examples, there is research suggesting that the roles of sustainability and social media-driven open innovation are differentiated by many types of open innovation activities. Social media-driven open innovation activities can be focused on gathering market insights that enhance customer focus directly, and these activities can enhance the link between customer focus on sustainability and product performance. Managers are taking a strategic approach to sustainability and embedding it in the product innovation process. Ideally, developers should manage social media-based open innovation carefully to fully benefit during the front end and back end of product innovation, especially in terms of sustainability. (Du, Yalcinkaya, Bstieler, 2016)

5.5 QUANTITATIVE MARKET RESEARCH METHODS

5.5.1 Surveys

Surveys can be broadly defined as the polling of customers to identify their level of satisfaction with an existing product or to discover needs for new products. Surveys are a basic building block and foundational to market research in product innovation. Surveys are ubiquitous. They can be and very often are used in combination with virtually all other market research techniques.

A survey consists of:

- A fixed set of questions asked of a sample of respondents.
- A sample that is large enough for the study intent and selected to consist of certain characteristics.

Surveys can be carried out as a qualitative or a quantitative technique. Qualitative surveys employ a sample selection with no statistical basis (often referred to as purposive or non-random sampling). Quantitative surveys employ statistical sampling procedures as previously discussed.

Surveys are a valuable market research tool for product innovation decision-making. Surveys can be used to provide insights, directly or indirectly, into any of the following:

- What do customers want or need?
- What refinements should be made to make the product more acceptable?
- What drives customers to purchase and re-purchase a product?
- What value proposition should be built into our new product?
- Will the customer buy the product: how often, where, and at what price?

Always question the reliability of survey results, both statistically and in terms of the validity of the questions and survey responses. Survey design is a role for experts and a topic that goes beyond the scope of this chapter.

5.5.2 Consumer panels

Consumer panels are defined as groups of consumers in specific sectors or segments, typically recruited by professional research companies and agencies, who are used as respondents to answer specific research questions relating to product testing, taste testing or other sensory testing, concept testing, concept sorting, and many other areas. Often, they are a specialist panel who may take part in numerous projects in a category. Consumer panels are particularly useful for short, quick surveys, where the emphasis is on a sample of those with specialized knowledge or selection criteria, rather than a representative sample of the general population. Following from the definition just presented, consumer panels fall into two broad categories:

- Untrained panels representing the attitudes, beliefs, perceptions, and behaviors of the target market. These panels, although not necessarily statistically representative of the target market, can at least provide valuable input to evaluation and design of desired features and functionality into a new product.
- Trained panels comprising individuals who are trained to assess, generally in some quantitative way, the specific attributes of a product. These panels are especially used in formulated products, such as food and cosmetics, where instrumental measurement of sensory characteristics is sometimes difficult. In such cases, trained panels can be invaluable as a means of objective evaluation of changes to product characteristics (for example, taste or texture) resulting from formulation or process changes.

Longitudinal research studies measure attitudes, beliefs, perceptions, and behaviors, provided there is a large enough panel that provides the opportunity to track a number of metrics over longer periods of time (years, even decades).

Advantages of consumer panels for market research:
- Untrained panels provide valuable insights into consumer preferences and suggestions for product improvement.
- Trained panels are invaluable in some industries, such as food and cosmetics, where instrumental measurements are either unavailable or unable to provide the required information.

Disadvantages of consumer panels for market research:
- Untrained panels, although useful as indicators of consumer preference and attitudes, may not be statistically representative of the target market.
- The use of trained panels to provide preference data should be avoided. Their training ceases to make them representative of the target market.

Consumer panels are valuable to product innovation decision-making. Consumer panels, especially in some industries such as food, pharmaceuticals, health and beauty care, and health care, form a very important part of the product innovation process:
- Untrained consumer panels are good indicators of how much a product is liked by consumers and their relative preferences, either with competitor products or among a range of product design options.
- Consumer panels are extremely useful in obtaining ideas for product change or improvement.
- Trained panels can be an instrument for objective measurement, providing the basis for consistent evaluation of specific product characteristics throughout the development process.

Surveys and panels are often used in a number of common quantitative research tests for the specific purposes and stages within product innovation and management.

5.5.3 Concept tests and concept sorts

Concept tests and concept sorts are quantitative research surveys that evaluate customer acceptance of a new product or service idea (referred to as a concept). These tests are used in the early phases of the new product innovation process prior to the development phase. Concept sorts help identify and rank which product concepts are strongest when a variety of options for development exist. Technology has made concept testing easy for participants and more convenient. Participants can complete concept test surveys online, with flexible scheduling, anywhere around the world. Testing and sorting concepts prior to development is more cost-effective at reducing risk and expense prior to incurring the increasingly larger development costs as the process progresses. Proof of concept can be the result of concept testing.

5.5.4 Sensory testing

Sensory testing is a quantitative research method that evaluates products in terms of the human sensory response (sight, taste, smell, touch, hearing) to the products tested. Sensory testing is widely used in consumer products and can be used throughout the new product process to explore concepts in early phases, or test prototypes or validate product performance prior to launch. Well-known examples of sensory testing are taste tests. Difference testing, such as triangle tests, include three samples, including two that are identical and one that is different. A duo-trio test compares two samples to a reference. One of the samples is identical to the reference. Paired comparisons, paired preference, and same/different are also common difference tests. The qualitative side to sensory testing includes collecting the descriptive reactions to each sample and the contextual, articulated difference between samples. Which sample is different and how is it different?

A hedonic test, common in many industries, measures consumer acceptance and satisfaction of the product and its attributes. Many product categories use a common standard for hedonic testing and a common nine-point hedonic scale for measuring the extent consumers like or dislike products in their specific categories. A mean score of seven or higher on the nine-point scale for liking or satisfaction may indicate an acceptable product or new product for that category.

5.5.5 Eye tracking

Eye tracking is a specialized form of sensory testing and uses specialized tools, including connected headsets or goggles, that measure where people look and for how long. The equipment tracks and reports where participants look first, second, third, etc., and provides a visual scan overlaid on an image of the object tested. It is used to answer questions on consumers' reactions to various stimuli, online products and services, websites, apps, images of products, packaging, and messaging. It is widely used in software, retail product packaging, marketing, and advertising.

5.5.6 Biometric feedback

Biometric feedback (biometrics), consumer neuroscience, and neuromarketing research are emerging techniques in market research. Biometric research relies on specialized tools, biometric technologies, and applications to study biological, cognitive, and emotional responses toward various products and services without actually asking questions or interfering with the experience. It uses tools such as functional magnetic resonance imaging, measuring changes to the blood flow in the brain, and can test a range of products and services in a variety of media formats. An example of the deep insight gained from this type of quantitative testing is the NeuroFocus research that earned a Grand Ogilvy award for the successful product marketing campaign based on the link between Cheetos and behavior deviating from social norms — something research respondents were unlikely to admit. Another application is collecting biometric feedback from sensors on shopping cart handles for monitoring consumer biometrics like pulse, temperature, and stress, and comparing against a baseline. In 2018, retail giant Walmart filed a patent application for a system and method for a biometric feedback shopping cart handle.

Some of the tools used in biometric market research are:

- fMRI, which stands for functional magnetic resonance imaging, used to measure the activity in the brain caused by changes in blood flow.
- EEG, electroencephalogram, used to measure brain waves at a subconscious level, facial expressions, tone of voice, product interactions, and reactions toward certain sets of variables or stimuli.
- Heart rate monitoring with an electrocardiograph to observe the heart's responses toward emotional stimuli including fear, relief, and stress.
- Facial coding, a tool used to decode underlying emotion expressed in the form of facial changes and to translate actual versus stated reactions toward products or services.

5.5.7 Crowdsourcing and big data

Over recent years, the power of computing and social media has led to new approaches to market research in product innovation. These include crowdsourcing and big data. These techniques don't fall neatly into the qualitative/quantitative framework. From the perspective of statistical reliability, although a sample may not be statistically selected, the sheer number of respondents in both of these approaches goes a long way to compensating for any lack of formal statistical reliability.

Big data

Big data is described as "a collection of large and complex data from different instruments at all stages of the process which go from acquisition, storage, and sharing, to analysis and visualization." (Pisano et al., 2015)

"The main driver of the interest in big data is the potential usefulness of it for informing marketing decisions," including those across consumer areas such as problem recognition, consumer search, purchase behavior, consumption, post-purchase evaluation, and post-purchase engagement. (Hofacker et al., 2016)

Big data and the big data analytics industry have matured significantly in the last 20 years. The act of gathering and storing large amounts of information for analysis is widely used. The concept gained momentum in the early 2000s when industry analyst Doug Laney articulated the now-mainstream definition of big data as the three Vs (Laney, 2001):

- Volume: Organizations collect data from a variety of sources, including business transactions, social media, and information from sensor or machine-to-machine data. In the past, storing it would have been a problem — but new technologies (such as Hadoop) have eased the burden.
- Velocity: Data stream in at unprecedented speeds and must be dealt with in a timely manner. RFID tags, sensors, and smart metering are driving the need to deal with torrents of data in near-real time.
- Variety: Data come in all types of formats — from structured, numeric data in traditional databases to unstructured text documents, email, video, audio, stock ticker data, and financial transactions.

Zikopoulos et al. (2015) provide a useful analogy with gold mining to explain the meaning and potential of big data:

"In the old days miners could readily spot nuggets or veins (high value per byte data) because they were visible to the naked eye. But there was more gold out there that wasn't readily visible. Trying to find it would have required the mobilization of millions of people.

"Today miners work differently. Gold mining leverages new generation equipment that can process millions of tons of dirt (low value per byte data) to find 'nearly-invisible to the naked eye' strands of gold. And with modern equipment those small strands can be extracted from the mass of dirt and processed into gold bars (high value data).

"Today there is a mass of data, residing in different forms in a range of different locations. The challenge for the future is to locate this data and process it into a form that is useful for a specific purpose."

Projected growth in big data analytics (BDA)

"The worldwide BDA market grew at 24.5% in 2017 vs. 2016, faster than we forecasted in last year's report as a result of better-than-expected public cloud deployment and utilization as well as progress in convergence of tools. Enterprises are moving more rapidly out of the experimentation and proof-of-concept phases to achieving higher levels of business value from their big data deployments.

"Looking forward, the overall BDA market will grow at an 11% compounded annual growth rate (CAGR) to $103B by 2027. Edge computing — including streaming and [machine learning] ML app deployments on smart devices — will boost the market in the out years." (Kobielus, Finos, Gilbert, 2018)

Advantages of big data for market research:

- Big data is cost-effective and improves indirect customer involvement.
- Big data enables managers to capture customers' explicit and implicit knowledge.
- It can be applied to any phase of product innovation.
- Data capture is in real time and can be generated much faster than traditional studies.
- It can refocus attention away from internal product-focused innovation and turns attention to innovation around the customer experience.

Disadvantages of big data for market research:

- Role of big data in the NPD process is directly affected by how data-driven the organization is overall.
- To organize and manage big data successfully, organizations need to have established innovation ecosystems and build data alliances with stakeholders, including partners, suppliers, and other entities with common interests.
- Stimulating and mining customer interaction via public software platforms generates data that can also be mined by competition.

Some additional examples of how big data supports NPD are capturing comparative search frequencies, keywords, #hashtag, opinion mining, sentiment analysis, emotions analysis, product reviews, brand monitoring, mentions, trending, and concept extraction.

Crowdsourcing

Crowdsourcing is described as the practice and use of a collection of tools for obtaining information, goods, services, ideas, funding, or other input into a specific task or project from a large and relatively open group of people, either paid or unpaid, most commonly via technology platforms, social media channels, or the Internet. Many companies and organizations also use their own websites as a means of crowdsourcing new product ideas.

Lego

Lego has a dedicated website and online community for close to one million users (2018) for fans and customers to contribute their own product ideas. The platform, Lego Ideas, motivates and incentivizes participation by allowing users to vote for their favorite idea, state how much they would pay for it, and explain why they like it so much. If more than 10,000 people support the idea then it goes to the official Lego review board, which decides whether or not to put it into production. The creator even receives name recognition on the product package and a 1 percent royalty on worldwide sales if the idea is commercialized. https://ideas.lego.com/

Anheuser-Busch

In 2012, Anheuser-Busch ran a crowdsourcing project to create a new beer. It varied slightly from the typical consumer-led crowdsourcing projects as the initial recipes were created during a competition involving the brewmasters at Budweiser's 12 breweries. However, more than 25,000 consumers were involved in the subsequent taste tests to decide the winning brew, so the wisdom of the crowd was involved at some point during the development process. The Black Crown variety came from the recipe created by the Los Angeles brewery and went on sale in 2013.

When using crowdsourcing for open innovation and product innovation, it is important to familiarize oneself with, and consider the effect of, reciprocal voting that can occur in Open Innovation environments and that may distort value of research results. It is important to use other inputs in addition to crowdsourcing to validate and successfully incorporate the crowdsourcing input into the new product process.

5.6 MULTIVARIATE RESEARCH METHODS

There are many options and variables to consider when developing new products. Multivariate research, testing, and analysis is used in product innovation and management to explore the relationship that exists between the numerous variables that impact new product success. In this type of research, a dependent variable is examined in association with one or more predictor or independent variables. Multivariate methods provide a more accurate view of the interactions, correlations, and tradeoffs that play out when looking at the possible ranges of product and market attributes and characteristics. It can point out which variables, attributes, and characteristics are highly correlated and can detect potential problems and risk to the product value proposition when decisions around choices need to be made.

A wide range of multivariate techniques can be applied to product innovation. Most of these require a sound understanding of statistics and the support of an expert. While they involve more complex design and analysis, they provide the potential to gain deeper and valuable customer insights.

Several multivariate techniques used in product innovation management are briefly outlined below.

5.6.1 Factor analysis

The main applications of factor analytical techniques are to reduce the number of variables and to detect structure in the relationships between variables. In product innovation, factor analysis can be applied to the prioritization and grouping of key variables as they relate to some particular issue of interest, for example:

- Product features, their relationship and impact on product preference.
- Relationships among products in the marketplace, showing those products that are perceived in common by consumers.

5.6.2 Multidimensional scaling

Multidimensional scaling (MDS) provides a means of visualizing, or mapping, the level of similarity of individual cases of a dataset. It is particularly useful in visually representing products that are perceived as similar by consumers. The distribution of products in multidimensional space can provide an indication as to the product dimensions considered important by consumers. It also provides an indication as to where gaps exist in the current product offering.

The basic MDS process is as follows:

1. Select the objects to be researched. An example is products within a specific product category, with a view to developing and launching a new product in this category.
2. Make a list of all possible paired combinations of the existing products. Techniques are available to reduce the number of pairs if the list becomes too long.
3. Ask a sample of the target market to rate the similarity or substitutability of products in each pair. A sample size of 30-50 is common.
4. Analyze the paired comparison scores using MDS software to generate a visual map representing the relationships among the products.

The dimensions of this visual map represent the bundles of key attributes that are important to consumers in their decision on similarity or substitutability. Usually the number of dimensions is kept to two or three for simplicity of communication. See Figure 5.1.

  |

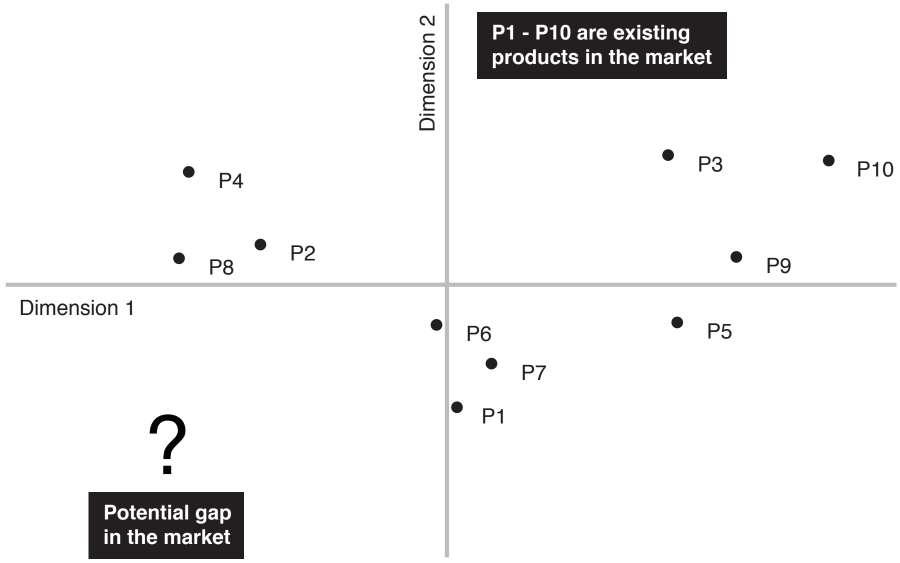


Figure 5.1 Multidimensional scaling example

5.6.3 Conjoint analysis

Conjoint analysis is a multivariate statistical technique used in product innovation to determine how people value different attributes (features, functions, benefits) that make up an individual product or service. The objective of conjoint analysis is to determine what combination of a limited number of attributes is most influential on respondent choice or decision making. The basic conjoint analysis process is as follows:

1. Potential attributes of the new product are defined with different levels or features of these attributes (e.g., battery life of 1 day, 5 days, 10 days).
2. The different levels or ranges of attributes are set randomly into combinations.
3. A sample of consumers (usually 30-50) is asked to rate the different combinations of attributes.
4. Results are analyzed to identify the most influential attributes in consumer decision-making.

Conjoint analysis example

Figure 5.2 presents an example based on the development of a cell phone plan. It shows how combinations of attributes can be presented to customers for their preference rating. Even in this example with six different attributes at three levels, the complete number of combinations is very large. Techniques are available to reduce this number of combinations to make the process more manageable for consumers.

	Standard Plan	Premium Plan	Ultra Plan
4G Unlimited data	4G speed below 25 GB/month	4G speed below 75 GB/month	Unlimited 4G
Unlimited talk & text	✓	✓	✓
Mobile hotspot data	15 GB at 4G	20 GB at 4G	Unlimited 4G
Cloud storage	-	200 GB	500 GB
Video resolution	480p	720p	720p
Apple® Music	-	6 months	Unlimited
Cost	$60	$100	$120

Figure 5.2 Conjoint analysis example — cell phone plans

5.6.4 A/B testing

A/B testing is a form of multivariate research designed to test and compare two samples or variables — where other forms of multivariate testing, such as conjoint analysis, involve two or more variations and variables. The majority of A/B testing is executed online and widely used in web development and digital marketing to determine which of two variants is more effective. Other multivariate tests eliminate the need to run sequential A/B tests on separate variables with the same goal. In A/B testing, sample size for the study is split equally testing each variable. For multivariate tests, larger samples may be required, depending the number of variables being tested.

For software and web development, drivers for using A/B testing over multivariate testing are the amount of time and traffic required, depth of insights desired, and perhaps the maturity of the product or concept. An A/B test may not be appropriate to obtain deep insights on a new-to-the-world concept.

A/B test example

If it is known that one or more of the variables being tested do not have a measurable or significant effect on the desired outcome, it may be more effective to conduct an A/B test. For instance, if the placement of the main image on a landing page does not affect conversion, and changes to the headline or call-to-action statement do, an effective approach may be to run an A/B test on the headline rather than a multivariate test that includes image placement.

5.6.5 Multiple regression analysis

Multiple regression analysis is often used in product innovation to analyze survey-based data. It provides detailed insight that can be applied to new products or improve products or services when there are any number of factors, key drivers, and product attributes that can impact the product's value proposition from the customer's point of view. It is used more often than simple linear regression in product innovation due to the number of factors that can impact new product success. It can be used to identify which variables have an impact on the topic of interest and is used to predict the value of a variable based on the known value of two or more other variables (predictors). In the analysis, the results are often plotted on an axis that displays the relationship between the data sets. Multiple regression analysis is widely used to predict, optimize, support, or validate decisions, avoid risk or prevent mistakes, and provide new insight into unarticulated relationships in the product variables being studied.

5.6.6 Total Unduplicated Reach and Frequency (TURF) analysis

Total Unduplicated Reach and Frequency (TURF) analysis has its roots in media scheduling and is used in product innovation and product management to understand and maximize the market potential of product lines and product platforms, especially when multiple choices and repeat purchases are involved over a product's life cycle. The analysis is used to assess and optimize the combination of products in the offering, taking into consideration the frequency of purchases and appealing to the greatest number of customers.

TURF analysis example

After a concept test and sort, a beverage company looking to introduce a new line of flavored waters has developed recipes for ten different trending flavor varieties. The company conducts a TURF analysis that gives results indicating the top five flavors that contribute to 83 percent of targeted consumer reach. The results indicate that these five varieties in the product line launch would optimize purchase and minimize cannibalization of other flavors and help direct the product manager to continue development of these top flavors that appeal to the largest number of customers with the highest repeat purchase intent.

To summarize the value of multivariate analysis to product innovation decision-making: multivariate techniques, although somewhat complex to apply, do provide a useful approach to understanding the consumer and the market:

- What opportunities are out there? Multivariate techniques are useful in understanding relationships among product attributes and current product offerings, and identifying gaps in that market.
- What do consumers need? Multivariate techniques provide the opportunity to identify unrecognized or unarticulated needs and get to the subconscious of the customer. Techniques ask for information indirectly rather than directly, e.g., through product similarity or substitutability comparison.

5.7 PRODUCT USE TESTING

Product use testing measures the performance of a product under specific conditions replicating actual consumption, operation, manipulation, or handling. Quantitative product use testing is expensive due to the number of prototypes needed to produce statistically reliable results.

When the product is utilized or consumed and tested in the participant's home setting, the test is commonly referred to as an in-home use test (IHUT) or home-usage test (HUT). An IHUT is especially useful when the product is used frequently, two or more times per week, or if the product is a food, beverage, or grooming product and can be consumed during different use occasions or in different recipes. It is also useful if the usage is a sensitive or private situation. An IHUT is also useful to track satisfaction over a period of time. Product is shipped to participants, who log their usage experiences and responses into online software. Product use in the home or other intended use environment is important to the reliability of research results.

Product use testing is different than test marketing (brand new product in the market) and market testing (existing product in new market) and focuses on the product meeting consumer needs and requirements prior to launching the product in the market. Product use testing and test marketing are effective research methods after development and prior to product launch.

Market testing is done after the new product's performance has been validated as a viable solution for the user and tests distribution, merchandising, and retail conditions for the product in a new market for market expansion. Test marketing is discussed later in this chapter.

5.7.1 Alpha, beta, and gamma testing

Alpha, beta, and gamma testing is a form of market research primarily used in the software or technology industry to test a new product during development and just prior to launch. This form of market research may not be strictly quantitative in the sense of providing a specific level of statistical confidence due to the lack of statistically based sample selection. It does, however, provide the level of detailed feedback that only comes from customer use of the product in its final, or near to final form and functionality.

Alpha testing

Alpha testing is a form of usability testing, which is normally done by in-house developers. On rare occasions, alpha testing is done by the client or an outsider. Once the alpha testing version is released, it's then called the alpha release.

Beta testing

Beta testing is done by a number of the end users before product delivery. The users give feedback or report defects, change requests are made and fixed prior to full product launch. The version release after beta testing is called beta release. Beta testing can be considered pre-release testing. Beta test versions of software are now distributed to a wide audience partly to give the program a real-world test and partly to provide a preview of the next release. The main objective behind beta testing is to get feedback from different groups of customers and check the compatibility of the product in different kinds of networks and hardware.

Gamma testing

Gamma testing (or a gamma check) is performed when the application is in its final state and ready for release to the specified requirements. This check is performed directly without going through all the in-house testing activities. The test may be a limited release to a small number of users or only test a limited number of specifications. No feature development or enhancement of the software is planned or undertaken as a result of this test, and only tightly scoped bug fixes are written at this stage. Gamma testing is less common, as greater pressure has been imposed on cycle-time reduction and speed to market.

5.7.2 Virtual and augmented reality

Virtual reality (VR) testing is a growing segment of the market research field and conducted using specialized equipment including a headset and/or gloves with tracking sensors that create three-dimensional (3D) simulations and enable participants to interact in a realistic environment.

VR is used in conjunction with tools already used in market research, such as eye tracking and consumer behavior analysis market environment simulations. VR allows companies to perform product use testing without developing actual prototypes, and as a result, minimizing large financial risks. It also enables researchers to observe and examine consumer behavior without costly trials in the marketplace.

Augmented reality (AR) is similar to VR. Whereas VR replaces the participant's real world with an entirely separate reality, AR overlays elements of a new reality into the participant's present environment. AR is sometimes referred to as mixed reality and has the added convenience that it can be viewed and interacted with on device screens such as computers, displays, tablets, phones, and watches.

VR and AR platforms are already currently used by companies like Coca-Cola, Heineken, and Nike in their social channels and networks, and in the broadcasting of large commercial sporting and entertainment events, promoting immersive experiences. These are the same platforms that allow researchers and developers to gain in-depth insight by offering an immersive experience with a high level of interaction, key elements for market research. A 2016 Goldman Sachs Global Investment Research study estimated that by 2025, the virtual reality market will be about $35 billion for games, events, health, engineering, and entertainment video markets.

5.8 TEST MARKETING AND MARKET TESTING

Market testing in its most general definition covers the research methods for all products, new or existing, tested under in-market conditions for the purpose of reducing the risks of launch or expansion failure, and includes test marketing methods. Where test markets focus on reducing risks for new product launches, market testing can also be defined more narrowly to mean testing the expansion of an existing product to a new market for the purpose of reducing the risk of a failed expansion strategy.

In this more-narrow sense, market testing describes the methods for studying the controlled expansion of an existing product in a new market, market segment, or new use case that it had previously not been introduced. This includes, and is not limited to, testing new target users, geographies, demographics, or any new market attribute that was not a target in the initial product launch. Market testing is used to measure and check the market potential of the product expansion in the new or different market, in terms of acceptance, sales, marketing program effectiveness, messaging, positioning, and more.

In summary, market testing is used to reduce the risk of a market expansion strategy that looks to expand the product's market size by focusing on different segments of consumers. The approaches to market testing are similar to test marketing and can include sales wave research, simulated market tests, and controlled market tests.

Sales wave research
Customers who are initially offered the product at no cost are re-offered it, or a competitor's product, at slightly reduced prices. The offer may be made as many as five times. The number of customers continuing to select the product and their level of satisfaction are recorded.

Simulated test marketing
Thirty to forty customers are selected and surveyed on their brand familiarity and preferences in a specific product category. These customers are exposed to promotional material related to the product. They are then provided with a small amount of money and invited to a store where they may buy any items. This approach is designed to measure the effectiveness of the promotional material.

Controlled test marketing
A panel of stores is selected to stock the new product under real market conditions. Shelf position and number of facings are controlled, and sales are measured at checkout. A sample of customers is later interviewed or surveyed to give feedback on the product.

Advantages of test marketing:
- It provides information that significantly increases the probability of making the correct decision when expanding the product to the new market.
- It significantly reduces the probability of wasted capital and other expenditures on an unsuccessful market expansion.
- All elements of the distribution and marketing plan can be tested and validated.
- Data can be used to improve sales forecasting for full launch.

Disadvantages of test marketing:
- It is time-consuming and expensive.
- It delays full expansion launches.
- It provides competitors with an early insight into potential market plans and allows them more time to launch a competitive response.

5.9 MARKET RESEARCH AT SPECIFIC STAGES OF PRODUCT INNOVATION

New product development and innovation typically involve research and testing at each stage of the development process prior to moving to the next stage. Plan on using a number and variety of market research methods over the course of the product innovation project from pre-concept discovery research on the front end, to concept testing, product use testing, test marketing, to market testing and more throughout the product life cycle. Each method has its advantages and no one tool or method is able to answer all questions. It is also important to understand which methods explore and discover insights, and which methods confirm and validate, or narrow possibilities and eliminate options. Let the project decisions that need to be made at each stage dictate the research methods and tools required.

The following outlines some market research methods best suited to each stage.

Pre-concept stage (opportunity identification and evaluation)
This phase is often called the front end of innovation or the discovery phase. Opportunities may come in the form of totally new products, modifications or improvements to existing products, or line extensions to existing product lines or platforms. The primary focus is identifying these opportunities and early-stage evaluation of their potential. Various forms of primary and secondary qualitative market research methods are well suited.

Secondary methods provide good sources of new ideas, including: Internet search, trade fairs, trade journals, patents, suppliers, social media channels, and government and trade statistics.

Primary qualitative methods are useful, including:
- Focus groups involving customers or other stakeholders, distribution channel members, sales force representatives, organization staff.
- Social media sites, both general social media sites and specific discussion forums and blogs.
- Customer site visits, particularly for B2B product innovation.
- Ethnography for identifying unarticulated needs that can lead to product ideas.
- Multivariate analyses for identifying gaps in the current market offerings or in identifying the underlying attributes that are valued by customers and which can be formed into the new product concept.

Evaluating ideas and early stage business analysis
During this stage the key market information required relates to market size and sales potential, competitor and competitor products, target market characteristics, and the price the customer is likely to pay. This information provides the basis for early-stage financial analysis (discussed in Chapter 7).

Secondary research can provide some general information on aspects of the target market, sales potential, and competitive landscape.

Primary research methods include focus groups, interviews, and non-statistically based surveys to provide more specific information. Brainstorming, ideation, initial concept tests, and concept sorts can be helpful in translating and ranking ideas and solutions into the strongest ideas to funnel into concepts for further development.

Concept development and testing
During this stage, a more detailed concept description is sought, leading to product design specifications (refer to section 5.5.3). Customer and other stakeholder input are required to identify the key benefits, attributes, and functionality desired in the product.

Primary qualitative research methods — including focus groups, lead-user groups, online discussion forums, customer site visits, surveys, concept testing and concept sorts, sensory testing, recipe formation and testing, and specific multivariate techniques such as conjoint analysis and TURF analysis — are particularly useful at this stage.

Secondary research into competitive solutions includes various online sources and intellectual property databases for existing patents and trademarks. More detailed and robust secondary research on market potential and the business case is important to justify the increasing cost of development in the next stage.

Prototype development and product use testing

During this stage, the concept is taking physical form with possible functionality. Project costs are starting to rise significantly, and it is increasingly important to make the right decisions regarding product benefits, form, and function. The availability of samples or prototypes that display form and possibly function provide a far better basis for seeking customer feedback than the concept description (words and images) used to describe the product in the previous stage. Demonstration of the prototype during research will certainly add significantly to customer understanding of the product and, in turn, results in more valuable and reliable feedback.

At this stage, accuracy and reliability of information become more and more important. Consideration should be given to primary quantitative research including surveys, alpha testing, and consumer panels, complemented with focus groups and customer site visits. Virtual reality, 3D prototype models or visuals, images, and video are useful as stimuli for research when building iterative physical prototypes are cost prohibitive.

Pre-launch product and market testing

At this stage, the product is developed and manufactured to its final commercial form and functionality. Next comes the most expensive step of full product launch. Although obtaining the most reliable information to avoid product failure is a critical consideration, this often has to be balanced against the need for speed to market and the cost of testing. If speed to market is an absolute priority, or the risk of product failure is relatively low, then a beta test or full launch may be appropriate. Where there is significant potential for damage to a brand or financial loss, then a test market may be justified.

Post-launch product testing and market research

Once the product is launched and throughout its life cycle, market research often plays an important role in determining its performance and success. Market research provides information for decision making around line extensions, market expansion, and understanding competitive response. Some examples include the use of customer panels or lead user groups that provide answers to specific time-sensitive questions or longitudinal studies over a product's lifetime, competitive benchmarking and tear-down analysis, B2B customer satisfaction surveys, etc.

Many companies purchase syndicated industry data, scan-track data, or participate in industry studies to learn more about their customers, markets, and market share over time. Conjoint or TURF analysis are some of the research methods that may be used for adding features or varieties to a product line once launched. Data on the potential for line extensions, feature enhancements, market or distribution expansions may be required, and research methods are the same as, or similar to, new products research by stage, starting with identifying the opportunity and building a business case.

A summary of market research methods by stage of the product innovation process is provided in Figure 5.3.

Development Stage	Market information required	Level of risk	
Opportunity identification	Source of ideas - new or product improvement Information on a specific market - their needs and desired benefits	Relatively low. Project costs are low and no commitment to capital. Proceeding to the next stage of concept evaluation should not be costly with limited commitment to resource and project continuation.	Mainly qualitative: • Secondary research • Social media • Focus groups • Customer site visit • Lead user groups • Ethnography • Multivariate tools
Opportunity evaluation	Does an opportunity have market potential. Who is the target market and how large is the market. Information required for an early stage financial analysis.	Relatively low, but at this stage you are heading down the road to project commitment where costs and project risks can rise rapidly.	Qualitative with some attempt to quantify: • Secondary research • Focus groups • Customer site visits • Surveys - face to face or on line
Concept development	Evolving the initial idea into a more detailed concept description. Relating user needs to product attributes functionality and, in turn product design specifications	Low to medium. But a commitment at this stage leads to much higher financial commitment in more extensive design and prototyping.	Mainly qualitative: • Focus groups • Lead users • On-line discussion forums • Customer site visit
Prototyping and product testing	Input from the target market on preferences and product improvements is required in developing form and functionality that us starting to represent the final product. Also information that can provide more confidence in the financial analysis and the business case for commercialization.	Medium to high. A commitment at this stage is leading to potential capital investment and high costs of final commercialization.	Qualitative with some attempt to quantify: • Secondary research • Focus groups • Customer site visits • Surveys - face to face or on line
Pre-launch testing	Information is required from the target market on product acceptance (possibly relative to competitors), sales potential, pricing. All required to firm up on the business case for commercialization.	High. Potential for high capital investment of cost of commercialization. The trade off between uncertainty leading to product failure and the pressure for speed to marker must be considered.	Qualitative: • Beta testing • Market testing
Post-launch and life cycle management	Information determining product success and measuring distribution, sales, market share, demand, competitive response, customer user satisfaction are required. Data on the potential for line extensions, feature enhancements, market or distribution expansion may be required, and research methods are the same as, or similar to, new products research by stage starting with identifying the opportunity	High. Commitment of ongoing human and operational resources are required to launch and ,maintain products in market. Firms risk long-term financial sustainability by ignoring changing consumer needs, demand and competitive landscape.	Qualitative: • Primary sales, distribution data • Syndication data • Longitudinal and satisfaction surveys • Secondary research • Industry data • Economic and consumer trends • Competitive analysis • Social media analysis

Figure 5.3 Market research metrics and key performance indicators

5.10 MARKET RESEARCH METRICS AND KEY PERFORMANCE INDICATORS

While primary research is designed to help answer unique and specific questions that guide product innovation and management decisions, there are also a number of common metrics used in market research for product innovation, development, and product life cycle management that measure, monitor, analyze, and present results in a comparable and efficient way to track product success. These common measures are ubiquitous across industries and categories and provide a core set of transferable measurements across businesses.

The following are common product innovation and management research metrics with a brief and basic description of what is measured:

Acquisition effort – The extent to which your product or service is accessible to your customer.

Awareness – Product and brand (aided and unaided); the extent to which customers are familiar with your product or brand.

Brand development index – Sales of your brand compared with its average performance in all markets.

Brand image – How customers think and feel about your product and brand.

Convenience – The extent to which your product or service makes your customer's life easier, saves time or effort, etc.

Customer attitudes – The extent to which your customers have a favorable or unfavorable attitude toward your product or service.

Distribution – The extent to which your product is available in the market.

Ease of use – The extent to which your product or service is simple to operate, consume, engage, or interact with.

Engagement – The extent to which your customers interact in a relationship with your company, brand, product, or service.

Installed base – The number of units of sale that are actually in use over a particular time frame.

Market penetration – The percentage of your target market that have you have reached at least once in specific period of time.

Market share – The percentage of the total market held by your company, brand, product, etc.

Market size – A measure of the total market potential (in terms of sales, profit, number of potential buyers, units sold, volume, etc.) for a company, product, or service.

Net promoter score – The likelihood someone would recommend your product or service to a friend.

Percent of all commodity volume (%ACV) – The percentage of the total annual sales volume aggregated from all retailers where your product can be sold.

Pride (to own, to serve) – The extent to which your product or service contributes to a positive sense of self for your customer.

Satisfaction – The extent to which your product or service meets the needs of your customer.

Usage and purchase intent – The extent to which someone says they will use or purchase your product or service.

Willingness to pay – The highest price a customer says they will definitely buy your product or service.

5.11 IN SUMMARY

- Market research includes a range of techniques that are essential to product developers and managers for gathering market information in the effort to improve decision-making throughout the new product innovation process and the product life cycle.
- A broad range of market research techniques provide varying levels of quality and reliability of information. It is important to recognize the costs and risks associated with a specific decision and select a technique appropriate to these costs and risks.
- The two basic categories of market research are primary, original research conducted by an organization (or someone they hire) specifically for their objectives, and secondary research that involves searching for existing data originally collected by someone else.
- Generally speaking, techniques that are founded on some form of statistical sampling provide greater reliability and confidence in the information. These are referred to as quantitative techniques. Those techniques that provide mainly descriptive information without any prescribed level of statistical reliability are referred to as qualitative.
- Ongoing application of market research throughout the new product innovation process significantly increases the chances of product success. Specific techniques are more appropriate at different stages of the process.
- Technology has advanced access to and reliability of newer techniques such as crowdsourcing and big data. These are now common sources of information and are increasingly better at statistical sample selection. They provide large volumes of data that can often compensate for the lack of statistical reliability.

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Practice questions: Market research

1. A product manager reviewed technical publications, electronic databases, and websites prior to designing a research project that directly contacts prospective customers. This review of already-published materials is an example of:
   A. Market testing.
   B. Voice of the customer.
   C. Portfolio management.
   D. Secondary market research.

2. During new product development, companies often use ______ to measure end user satisfaction with a product and to determine whether the company can deliver the total quality product as promised.
   A. Lead user research.
   B. Product use testing.
   C. Secondary research.
   D. Quality function deployment.

3. You are responsible for validating the value proposition of adding a number of new features to your current product line. A way to explore the association between adding one or more new features and the perceived value to the user would be to:
   A. Color code the feature sets so that they are easily identified by the user.
   B. Add fake sets of features to see if respondents identify the actual product features.
   C. Run a volumetric study of the most profitable product prototype to forecast sales.
   D. Conduct a conjoint study varying feature sets and price points to optimize the new feature set and product price.

4. Factor analysis, cluster analysis, multidimensional scaling, conjoint analysis, and multiple regression analysis are examples of _____.
   A. Qualitative research techniques.
   B. Multivariate research techniques.
   C. Voice of customer techniques.
   D. Ethnographic research techniques.

5. Information gathered by other researchers for other purposes, the fit between research method and research purpose, unknown sample size, varying levels of quality, and dated information are all pitfalls of which type(s) of market research?
   A. Survey research.
   B. Voice of the customer.
   C. Secondary market research.
   D. All of the above.

6. A software company is developing an update to a specific app for online shopping. The company has extensive experience with its target market through previous product launches. Even if there are minor faults with the app, these can be quickly remedied after launch without significant negative customer response. Speed to market is critical. The company is seeking customer reaction to the improved features and functionality of the new app. What market research approach would you recommend?
   A. Focus groups.
   B. In-house alpha testing followed by beta testing.
   C. Test marketing.
   D. Factor analysis.

7. Research that involves collecting information specifically tailored to your needs (such as focus groups or surveys) is known as _____.
   A. Primary research.
   B. Secondary research.
   C. Qualitative research.
   D. Quantitative research.

8. The primary benefit of a focus group in marketing research is _____.
   A. The ability to develop broad insights.
   B. Low cost.
   C. Ease of execution.
   D. Deep insights.

9. A toy manufacturing company is developing a “powered vehicle” for 10-12-year-old children.
   Potential risks: The company has extensive experience in the toy market, but mainly with under 5-year-olds. The main risks associated with the project relate to a lack of previous engagement with the 10-12-year group, and meeting their specific requirements. Getting the product right is more important than speed to market.
   Market information required: Target market input to the concept development and design specifications.
   What market research technique would you recommend?
   A. Consumer panels selected from the target age group.
   B. Alpha testing.
   C. Ethical approval followed by consumer panels from the target age group.
   D. Crowdsourcing.

10. Social media is particularly good for reaching __________.
   A. Potential new customers.
   B. Lead users.
   C. Customers in foreign markets.
   D. Those needing customer service.

Answers to practice questions

1. D	6. B
2. B	7. A
3. D	8. D
4. B	9. C
5. C	10. B

6

CULTURE, TEAMS, AND LEADERSHIP

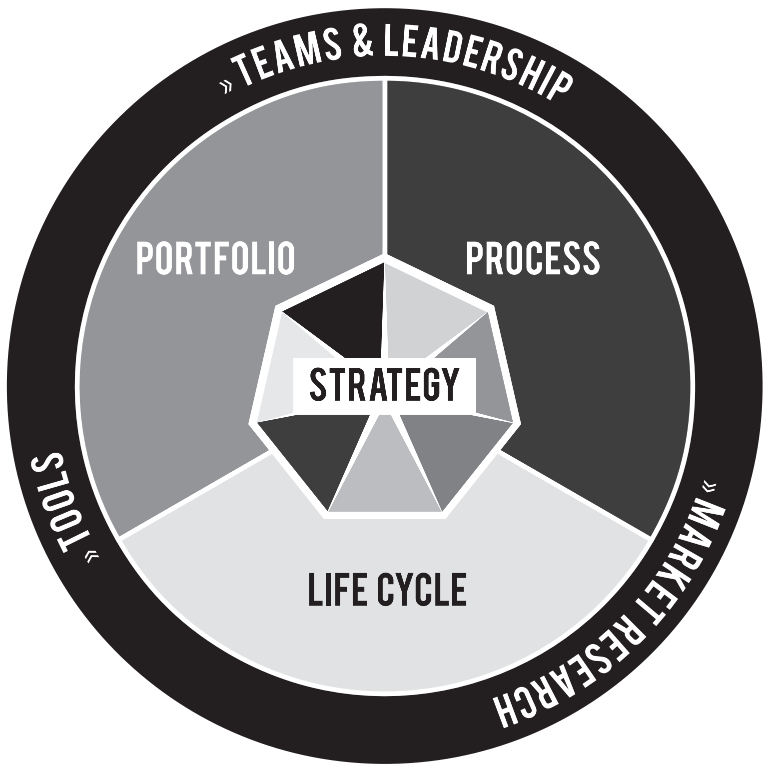
Essential to forming and maintaining an innovative environment that enables, encourages, and rewards product innovation processes and practices

6. Culture, Teams, and Leadership

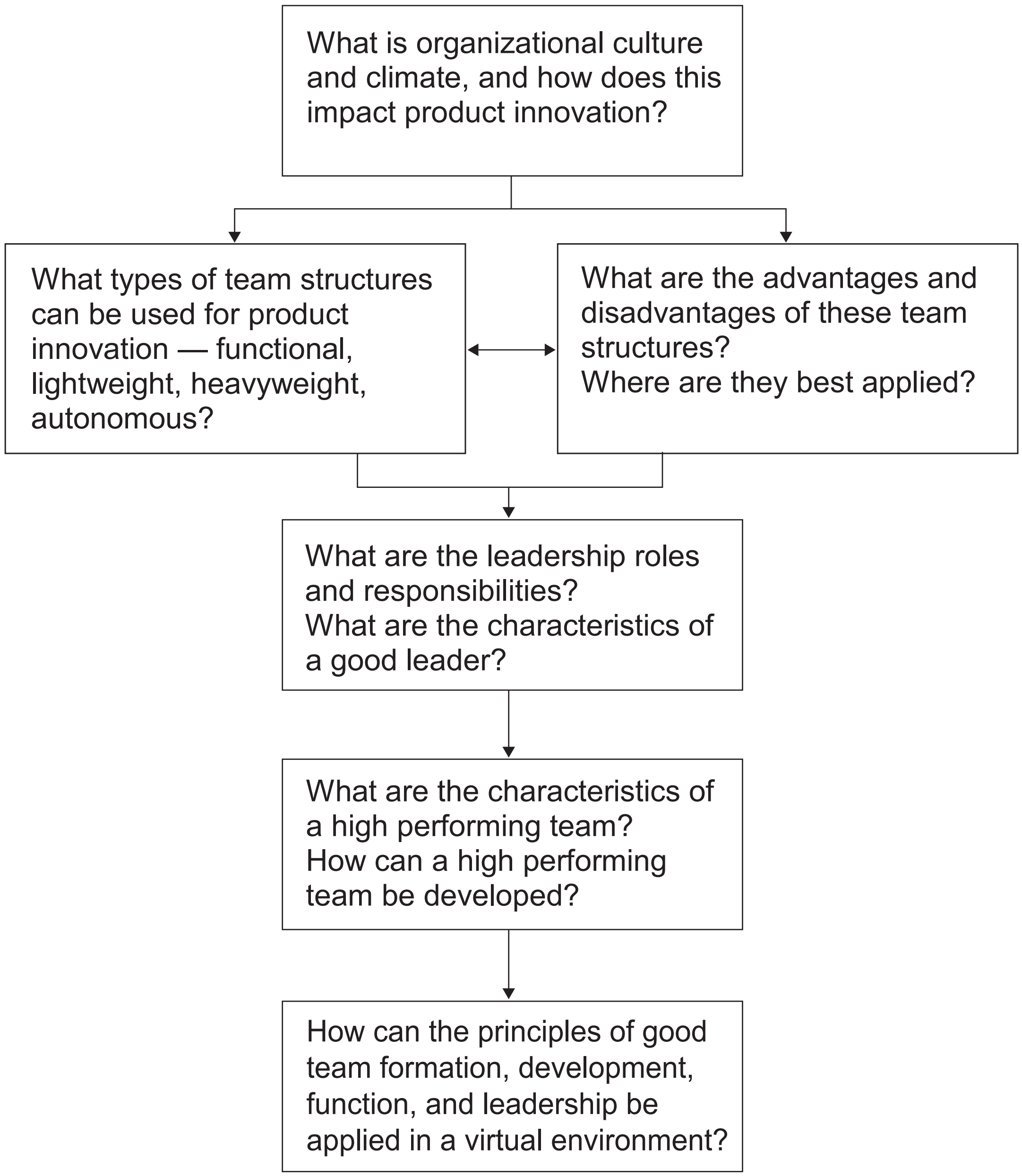
THE CONTENT

What you will learn in this chapter

While strategies, processes, and tools are important for product innovation success, ultimately it is people that really matter. In this chapter, we discuss the importance of developing the right culture of innovation; the roles and responsibilities of management; what is required to achieve a high performing team, team development, and team leadership; and what team structures are appropriate in specific situations.



The Chapter Roadmap



While strategy, process, and the application of appropriate tools are essential to product innovation, these alone will not lead to the sustained success of the organization. People are ultimately what make an organization successful. It is the culture, teams, and leadership that ultimately provide the framework within which the strategy and process can be positively and successfully implemented.

6.1 INNOVATION CULTURE AND CLIMATE

Culture is the common set of shared beliefs, core values, behaviors, and expectations of the people within an organization. Generally, culture:

- Reflects the organization's values;
- Is observed in customs, ceremonies, and rites;
- Determines how work is accomplished; and
- Expresses an organization's long-term sustainability.

Culture is unstated but is observed as a common set of behaviors in activities by which an organization is identified. In contrast, climate is a localized set of characteristics in a specific work environment. Employee behavior is strongly influenced by perceptions of the team climate in which they carry out daily tasks and activities. Elements of a team climate include:

- Leadership quality,
- Frequency and type of communication,
- Task responsibility,
- Trust and autonomy,
- Recognition and rewards,
- Opportunity for advancement, and
- Employee engagement.

Successful organizations understand the importance of establishing a culture and climate of innovation. Leading organizations establish successful innovation environments for employees and team members by:

- Communicating clear strategic goals;
- Building diverse, customer-focused teams;
- Supporting experimentation;
- Providing opportunities for collaboration and networking; and
- Developing talent and organizational capabilities.

6.1.1 PDMA research findings

PDMA's periodic CPAS studies provide evidence for the importance of culture and climate in successful innovation (Markham & Lee, 2013). However, culture is a unique trait at each organization and varies across industries and companies. What works for one firm cannot necessarily be duplicated in another because each organization's new product innovation is driven by separate vision, mission, and strategic objectives. Unfortunately, many organizations fail to establish a thriving innovation culture leading to unsustainable growth with product innovation. For example, a recent study of 150 American companies demonstrated widespread gaps between employee views of their work environment and engaging, creative innovation team climates (Denning, 2015).

- Only 5% of survey respondents felt highly motivated to innovate,
- More than 75% reported their ideas were poorly reviewed and analyzed,
- One in seven (16%) did not believe intellectual property was viewed a critical business function, and
- Nearly half (49%) felt they would not receive any recognition or benefit for developing successful ideas.

Common culture and climate factors that lead to successful innovation include:

1. Strategic and innovation goals are clearly communicated across all levels of the organization.
2. Reasonable failures are accepted as learning opportunities and are not punished.
3. Individual and team performance are appropriately recognized and rewarded in support of innovation goals.
4. Hiring decisions include both functional capability as well as fit with the innovation culture of the organization.
5. Internal and external communications are clear and consistent.
6. Constructive conflict is encouraged to support idea generation and problem solving.
7. Work is engaging and leaders encourage both professional and personal growth.

6.2 MANAGEMENT RESPONSIBILITIES

In this section, the roles of management are discussed with respect to several areas crucial to successful new product innovation. These include:

- Strategy,
- Product innovation processes,
- Organization and teams, and
- The product itself.

It is important to recognize that specific job titles and role allocations vary from organization to organization and industry to industry.

6.2.1 Product innovation strategy roles

As indicated in Chapter 1, overall corporate vision and mission is determined by a corporate executive team. A typical executive team includes senior representatives from key corporate functions, such as finance, marketing, manufacturing, and technology. A company's board of directors may be directly or indirectly associated with the executive team with the CEO (chief executive officer) linking the two groups.

Business strategy is developed by the executive team of a specific business unit, led by the senior member of the business unit. This person may, for example, have a title such as "VP of Operations" or "VP of Business A."

In contrast, **innovation strategy** is developed by a cross-functional team of senior managers, normally led by a senior executive, such as the CEO, chief technology officer (CTO), chief innovation officer (CIO), or VP of innovation. Senior management ensure alignment of the innovation strategy with the overall business strategy and coordinate with the associated functional strategies. In this way, innovation is integrated consistently across organizational objectives. As indicated in Chapter 2, active product innovation projects are assigned to product innovation teams only when the individual project goals align with the organization's strategy and there are adequate resources available to work the project.

Functional strategies, including marketing, manufacturing, procurement, and finance are developed by the functional leader and a senior team from the specific functional area. Normally, goals are implemented by these functional leaders to support the implementation of higher-level strategies and to achieve tactical objectives.

Product strategy will normally be developed by the senior product manager, such as the VP of product management, and the appropriate business unit. Whereas the overall business and innovation strategies may change very little on an annual basis, product strategies reflect changing trends and market opportunities. The product strategy includes life cycle management and product or brand management of individual products and platforms (see Chapter 7).

These strategies are linked in a hierarchy as shown in Figure 6.1.

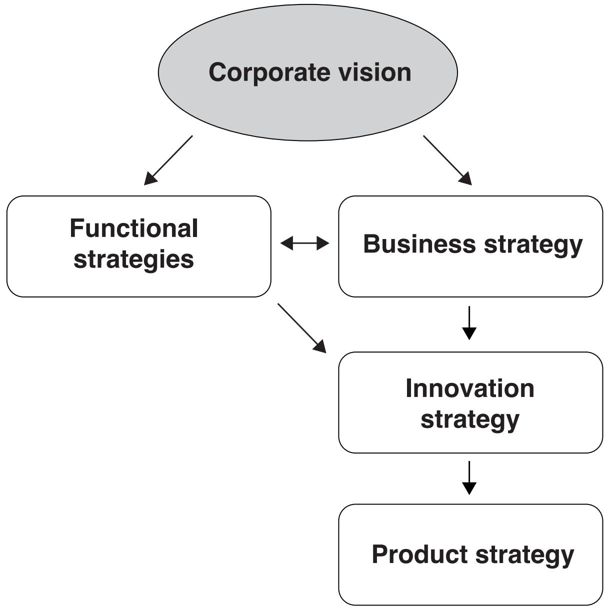


Figure 6.1 Strategic management

6.2.2 Product innovation process roles

Organizations that successfully launch repeatable innovations typically include several specific management roles. In some cases, these innovation leaders have designated titles, while in many organizations these roles are filled by business or functional leaders. In particular, titles and designations vary depending on the project management methodology (e.g., conventional waterfall processes versus emerging Agile systems as discussed in Chapter 3).

First, the **process champion** is a senior executive responsible for establishing the new product innovation process. A process champion works to ensure quality and consistency of implementation of product innovation processes. Training of new staff members and talent development to support innovation also fall within the responsibility of the process champion. Note that facilitation of product innovation processes and training may be delegated to the process owner or other functional managers.

The **process owner** is typically a senior manager responsible for the strategic results of the organization's innovation programs. This includes innovation strategy alignment activities, product innovation process throughput, quality of process outputs, and active participation by all levels of employees across the organization.

A **process manager** is necessary for successful implementation of any product innovation process. Usually, process managers are functional leaders with responsibility to ensure that the product portfolio decisions are implemented in an orderly manner. In addition to ensuring the adequacy of approved schedules, budgets, and resources, the process manager often facilitates innovation training, brainstorming, ideation, and post-launch reviews. The process manager will gather and analyze data to support metrics of the organization's innovation system.

Project managers are responsible for the execution of individual product innovation projects. They follow the accepted methodology for project management (e.g., staged and gated process or scrum) and ensure that project milestones are delivered on-time and on-budget. Depending on the product innovation scale and scope of work, project managers may serve only in a supervisory role or may also work on the technical or marketing aspects of the project.

Of course, the individual team members are responsible for implementing the work of an innovation project. Team members must be trained in both product innovation process implementation as well as demonstrate functional knowledge and expertise to accomplish the work of the project. The most successful innovation companies use cross-functional teams throughout the product innovation life cycle. Diversity in skills is an important factor in identifying novel product solutions. However, diversity based on characteristics that are not job-related (such as age, nationality, or other demographics) can lead to increased team conflicts (Weiss, Backmann, Razinskas, & Hoegel, 2018). Conflict management is discussed in section 6.4.5. Successful product innovation teams build creativity through job-related characteristics instead, such as functional experience.

6.2.3 Product innovation management

Management of product innovation and specifically the role of the product manager throughout the product life cycle are discussed in greater detail in Chapter 7. Product managers help to build value by creating brands with emotional attachment and psychological benefits for a customer. These attributes go beyond quality and pricing, and a product manager is usually tasked with monitoring customer needs along with matching the marketing mix to the proper stage of the product life cycle (introduction, growth, maturity, and/or decline).

6.3 PRODUCT INNOVATION TEAM STRUCTURES

High-performing, multi disciplinary teams improve the quality of the product and decrease project development times. Cross-functional communication brings issues to light sooner and facilitates collaboration. Hand-offs between functional teams at milestones reduces knowledge transfer and should be minimized. Successful innovations are delivered by product innovation teams that combine R&D, technology, operations, and marketing skills throughout the development project. An ideal cross-functional team shares the following group characteristics:

- Includes all necessary functional representatives;
- Ensures team member assignments are continuous from project initiation to market launch;
- Provides appropriate communication tools;
- Establishes clear project and team objectives with expected performance outcomes; and
- Indicates functional, project, and career alignments.

Typical project team structures used in innovation range from a model with deep, functional expertise to autonomous teams tasked with designing and developing new-to-the-world products. Wheelwright and Clark (1992) first identified four common product innovation team models:

- Functional team,
- Lightweight team,
- Heavyweight team, and
- Autonomous team.

6.3.1 Functional teams

Functional teams are typically built from an organizational hierarchy. As indicated in Figure 6.2, product innovation team members are drawn from individual functions, such as engineering (“ENG”), manufacturing (“MFG”), and marketing (“MKG”). Each individual team member holds responsibility for a portion of the product innovation project that corresponds to their functional expertise. Team members’ work is very loosely coordinated by one or more functional managers and the work often involves hand-offs among the functions.

A functional team can be used successfully in product innovation under the following situations:

- In developing fundamental research for deployment across a broad set of product lines, and in which deep functional expertise and knowledge is critical to development;
- In entrepreneurial and small businesses, where there are few resources and few projects worked simultaneously; and
- In organizations that seek incremental product improvements as part of a defender strategy so that functional competency outweighs the need for multi disciplinary activities.

Team member performance and tasks are generally maintained by the functional manager. Overall organizational success metrics are often tied to production efficiency and sales, rather than innovativeness, for companies that mostly deploy functional teams for new product innovation. Functional teams are also used for very low-risk product improvements, especially in slow-moving industries.

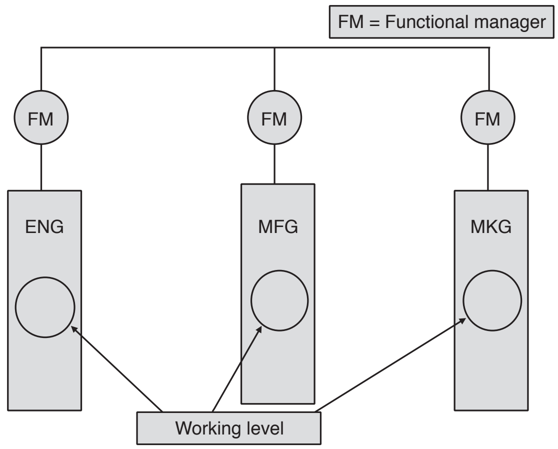


Figure 6.2 Functional team structure

6.3.2 Lightweight teams

As illustrated in Figure 6.3, and as compared to a functional team, a lightweight team includes a degree of coordination for the new product innovation project. Functional liaisons are identified, and a project manager is named. As discussed previously, the project manager may also be a significant independent contributor for the project work in a lightweight team. Team members continue to report to their own functional manager with the added responsibility of the innovation project.

Some pros and cons of using a lightweight team for new product innovation:

- Team communication and coordination are improved compared to a functional team.
- Project work is planned and hand-offs among functions are coordinated to ensure project progress.
- Team leaders are often given accountability for results — yet have little to no formal reporting authority of team members.
- Communication can be disjointed among functions.
- Disruptive ideas and concepts are poorly implemented in a lightweight team due to a lack of cohesive goals among functional team liaisons and functional supervisors.

Lightweight teams are often used for minor product improvements in which the development work requires coordination among functions. Functional team members have deep expertise regarding the product and features but may not be in a position to participate in the project throughout the full design and development life cycle. This can lead to personal frustration for project team members as they support functional activities of their primary job assignment over innovation projects.

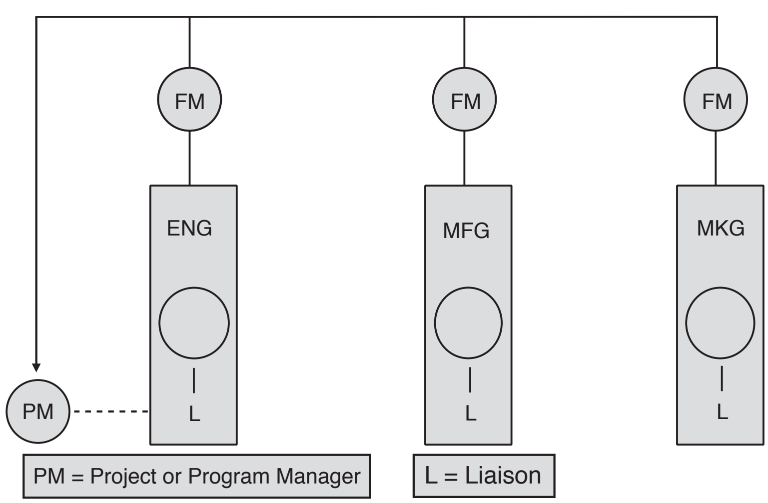


Figure 6.3 Lightweight team

6.3.3 Heavyweight teams

In contrast to the lightweight team, a heavyweight team has greater focus on the project than on functional alliances. As shown in Figure 6.4, a cross-functional core team is assembled with members from every discipline necessary to accomplish the product innovation work. The project leader is a full-time position and includes activities of coordination and communication, both internally and externally. A key driver for project work comes from the market as the product innovation team converts a concept into a commercially viable product or service.

Because the role of the project manager is clearly delineated and the innovation work is more complex, the project manager formally directs the work of individual team members. In the heavyweight team model, the project manager has responsibility over the work of staff members, but the functional managers retain career management and ultimate authority for their performance.

While communication, coordination, and collaboration are highly focused on the product innovation project in a heavyweight team, this organizational structure is not right for every project. The heavyweight team structure should be used when the technical or marketing development is complex, involving new applications, customers, and markets. Teams can be large with each core team member supervising another sub-team within their function. Heavyweight teams are more resource intensive than functional workgroups and lightweight teams, requiring skilled leadership that can focus and energize team members across a broad spectrum of functions and disciplines. In many cases, the heavyweight team members are dispersed geographically, and the team leader will deploy additional tools and techniques to manage the virtual team (see section 6.6).

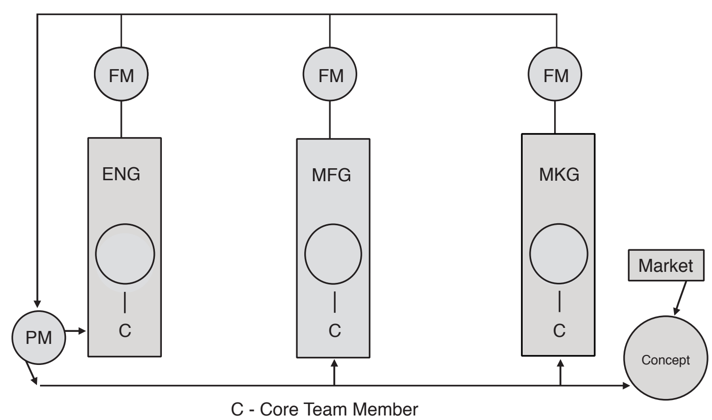


Figure 6.4 Heavyweight team

6.3.4 Autonomous teams

The word autonomous means "independent and self-governing." Thus, autonomous teams are used in new product innovation for major, long-term ventures. Such teams are sometimes called "tiger teams" and aim to model the structure of an entrepreneurial start-up firm within corporate boundaries. Clayton Christensen has recommended the autonomous team structure for radical, disruptive innovation (Christensen & Raynor, 2003).

Autonomous teams, as shown in Figure 6.5, are led by a senior executive as the project manager and remove team members from their home function to form the stand-alone project venture. The project leader has full and complete authority and responsibility for the team and the success of the new product innovation effort. Often the venture team is housed in a separate location, away from the organization's headquarters or operational facilities, to yield higher independence and autonomy for the development team.

A key advantage of autonomous teams is the laser-like focus on the purpose and mission of the project. Often these teams work on new-to-the-world products with disruptive technologies entering (or creating) brand new markets. This type of work is typically energizing to team members and they often remain assigned to the maintenance and growth of the new product line over its subsequent life cycle, including development of next generation products and services.

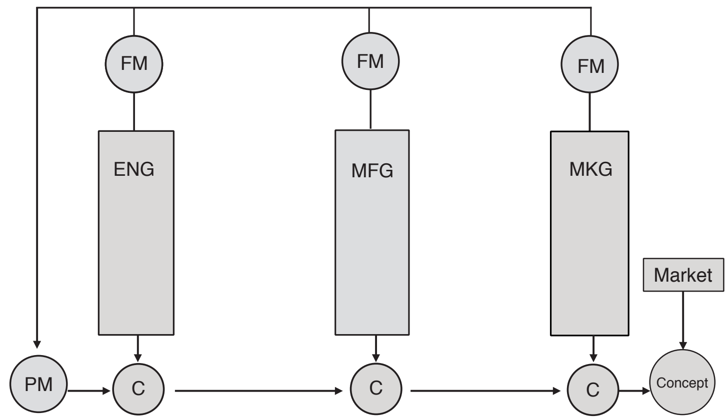


Figure 6.5 Autonomous team

6.3.5 Strengths and weaknesses

Each organizational structure for new product innovation projects has strengths and weaknesses (see Figure 6.6). Senior leaders work with the portfolio management team, the product innovation process owner, and product innovation process manager to identify the appropriate team structure for each innovation project. In general, projects requiring depth of knowledge and expertise with little customer interaction are better suited to execution by a functional work team or a lightweight team. As the complexity of the technology and business development increase, team structures such as the heavyweight and autonomous teams become more valuable.

Strengths of one team structure can be weaknesses for others. For example, having a deep knowledge about a single product technology is a strength for the work of a functional team — but a heavyweight or autonomous team needs to have open, customer-focused perspectives to yield broadly applied and creative solutions. Career congruency is well-established for lightweight teams but may be less certain for individuals working on a complex product innovation project under a new venture.

Type of development Team	Strengths	Weaknesses
Functional	Optimal use of resource, expertise, depth, scale economies. Control accountability. Career path congruence.	Lack of breadth. Rigid and bureaucratic. Task not project oriented. Slow and disjointed. Turf expertise driven.
Lightweight	Improved communications and coordination. Less idle time between task.	Weak project leader and project focus. Frustrating to individuals.
Heavyweight	Strong projects focus, commitment and accountability. Integrated solution.	Difficult to staff. Requires depth. Must break down into functional barriers
Autonomous	Focus on results. Own business objectives Innovative	Independent, not integrated with rest of organization. Autonomy is core value.

Figure 6.6 Team structure comparison

6.4 TEAM DEVELOPMENT

6.4.1 What defines a high performing team?

Katzenbach and Smith (1993) have defined a team as "a small number of people with complementary skills who are committed to a common purpose, set of performance goals, and approach for which they hold themselves mutually accountable." High-performing teams typically grow and develop through a number of well-known stages and processes. Team leaders work with the product innovation process champion and product innovation process owner to ensure that innovation team members have the right skills and that the team structure is appropriate for this scale and scope of the project work. Innovation teams are successful when the team climate assures strategic alignment, engagement, and empowerment as key arenas.

- **Strategic alignment:** Team members need to understand how the project is connected to and driven by business objectives. The common purpose of the project is aligned with and contributes to the overall goals of the organization.
- **Engagement:** Motivated team members feel a sense of pride in their work and camaraderie with their fellow teammates. Rewards and recognition for both individual and team contributions drive improved performance.
- **Empowerment:** Empowered team members are more creative and make decisions that lead to better product designs. Open dialogue is encouraged, and team members' views are considered in decision-making for innovation projects. The team itself is empowered to do the work in the best way possible.

As illustrated in Figure 6.7, team success factors of strategic alignment, engagement, and empowerment are supported by additional elements. For example, strong **leadership** is required for an innovative team climate, as are **interaction** and **involvement** in which all team members have an equal voice in team decisions. **Self-esteem**, one of the values in Maslow's hierarchy, is reinforced by management and leadership for team members, and is shared through rewards and recognition. **Open communication** is extremely important for innovation teams so that the team members can speak freely to share ideas and concepts.

In addition to empowerment at the team level (shown in the central core of Figure 6.7), individual **empowerment** means that each person is treated equally and that the team climate is mutually supportive of each team member. **Effective processes** are also important for successful innovation teams. These processes include standards for knowledge sharing and meetings, as described in section 6.6 on virtual teams. **Trust** and **diversity** are both key characteristics to build an engaged and empowered team, because creativity will flourish when team members share trusting relationships and when different experiences contribute to unique solutions. Productive **conflict management** (see section 6.4.5) is a common characteristic among high-performing innovation teams since some conflict can drive creativity but unhealthy conflict can hinder the accomplishments of a team.

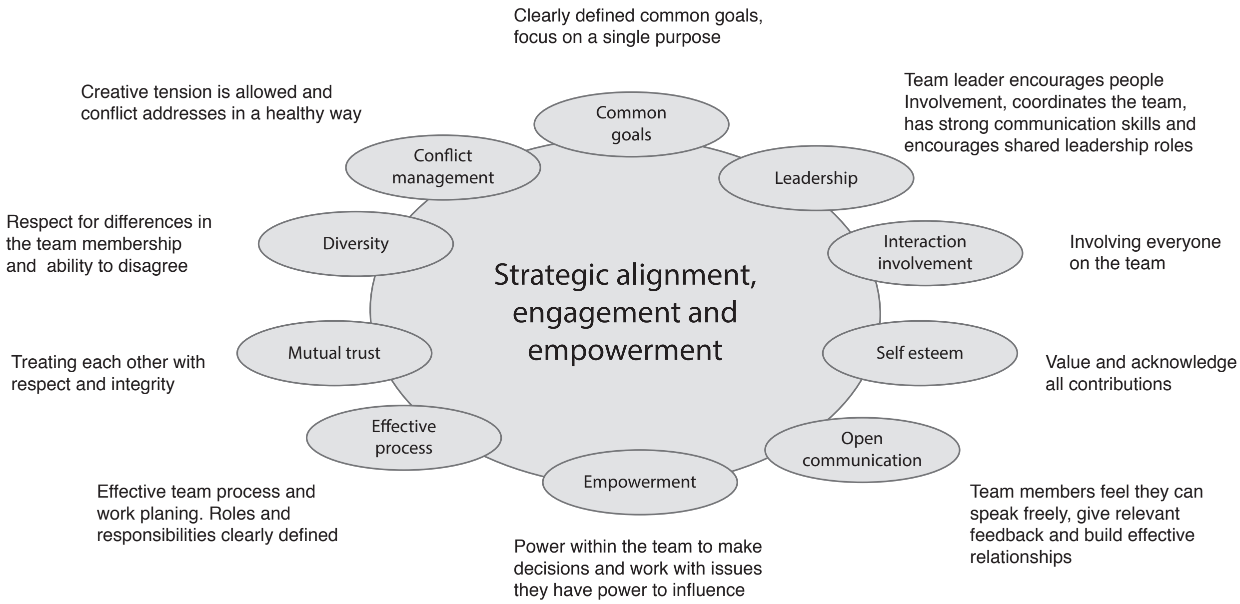


Figure 6.7 Framework for a high-performing team

Finally, as indicated with strategic alignment, a successful innovation team requires a project goal that is clear and succinct. Common goals unite team members and are especially important when working with team members in functional groups or who are dispersed as in a virtual team.

6.4.2 Team formation

Psychologist Bruce Tuckman (2001) developed a model of the growth stages of high-performing teams in the 1960s. His research indicates that teams must advance sequentially through a series of activities and emotions in order to reach their highest collaborative working potential. A team that is disrupted by changes in membership, for example, will backtrack to the initial stage and again advance sequentially through the team formation phases. These phases are: forming, storming, norming, performing, and adjourning. Note that if the team is ongoing, as in manufacturing or marketing, the phase of “reforming” is substituted for “adjourning.” Because product innovation teams are typically project-oriented, the adjourning stage is most common.

Forming: In this stage, most team members are positive and courteous to one another. Some are anxious, as they may not fully understand what the team will do. Others are excited about the task ahead. The leader plays a dominant role at this stage, because team member roles and responsibilities are generally not defined. Typically, this stage is not lengthy because as people start to work together, they make an effort to get to know their new colleagues. In many instances, team members are appointed to innovation teams based on skills or product expertise and may assume a set of expectations for their role on the team.

Storming: The storming stage is characterized by conflict and it is the primary responsibility of the team leader to manage these disruptions in a healthy way. People assigned to the team may be frustrated with the pace of development on the team or confused by apparent duplication of roles. Often the problem statement is not clearly defined, and the storming stage is used to clarify the team’s purpose and goals. Many teams, especially with weak or inexperienced supervision, can get stuck in the storming stage.

Norming: Gradually, the team moves into the norming stage. This is when people start to resolve their differences, appreciate colleagues’ strengths, and respect the leader’s authority. During the norming stage, team members establish their own ways of working together and agree upon standard practices. One way in which teams can reach agreement is to document the project goals and team processes in a team charter.

Performing: The team reaches the performing stage when hard work leads — without interpersonal friction — to the achievement of the team's goals. The team structures and processes, established by the team, are working well. The leader delegates more work to individual team members and concentrates on developing individual team members and skills for the overall group. Team members feel comfortable with each other and enjoy being part of the team. Project work is completed at a rapid pace and learning is at a high level.

Adjourning: As indicated, in all temporary teams, the stage of adjourning arrives as the team's work on the project is complete. In product innovation projects, the product is launched and turned over to standard business operations. Team members are free to be assigned to other projects or are returned to their home organizations. In some cases, team members are reformed into new business divisions for ongoing support of the new product.

6.4.3 Work styles

As a team is formed and develops, both personal and professional work style preferences can impact the effectiveness of the team. Work styles are especially important for team members to understand and respect in cross-functional, multi disciplinary teams (Jurgens-Kowal, 2019). Individual bias can hinder trust and increase conflict if team members fail to recognize and value diversity within the team. For example, a classic point of conflict arises on innovation teams between engineering and marketing representatives. Engineers and marketers typically use their own jargon and are assumed to approach problems from very different perspectives. Engineers may assume marketers make only qualitative decisions while marketers may assume the engineers are too slow and plodding in their analysis. Other business discipline representatives face similar dysfunctions based on personality assumptions.

Using a work style assessment during the forming stage of a project team can help team members to overcome bias and assumptions. Work style assessments, like DiSC®, provide a tool and common vocabulary for team members to improve communication and collaboration. In particular, DiSC creates a team profile index that allows team members to discuss problems, motivators, and stressors while guiding enhanced dialogue for creativity (Scullard & Baum, 2015).

The DiSC work assessment tool describes each individual's preferred working style. It has an advantage over personality assessments (such as the Myers-Briggs or Big Five Personality Traits) because the behavior of a team member in a professional setting is not solely a reflection of a person's personality. The four primary categories of work styles include the following.

D-Dominance: Individuals with a "D" work style tend to prefer a fast pace of work. They are quick to make decisions and may be perceived as overly demanding. These team members are action oriented.

I-Influence: Team members with an "I" work style are highly energetic and talkative. They will build social relationships easily and will seek new people with whom to engage. Some team members may view those with the "I" style as "all talk, no action"; however, these team members add enthusiasm to the work.

S-Steady: Innovation team members with the "S" work style are considered even-tempered and calm, valuable traits when the new product innovation work is chaotic or unstructured. These team members are more accommodating than many other people and will easily show empathy for others. While other team members may view their work pace as moderate, these individuals help to stabilize uncertain project activities.

C-Conscientious: The final category of DiSC work styles are people who are analytical and reserved. These team members need to have a complete dataset to evaluate before making a rational decision. They are often perceived as unemotional but pride themselves on accurate, detailed work. Others may view their attention to detail as a hinderance to project work.

In most cases, product innovation project work is best accomplished with a balance of team member work styles. Both a diversity of product experience and diversity of work styles can lead to increased creativity that yields more novel product solutions.

6.4.4 Project team life cycles

All project teams go through a life cycle in which the project is initiated, accepted, planned, and executed (Jurgens-Kowal, 2019). Different team members offer strengths to each particular stage of innovation based upon their natural working style. The Z-model, shown in Figure 6.8, illustrates the overall life cycle of an innovation project (Inscape Publishing, 2006). Note that the flow of a project follows a shape like the letter “Z” as the life cycle moves from creating through advancing, refining, and executing the innovation project.

Regardless of the product innovation process selected (see Chapter 3), new ideas are born during the project initiation phase. Successful project teams operate with an open atmosphere and are receptive to various perspectives and concepts that will address customers’ issues. Individuals who are creators excel during this phase of work because they enjoy brainstorming ideas and are energized by considering lots of different ideas. Other team members, particularly those who are action-oriented, such as refiners and executors, may find the work style of creators frustrating because ideas are introduced, discussed, and discarded without consideration of how the concept would be implemented into the product design.

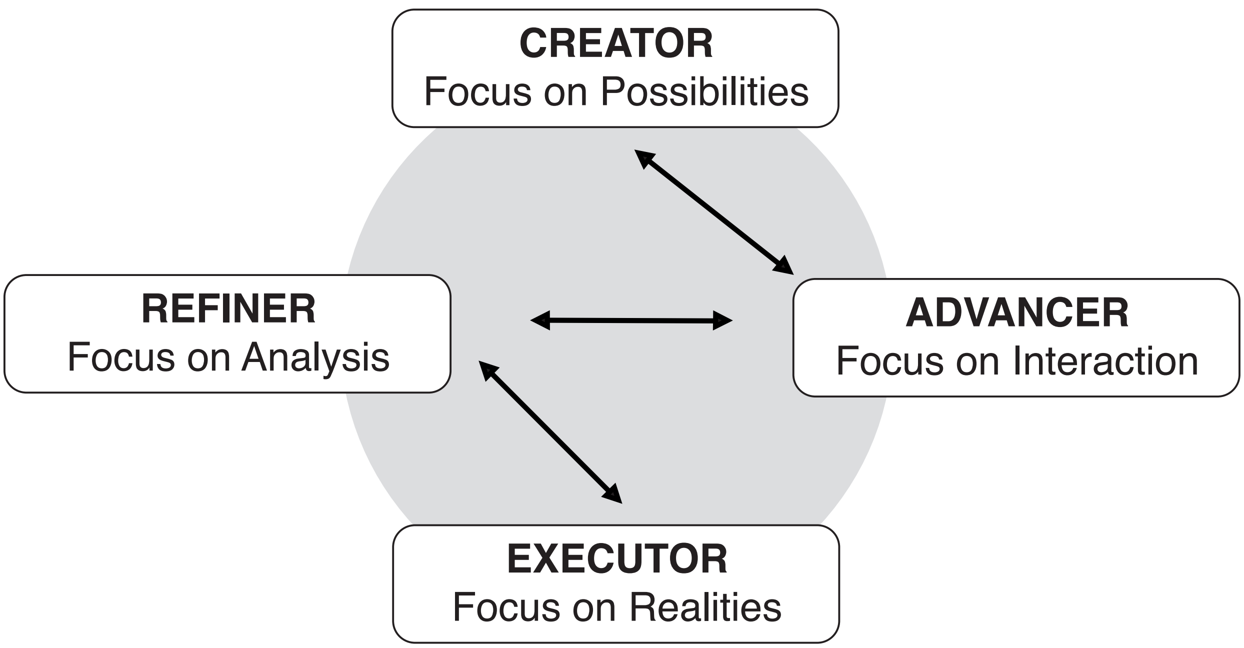


Figure 6.8 The Z-Model for innovation

As the ideas for the project are solidified, advancers will next work on broad strategies to implement the idea. These individuals focus on interactions and help communicate the importance of the innovation project to key stakeholders. Advancers play a key role in communicating the importance of the project. Yet, people on the team with different work styles may view the interactions as unnecessary or premature, especially team members who identify as creators.

As the innovation project matures in the project life cycle, the next stage will balance the new product concepts against reality to generate business and project plans. This type of work is ideal for refiners, who enjoy analytical work and can coordinate various aspects of a job. An outcome of this stage is a detailed plan of work to design and develop the new product. While refiners are focused on details and rational planning, others may find their pace of work too slow or too determined. For instance, creators may want to return to brainstorming of opportunities rather than freezing product specifications and advancers may feel that detailed planning is unnecessary until all stakeholders, including internal and external parties, have expressed buy-in.

Finally, as a project moves to completion, executors move to translate the ideas into action. They are also detail-oriented and focus on delivering the milestones established during the planning phase of the project. There is a natural tension between executors and creators as the former desire to take action toward the goals and latter tend to revisit concepts for new or better ideas.

Most teams are staffed with personnel reflecting the four major work styles. Successful team leaders and managers balance the workload and tasks throughout the innovation project with team members best suited to the activities necessary to complete each stage of work. Thus, creators may take the lead during project initiation but will have a less dominant role during the planning phases of the project. Some teams will be heavily populated by individuals with a select work style, such as a team with many advancers and few creators, refiners, or executors. In such an instance, all team members should be trained to accept and take on the missing roles in order for the innovation project to progress through the project life cycle phases in a timely fashion.

An excellent team-building exercise for innovation teams during project kick-off is to conduct the Team Dimensions Profile assessment. This allows team members to learn their natural work styles and for the project leader to balance work assignments during the innovation project life cycle. Further, the common language following the Z-model assists team members in forging communication protocols and procedures during the innovation project. Understanding work style preferences (DiSC or Team Dimensions) and a standard life cycle for innovation projects helps teams move beyond the Tuckman forming and storming stages into productive work policies for norming and performing.

6.4.5 Conflict management

Diversity, however, can introduce conflict (Jurgens-Kowal, 2019). While dialogue and problem-solving are usually considered "healthy conflict," disruptions to teamwork and the ability for group members to collaborate can hinder effective and productive project accomplishments. Conflict that is not addressed directly or is dismissed as not important can fester, arising later to disrupt relationships and productivity of the team. Potential causes of conflict on an innovation team include (Kerzner, 2013):

- Resources, both people and financial;
- Equipment and facilities;
- Capital investment;
- Budget and costs;
- Technical opinions and trade-offs;
- Functional priorities;
- Organizational procedures and policies;
- Regulatory limitations;
- Scheduling;
- Project and functional responsibilities;
- Project constraints and boundaries; and
- Work style differences.

A traditional approach to conflict management is known as the Thomas-Kilmann model (Kilmann & Thomas, 1978). The two dimensions shown in Figure 6.9 are cooperativeness and assertiveness. Cooperation is viewed as a "concern for others" and is characterized by behaviors to encourage acceptance of views from other team members. Assertiveness is also known as "concern for self" and focuses on getting one's own views accepted by others. By combining various levels (low, medium, high) of cooperativeness and assertiveness, several conflict management styles are evident.

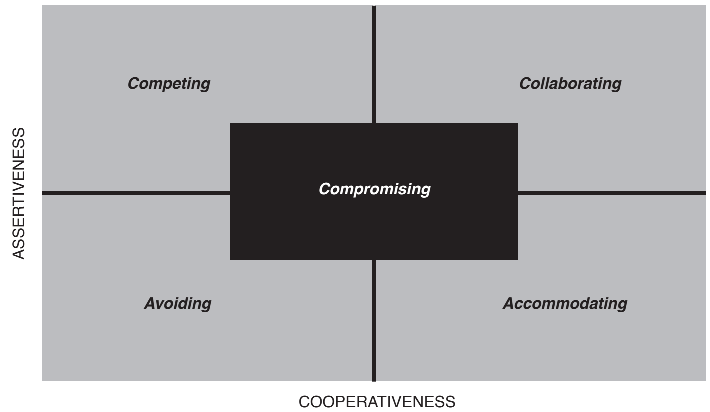


Figure 6.9 Thomas-Kilmann conflict model

- **Avoiding:** Avoiding is characterized by low concern for others (cooperativeness) and a low concern for self (assertiveness). In many cases, the avoiding style leaves the problem unresolved. In other situations, a person may assume they are not part of the problem and leave the situation for others (who are closer to the problem) to engage in generating a solution.
- **Accommodating:** In conflict resolution, the accommodating style is characterized by a high level of cooperation but a low level of assertiveness. In this situation, a team member may yield the conflict to others in order to maintain harmony on the team.
- **Compromising:** At an intermediate level of cooperativeness and assertiveness is compromising. In typical interactions, many people believe that compromising is an effective solution, yet compromise is often viewed as a lose-lose solution because no one gained the view for which they had negotiated. It is frequently difficult to implement compromise solutions because splitting the difference fails to garner across-the-team buy-in.
- **Competing:** With a high level of assertiveness and a low level of cooperativeness, competing is often considered a directive way of resolving conflict. Using the competing style to resolve team conflicts can be useful when decisions are simple or binary. It is also the preferred method of conflict resolution when safety or regulatory requirements are debated.
- **Collaborating:** Many people believe that collaborating is the most effective method of conflict resolution because it involves high degrees of concern for others and concern for self. Collaboration requires dialogue among all team members so that each can express their own view of the situation. A drawback of collaboration for conflict resolution is that it is a time-consuming method and may not be necessary for every discussion item.

Managing conflict in project teams requires effective communication and negotiation. The team charter documents the process for escalation of conflicts, especially regarding decisions of resourcing and funding.

6.5 LEADERSHIP

As previously discussed, executives in senior management provide and set the direction for innovation through strategy and portfolio decisions. The product innovation process champion, process owner, and process manager also provide direct leadership for innovation teams. Innovation team leaders manage both the human resources of a project and the logistical goals of the project, such as scope, schedule, and budget. Effective leaders are emotionally intelligent and support the team as servant leaders rather than task dictators.

6.5.1 Roles and responsibilities

The team leader provides direction, guidance, and support to a group of individuals working toward a specific goal. Effective leaders know the team members' strengths, weaknesses, and motivations. Team leader roles include:

- Providing purpose (what the team should achieve);
- Building a star team, not a team of stars;
- Establishing shared ownership for the results;
- Developing team members to their fullest potential;
- Making work interesting and engaging;
- Motivating and inspiring team members;
- Leading and facilitating constructive communication;
- Monitoring progress without micromanaging.

6.5.2 Organizational communications

Team selection, its development, and ongoing operation are significantly impacted by a range of factors, both internal and external. Effective communication plays a significant role in the performance of the team and the interactions with the team leader.

Team performance is influenced by the following communication issues.

1. Culture and environment of the organization incorporate the values and behaviors that are encouraged for high performance.
2. Structure of the organization includes the roles and relationships among various functions.
3. Processes are in place to promote and enhance team performance, such as utilization of a team charter document to outline team member expectations.
4. People on the team include sufficient representation of skills and capabilities and are rewarded with recognition that drives individual motivation.
5. Leadership at all levels, including senior management, is engaged and provides direction and support.
6. Collaboration and cooperation are critically important within the core team and will extend as necessary to other functions and sub-teams as indicated in Figure 6.10.

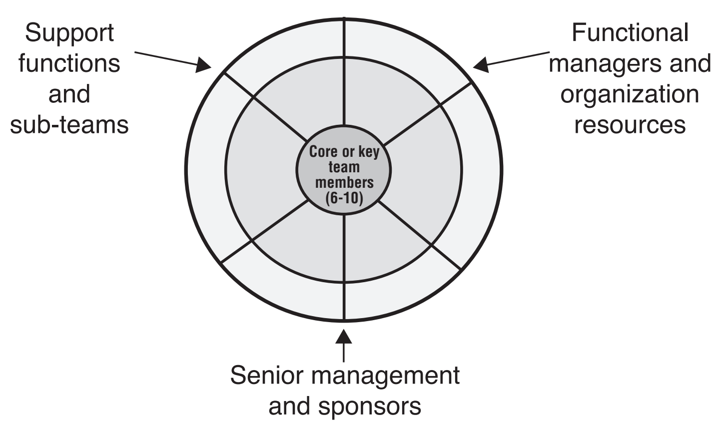


Figure 6.10 New product team/network structure: Communications network

6.5.3 Emotional intelligence

Effective leaders are high in emotional intelligence (EQ). As Goleman (1988) has noted, technical competency and IQ are necessary but insufficient qualities for strong leadership performance. Emotional intelligence is comprised of self-management components and of elements directed toward managing relationships (see Figure 6.11).

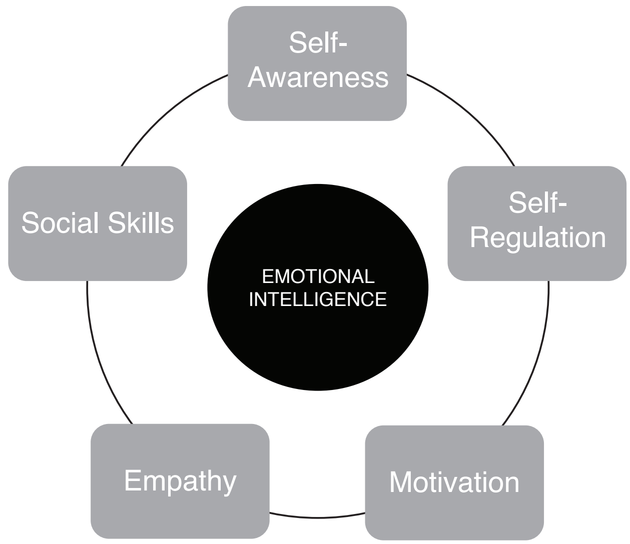


Figure 6.11 Elements of emotional intelligence for innovation leaders

Self-awareness is the first self-management component in EQ. Leaders with a high degree of self-awareness are typically self-confident, having a deep understanding of their own emotions, strengths, weaknesses, and needs. Their decisions mesh with their value systems, and they can debate and discuss with a balance of candor and realism.

Self-regulation is another trait of a leader with high EQ. Self-regulation is the ability to control emotional impulses and to channel bad moods into positive energy. Leaders with self-regulation are better able to cope with change and create team climates with trust, respect, and fairness. Such leaders practice reflection and thoughtfulness to enhance their own personal integrity.

Motivation is a characteristic of self-management leading to high EQ. Motivated leaders seek creative challenges, love to learn, and take pride in accomplishments. Leaders with high self-motivation also keep score in order to raise the performance of the organization and are typically viewed as optimistic.

Empathy and social skills are the two elements of EQ that are supported by the traits of self-management, yet are reflected in effective relationships. Leaders with **empathy** recognize and respect others' feelings, understanding how and when to provide feedback. An empathetic leader will respond to unspoken body language as well as to spoken words to create relational bonds. Innovation leaders use coaching and mentoring to increase empathy with team members, which in turn improves job satisfaction, improves performance, and decreases turnover.

Social skills may not traditionally be valued as leadership competencies. However, leaders with high EQ exhibit valuable social skills, such as an ability to motivate and direct teams. In building rapport with various functions, team members, suppliers, distributors, and customers, leaders with high social skills can rely upon a broad network to gain success. Individuals who exhibit the highest levels of self-management are usually also adept at social skills.

6.6 VIRTUAL TEAMS

While it can be a benefit to co-locate product innovation teams, especially if the organization is using an Agile process, it is often impractical and infeasible to house a team in one place. **Virtual teams** conduct most, if not all, of their communication via electronic means. Team members are assigned to different working locations, and the degree of dispersion of the team can vary depending on the distance between work locations and the number of team members assigned to each location.

Virtual, or dispersed, teams are a normal configuration for conducting innovation project work today. Virtual teams can offer advantages over traditional, co-located teams. For example, virtual team members can access local market information across the globe which leads to better innovation results.

Virtual teams, however, are not without challenges, especially when cultural, ethnic, or language barriers arise in communication (Hardenbrook & Jurgens-Kowal, 2018). The Virtual Team Model (VTM) provides five elements and 16 operational practices to bridge the inherent communication gaps in a virtual team (see Figure 6.12).

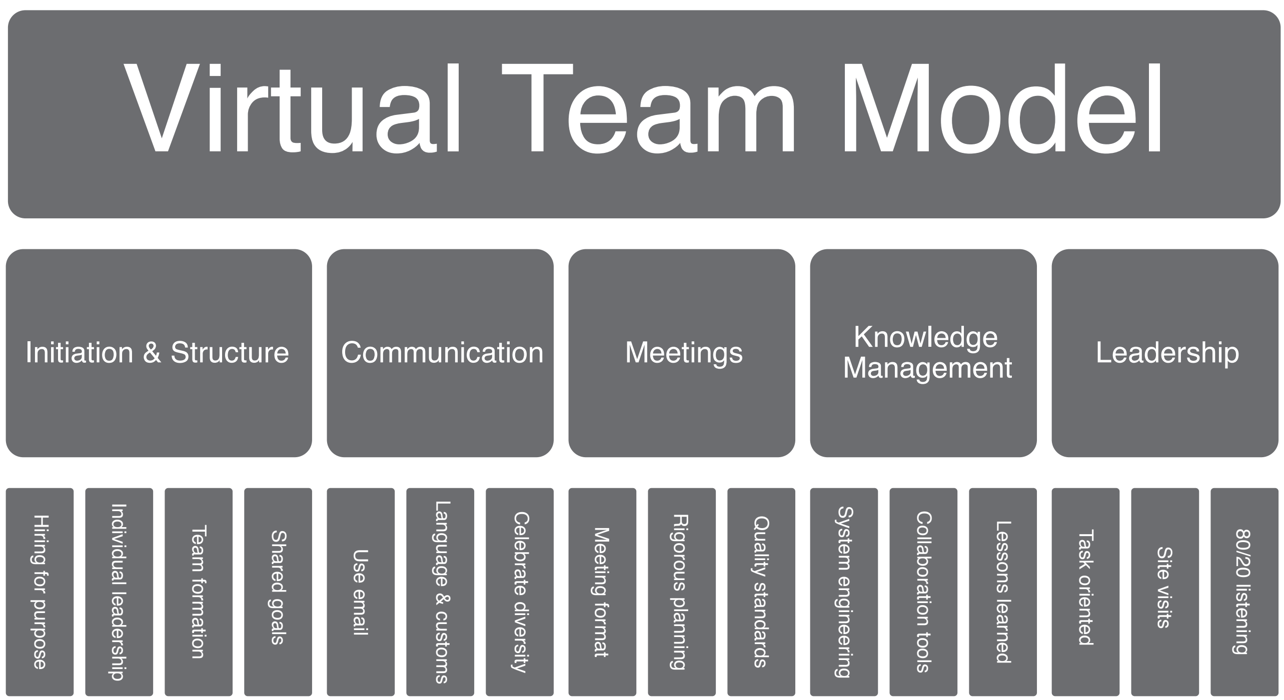


Figure 6.12 Virtual Team Model

6.6.1 Initiation and structure

Virtual teams, like traditional co-located teams, will go through the development stages as discussed in section 6.4.2. What is different about virtual teams is team members are more task-oriented, so the purpose of the project and shared objectives take control. The important operational practices for initiation and structure in the virtual team model include:

- **Hiring for purpose:** In many situations, selection of team members in a face-to-face project includes functional staff who are available for the project time frame. For a virtual team, it is important to select team members who share the mission and vision of the project statement. Because these individuals are often working independently, hiring for purpose assures their alignment with strategic objectives so that decisions are naturally coordinated with the project and organizational goals.

- **Individual leadership:** Dispersed team members are not interacting with a directive leader on a daily basis. They need self-motivation to schedule and complete project tasks. Virtual team members represent the project to their local management in local markets and thus require both generalist and specialist knowledge. Such team members can work on in-depth problems within their field of expertise but also need broad education and experience to represent the project, the product, and the brand locally.
- **Team formation:** As indicated in section 6.4.2, teams usually advance through stages of forming, storming, norming, performing, and adjourning. Phases such as storming and norming can be more difficult without face-to-face dialogue. For larger projects or complex innovation work, a face-to-face kickoff meeting can facilitate the necessary conversations to build trust among team members. If a face-to-face kickoff meeting is impossible, frequent video conferencing accompanied by social team-building activities serves as a secondary substitute. Building trust is an important outcome of the team formation phases.
- **Shared goals:** Team members working from a common office or lab space receive frequent feedback on their progress. However, dispersed team members often work alone in isolated spaces. Rather than relying on natural conversations and interactions of a co-located team, virtual teams are successful by focusing on the common goal. Team leaders should reiterate the shared purpose at every opportunity, and because the dispersed team members are highly task-oriented, they will be motivated to work toward completing that objective.

6.6.2 Communication practices

Usually face-to-face communication is the richest form of discussion, because body language, facial expression, and gestures make up as much as 80% of communication. Even with the high-quality video conferencing available today, many components of face-to-face communication are lost among dispersed team members. Three operational practices within the Virtual Team Model can improve the outcomes of dispersed project work teams:

- **Email:** First, communication in dispersed teams is hampered by several issues — bandwidth of video and phone conferencing tools; time zone coordination; comfort with the chosen team language; and cultural norms. Using email as a primary communication tool overcomes many of these barriers because it is asynchronous and provides a record of project decisions. Other social media and software tools are becoming available to allow collaboration for dispersed teams and as the power of these tools increases, they make good choices for primary team conversations (e.g., Slack™ and Yammer™).
- **Language and customs:** While English is often chosen as the primary language for a dispersed team, individual skills, comfort, and competency may vary. Team members who share a different primary language may feel uncomfortable speaking during team meetings. The team leader sets the tone for acceptance and patience if team members use awkward phrasing or poor grammar. Team members should feel free to ask clarifying questions and use email to document formal project decisions.
- **Celebrate diversity:** Teams need internal trust to succeed. Intellectual trust is sufficient for co-located teams demonstrating their educational background an experience (Rosenfeld, Wilhelmi, & Harrison, 2011). However, when the innovation challenge involves more risk, emotional trust surpasses cognitive capability as a measure for success. Dispersed teams establish emotional trust by building shared goals and celebrating their diversity. Virtual teams can inspire deeper respect and trust for one another by telling stories of their local cultures, such as special holidays or sporting events. Personal relationships lead to increased trust and team cohesiveness.

6.6.3 Meetings

In many projects, meetings are used for one-way communication to inform the project leader of status. Meetings in a virtual team serve also as a primary exchange for ideas, concepts, and planning future work. Three operational practices associated with meetings yield significant performance improvements for globally dispersed teams:

- **Medium format:** To keep team members interested and engaged in meetings, the format of the meeting varies. In particular, the time of the meeting should rotate so that no single geographic area is unfairly inconvenienced. Video conferencing is used to ensure team members are participating in the meeting and not multi tasking. Each team member is expected to actively participate in the meeting and the person responsible for distributing minutes is also rotated for each meeting.
- **Rigorous planning:** Traditional face-to-face meetings for co-located teams are often spur-of-the-moment sessions. However, dispersed teams require significant preplanning of the meeting format and agenda. For monthly meetings, the agenda is distributed about a week in advance. The project shared goals are discussed at each meeting, reinforcing the team structure. Minutes of the meeting, verifying follow-up actions and responsibilities, are distributed within a couple of days of the meeting. If the video conference is recorded, a link to the meeting is provided with the meeting minutes.
- **Quality standards:** Because of the nature of project work conducted by a virtual team, the quality of each component is important. The selected product innovation process (see Chapter 3) provides quality governance at a high level for the innovation project. During project execution, meetings are used to verify and validate quality standards as the various pieces of the new product effort come together from all over the globe.

6.6.4 Knowledge management

An important element of innovation work is to transfer lessons learned to both operational and next generation R&D teams. Knowledge management is the element within the Virtual Team Model framework that describes what and how to document innovation learnings from dispersed teams. Effective use of knowledge management speeds next-generation product innovation and creates a data repository to drive product innovation process in portfolio analysis. Three operational practices make up the knowledge management element of the Virtual Team Model:

- **Systems engineering:** Discussed in Chapter 3, systems engineering rigorously documents project work to minimize errors in hand-offs and to ensure customer requirements are fully incorporated in the design. Systems engineering is especially useful for virtual teams because version control is maintained across project work that might be completed anywhere in the world. Enhanced documentation produced by systems engineering may not be necessary for co-located teams but sustains the ability of dispersed teams to work in a project 24/7. In this case, systems engineering serves as an additional layer of coordination and communication.
- **Collaboration tools:** Innovation work is most successful when the team members collaborate with each other, with customers, and with suppliers and vendors. Crowdsourcing tools (see Chapter 5) are an example of collaboration software used with customers. Cloud communication and project management tools aid the dispersed team in knowledge transfer and project progress updates, including project scope, schedule, and budget. Software and collaboration tools are continually being updated, but a dispersed team should not be introduced to technology changes, without appropriate training, for the duration of the project.

- **Lessons learned:** Agile project teams conduct a retrospective at the conclusion of each sprint. Word-of-mouth stories are built into local organizational cultures. Yet, common knowledge built on a virtual team is often not captured in the central repository. During regular team meetings and during lessons learned reviews at the completion of a project, specific technical and team learnings are documented. As an example, an electronic whiteboard tool that proves especially effective for an innovation team should be documented in the company's lessons learned database as a best practice. The lessons learned reviews address what went well on a project, what went poorly, and what could be improved next time.

6.6.5 Leadership

While leadership skills are universal, some special applications are necessary to manage a dispersed team. Individual leadership and motivation are necessary skills for team members, a part of initiation and structure in the Virtual Team Model. Additional operational practices within the leadership element include focus on the project work, visiting team member locations, peer visits, and deep listening.

- **Task-oriented:** Leadership in a face-to-face team involves motivation and monitoring. Management in a co-located team environment is often indirect and personal relationships are easily established. Virtual team members are normally more self-motivated, and they are driven by the challenge of the work itself. They are used to working autonomously, so the leader's role in a dispersed team involves more coordination of work. Performance measurements focus on task completion, timing and integration of piece work, and overall project goal alignment. Recall that a large part of the leader's responsibility on a virtual team is to ensure and reiterate sharing of the project goals.
- **Site visits:** A project leader on a virtual team connects and coordinates the work. The leader should visit all team members at their local work site in order to build trust, rapport, and understanding. Site visits demonstrate commitment to the project as well as the priority of the work. The project leader can discuss other work assignments with team members' functional managers during site visits, too. Site visits are not limited to the project leader. An effective way to gain the benefits of a co-located team without the expense is to encourage **paired site visits**. These exchanges of working level team members between sites allow pairs of team members to address specific project trouble areas while also building stronger interpersonal relationships.
- **80/20 listening:** Finally, leadership is most effective when leaders spend time **listening** rather than talking. Especially for virtual teams, where team members are technically skilled, self-motivated, and work autonomously, a project leader serves the team best with deep listening. Pareto's law of getting 80% of the benefit by addressing the highest impact 20% of issues is at the heart of 80/20 listening. Team leaders need to clearly understand the challenges faced by remote team members and assist as quickly as possible. Many one-way, directive communications from the leader to the team can be handled by email, newsletter, or discussion board, thus preserving meeting time for active listening and problem solving.

6.6.6 Effectiveness of virtual teams

Virtual teams support Lean new product innovation by reducing cycle time in uncertain environments because the focus on customer spans both local and global scales. Anytime, anywhere connectivity allows virtual teams to drive project goals with generalist-specialist skills to yield cost-effective, practical new product innovation. Team members for virtual teams are selected for their motivation and shared purpose for the project mission. This leads to better and quicker decisions and produces reusable, shareable knowledge for future innovations.

6.7 SUSTAINABILITY: TEAMS AND LEADERSHIP

Sustainability is based on managing goals for people, profit, and planet simultaneously. Ultimately, implementing sustainability is dependent upon the teams and leaders involved with innovation. Best practices for sustainable innovation all focus on the relationships of people with each other and in executing new product development projects in an environmentally responsible manner. Antonisse and Metz (2013) list five best practices for sustainability.

1. **Use sustainability to drive innovation success and competitive advantage.** A strategy that includes sustainability goals generates a leadership position for companies. Innovation project objectives are implemented by the individual project teams and functions. Thus, in line with achieving a mission of environmental sustainability, innovation teams should include training to incorporate these goals in the execution of projects. Moreover, team decisions should integrate sustainability as well as impact on schedule and budget for new product development work.
2. **Get top management commitment.** As with any strategic initiative, senior management must support sustainability goals within innovation. Team leaders should echo senior management's commitment to responsible development through specific project goals and decisions regarding materials and sourcing for new products.
3. **Integrate sustainability into existing innovation initiatives and processes.** Best-in-class performance for innovation programs specify cross-functional teams and concurrent development. Incorporating sustainability goals into innovation programs includes not only blending engineering and marketing functions but also instilling a focus on renewable and recyclable materials for products under design and development.
4. **Hold line organizations responsible for measurable results.** Design for Sustainability (DFS) is discussed in Chapter 4 — where an assessment is based on people, planet, and profit. At various stages in a product's life cycle, a mix of qualitative and quantitative metrics apply, and an organization's leaders need to consider all phases of the innovation. Supplier qualifications should also include their approach to sustainability in order to integrate appropriate information throughout the new product development cycle. Operations and manufacturing organizations must be attentive to the impacts of emissions, labor practices, and product performance as value chain drivers for sustainability, especially if production is outsourced. For example, suppliers and vendors may be required to attest and sign a statement of sustainability or other code of conduct agreement specifying fair and legal treatment of the environment and labor.
5. **Invest in sustainable innovation-related capabilities and resources as well as leveraging existing capabilities.** A lack of available resources, information, and incentives can derail a sustainability approach to innovation. When the organization's leadership commits to sustainability as a strategic goal, they will hire senior executives and consulting advisors who reflect the goals and values of sustainability. Moreover, leaders must support sustainability by building new competencies for the NPD teams, such as green chemistry, biomimicry, and life cycle analysis expertise.

As indicated, effectiveness of sustainability initiatives relies upon management practices, support, and implementation. Like all areas of innovation, the impact of management on sustainability results in successful execution of the strategies. Incentives are used to motivate senior management to pursue strategic opportunities related to the environment, social issues, and governance. This is especially important because the payoffs from sustainability goals are often more uncertain and longer-term than other corporate strategic objectives. The following steps are recommended to create management incentives that signal commitment to sustainability (Burchman & Jones, 2019).

1. Examine the business case and context for sustainability.
2. Clarify the scope and breadth of sustainability goals.
3. Determine the duration of the incentive period, keeping in mind that sustainability goals are often more long-range than typical executive change objectives.
4. Attach awards to milestones as well as the end result due to uncertainty and lengthy timeframes.
5. Structure the incentives to combine with leadership training and commitments for a supportive culture.

6.8 METRICS: TEAMS AND LEADERSHIP

In order for teams to effectively work together, success metrics must focus on team behaviors rather than individual performance. Successful measures of innovation performance are complicated by the expectations of experimentation and risk. Standard business metrics often do not apply to innovation teams.

6.8.1 Incentives for innovation

Incentives are used to motivate employees to improve performance and increase productivity. Typical pay-for-performance incentive programs focus on short-term financial results and may include disincentives for failures, such as lower compensation and possible termination. While research shows that such pay-for-performance systems boost productivity in routine work, studies also indicate that open-ended, creative tasks call for different incentive systems (Manso, 2017). Staff must be encouraged to explore and exploit novel and unique opportunities with tolerance for, and perhaps expectation for, early failure.

Compensation may include deferred rewards, such as stock options with long vesting periods, in order to encourage innovation professionals to engage in necessary, long-range research for new product development. In this situation, compensation depends not only on the end result but also the pathway through the development life cycle. Exploration for innovation includes natural failures and risk-taking that is quite different than typical work tasks requiring repetitive activities. Long-term rewards must be tied to innovation performance because standard pay-for-performance systems will punish failures and miss the identification of potentially radical innovations.

Termination is often a response for poor performance within a conventional pay-for-performance system. However, due to the long-term and risky nature of innovation, longer-term contracts for professionals working on NPD teams should be the norm. If the loss of a job is a threat to experimentation, individuals and teams will seek out only the least risky and conventional improvements for product development. Instead, management can create a culture of acceptance for calculated risk, especially when the experiments for new products and new services are closely aligned with strategic goals.

Failure is an expectation when developing new products and services. Markets and technologies change, especially during long development cycles. Feedback from customers and potential end-users can influence significant change in a product design during the development process as well. Therefore, failed experiments are anticipated. The product innovation process (Chapter 3) is designed to link the company culture with a systematic approach to innovation such that early stage exploration is less costly and that the business case is developed in parallel with experimentation that reduces overall financial risk. In addition to the product innovation process, leaders encourage innovation teams to take calculated risks for development. This means that mistakes and errors are not only tolerated, but experiments designed for learning that fail are accepted as part of the overall innovation process.

6.8.2 The Balanced Scorecard

The Balanced Scorecard is discussed as a generalized metric framework for a business in Chapter 7. The Balanced Scorecard is useful for innovation programs because it focuses on metrics beyond financial returns. Specifically, a typical Balanced Scorecard dashboard addresses financial, customer, business process, and learning and growth measures (Kaplan & Norton, 1996). The latter category is of interest to develop efficient innovation teams and leadership.

As with all metrics, the measure addresses strategic objectives. Several examples of measures that are included in a Balanced Scorecard within the learning and growth category address team-building, knowledge transfer, and leadership development for innovation.

- **Training programs.** Effective training is essential to productive innovation. Suggested metrics include: 1) development of corporate-wide innovation training programs, 2) number of personnel trained, 3) incorporation of innovation training as part of the onboarding process for new hires, and 4) percent of NPD staff engaged in deep learning for innovation over a three- to five-year period.
- **Culture.** As indicated earlier, both culture and climate impact the effectiveness of innovation. A suggested metric for improving innovation culture includes review and implementation of appropriate incentive systems, including stock options, long-term contracts, and tolerance of failure.
- **Strategy.** Understanding the innovation strategy for team members at all levels of the organization is imperative to successful new product development. Ideas aligned with strategic objectives are nurtured and developed effectively. Suggested metrics for strategy as part of innovation learning and growth include: 1) discussion of strategic objectives at regularly scheduled management townhall meetings, 2) required written responses to all "suggestion box" ideas, and 3) reward systems commensurate with the ideas and new product commercialization that are aligned with the corporate and innovation strategies.
- **Customer.** Customers are the final vote of acceptance for any new product or service and financial returns often reflect the scale of customer satisfaction. Successful innovation teams include customer feedback as part of the product innovation process, whether the company follows a staged-and-gated approach or an Agile method, like scrum. Suggested metrics for learning and development of customer insights include the number, type, and extent of testing with potential customers during the development life cycle. Quality measures, such as returns and warranty work, are naturally associated with customer satisfaction of new products.

6.8.3 Innovation Health Assessment©

As the old adage goes, *what gets measured gets done.* Research shows that using cross-functional teams in innovation is a leading indicator of success along with effective leadership, investments in training, and engaging employees. The Innovation Health Assessment© (www.simple-pdh.com/courses/innovation-health-assessment/) is a tool that allows innovation teams to measure their performance against industry benchmarks as well as within teams to establish areas for innovation improvements. Individuals, NPD teams, project leaders, and senior management all benefit from taking the assessment because it provides measures of an organization's innovation ecosystem and highlights areas of strength with opportunities for improvement.

The Innovation Health Assessment is broadly categorized with the areas in this volume of the *PDMA Body of Knowledge* including strategic alignment, product portfolio management, product innovation processes, life cycle and product management, teams and leadership, product innovation tools, and market research. Specific to teams and leadership, the Innovation Health Assessment provides internal and external benchmarks for product innovation teams regarding:

- Senior management reviews of individual projects and the portfolio;
- Allocation of team resources according to strategy;
- Knowledge transfer via lessons learned among product innovation teams and team members;
- Customer involvement as part of the team during product development projects;
- Use of product innovation process tools, specifically Open Innovation and design thinking (see Chapter 1 for Open Innovation and Chapter 4 for design thinking) to involve customers as part of the product innovation team; and
- Awareness of competition for the team and leadership in order to improve product development focus.

6.9 IN SUMMARY

- While strategy and process are essential to product development and product management, this alone will not lead to the sustained success of the organization. People are ultimately what make an organization successful. It is culture and climate that ultimately provide the context within which strategy and process can be positively and successfully implemented.
- Every organization has a unique culture. There are, however, some key elements that underpin the innovation culture of most successful organizations, as follow.
  - A clear sense of goals and direction that are communicated, understood, and shared across the organization.
  - Experimentation is encouraged and tolerated.
  - Performance metrics for innovation teams are tied to strategic objectives and team metrics outweigh individual performance metrics.
  - Fit with the organization's innovation culture is included in hiring criteria.
  - Constructive conflict and debate of ideas is encouraged.
  - Innovation work is designed in such a way that rewards reflect team, individual, professional, and personal accomplishments.
  - Ongoing training is integrated to build and support teams and leadership in the innovation journey.
- Cross-functional representation is the most effective model for product development. Specific team structures are selected based upon the scope, scale, and complexity of the specific project, and include:
  - Functional teams,
  - Lightweight teams,
  - Heavyweight teams, and
  - Autonomous teams.
- Teams grow and develop through a variety of processes. Understanding different work styles enhances the effectiveness of team communications and each individual's preferred way of working. Work style assessments are used in kickoff meetings and throughout the innovation project work to build a common vocabulary for team communications. DiSC® is a suggested work style assessment for effective teamwork.
- A typical innovation project life cycle follows phases of idea creation, gaining support for the concept, planning the new product development project, and executing the work. Different team members have strengths and competencies that will enhance their capabilities during these life cycle phases. When the team lacks a specific skill set that is best suited for a specific phase of the innovation life cycle, the other team members must set aside their own preferred working styles in order to complete the project work.
- Conflict occurs on all projects due to different approaches to the technology or marketing of the new product as well as challenges in scope, schedule, and budget. Healthy conflict supports new ideas and problem-solving. The Thomas-Kilmann conflict model offers five categories of conflict management based on the level of assertiveness and cooperativeness. The ideal conflict management solution for each situation is different depending on the circumstances, especially the risk of the decision resulting from the various perspectives driving the conflict.
- Leaders and team members engage in communication within the team and with stakeholders external to the team. Communications include those with the functional organizations, such as legal and logistics, as well as the customer and senior management who fund the project. In all cases, the core team should provide a consistent message regarding the new product development project.
- The best leaders score high on emotional intelligence (EQ), which involves factors of self-awareness, self-regulation, motivation, empathy, and social skills.
- Many organizations today use virtual, or dispersed, teams for innovation work. The benefits of a virtual

team include access to specially skilled team members and insights to local markets. The Virtual Team Model (VTM) includes five elements and 16 practices to overcome the natural barriers of communication when the normal means of communicating are electronic rather than face-to-face. The five elements include:
  - Structure and initiation,
  - Communication modes and methods,
  - Meetings,
  - Knowledge management, and
  - Leadership practices.
- Innovation team members are responsible for sustainability of development, including assurance of the triple bottom line. Incorporating sustainability goals into executive auxiliary compensation is one way to ensure strategic alignment.
  - When cross-functional teamwork is expected for innovation work, team performance metrics should be deployed. Measures of team improvement include the learning and growth category within the Balanced Scorecard and the Innovation Health Assessment benchmark.

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ADDITIONAL READING

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Practice questions: Culture, teams, and leadership

1. Ensuring that the right team principles are in place to promote high performance is an aspect of a management role and is called…
   A. Team motivation.
   B. Team development.
   C. Project management.
   D. Senior leadership.

2. The role responsible for establishing the product innovation process and for ensuring its quality and consistency and ongoing training in its application is called:
   A. Process manager.
   B. Process champion.
   C. Process owner.
   D. Process developer.

3. You are hired as a new product development consultant by an established company that is having challenges with its new product development innovation initiatives. Upon observing the work practices across the company, you note an emphasis on individuals working alone, very little social interaction either at or outside of work, limited recognition of staff performance, and frequent criticism of failure. What specific area would you recommend as the primary focus for the company to improve its product innovation?
   A. Better tools to assist in all aspects of product innovation.
   B. An improved product innovation process, used by all staff.
   C. Developing a culture of innovation.
   D. Encouraging senior managers to get more involved in product innovation.

4. The set of properties of the work environment, perceived directly or indirectly by employees to have a major effect on employee behavior, is termed:
   A. Culture.
   B. Environment.
   C. Climate.
   D. Organizational structure.

5. Ensuring, over time, that a product (or group of products) or services meets the needs of customers by continuously monitoring and modifying elements of the marketing mix is generally the role of a…
   A. Product manager.
   B. Project manager.
   C. General manager.
   D. Marketing manager.

6. Which of the following best describes a team?
   A. A group of individuals who meet regularly.
   B. People who enjoy doing the same things.
   C. A group of people with a common purpose for which they hold themselves mutually accountable.
   D. A group of people appointed to complete a specific task.

7. Tuckman identified five stages of team development. What does the forming stage involve?
   A. Deciding on team direction.
   B. Bringing the team together and getting to know each other.
   C. Appointing a team leader.
   D. Resolving differences among team members.

8. A functional team is best suited for which type of project?
   A. Highly complex, requiring strong cross-disciplinary collaboration.
   B. Product development that is totally new to the company.
   C. A project that demands total commitment from team members.
   D. Relatively simple product line extensions or improvements.

9. What type of assessment helps a team achieve increased communication during the work of the project?
   A. Personality assessment, like the Myers-Briggs Type Indicator.
   B. Work style assessment, like DiSC.
   C. Functional resource assessment as used in creating the project budget.
   D. Project portfolio management assessment.

10. A company has decided to embark on a high-risk project that is focused on the development of a product outside the traditional boundaries of company operation. What type of team structure would be most suitable for this type of project?
    A. Autonomous.
    B. Lightweight.
    C. Functional.
    D. Agile.

Answers to practice questions

1. B	6. C
2. B	7. B
3. C	8. D
4. B	9. B
5. A	10. A

7

PRODUCT INNOVATION MANAGEMENT

Maximizing the return from product innovation through application of sound management practices throughout the product life cycle

7. Product Innovation Management

THE CONTENT

The chapter is divided into three sections:

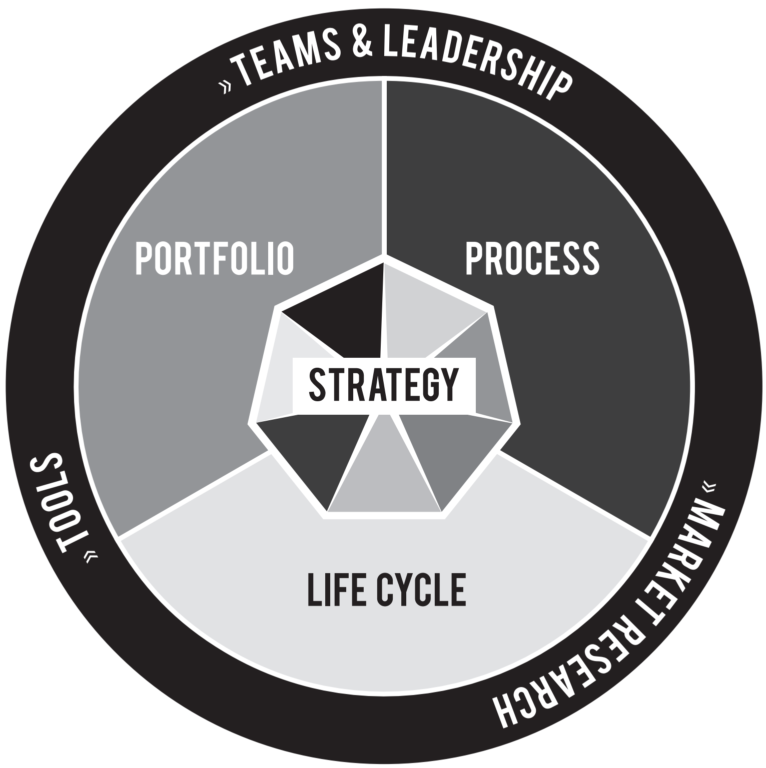
SECTION 1
What is product innovation and what is the role of product innovation management?

SECTION 2
What is the product life cycle and how is product innovation managed through this life cycle?

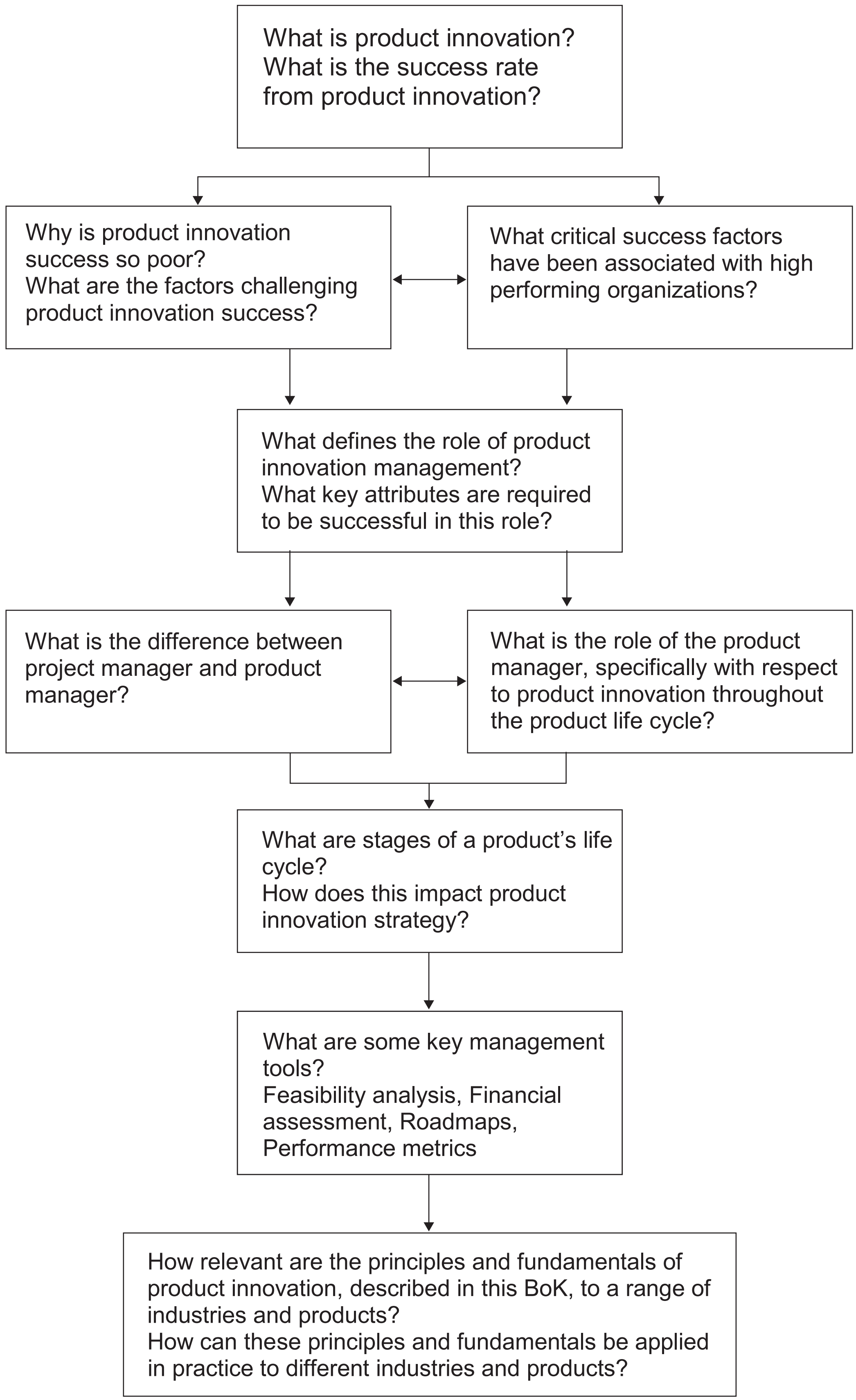
SECTION 3
Some of the key tools for managing product innovation and how to measure product innovation performance leading to continuous improvement.

What you will learn in this chapter

The first six chapters of this book present a comprehensive overview of product innovation from the definition of clear strategic goals, through the development of a balanced portfolio, to the processes required for successful new product outcomes. Supporting this overall product innovation framework are the tools related to design, market research, and business analysis and most importantly, the culture, teams, and leadership. This chapter goes beyond the initial product innovation and launch to the product's life cycle and presents the strategies, tools, and metrics required for successful product management.



The Chapter Roadmap



SECTION 1
What is product innovation and what is the role of product innovation management?

7.1 INTRODUCTION

Product innovation has been defined as the creation and subsequent introduction of a good or service that is either new, or an improved version of previous goods or services.

The scope of product innovation from strategy direction through portfolio management, and from individual project management through to commercialization, implies a high degree of complexity. It is influenced by a wide range of inputs and variables:

- Controllable – company culture, strategy, capability, organization, finances.
- Uncontrollable – competitors, government policies, international environment.

It involves a cross-section of players:

- Internal – the board, general management, marketing, production, finance, purchasing.
- External – consultants, suppliers, regulators, agents, the trade, customer/consumers.

Successful product innovation seldom happens by accident. Reports from a range of sources quote failure rates for new product launches from 70 to 90 percent. (Schneider and Hall, 2011) and (https://www.publicity.com/marketsmart-newsletters/percentage-new-products-fail/) Moreover, a large proportion of financial and human resources devoted to product innovation are focused on products that will fail in the marketplace.

7.2 CRITICAL FACTORS FOR PRODUCT INNOVATION SUCCESS

Kahn (2013) quotes the following factors critical to product innovation success:
Critical success factors at the project level:

- Unique, superior products;
- Strong market orientation;
- Pre-development homework;
- Sharp, early, and stable product definition;
- Planning and resourcing the launch;
- Quality of execution of key activities from idea to launch;
- Speed — but not at the expense of quality of execution.

Critical success factors — people and environment:

- The way project teams are organized;
- The right environment — climate and culture;
- Top management support.

Critical success factors — strategy

- A product innovation and technology strategy;
- Leveraging core competencies;
- Targeting attractive markets;
- Portfolio management;
- The necessary resources.

Results from PDMA benchmarking studies (Markham and Lee, 2013) point to the following differentiating factors for organizations that are high performers in product innovation:

1. **Innovation culture**
   In the best companies:
   - Failure is understood;
   - Managers establish objectives;
   - Innovation is considered in recruitment;
   - External communication is used;
   - Innovation and risk-taking are valued;
   - Constructive conflict is encouraged;
   - Internal communication is effective.

2. **New products strategy**
   The best companies:
   - Use a well-defined new products strategy to direct all new product innovation activities;
   - Use a "first to market" strategy;
   - Are more likely to focus on sustainability;
   - Are more likely to apply intellectual property considerations;
   - Apply a global business model (operations in multiple countries).

3. **Portfolio management**
   The best companies:
   - Use portfolio management tools to select projects and to ensure ongoing balance across projects:
     - Radical vs. incremental,
     - Low vs. high risk,
     - New vs. existing markets.

- Specific tools used include:
  - Scoring models,
  - Strategic buckets,
  - Financial models.

4. **New product process**
   The best companies:
   - Use formal, cross-functional processes;
   - Continuously re-design the process;
   - Use specialized structures to drive new product innovation;
   - Adopt flexibility according to product category;
   - Have senior managers who understand and support the new products process.

5. **The front end of innovation**
   The best companies:
   - Spend considerably more effort to understand customer needs;
   - Use formal processes for idea assessment (recognizing the importance of making the right decisions at this early stage);
   - Use Open Innovation to gather and develop new ideas;
   - Use social media — discussion forums, blogs, innovation hubs, wikis, etc. — to gather customer information and opinion.

6. **Development tools**
   The best companies:
   - Use market research tools significantly more;
   - Use engineering design tools more frequently;
   - Place more emphasis on project planning tools.

7. **Measures and metrics**
   The best companies:
   - Use formal metrics for measuring and reporting on new product performance;
   - Use metrics for both outputs and process:
     - Outputs – such as profits from product innovation over the past 5 years;
     - Process – such as milestones on time or time to market.
   - Use metrics as a basis for learning and continuous improvement.

7.3 MANAGING PRODUCT INNOVATION

The role of managing product innovation can lie with a range of job titles — from the CEO of small to medium sized companies, VP of innovation in large companies, product innovation manager, brand manager, product manager, and more. Currently, the role of product manager is growing in prominence around the world. Product manager roles are increasingly coveted positions, with high salaries and ample opportunities for growth. In fact, product management ranks fifth on Glassdoor's 2019 list of best jobs in America, with over 11,000 job opportunities available.

7.3.1 The role of product management

Martin Eriksson, in his oft-quoted definition of product management, calls it the intersection between business, user experience, and technology. Refer to Figure 7.1. As Marty Cagan, founding partner of Silicon Valley Product Group and a 30-year veteran of product management, puts it, "The job of a product manager is to discover a product that is valuable, usable, and feasible."

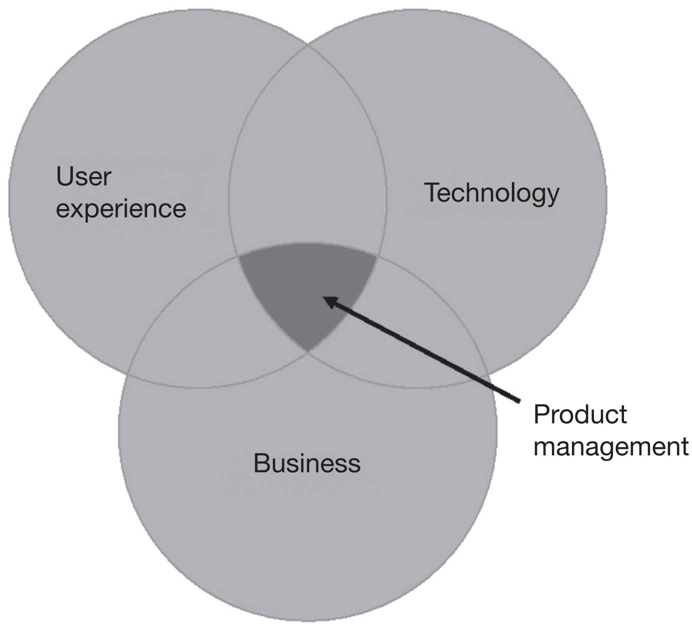


Figure 7.1 The product management intersection

A good product manager is experienced in at least one of these, deeply interested in all three, and can work with and learn from those that are expert in all three.

Business: First and foremost, product managers are responsible for delivering value to their organization through revenue generated from products sold to customers. Meeting business objectives and goals is paramount, as success in those areas ensures the ability of a company to succeed and thrive, returning value to owners, shareholders, etc.

User experience: In current vernacular, "UX" is often associated with interface design, human factor design, etc., and while those are definitely a part of the "user experience," UX ultimately comes down to understanding the customer — jobs they are trying to get done and problems they are trying to solve. Product managers don't have to be full-time designers, but they do need to make sure they are spending plenty of time with customers to discover these things.

Technology: Product managers need to have a level of understanding of not just "what" is being built, but also "how" it's built. They don't need to be engineers or developers, and they don't need to know how to code or design a PCB — but they do need to have a level of understanding that allows a shared language between themselves and developers and engineers.

The product manager is the person who creates the internal and external product vision and leads product management from scratch. The product manager develops the positioning strategy while working with stakeholders and teams throughout the process. Some of the key responsibilities of the product manager are:

- Understand customer experience;
- Develop vision;
- Prioritize processes and activities;
- Develop product pricing and positioning strategies;
- Negotiate with stakeholders;
- Build and follow a roadmap;
- Arrange product testing groups;
- Drive product launch;
- Participate in the promotion plan development;
- Build and maintain product awareness on all levels among product teams.

Product manager skill set for success

The first thing that a product manager does is see the opportunity to develop a new successful product or improve an existing one, adding necessary features to it. The product manager must be aware of current trends to make the right decisions when a company decides how to build or improve the product.

The product manager's skill set includes:

- Understanding a product and related needs of the customers;
- Market knowledge;
- Innovation awareness;
- Strategic thinking;
- Technical knowledge;
- Expert communication skills;
- Relationship management;
- User behavior understanding and empathy;
- Ability to explain business and technical requirements to all members of a team;
- Ability to measure the success of a product.

A **project manager runs product innovation**. Throughout the entire development stage, this person ensures that the project is in line with budget and time frames. A project manager's main role is tracking progress and organizing the workflow to provide on-time project completion.

A **product manager is responsible for market success**. Product managers develop the product strategy and engage in product existence and development from ground zero to complete withdrawal from the market — basically, supporting it during all stages of the product life cycle. Being responsible for strategy development, a product manager communicates with other departments, such as marketing or sales, to transfer to them a complete vision and build a product roadmap.

Putting it all together

A product manager is ultimately responsible for bringing an idea to life and commercializing it for the organization he/she works for. That includes providing methods to vet or screen ideas and guiding the product innovation process. The product manager is ultimately responsible for the outcome of a product launch. It's hard to measure all these activities with independent, measurable indicators, but some key ones typically include monetization, user engagement, and the level of user satisfaction. These measures will vary depending on the company and industry. Some product managers focus mainly on development, writing specifications, and supervising development progression, while others display more focus on marketing and sales by developing a marketing plan and training a sales team.

It may seem as if a product manager performs administrative tasks rather than actually "making" something, but that's not true. They are constantly working on improving the existing product, analyzing data, doing market research, and observing current trends of the industry. Eventually, a product manager has to make the tough decision of what products to build or improve, how to price them, how to position them with customers, and ultimately how to guide them to commercial success.

7.3.2 What is product management NOT?

While discussions around defining product management are important, it is also helpful to distinguish what product management is not. For many not involved in actual product management, it is often confused with project management. Let's start with a simple definition:

A **Project** is a process of creating a product or a service.

A **Product** is something that solves a customer problem and satisfies market demand.

The key differentiating factors between product and project management are summarized in Figure 7.2.

Project Manager	Product Manager
Development	Strategy
Plan	Vision
Team-oriented	Business-oriented
Technical knowledge	Industry knowledge
Budget	Profit
Completion	Growth

Figure 7.2 Product management vs. project management

7.3.3 Product management strategies

Chapter 1 provides a detailed discussion of business and corporate strategy; these overarching strategies impact, and are impacted by, the product innovation strategy.

Much of how a product manager succeeds can be summarized in four key strategies a product manager focuses on:

- Create a vision;
- Develop a plan to execute the vision;
- Guide the development of products (product innovation);
- Commercialize the products (marketing and sales).

Vision: If we were to compare product management to a road, the vision is both a road sign and a destination. Vision defines the final product and shows the direction toward achieving it. It's not a product innovation strategy (yet), but this is where the strategy development starts — with idea management when a team discusses a new product. The vision can be articulated during a brainstorm or may be based on a backlog of ideas.

When developing the vision, a product manager sets the goals for the product and defines specifications. A well-specified product vision answers the following questions:

1. What is the user persona (personas) for the product?
2. Which problems will the product solve?
3. How can we measure the success of the product?

Develop a product strategy: Once a vision has been developed, it must be translated into a specific strategy. While a vision defines the goals for a product, strategy describes a way to achieve them and sets main milestones. This must be a clear and realistic plan for the team that works on a product.

An effective product strategy defines the main features of a product, users and their needs, and key performance indicators (KPIs) that the product must meet. These elements can be organized around the product strategy — with equal importance. Refer to Figure 7.3.

Figure 7.3 Product strategy triangle

Strategy development starts with market and customer research. Market research is a process of information collection and analysis of the market and its present or potential customers. It looks at current/potential customers and their spending/buying habits, their brand awareness/sensitivity, and other metrics that uniquely identify what purchase decisions they make and how they make them. Chapter 5 provides a detailed discussion of various market research techniques and how they can be applied throughout the product innovation process.

Finally, product strategy is typically documented in a written form that is often referred to as a roadmap. This roadmap is a tool that provides a framework for the team with a timeline and specific actions; it illustrates the vision, goals, and current state of product innovation. A good roadmap is clear and serves as a visual guideline for all members of the team. Regardless of the specific roadmap structure, it must depict the current state of things and the next steps. More detail on roadmaps is provided in a later section of this chapter.

Execute the plan (product innovation): New product innovation typically involves a number of stages: idea generation, scoping, business case development, build, test, and launch. There are many variations on these various stages, with some adding additional stages like idea screening, marketing strategy development, concept development, and others. But the main tasks are to generate and select ideas, determine the effort and scope of the development required, build a business case to justify the effort, expend the effort to develop the product, test and evaluate it, and ultimately commercialize it. Earlier chapters in this book go into much greater detail on the product innovation process.

Commercialize: The final stage of product innovation is introducing the product to market and its customers. At this stage, marketing and launch plans have to be finalized, the sales teams trained, channel partners and distributors brought into the loop and the manufacturing organization gets ramped up to make sure product is available as sales are made. Through the whole process, the product manager delivers an operating plan, which aims to track the growth of a product in the market: the revenue, ROI, key customers, and other metrics.

Once the product is in the market, the product manager needs to continue to monitor its success: sales, level of customer satisfaction, potential issues and their solutions, and customer feedback. In start-ups and smaller companies, the product manager may have more responsibilities at this stage. In this case, the product manager can be involved in the following processes:

1. Writing business and use cases;
2. Configuring the product launch plan and distribution models;
3. Specifying the target market;
4. Defining the pricing strategy;
5. Setting sales support and required tools.

In larger businesses, these activities are usually distributed among members from the product, sales, and marketing teams but still with significant input from the product manager.

At a point after product launch, when the product has begun to establish its position in the market (or in some cases, failing to do so), the product manager tracks its progression and reiterates the same steps across its life cycle. The product manager uses data to understand the success (or struggles) of a product. Measures like the number of products sold and customer feedback — all are analyzed and communicated to the team to help improve sales and marketing strategies.

SECTION 2
What is the product life cycle and how is product innovation managed through this life cycle?

7.4 THE PRODUCT LIFE CYCLE

7.4.1 Introduction to the product life cycle
The product life cycle (PLC) is the sequence of stages from introduction to growth, maturity, and decline through which most products progress; see Figure 7.4. The PLC has a significant impact on marketing strategy, the marketing mix and on new product innovation.

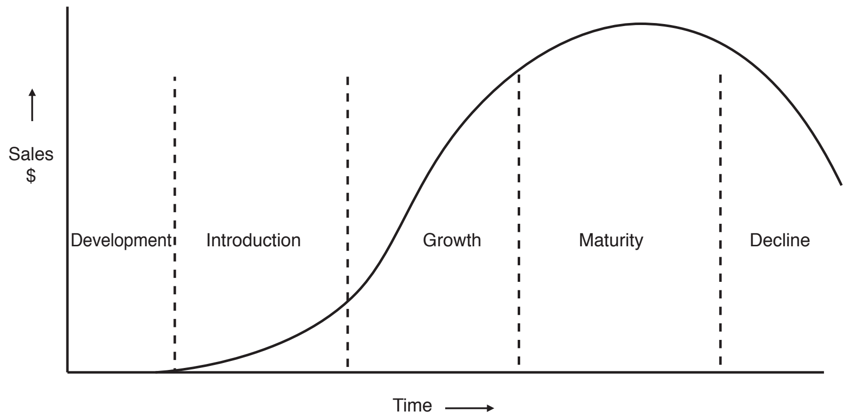
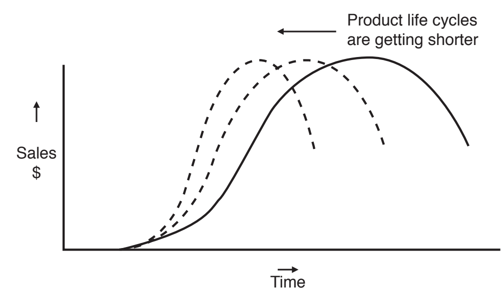


Figure 7.4 Product life cycle stages



Product life cycles are getting shorter as:
- Customers become more demanding;
- Competition is increasing;
- Technology is constantly improving/changing;
- Global communication is increasing.

The shortening of the life cycle for most products has put significant pressure on:
- Constantly refreshing the organization's products — including both new products, and modifications and improvements to existing products.
- Management of the marketing mix throughout the product's life cycle.

7.4.2 The stages of the PLC (and their impact on cash flow)
- **Development:** The organization identifies, plans, and resources effort to develop a product intended to be commercialized and generate revenue. Negative cash flow as investments are made.
- **Introduction:** The organization seeks to build brand awareness and develop a market for the product. Cash flow returns to neutral and begins to swing positive as sales are generated.
- **Growth:** The organization seeks to build brand preference and increase market share. These efforts accelerate sales, thus driving cash flow significantly positive. Some investment still occurs here to support branding and marketing efforts.
- **Maturity:** Competition increases. The organization seeks to defend market share while maximizing profit. Break-even cash flow has been achieved. Cash flow levels out as additional awareness no longer drives equal incremental sales. Investments level off to maintain revenue.
- **Decline:** Sales start to drop off and the organization needs to make tough decisions on what to do with the product. Cash flow declines as any additional investments do not drive incremental sales. Investments stop and are focused on other products.

Inclusion of the product innovation phase as part of the overall product life is shown in Figure 7.5.

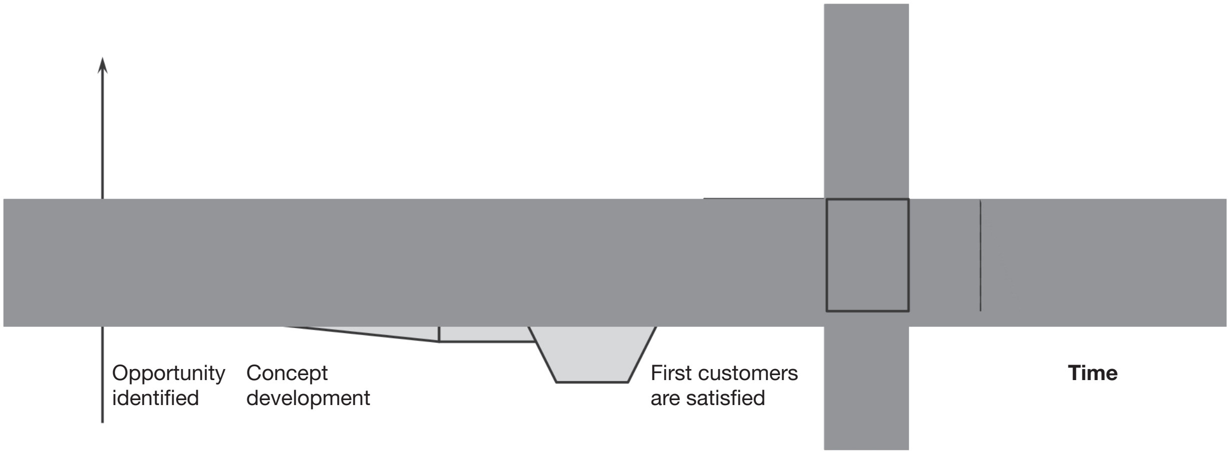


Figure 7.5 Product life cycle from conception to grave

7.4.3 Managing the product life cycle

Different strategies are required for the elements of the marketing mix (product, price, distribution, and promotion) at each stage of the PLC.

Introduction stage

- **Product** branding and quality level are established, and intellectual property protection (such as patents and trademarks) is obtained.
- **Pricing** may be low **penetration pricing** to build market share or high **skim pricing** to recover development costs.
- **Distribution** is selective until consumers show acceptance of the product.
- **Promotion** is aimed at early adopters. Communications seek to build product awareness and to educate potential consumers about the product.

Growth stage

- **Product** quality is maintained, and additional features and support services may be added.
- **Pricing** is maintained as the organization achieves increasing demand with little competition.
- **Distribution** channels are added as demand increases and more customers accept the product.
- **Promotion** is aimed at a broader audience.

Maturity stage

- **Product** features may be enhanced to differentiate the product from that of competitors.
- **Pricing** may be lower due to new competition.
- **Distribution** becomes more intensive and incentives may be offered to broaden the opportunities for customers to purchase.
- **Promotion** emphasizes product differentiation and new features as they are added.

Decline stage

- **Maintain the product**, possibly rejuvenating it by adding new features and finding new uses.
- **Harvest the product** by reducing costs. Continue to offer the product, but to a loyal niche segment.
- **Discontinue the product**, liquidate remaining inventory, or sell it to another organization.

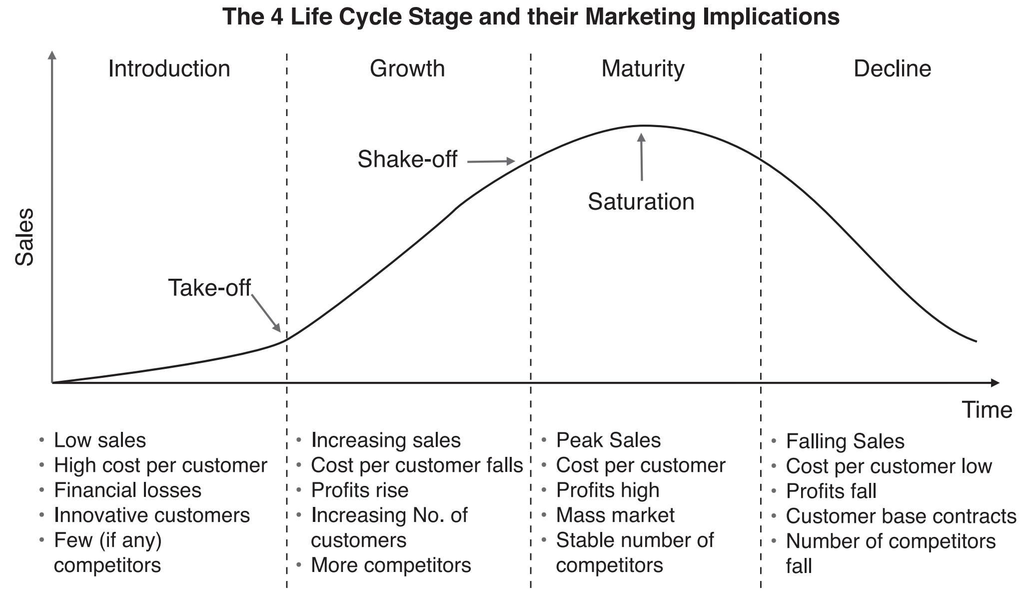


Figure 7.6 Product life cycle from conception to grave. Claessens, M. (2017)

7.4.4 Impact of the PLC on the product portfolio

The management strategies at different stages of the PLC, outlined above, emphasize the importance of product improvement, addition of new features, line extensions, and cost reductions. All must be accounted for in the new product portfolio. The overall business strategy and the innovation strategy provide the direction and framework for product portfolio management. These strategies should establish the priorities across the various product innovation options, including:

- New-to-the-organization/world products;
- Line extensions;
- Cost reductions;
- Product improvements.

"New-to-the-organization" and line extensions have the potential to establish new products for the organization, while cost reductions and improvements are essential tools in PLC management to rejuvenate and prolong a product's life.

The question "what defines a product?" in terms of the classic product life cycle description is an interesting one. In the case of the iPhone, is the iPhone itself the product or are the various model iterations — 2G, 3, 4, 4S, etc. — the products? The answer is that the iPhone itself has a life cycle and the individual models also have their own life cycles that contribute to extending the overall life of the iPhone. The extension of a product's life through feature enhancement and new model release has become an important component of most organizations' product innovation portfolio.

The trend toward more frequent product modification and feature enhancements — particularly in the electronics, software, and Internet industries — has placed greater pressure on speed to market and reduction in product innovation cycle times. In turn, this strategic focus for product innovation has significantly influenced the new product process with a strong drive toward Lean and Agile.

In addition to ensuring a balance across the types of product innovation it is also important that portfolio management recognizes the need for a balance of products across the PLC. Obviously, having a high proportion of products in the introduction or launch phase places significant financial pressure on the organization. On the other hand, a high proportion of products in the decline phase does not present a very positive future for an organization. Figure 7.7 shows a distribution of products across the PLC.

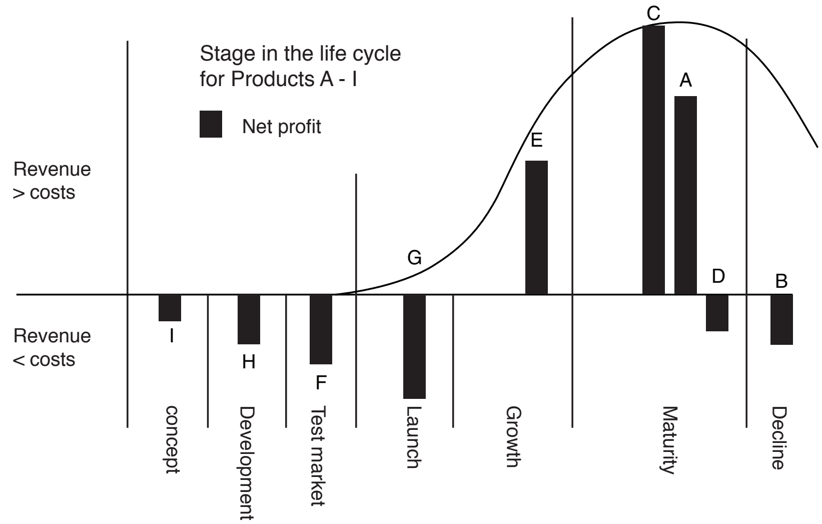


Figure 7.7 Balancing the product portfolio across the product life cycle

7.4.5 The product manager's role in the product life cycle

Product managers play a critical role in guiding a product through its life cycle. This role takes on different responsibilities during the PLC with an overall eye on maximizing the success (revenue, market share, customer satisfaction — pick your KPI) of that product.

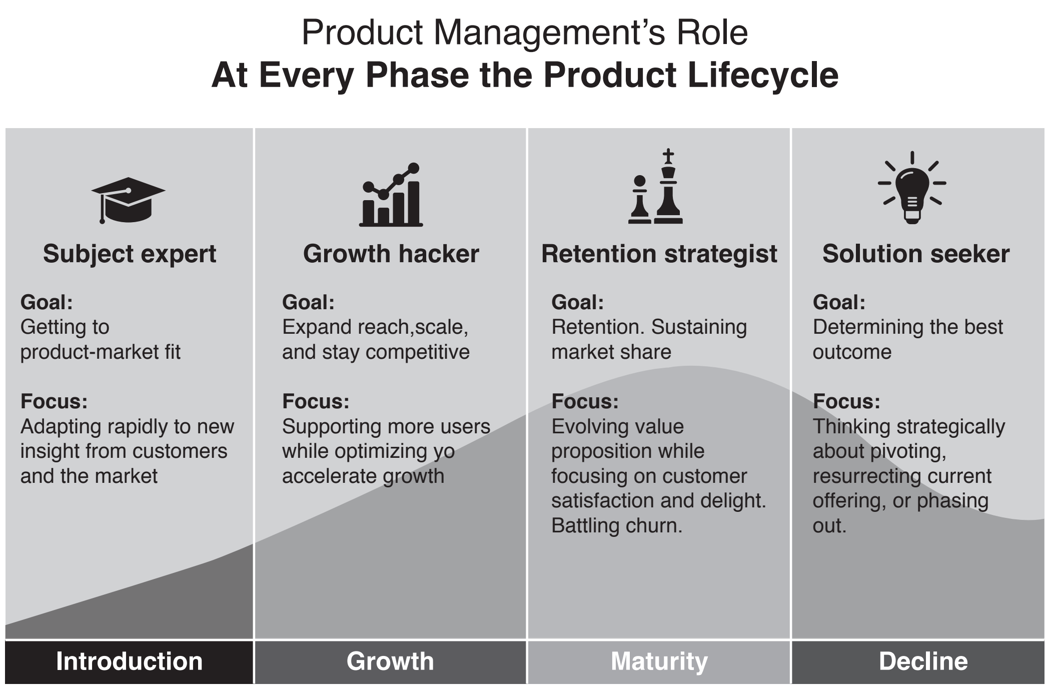


Figure 7.8 Product manager roles in the product life cycle. ProductPlan® https://www.productplan.com/product-management-role-product-lifecycle/

Product introduction

Depending on the type of product (line extension, new-to-the-company, new-to-the-world), a product manager's role during the introduction phase will vary slightly. But in general, their responsibility involves validating the fit for the market, ensuring that the product is priced correctly, and being the expert and champion for the product as it's trying to get a foothold.

Validating the fit and being quick to adjust is a key part of what product managers often need to focus on for "new-to-the-company" (NTC) and "new-to-the-world" (NTW) products. There may have been (or not…) market research and concept validation prior to launching the product, but nothing provides solid, useful feedback as the type that comes from paying customers. Product managers have to be sure they are paying attention to customer feedback during this phase. Just as importantly, they have to take that feedback and build useful information for the development or engineering teams to use. Refining the value proposition is critical at this point as well. Feedback from real users may undermine existing value proposition points — necessitating that they be changed… or eliminated. New, previously unexpected values may also be uncovered that have to quickly be folded into the overall value proposition to ensure the product is still addressing its intended customers and solving the problems/doing the jobs it was intended to do.

Pricing can also be challenging at this phase. For simple line extensions, it may be a relatively straightforward calculation. But for new products that are "new," pricing may present challenges. Depending on the corporate/company focus, new products may be priced aggressively to capture market share early, or absent significant competition, may be priced to maximize operating KPIs like margin or revenue. In both cases, a misstep can have an impact on the potential success of the product. If pricing aggressively for market share, the dangers are that customers become conditioned to expect new features and capabilities in new products at the same (or lower) price as a previous generation product. This may undermine a value proposition or set the market at the low end of the price scale with no room to maneuver as the market matures. The pricing decision will have to be made so that it supports the value proposition and supports the business plan for the product. It is a dynamic decision to balance building momentum during a launch with the need to be sustainable over the long term.

In short, during the introduction phase, product managers have to be sure they are listening to the market and their customers, move the organization to adapt as needed, and provide the encouragement needed through proper pricing to accelerate the adoption of the product.

Growth

During the growth phase, the product manager can begin to focus on accelerating adoption, refining the pricing strategy, and identifying additional product innovation opportunities for the product.

As the product begins to develop some momentum, this is the time when a ramp-up in marketing can be beneficial. As the value proposition is clarified and feedback from the customer has been folded back in to the product positioning, efforts to more broadly introduce the product to the market can be effective. During this phase, profit margins start to improve/increase due to economies of scale, reducing the piece-part price of the product. During the growth phase, product managers have a few key things to focus on. One is to be aware of the growing set of competitors that will likely begin to emerge, which can begin to have an impact on pricing strategy. Competitors may try to undercut established pricing in order to get a foothold. Another key issue for product managers to focus on is ensuring that some of the profit being captured finds its way back into the product innovation process to help set the stage for product enhancements and extensions. Lastly, this is the time to ensure that feedback from customers and the market is captured to fold back into the product positioning and value proposition, to make sure that the product continues to successfully navigate the chasm that can exist in the transition from introduction through the early growth period.

Maturity

During the maturity phase, most of the uncertainty around positioning and value proposition has been taken care of — which sounds good; but it's also during this phase that sales growth slows considerably, with most customers who wanted to buy your product having already bought it. Many fewer new buyers are entering the market, so hanging on to existing customers becomes very important. For product managers, this is often the time to focus on the numbers. Carefully managing product costs, marketing and sales costs, etc., can often extend the life of a mature product. This is also the time that customer feedback from the growth phase can be leveraged into product line improvements/extension to prolong the effective life of the product.

Decline

All good things come to an end. There is a time for all products when their contribution to the organization begins to decline. This is due to newer products offering more effective competition, a change in the market that has customers pivoting to a new/different solution or even the decline of an entire market due to disruptive innovation that makes the entire category/market no longer relevant. Product managers have just as important a role during decline as in the other phases. Most important may be to clearly understand what is driving the decline. If it is due to competitive changes, then additional marketing or promotion may be necessary. If market/customer needs are changing, then extensions or updates to the product may extend its productive life. If there is a disruptive innovation causing the decline, product managers need to look at whether their company can become part of the disruption. Regardless of the diagnosis and chosen path forward, a final critical responsibility of the product manager is to effectively manage the end-of-life and transition of the product to whatever comes next. An effective end-of-life transition is often overlooked, but can make or break the effectiveness and success of future products and product enhancements and extensions.

7.5 WHAT IS THE CHASM IN THE PRODUCT LIFE CYCLE

For product innovation, a critical part of the product life cycle occurs near the beginning — after introduction, but before growth has fully kicked in. This section is often called the "Chasm" (see Figure 7.9). This term was introduced by Geoffrey Moore in his book *Crossing the Chasm* (2014).

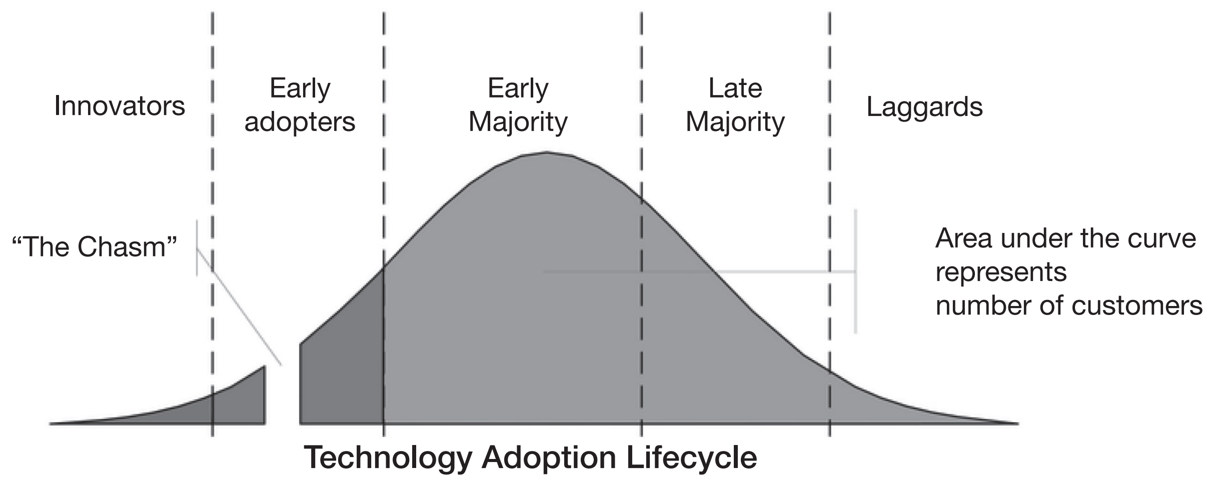


Figure 7.9 Crossing the Chasm
Used by permission of Geoffrey A. Moore (2014) *Crossing the Chasm,* 3rd Edition

This gap (or chasm) is one that must be navigated to fully realize the growth potential of a product. This entire process by which we describe how and when consumers are willing to accept new products (or innovations) is referred to as Diffusion of Technology. This process was first fully described by Everett Rogers in 1962 (this curve is sometimes called the Rogers curve) and is still used and referred to today.

The curve above is a complement to the PLC curve — you can overlay this adoption curve onto the PLC curve such that innovators and early adopters typically appear during the introduction and early growth phase of a product.

So why is there a chasm? In its simplest form, the answer is because innovators and early adopters buy innovation as a change agent. They want to be ahead of the curve and get ahead of the competition — even if it's got bugs. The "early majority" adopters are buying an innovation as an enhancement to their productivity — to improve what they do, not necessarily completely disrupt it. But in new product innovation, it's never (or rarely) a seamless transition between early innovation and fast-growing successes.

7.5.1 Crossing the chasm

Understanding why a chasm exists is important to begin to formulate ideas about how to cross that chasm effectively. Some products make the leap, while others don't. Some of the reasons and ways the chasm is successfully negotiated:

1. The product/innovation has a relative advantage (that can be perceived) over the existing solution it is attempting to replace. This "measurable advantage" can take many forms — economic, social prestige, convenience, performance, etc. The greater this perceived advantage, the more likely that the product or innovation will make it past the chasm and continue to be adopted. There are no hard and fast rules, though, for what constitutes a relative advantage. It depends on the user group being targeted and its needs and perceptions.
2. Its perceived consistency with past or existing practices, values, past experiences, and needs of the user group. The degree to which the innovation demonstrates this consistency will influence how quickly it is adopted — or if it is adopted at all.

3. Simplicity — the degree to which an innovation is perceived as being either easy or difficult to understand — will impact its adoption. The easier or simpler an innovation is perceived to be, the more likely it will make it across the chasm and it will likely be adopted more quickly than innovations that are more complex.
4. How easy is it for new users to "give it a try"? This is called trialability; the easier it is for users to test and experiment with the innovation on a limited basis before committing to it, the less risky the innovation appears and the more likely it is that users will adopt it.
5. The easier it is for new potential users to quickly and easily see the results of using a new innovation, the more likely they are to adopt it. These visible results again lower the perceived risk and uncertainty, and make it easier for peers within the targeted user group to share experiences which can accelerate the acceptance and adoption of a new technology.

7.5.2 The "go-to-market" processes

Go-to-market: Old school approach

The "old school" approach is very much a linear process of "make the product" and then figure out how to "sell the product" (see Figure 7.10).

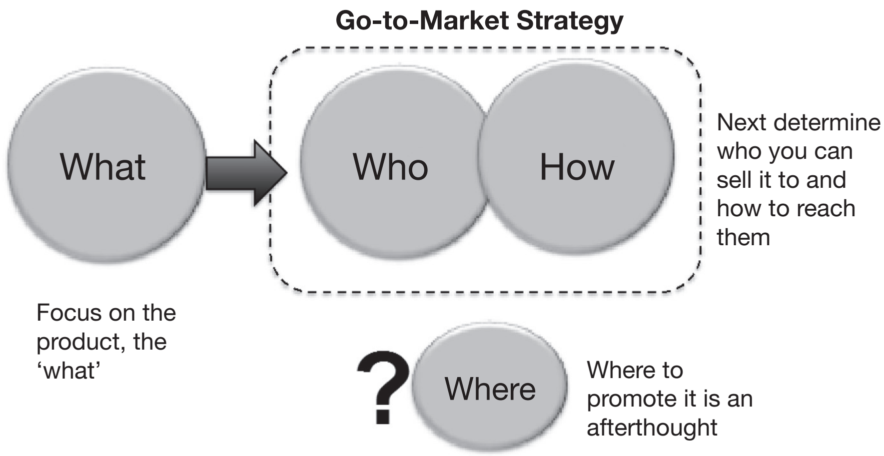


Figure 7.10 Go-to-market: Old school approach

Go-to-market: New school approach

The "new school" approach to developing a go-to-market strategy is an iterative process (see Figure 7.11).

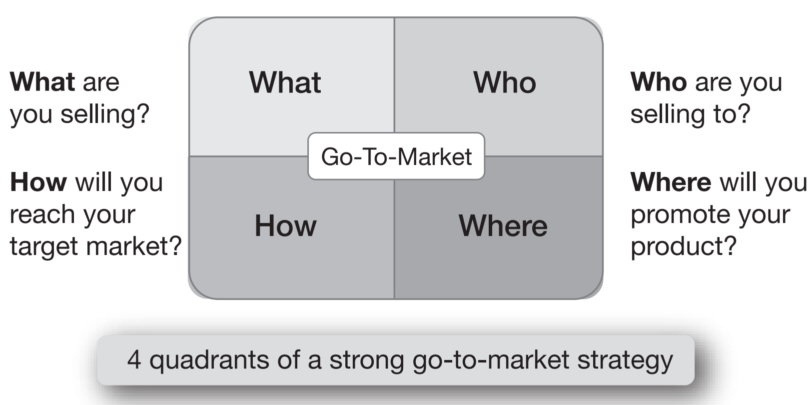


Figure 7.11 Go-to-market: New school approach

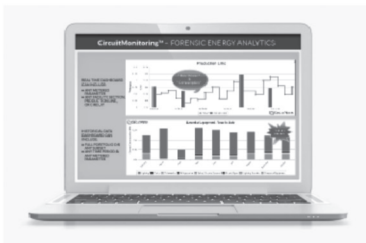
Case studies to demonstrate the "new school" approach

Following are two case studies to demonstrate the "new school" process to developing a go-to-market strategy for a new product. The products are "the CircuitMeter," a low-cost energy management solution for commercial buildings and "the LifeBike," an innovative eBike with a unique sitting position (refer to Figure 7.12).

CIRCUITMETER

SIMPLE • AFFORDABLE • ENERGY ANALYTICS

- Low cost energy management solution for commercial buildings



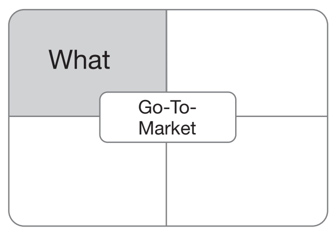
LIFEbike

- Innovative eBike with a unique ergonomic sitting position (e.g. its cool)

Figure 7.12 Go-to-market case studies

What are you selling?

The first step is to define exactly what it is you are selling. This should be based very much on the concept description and design specifications that evolved throughout the development process. What **unique** benefits does your product provide in comparison to **competitors**? Typically, competition is based on either cost or differentiation. Remember that you are usually selling in a competitive environment where what you are selling impacts your competitors and vice versa.



The value proposition

This description of what product you are selling can now be developed into a value proposition, defined as "a short, clear, and simple statement of how and on what dimensions a product concept will deliver value to prospective customers. The essence of 'value' is embedded in the trade-off between the benefits a customer receives from a new product and the price the customer pays for it." (PDMA Glossary)

Value propositions for the product examples above are shown in Figure 7.13, focusing first on defining the benefits.

CIRCUITMETER

SIMPLE• AFFORDABLE• ENERGY ANALYTICS

- Find energy problems faster
- Measure solution payback

LIFEbike

- Compact
- Comfortable riding position

Figure 7.13 Value propositions for case studies

Now the product features are related to the key benefits. Refer to Figure 7.14 for this exercise on the CircuitMeter product.

Defining Unique Benefits
Example: CircuitMeter

Features	Benefits
Circuit level data measured each second with ability to analyze power harmonics	Quickly find options for energy savings
Cloud based analytics	Compare/contrast data across buildings
Low cost	Fast ROI

Figure 7.14 Defining the unique benefits for the CircuitMeter

The whole solution

Having defined the key benefits through the value proposition, the "whole solution" needs to be defined — what the product is intended to deliver in terms of core benefits plus tangible and augmented features. Then, what part of the whole solution are you selling? Or what part can you sell? Refer to Figure 7.15 for the whole solution for the CircuitMeter example.

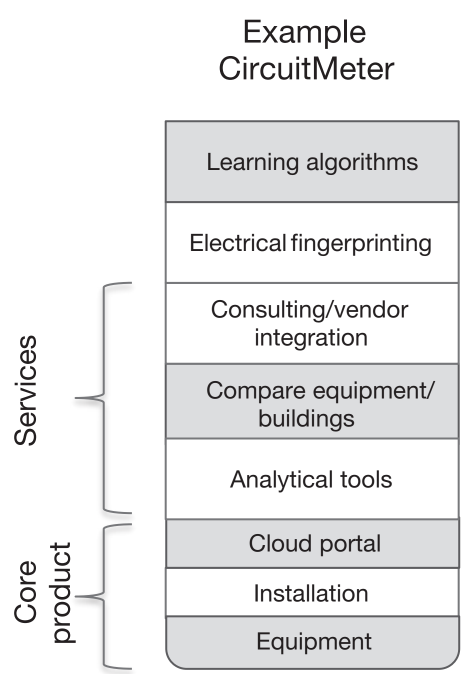


Figure 7.15 CircuitMeter solution

Who are you selling to?

The next key question is "who are you selling to?" Think about segments, not market size and share of market. See Figure 7.16.

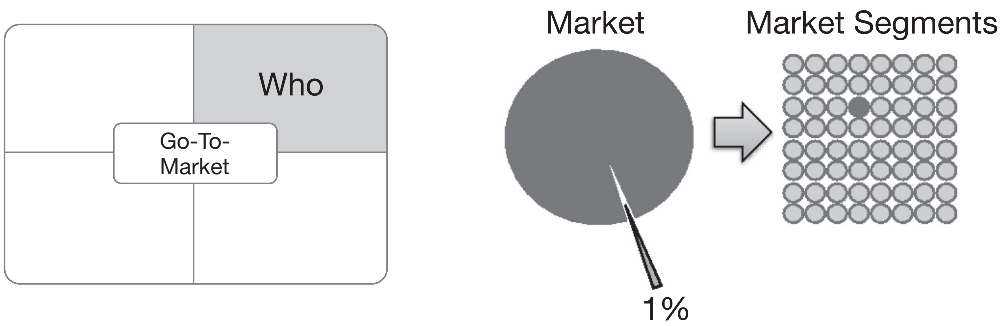


Figure 7.16 Defining the market

An example of market segmentation applied to the LifeBike case study is shown in Figure 7.17.

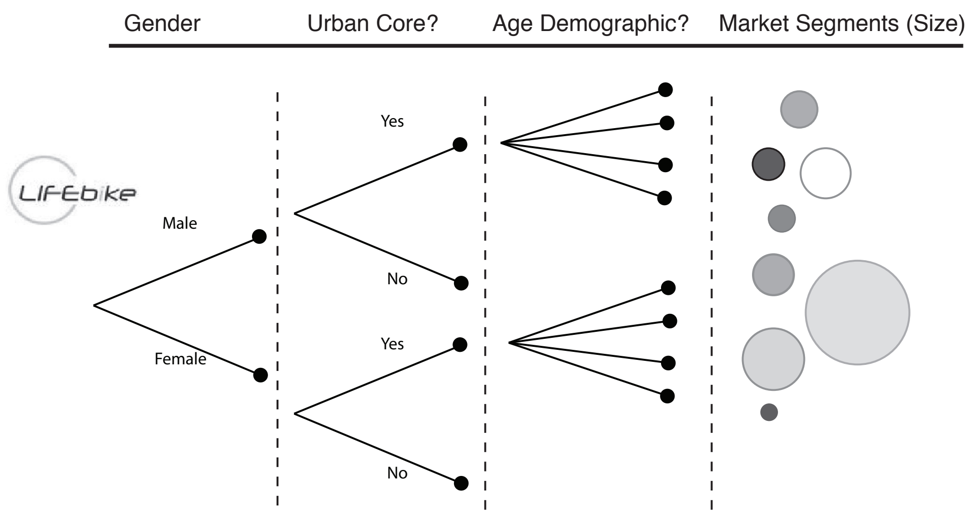


Figure 7.17 Market segmentation for the LifeBike

Refining the target market

This is the process of comparing the needs of each segment with the primary benefits. Figure 7.18 shows two benefit dimensions for the LifeBike example — ease of storage (compactness) and riding position (comfort). Various segments of the target market are represented by circles. The two segments whose needs match the LifeBike benefits are university students and female professionals who live and work in a city. The major competition is positioned in a different area of the market and appeals to different market segments.

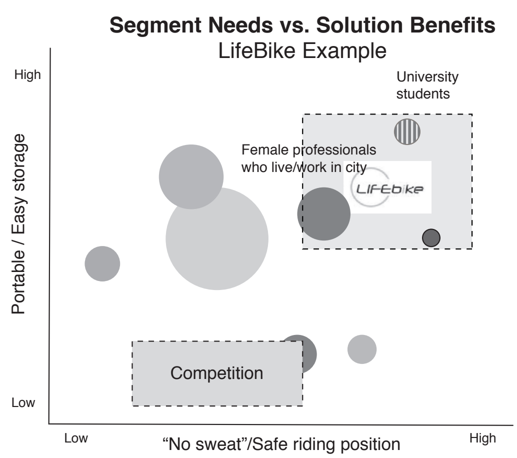


Figure 7.18 Segment needs vs. solution benefits for the LifeBike

Figure 7.19 shows a segmentation analysis for the CircuitMeter product. The four segments are analyzed according to the intersection of product benefits with customer needs, plus the ease of selling to each segment. Ease of selling is also a dimension that is viewed through the consideration of market concentration and market access.

Segmenting Beyond Fit with Value Proposition
CircuitMeter Example

		Fit with value proposition		Ease of selling		
Market Segment	**Market Size**	**Needs/Solution Fit**	**Propensity to spend**	**Market Concentration**	**Market Access**	**Overall Segment Attractiveness**
Retirement homes.	◑	◑	◑	◕	◕	◕
Corporate, Single Tenant	●	◑	◑	◑	◕	◑
Hotels	◑	◑	◔	◕	◑	◑
Multi-tenant Buildings	◔	◔	◔	◔	◔	◔

Low ○ ◔ ◑ ◕ ● *High*

Figure 7.19 Segmentation analysis for the CircuitMeter

Beachhead strategy

A beachhead strategy is a leveraged approach to a market rollout. It selects the highest potential segment for initial launch and based on its success, the product is then launched in a succession of other segments. Refer to Figure 7.20 for an example with the CircuitMeter product.

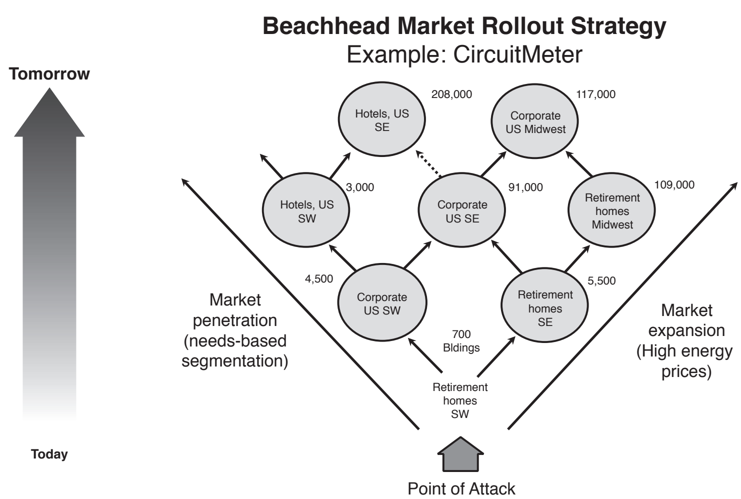


Figure 7.20 Beachhead launch strategy for the CircuitMeter

Reaching your target market

Reaching your target market segment and making the new product available is a critical element of the go-to-market strategy. Key decisions include which channel to use and what partners to involve. Refer to Figure 7.21.

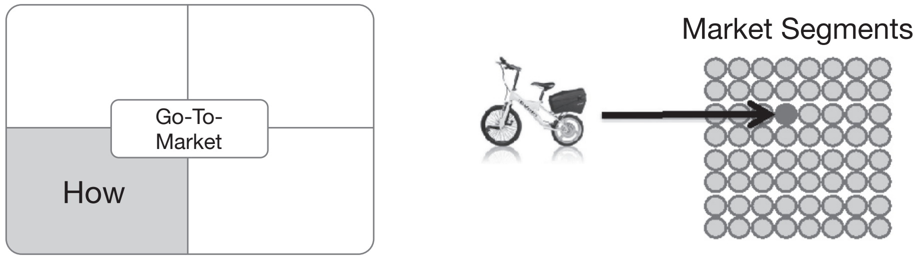


Figure 7.21 Getting the new product to the selected market segment

Channel(s) strategy
Many channel options are available for reaching the target market. A selection of these options is shown in Figure 7.22.

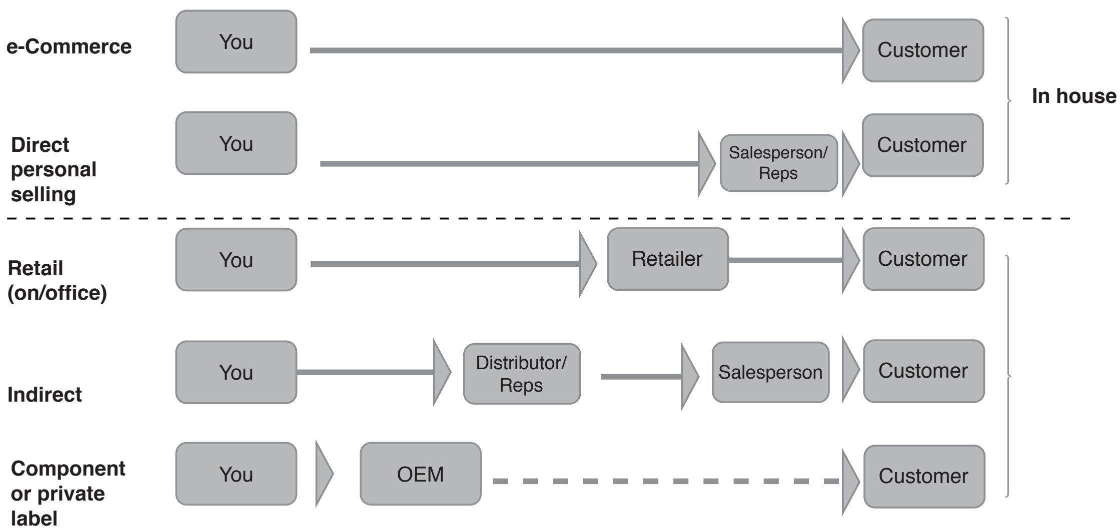


Figure 7.22 Channel options

Factors to consider in channel selection
Product factors

- In general, highly sophisticated products are distributed directly to buyers whereas unsophisticated or standardized (commoditized) products with low value are typically distributed through indirect channels.
- The product may be year-round or seasonal, fragile or sturdy, durable or perishable.
- The stage of the product life cycle is important. At the early stage, gaining market share is important and it may be an advantage to have a number of distributors. In the maturity phase, distribution efficiency and cost savings are critical.

Organization factors

- Organizations that don't have — or can't afford — their own sales force are more likely to use agents or brokers to reach wholesalers or other buyers.
- Organizations that are targeting a wide range of markets are also likely to use channels external to the organization, whereas organizations that manufacture a range of products for a particular target market are probably best suited to direct channels.

Price factors

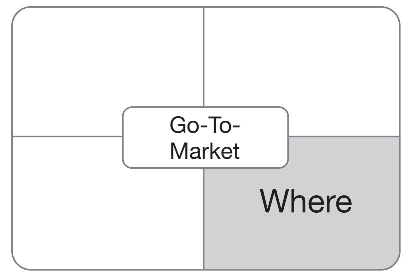
- Inclusion of a number of intermediaries in the distribution channel can add significant cost that results in a significantly higher final selling price.

Customer factors

- Ultimately, the key factor to consider is reaching your customer in the most effective way.
- You need to know your potential buyers, where they buy, when they buy, how they buy, and what they buy.
- In the case of products that are purchased by a customer at a physical outlet, there are three main levels of distribution coverage:
  - Mass or intensive — a large number of outlets.
  - Exclusive — a single outlet or chain of outlets.
  - Selective — a few retail outlets in a specific area.

Where will you promote your product?

Not only must the new product be made available to the target market segment in the right place, but customers must be made aware of product benefits and features.



- Align your promotion plan with your target market.
- Focus on reaching decision makers in the target market.
- Where do the decision makers get their information?
- Types of promotion include Internet/social media (Google AdWords, Facebook), PR (mass market publications vs. specialty publications), word-of-mouth (social media promos), trade shows, product demos, print media, and television.

Messaging is critical

It is critically important to convey the right messages about the product in the right way. The messages must not only convey the product benefits and features, but must resonate positively with the customers in the target market segment. Figure 7.23 show a positioning statement for the CircuitMeter.

CircuitMeter Positioning Statement

CircuitMeter is... [what]	...a forensic energy management solution...
...primarily for.... [target market]	...commercial building owners who want to accurately identify energy solutions and measure solutions impact.
The compelling reason to buy [benefits]...	• Fast payback • Simplifies actions/investment and measurement; • Compare with other building in real time.
...unlike [competitors]...	• Expensive meter-on-chip solutions; • High level, watered down. solutions that look only at total building energy use.

Figure 7.23 CircuitMeter positioning statement

Go-to-market summary

Figure 7.24 provides a summary of the eight steps in developing a go-to-market strategy.

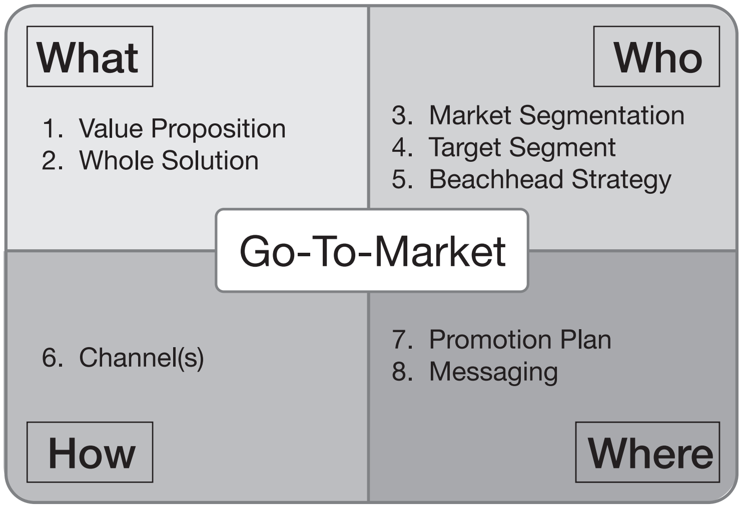


Figure 7.24 Summary of the steps in developing a go-to-market strategy

7.6 PRODUCT AND TECHNOLOGY ROADMAPS

Roadmaps are very important tools to assist in communicating the vision of a product line with internal and external stakeholders. They also help to organize and plan a logical and compelling release of features and capabilities over time. There are a number of do's and don'ts when it comes to roadmaps. There are also different types of roadmaps that can be used alone or in combination with others to properly communicate the product line vision.

There are any number of roadmap types — a roadmap is just a visual way to see the rationale and logic of how/why we're moving from point A to point B. There can be HR roadmaps, sales roadmaps, project roadmaps, etc. When thinking about products or services intended for an end customer, several types of roadmaps can be very helpful.

7.6.1 Product roadmaps

For product-driven companies (HW or SW, B2B or B2C), a product roadmap is essential to organizational alignment. A product roadmap illustrates high-level product strategy and demonstrates how a product will evolve over time. It includes upcoming features and the nitty-gritty of product innovation — like technical considerations and resourcing. A product roadmap is a powerful communication tool that product managers use to align different departments on one vision. It empowers the sales team to lead informed product conversations with prospects and the marketing team to plan campaigns that align with future product releases and product line extensions.

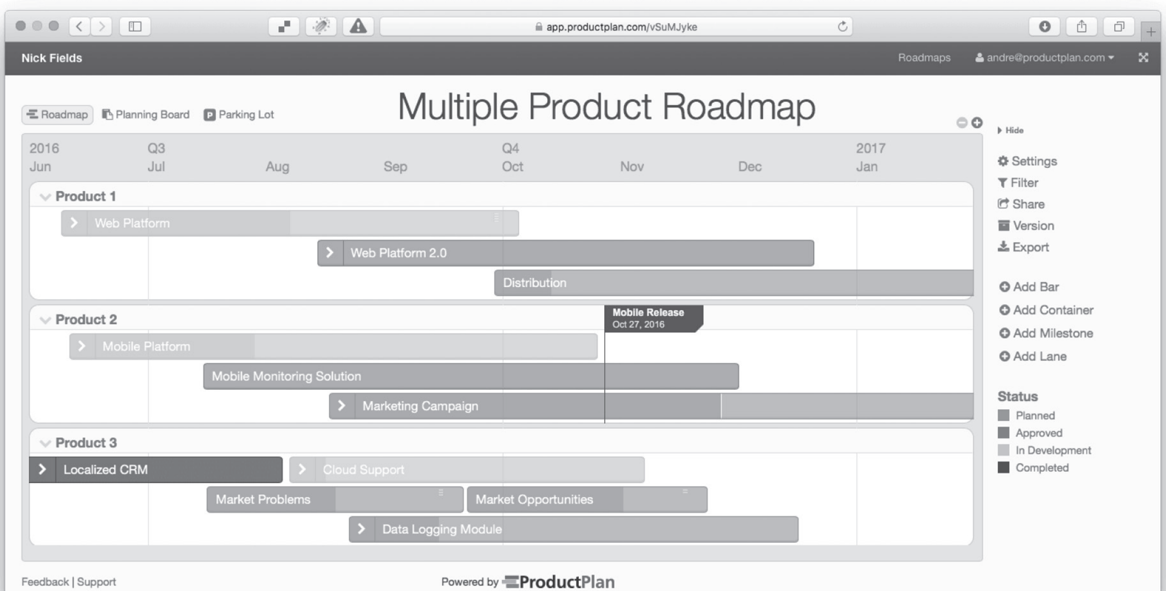


Figure 7.25 Multiple product roadmap
Reprinted with permission from ProductPlan https://www.productplan.com/product-roadmap-templates/

7.6.2 Technology roadmaps

Technology roadmaps are an important complement to the product roadmap in aligning technology planning and development to overall planning for the launch of a single product or a range of products. Technology roadmapping is particularly important in organizations that have a strong strategic focus on technology in underpinning the innovation strategy and new product innovation.

Figure 7.26 shows an example of a technology roadmap for 3D NAND process size for the major manufacturers of those devices.

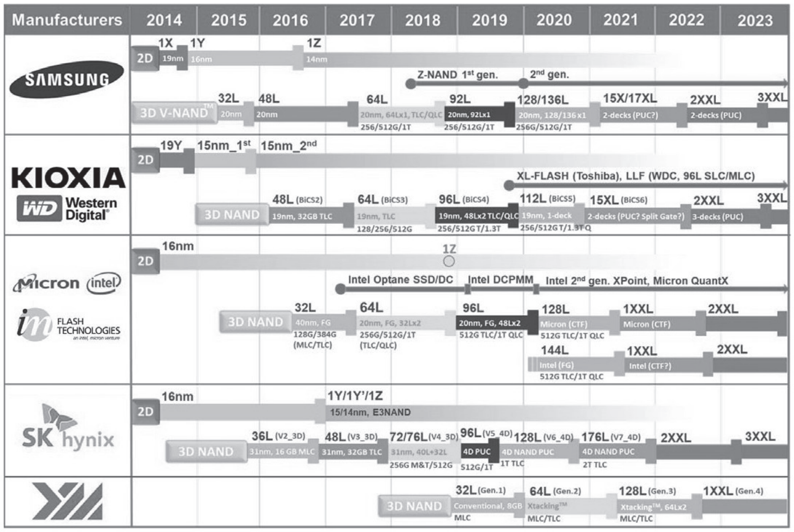


Figure 7.26 Example of a technology roadmap. TechInsights NAND Flash Memory Technology/Products Roadmap report. www.techinsights.com

7.6.3 Platform roadmaps

Platform roadmaps like the one in Figure 7.27 are critical when creating software/firmware platforms that other developers will use to build solutions. Examples of platforms include Microsoft Windows, Apple MacOS and iOS, Google Android, and others.

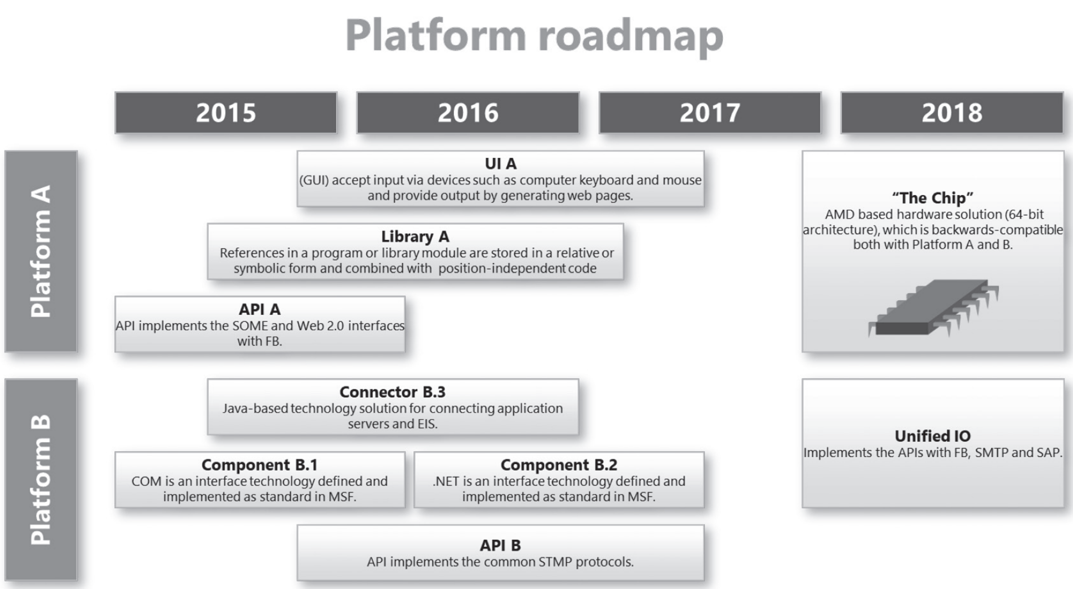


Figure 7.27 Example of a platform roadmap. Pendolin and Nurmela (2012) https://www.slideshare.net/pendolin/onion-model-for-roadmapping

7.6.4 Good practice application of roadmaps

- Share roadmaps carefully; roadmaps by their very nature contain a lot of information about your company's strategies, plans, etc. Their power can also be their weakness, in that they can cause problems if not carefully controlled. We're not necessarily talking about corporate espionage — even within your own company, an improperly controlled roadmap presentation can cause confusion, concern, and could set back your efforts.
- Be sure to mark your roadmaps as "Confidential — Do Not Distribute" whenever you do share them.

- Consider having versions of your roadmaps with different levels of granularity. This will help you ensure they are consistent whether used within your company or outside. It also lets you share a high-level version with non-employees and more detailed versions with those directly impacted by the roadmap.
- Be sure your roadmaps are developed collaboratively — get feedback early and often. For a roadmap to be effective, it has to be fully supported by those it affects. Making sure the team fully buys into the roadmap will help ensure its effectiveness.

SECTION 3

What are some of the key tools for managing product innovation and how can product innovation be improved through application of appropriate performance metrics?

7.7 FEASIBILITY ANALYSIS

Feasibility analysis is the process of analyzing the likely success of a project or a new product. Various levels of feasibility analysis should continue throughout the product innovation project and throughout a product's life cycle. Aspects of a feasibility analysis are inherent in the gate reviews of the Stage-Gate® process (described in Chapter 3), but also in other methodologies such as systems engineering, wherein the upfront analyses of user requirements will require early feasibility analyses to be performed.

As the project progresses and the cumulative costs increase, it becomes increasingly important to make the best decisions, based on the best available information, to mitigate the risk of project failure. Detailed feasibility analysis becomes increasingly important.

7.7.1 What to consider in a feasibility analysis

A checklist of some of the major issues to be considered in a feasibility analysis follows:

Market potential:
- Does a market exist?
- What sales can be achieved?

Financial potential:
- What profit can be made?
- How much would need to be expended to achieve this profit?
- What is the return on investment?

Technical capability:
- Does the company have the capability to further develop the product?
- Does the company have the technical capability to manufacture the product?

Marketing capability:
- Does the company have the capability to market the product?
- Is there financial capability to promote it?
- Is there access to distribution channels?

Manufacturing capability:
- Does the company have the capability to manufacture the product?
- What equipment is necessary? Is it available?
- What is the manufacturing capacity? Is it sufficient?
- Are raw materials/components available?

Intellectual property:
- Does the product have intellectual property value?
- How should this be protected or realized?

Regulatory implications:
- What legal implications are there for the product, its manufacture, and its marketing?
- Does the company have the capability to handle these?

Investment requirements:
- What are the capital investment costs? Is funding available?
- Does the return on investment meet the hurdle rate?

7.8 DEMAND AND SALES FORECAST

There are different approaches to assess demand for new products. Given a particular demand, the organization can forecast the sales potential — which is critical for the overall new product feasibility analysis, financial projections, and production planning as required by the product life cycle.

There are several demand models such as the Bass model, ATAR, purchase intention, chain ratio method, exponential methods, and several time series analyses. A description of the most important methods follows.

7.8.1 Bass model

The model is appropriate to forecast sales of an innovation, new technology, or a durable good. It assumes that the diffusion process is binary (either the consumer adopts or waits to adopt). It attempts to quantify the number of customers that will adopt the product over time and when they will adopt it. This model is used in industry because of its effectiveness and simplicity.

The Bass model takes two forms: a basic and a generalized form. The basic model requires the assessment of three parameters: p, q, and N. The parameter p is the coefficient of innovation (initial trial of the product or penetration) and q is the coefficient of imitation (diffusion rate parameter). Both coefficients p and q take a value between 0 and 1 and are affected by either product related (low complexity, high compatibility, observable benefits) or market related (links among potential users, communication, etc.) factors. N represents the total number of customers in the adopting target who will eventually adopt the product. No repeat or replacement purchase is considered in the estimation.

The model either requires some historical sales data or the input of the values for p and q to estimate demand over time. The demand generally shows an S-shaped curve.

7.8.2 ATAR model

Crawford and DiBenedetto (2008) presented a model for forecasting sales potential. The ATAR (Awareness-Trial-Availability-Repeat) model is a forecasting tool that tries to mathematically model the diffusion of an innovation or new product. For a person/organization to become a regular buyer/user of a new product or service, there must first be awareness that it exists, then there must be a decision to try it, then they must find that the item is available to them, and finally the person or organization must be satisfied enough to adopt the product or service or become a repeat buyer; refer to Figure 7.28 for an example.

Number of buying units	3,000,000
Percent aware	40%
Percent trial	20%
Percent availability	40%
Percent repeat	50%
Annual units bought	1.5
Units sold (product of above)	72,000
Revenue per unit	$25.00
Cost per unit	$12.50
Profit per unit	$12.50
Profit = Units sold x Profit per unit	$900,000

Figure 7.28 Example of ATAR analysis

7.8.3 Purchase intention methods

These methods use the results of concept testing as initial input and then adjust these with probability estimates from historical results or past experiences. For example, the results of a concept test for a hand cleanser (using an intent-to-buy scale from “definitely would buy” to “definitely would not buy”) showed that 5% of potential consumers will definitely buy the product and 36% will probably buy the product. In addition, the estimates based on the firm’s experience were that 80% of those who answer definitely buy (definitelies) actually buy and that 33% of those who answered probably buy (probablies) actually buy. The final calculation of an estimated market share will be:

Market share (forecasted) = (0.8) (5%) + (0.33) (36%) = 16%

7.9 FINANCIAL ANALYSIS

Financial analysis is arguably the most important element in the feasibility analysis. It is critically important that financial analysis starts at the early stages of a project and is developed in detail and accuracy as the project proceeds. Figure 7.29 provides a basic framework for financial analysis to determine project potential.

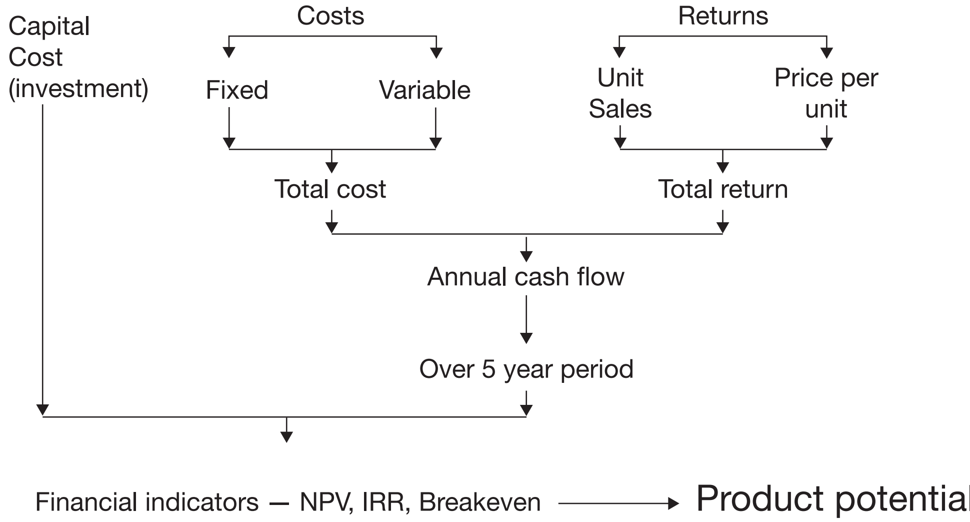


Figure 7.29 A framework for financial analysis of a new product

7.9.1 Cost determination

The basic elements of cost are fixed costs, variable costs, and capital costs.

Fixed costs are expenses whose total does not change in proportion to the activity of a business within the relevant time period or scale of production. Examples include administration, rent, rates, and general management.

Variable costs are expenses that change in proportion to the activity of a business. Examples include production labor, power, cleaning materials, and manufacturing materials.

Total cost = Fixed costs + Variable costs

Capital costs are costs incurred on the purchase of land, buildings, construction, and equipment to be used in the production of goods or the rendering of services.

Working capital is the money spent in direct and variable costs associated with a product or service while awaiting sales. This would include all costs of manufacturing and marketing, together with capital costs of new equipment, etc.

7.9.2 Selling price determination

The ex-factory price is the sum of all costs associated with the product plus any margins accruing to the company. It is the price at which the organization makes the product available to a buyer. The buyer is responsible for paying for transportation and other costs to send the product where it is needed, or on-sold to other customers.

When the product is sold beyond the "factory door," the selling price to final customer will be determined by the sum of ex-factory price and all costs associated with getting it to the final customer, including the margins charged by distribution channel members. An example of a basic distribution channel is shown in Figure 7.30. The complexity of the distribution channel varies greatly from product to product and organization to organization, and will have a significant impact on the mark-up from ex-factory costs to final customer selling price.

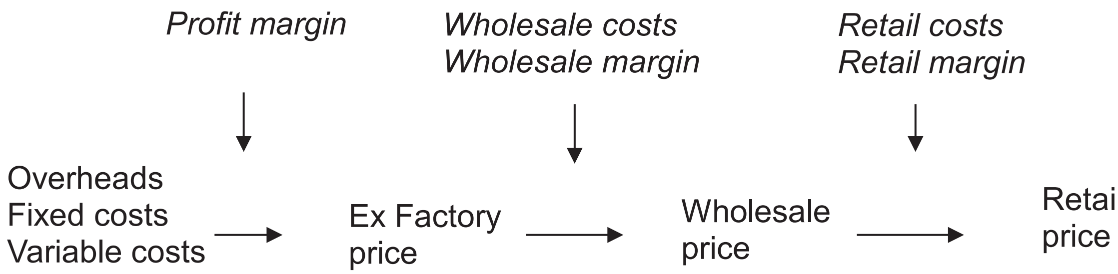


Figure 7.30 Example of a basic distribution channel, showing product cost mark-ups

7.9.3 Return on investment

Return on investment (ROI) is defined as the return from an investment relative to the investment's cost. It can be used to assess the value of a single investment or as a means of comparison among alternative investments.

Most organizations have a required level of return required for investments — this is often referred to as the **hurdle rate**, e.g., 10% or 15%.

The hurdle rate is determined by:

- Rates of return on alternative avenues of investment. An obvious example is, "Can I get a better return from putting the money in the bank rather than investing in a plant to manufacture a new product?"
- The level of risk. A higher hurdle rate is normally assigned to higher-risk investments — just as high-risk shares and bonds may promise a potentially greater return.

Measures of return on investment

Three of the most commonly used measures of return on investment are:

- Payback period,
- Net Present Value (NPV),
- Internal Rate of Return (IRR).

7.9.4 Payback period

Payback period is defined as the length of time it takes to repay the capital investment. So, for example, if capital costs (for new plant and buildings) are $1 million, how many years does it take for cumulative profits to exceed $1 million?

Although payback period is a commonly used and relatively simple measure of return on investment, it fails to capture the important element of the time value of money. It fails to account for the timing of the receipts of returns on an investment. The payback period is useful because it is simple and intuitive.

Figure 7.31 shows three potential investment options (A, B, and C) with projected returns over a 5-year period. Each option requires the same capital outlay of $100,000 and has the same payback period of 5 years. Which would you choose? Why?

Option	Year 1	Year 2	Year 3	Year 4	Year 5
A	20,000	30,000	40,000	10,000	
B	20,000	20,000	20,000	20,000	20,000
C		10,000	30,000	50,000	10,000

Figure 7.31 Different schedule of returns for the same investment

The key to answering the question, "which is the best option?" lies in the timing of the receipts over the 5 years. Using net present value (NPV), you will find that option A is best, as shown in Figure 7.32. More detail on the meaning and calculation of NPV is covered later in this section.

Option	Year 1	Year 2	Year 3	Year 4	Year 5	NPV
A	20,000	30,000	40,000	10,000		79,858
B	20,000	20,000	20,000	20,000	20,000	75,816
C		10,000	30,000	50,000	10,000	71,164

Figure 7.32 NPV calculation for options shown in Figure 7.31

More on the time value of money

A dollar that you invest today will bring you more than a dollar next year — having the dollar now provides you with an investment opportunity.

$1 today → Investment at 10% interest → Gives $1.10 A year from now

Present value (PV) provides a means of putting future money in today's terms (or value). This is achieved by modifying the future value by a factor that represents the change in value of money from today's value.

Future value = original amount x (1 + interest rate)$^{\text{number of periods}}$

$$FV = PV \times (1+i)^n$$

Rearrangement of this equation gives the following for present value:

$$PV = FV/(1+i)^n$$

7.9.5 Net present value (NPV)

Net present value is the cumulative PV of returns (or benefits) minus the cumulative PV of costs.

Present value discount factors

Figure 7.33 shows the factors that need to be applied at different time periods and interest rates. So, for example a revenue of $1000 in 5 years' time, where the interest rate is 10%, equates to a present value of $602.90.

Year	Rate			
	10%	20%	30%	40%
1	.9091	.8333	.7692	.7142
2	.8264	.6944	.5917	.5102
3	.7513	.5787	.4552	.3644
4	.6830	.4823	.3501	.2603
5	.6029	.4019	.2693	.1859
10	.3855	.1615	.0725	.0346
20	.1486	.0261	.0053	.0012

Figure 7.33 Discount factors for NPV calculation

Calculating the cumulative NPV of a new product

Figure 7.34 shows a relatively simple calculation of NPV for a new product. Clearly, a lot of work is required to derive the data included in this simple table:

- Decide on the potential life of the product or the time period for the NPV calculation (in this case, 5 years).
- Project the benefits (returns) for each year of the product's life.
- Project the costs for each year of the product's life.
- Calculate the annual cash flows (the difference between returns and costs).
- Calculate the present value (PV) for each year's net cash flow.
- Add together the individual PVs over the life of the product. This is the cumulative net present value (NPV). In this case, $25,673.

	Year 1	Year 2	Year 3	Year 4	Year 5
Benefits	3500	10800	15000	20000	21000
Costs	8370	3500	4800	7800	8000
Cash flow	-4870	7300	10200	12200	13000
Present value factor	0.9091	0.8264	0.7513	0.6830	0.6209
PV	-4427	6033	7663	8333	8072
NPV	25673				

Figure 7.34 A simple example of NPV calculation (the discount rate applied is 10%)

7.9.6 Internal rate of return (IRR)

Internal rate of return (IRR) is defined as the discount rate at which an investment has a zero net present value. It is used to evaluate the attractiveness of an investment in a project or product. Calculation of the IRR provides a comparison with both the company's hurdle rate and with alternate forms of investment, either internally or externally.

So, for example, if the IRR for the project is less than the current bank interest rate, all other things being equal, it would be more profitable to put the money in the bank than execute the project.

Financial analyses in product innovation are done for two broad purposes:

- To evaluate the true rate of return for a single investment.
- To compare a number of alternative investments. This is often a major tool used in portfolio management (refer to Chapter 2).

Financial analyses should be applied throughout the product innovation project. Even in the very early stages (the fuzzy front end), crude financial analysis can often provide a very quick indicator of project viability. As the project proceeds and risks associated with higher costs become more significant, financial analysis should be more rigorous. The data on which the analysis is based need to be more reliable.

7.9.7 Spreadsheets for financial analysis

Most commonly used spreadsheets have embedded financial functions including NPV and IRR. The use of simple spreadsheets for financial analyses provides a powerful tool for product managers. Perhaps the greatest benefit is the facility offered by spreadsheets for "what-if" or "sensitivity" analysis providing an excellent basis for risk assessment — e.g., what is the effect on the IRR if the market share is half of what is projected? Or what is the impact of doubling in the cost of a major component?

Refer to Figure 7.35 for an example of a financial analysis spreadsheet for a new product opportunity.

MARKET DATA

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Market growth		1400%	120%	120%	120%
Market (units)	100	1,400	1,680	2,016	2,419
Market share (%)	100%	100%	60%	54%	49%
Market share (units)	100	1,400	1,008	1,089	1,176

Costs

Variable cost/unit	$	***Fixed costs (overheads)***	$
Direct materials	120	Manufacturing	40,000
Packaging	20	Marketing	30,000
Sales and mkting	40	Salaries	80,000
Direct labour	240	Admin	20,000
Total variable cost	420	Total fixed cost	170,000

Pricing	$
Retail price	3300
Retailer gross margin %	40%
Retailer gross margin $	1320
Mfg selling price	1980

Equipment cost	$2,600,000	Cost of capital	

Summary of Operating Cash Flows

	Unit Prices	Year 0	1	2	3	4	5
Sales volume			100	1,400	1,008	1,089	1,176
Sales revenue	1980		198,000	2,772,000	1,995,840	2,155,507	2,327,948
Variable cost	420		42,000	588,000	423,360	457,229	493,807
Contribution margin	1560		156,000	2,184,000	1,572,480	1,698,278	1,834,141
Fixed costs			170,000	170,000	170,000	170,000	170,000
Operating cash flow			(14,000)	2,014,000	1,402,480	1,528,278	1,664,141
Investment		(2,600,000)	0	0	0	0	0
Total cash flows		(2,600,000)	(14,000)	2,014,000	1,402,480	1,528,278	1,664,141
Cost of capital, r	20%						
NPV	$1,004,363		IRR	33.2%			

Figure 7.35 Example of financial analysis spreadsheet

7.10 PROJECT MANAGEMENT

This section provides a general overview of project management as applied to product innovation. More in-depth information on project management can be gained through reference to the Project Management Institute and its associated reference material and qualifications (PMBOK®, 2017).

7.10.1 Project management in the context of product innovation

"The definition of a project includes a specific start and stop date for the work as well as achieving goals with a temporary team" (Project Management Institute, 2017). Although the overall process of developing and commercializing a new product may be seen as a single project, it can also be viewed as a composite of a number of small projects, for example:

- Generating a list of potential new opportunities.
- Analyzing the commercial potential.

The five steps in a project are defined in the guide as (PMBOK®, 2017):

1. Initiating
2. Planning
3. Executing
4. Monitoring and controlling
5. Closing

These steps are somewhat different than those defined for a structured product innovation process (such as Stage-Gate®), primarily because the product innovation process defines the overall roadmap from ideation to commercialization, while project management defines the structure and detail required to achieve the individual goals within the product innovation process, and, in turn, the overall goal of successful commercialization.

7.10.2 The Triple Constraint

One of the most common challenges with any project is managing the Triple Constraint — scope, schedule, and budget — as shown in Figure 7.36.

The Triple Constraint is normally displayed as an equilateral triangle. If one of the core elements of a project changes, the project becomes unbalanced, e.g., if the scope of a project is increased, the schedule and the budget will need to be adjusted. The Triple Constraint emphasizes the very important point that scope, schedule, and budget of a well-planned project are highly intertwined.

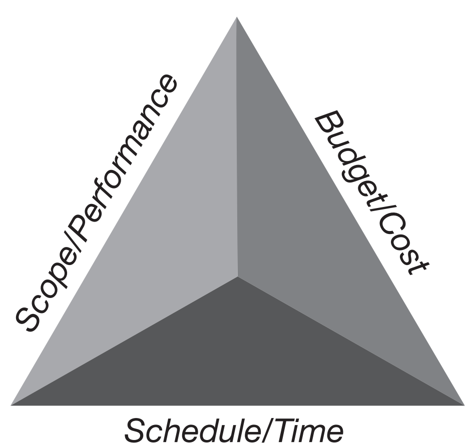


Figure 7.36 The Triple Constraint. Source: Dobson, M.S. (2004)

7.10.3 Project scope

The Project Management Institute provide two uses for the term scope (PMBOK®, 2017):

Project scope
"The work that needs to be accomplished to deliver a product, service, or result with the specified features and functions."

Product scope
"The features and functions that characterize a product, service, or result."

In product innovation, the clarity of scope (both in terms of project and product) is provided in the product innovation charter.

7.10.4 The schedule

The schedule includes the activities and key milestones to successfully achieve the project goal. Project schedules are often constructed and illustrated using a bar chart or a Gantt chart, as shown in Figure 7.37. In any project, certain activities cannot begin before other activities have been completed. These activities are defined as critical path items, whose delay will directly impact the budgeted completion of the project.

7.10.5 Critical path method (CPM)

In a project plan, the critical path is the longest path from start to finish or the path without any slack. Thus, the path corresponding to the shortest time in which the project can be completed.

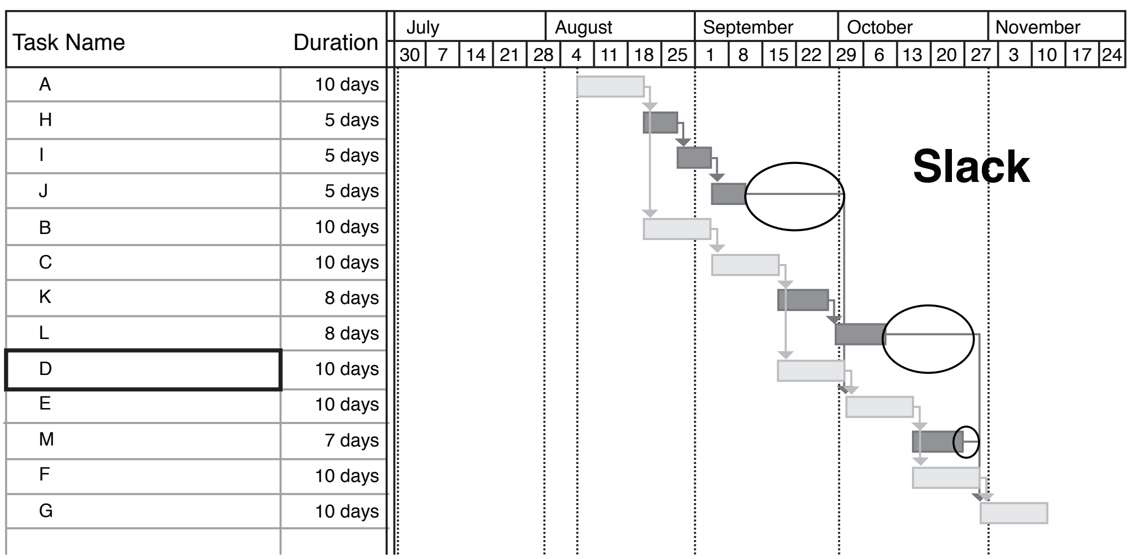


Figure 7.37 The Gantt chart and critical path

7.10.6 Schedule compression

In many cases, a project's end date is fixed — for example, the new product launch date. If a project falls behind, it will be necessary to seek ways to compress the schedule without significant impact on the scope. Basically, there are two ways to achieve schedule compression:

- Add resources (and cost) or,
- Do tasks in parallel that otherwise would have been done in series.

7.10.7 Budget

The project budget is defined as the anticipated cost required to complete the scope of the work on time. There are several ways to prepare a budget:

- Bottom-up: Identify all individual cost elements and sum these across the project.
- Parametric: Infer the cost of the project from similar projects that have been done in the past.
- Historical data: Use specific cost data from past projects, such as prototyping or market research, as a basis for budget estimation.
- Company-specific methods: Larger companies will often have specific models and methods that are applied to project budgeting.

7.11 RISK MANAGEMENT

7.11.1 What is risk management

Project risk is "an uncertain event or condition that, if it occurs, has a positive or negative effect on one or more project objectives such as scope, schedule, cost, or quality" (PMBOK®, 2017).

Risk management is the identification, assessment, and prioritization of risks followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events or to maximize the realization of opportunities.

Project risk management is an important aspect of project management. Risk management is one of the ten knowledge areas defined in PMBOK. Project risk can be defined as an unforeseen event or activity that can impact the project's progress, result, or outcome in a positive or negative way. A risk can be assessed using two factors: impact and probability.

The causes of risk can come from various sources, including: a requirement, such as legal requirements imposed by laws or regulations; an assumption, such as the conditions in the market (which may change); a constraint, such as number of personnel available to work on any given phase of the project; or a condition, such as the maturity of the organization's project management practices.

Known risks are those which can be identified and analyzed beforehand in such a way as to be able to a) reduce the likelihood of their occurrence, or b) plan a risk response to reduce their impact in the event that they occur. Unknown risks, on the other hand, are those that are not identified beforehand. If they are not identified, they cannot be analyzed, and of course cannot be managed proactively.

There are four possible responses to a risk, depending on whether there is low or high probability of it occurring, and whether the financial impact, if it does occur, is either high or low:

- Avoid: for high probability, high impact events.
- Transfer (such as purchasing insurance): for low probability, high impact events.
- Mitigate: for high probability, low impact events.
- Accept: for low probability, low impact events.

7.11.2 Risk management steps

According to PMBOK® (2017), risk management includes six main steps, in summary:

1. **Planning for risk management:** Start with a risk management plan — plan the work, work the plan; how risks are managed.
2. **Risk identification:** Use prior documentation — such as charter, budgets, schedules, plans, etc. Have the right people involved who know risks; have a risk owner. Use methods such as brainstorming, interviews, Delphi technique, and root cause analysis.
3. **Qualitative risk analysis:** Analyze probability and impact. Calculate and rank the risk score.
4. **Quantitative risk analysis:** Used for important risks, which can be quantified (limited or no number of risks). Quantitative models include discount cash flow and internal rate of return with sensitivity analyses.
5. **Risk response planning:** Strategies include avoid (don't take risky actions); transfer to somebody else (take insurance, set up contracts); mitigate (make changes to reduce probability); accept (let it happen, establish contingency reserves such as cost, schedule, performance).
6. **Risk monitoring and control:** Reassess new and existing risks. Use audits, variance, and trend analysis.

7.11.3 Risk management in product innovation projects

In Chapter 3, we introduced the new products process as one of risk and reward. A key element of this process is the recognition of the level of risk associated with the development and commercialization of the new product and taking appropriate steps to manage this risk. The decision-making gates in the Stage-Gate® process are a critical element of risk management, where informed decisions are made on the basis of sound information and data. The outcomes of the new products process are impacted by two categories of risk:

Project-based risks, which include:

- Resource availability: the right resource at the right place at the right time.
- Finance availability: sufficient to cover project and capital expenses.
- Resource capability: the type and numbers of available people with the appropriate knowledge and skills.
- Reliability of information: access to, and level of confidence in, information necessary to reliable decision-making.
- Scope definition: clarity and communication of scope to ensure alignment of all people associated with the project.

Product-based risks, which include:

- Commercialization of a product that:
  - Causes harm to customers;
  - Fails to deliver promised benefits;
  - Fails to meet regulatory requirements;
  - Does not meet customers' expectations with regards aesthetics, features, functionality, or price.

Risk management in product innovation should be viewed as a combination of the PMBOK six-step process and the application of the decision practices focused on the innovation strategy, the product innovation charter, the specific new products process, and the underpinning tools that enable sound decision-making.

7.11.4 Decision trees

A decision tree is "a decision support tool that uses a tree-like graph or model of decisions and the possible consequences, including event outcomes, resources, costs." It provides a highly effective structure within which you can lay out options and investigate the possible outcomes of choosing those options. Decision trees help to form a balanced picture of the risks and rewards associated with each possible course of action. Decision trees can be developed by hand or using one of a number of software tools available. An example is shown in Figure 7.38.

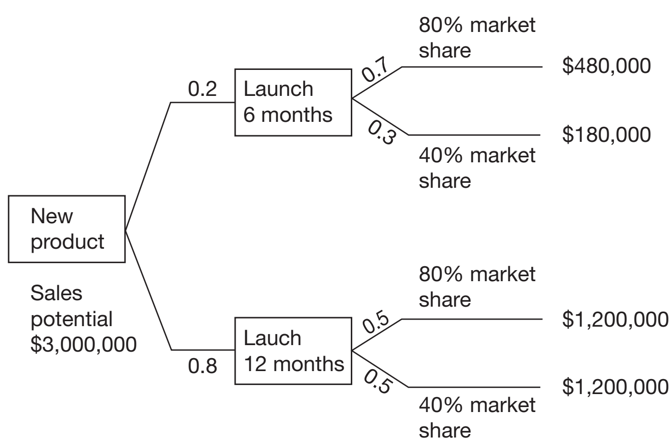


Figure 7.38 Example of a decision tree

7.12 METRICS AND KEY PERFORMANCE INDICATORS

Measuring product innovation performance is a key tool for product managers, both in reporting on the return on product innovation and for continuous improvement on processes and practices that lead to greater product innovation success.

Key performance indicators (KPIs) are measurable values that show you how effective you are at achieving business objectives. Metrics are different in that they simply track the status of a specific business process. In short, KPIs track whether you hit business objectives/targets, and metrics track processes. All KPIs are metrics, but not all metrics are KPIs.

7.12.1 The Balanced Scorecard

The principle of the Balanced Scorecard was developed by Kaplan and Norton (1992).

The Balanced Scorecard was developed to provide managers with a set of measures that give a fast but comprehensive view of the business. The Balanced Scorecard includes financial measures that tell the results of actions already taken. And it complements the financial measures with operational measures on customer satisfaction, internal processes, and the organization's innovation and improvement activities—operational measures that are the drivers of future financial performance.

Kaplan and Norton (1992) drew an analogy between organizational management and flying a plane. "Think of the Balanced Scorecard as the dials and indicators in an airplane cockpit. For the complex task of navigating and flying an airplane, pilots need detailed information about many aspects of the flight. They need information on fuel, air speed, altitude, bearing, destination, and other indicators that summarize the current and predicted environment. Reliance on one instrument can be fatal. Similarly, the complexity of managing an organization today requires that managers be able to view performance in several areas simultaneously."

The aim of the Balanced Scorecard, as designed by Kaplan and Norton, was "to align business activities to the vision and strategy of the business, improve internal and external communications, and monitor business performance against strategic goals." The Balanced Scorecard provides a relevant range of financial and non-financial information that supports effective business management.

The basis of the Balanced Scorecard

Kaplan and Norton devised a framework based on four perspectives — financial, customer, internal processes, and organizational capability — each aligned with business vision and strategy. See Figure 7.39. The Balanced Scorecard is based on the principle that no single measure can provide the full picture of the organization's health. A composite of a number of measures provides far more comprehensive and meaningful insight to the organization to learning and continuous improvement.

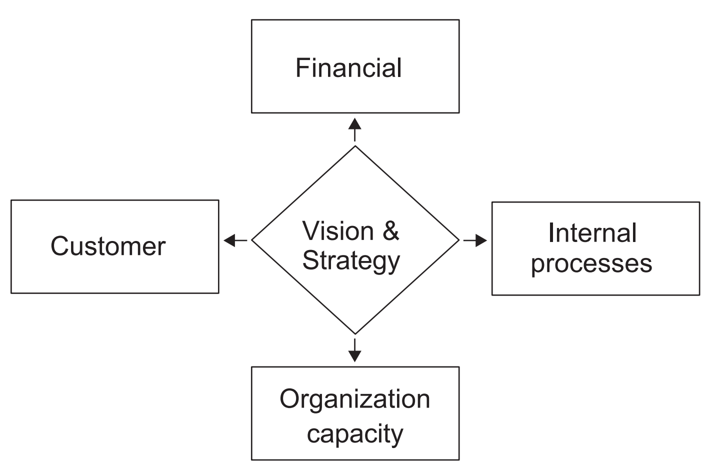


Figure 7.39 The four perspectives of a traditional Balanced Scorecard

The specific measures that are applied to each perspective will vary according to the organization's vison and strategy, and its strengths and weaknesses. Examples of specific measures are presented in Figure 7.40.

Scorecard perspective			
Financial	**Customer**	**Internal processes**	**Organizational capacity**
• Revenue • Net profit • Gross profit margin • Sales • EBIT • ROI	• Customer retention • Market share • Customer complaints • Brand equity	• Six sigma level • Unit costs • Machine downtime • Energy consumption • New product time to market	• Employee churn rate • Employee core competency profile • Employee satisfaction

Figure 7.40 Examples of measures under each of the four Balanced Scorecard perspectives

7.12.2 Product innovation metrics

Before discussing the application of the Balanced Scorecard approach to product innovation it is important to further define the terms Key Performance Indicator (KPI) and metrics, specifically as they can be applied within the context of product innovation.

As defined earlier, KPIs are measurable values that relate specifically to business goals, whereas metrics are designed to track the status of business processes that contribute to successful KPI outcomes.

"Performance metrics are a set of measurements to track product innovation and to allow an organization to measure the impact of process improvement over time. These measures generally vary by organization but may include measures characterizing both aspects of process, such as time to market and duration of particular process stages, as well as outcomes from product innovation such as the number of products commercialized per year and percentage sales due to new products." (PDMA glossary)

Metrics for reporting vs. continuous improvement

In many organizations, product innovation metrics are used as a key tool for management to report the returns on product innovation investment and to justify future investment. Metrics commonly used by senior management for reporting:

- Vitality index (% of current year's sales from product developed over past "n" years).
- R&D expenses as a percent of revenue.
- Break-even time, or time to profitability.
- Number of patents filed and awarded.
- Number of new products released over a specific time period.

Although these metrics are essential to justify investment in product innovation, they do not necessarily lead to learning and continuous improvement.

Let's take the simple example of weight control. If you set a goal to reduce weight, you can stand on the scales and find your current weight. But the scale measurement, although useful in giving your current weight, doesn't provide you with any direction for losing weight. And so it is with the reporting metrics for product development listed above. You have a measure of the current (or past) situation, but this doesn't provide you with a plan for future improvement.

Looking for causal relationships
If we can identify the causes or contributors to the final outcomes we have measured (e.g., break-even time), we can address these causes directly. And so to our weight-loss analogy: There is ample evidence as to the contributors to weight loss. Addressing these contributing factors will directly lead to weight loss (a better scale measurement):
- Eat less and/or better;
- Do more exercise;
- Drink less alcohol.

By measuring these contributing factors, we have a basis for action. So we could measure the number of steps we take per day as an indicator of exercise. Setting a target number of steps per day, and achieving this target, should lead us to weight loss. Using target metrics for each of the three contributing factors will probably lead to even greater improvement (Anderson, 2015).

What are the contributing factors for product development improvement?
There is a wealth of research carried out over recent years pointing to the key factors for product development success. PDMA literature provides an excellent reference source:
- The Comparative Performance Assessment Study (CPAS),
- The *Journal of Product Innovation Management,*
- Presentations by the Outstanding Corporate Innovation winners.

It is the responsibility of all involved in the product, especially the product managers, to research these key success factors and relate them to their own organization.

Following are some of the success factors identified in PDMA's 2012 CPAS — focusing on what differentiates the best companies from the rest (Markham and Lee, 2013). These success factors are categorized under the key headings of "doing the right things," "doing things right," and "culture, climate, and organization" as shown in Figure 7.41 and previously discussed in the introduction to this book.

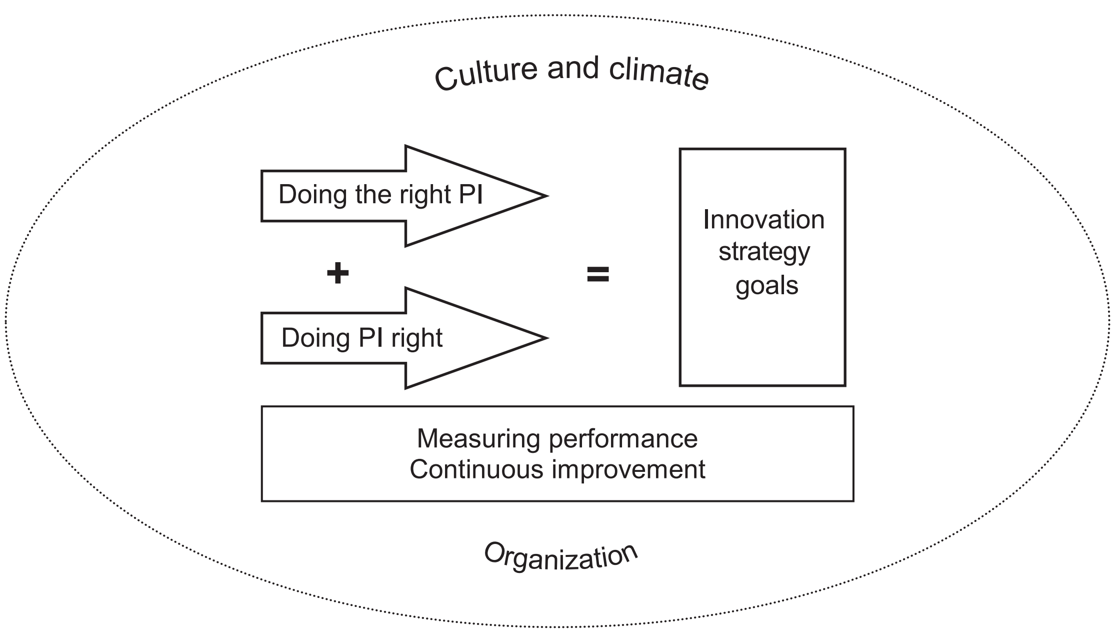


Figure 7.41 A simple and consolidated overview of product innovation

Doing the right things

The best companies:

- Spend more time per project, but on fewer projects.
- Adopt a first-to-market strategy.
- Establish global strategies for market and operations.
- Monitor new technology.
- Recognize the importance of intellectual property.
- Have a clear portfolio management strategy.
- Have formal idea generation practices.

Doing things right

The best companies:

- Use a range of engineering, R&D, and design tools (critical path, FMEA, Lean NPD, TRIZ, etc.).
- Use qualitative market research tools to identify customer needs.
- Use social media to gather information.
- Have a customer feedback system.
- Use a formal NPD process — but with flexibility.
- Involve senior management.
- Focus on team development and practices.

Culture, climate, and organization

The best companies:

- Involve senior management.
- Focus on team development and practices.
- Use cross-functional teams.
- Have good recognition and reward systems.
- Support external collaboration and open innovation.

From this single research study, we have a range of factors that have been linked to product development success. Just as we suggested measuring exercise as a contributing metric for weight loss, so we can use a selection of these success factors as a basis for performance measures that are linked to, or contribute to, product development success.

1. Is the organization **doing the right** product innovation? Does it have a clear innovation strategy, embedded with the overall business strategy? Does it have well-developed and applied portfolio management? Does it have the right KPIs and metrics in place to track strategic decision and outcomes? Does it learn and seek continuous improvement based on these metrics?
2. Is the organization using the **right processes**? Does it have a product innovation process that is appropriate to its company and products? Does it have a governance structure to ensure consistent application of the process or processes? Is the right team selection and development structure in place? Is there strong commitment and contribution from senior management?
3. Does the **organizational structure and climate** support its product innovation efforts? Does it actively foster the development and maintenance of a creative and innovative culture? Does it support active team development practices? Are there appropriate recognition and reward practices in place?

Figure 7.42 presents a more extensive summary of specific KPIs and metrics within the context of the simplified product innovation frame work.

Innovation KPIs	Metrics		
	Doing the right product innovation (PI)	**Doing product innovation (PI) right**	**Culture, climate, and organization**
Percentage revenue or profits from product innovation over the past 3-5 years; often described as the vitality index. Targets vary with best practice of 20-25%. Return on investment: Either individual new products or the entire development portfolio. Targets will depend on specific "hurdle rates" established for individual companies or specific products or product categories. Development and/or growth of specific target markets: For example, a target to increase exported products to 20% of sales or to capture a 10% share of the "recent mothers" market. Develop a new product category based on a recently acquired technology to achieve a 20% contribution to EBIT in 3 years.	Clearly defined innovation strategy linked to overall business strategy Innovation strategy clearly communicated to all staff. A pool of new ideas. Well-structured and managed portfolio management. Sound technology planning and roadmapping. Sound stakeholder and competitor intelligence.	A well-developed PI process — appropriate to company and products A formal idea generation process. Strong voice of customer input throughout development. Sound business case analysis. Fit for practice tools to support all stages of development. Gates achieved on time. Break-even cycle time.	Well-developed team selection and development. Cross-functional teams. A positive climate for innovation. Evidence of a "learning" culture Strong support for ongoing training. Strong support from senior management. Well managed and appropriate recognition and reward practices.

Figure 7.42 Examples of innovation KPIs and metrics

Success factor examples

An example of success factors and associated contributing metrics for "doing the right things" is shown in Figure 7.43.

Success factor	Contributing Metrics
Formal idea generation process	• No. of ideas generated • Success rate
Monitor new technologies	• No. of reports on new technologies • No. of meetings where new technologies are discussed
Clear portfolio management strategy	• Well defined NPD portfolio • On-going management of the NPD portfolio

Figure 7.43 Example of success factors and contributing metrics for "doing the right things"

An example of success factors and associated contributing metrics for "doing things right" is shown in Figure 7.44.

Success factor	Contributing Metrics
Use of market research tools for consumer input	• No. market research reports • No. of customer visits
Senior management involvement	• No. of project meetings attended by senior manager • No. of references to NPD by senior manager in company reporting
Formal NPD process	• NPD process actively used across the organization • No. of gates achieved on time

Figure 7.44 Example of success factors and contributing metrics for "doing things right"

An example of success factors and associated contributing metrics for "organization, climate, and culture" is shown in Figure 7.45.

Success factor	Contributing Metrics
Use of cross functional teams	• Representation of different functions at project meetings • No. of sessions on developing a high performing team
Open innovation – external collaboration	• No. of projects involving external parties • No. of external collaboration
Appropriate recognition and reward processes	• Performance rewards that promote individual and team performance • Examples of recognition and celebration of success

Figure 7.45 Example of success factors and contributing metrics for "organization, climate, and culture"

7.12.3 Developing a Balanced Scorecard for product innovation

The following process can be used to develop a Balanced Scorecard for product innovation:

1. Form a cross-functional product innovation improvement team, preferably with senior management representation and support. This team should be charged with establishing the balanced scoreboard framework as a tool both for reporting on innovation performance against strategy and for learning as a basis for continuous improvement.
2. Identify the KPIs that truly represent the important contributions of product innovation to achieving overall business goals. Ensure that there is an objective and quantifiable measure associated with each KPI, e.g., a percentage or a dollar value.
3. Benchmark the organization either with other organizations or with reported surveys on best practices. Identify what areas of current innovation practice are weak relative to the benchmark data. For example,

is there a demonstrable lack of senior management support? Is there a lack of cross-functional representation in innovation teams? Is there a lack of technical capability? Is there a mismatch between what customers are asking for and the attributes of newly developed products?
4. Select a small number of metrics to focus on (four to six). Do not select too many, as this will lead to a lack of focus and attention.
5. Monitor each metric based on quantifiable measures. For example, which functions are represented at innovation meetings? How often is senior management represented? Other measures may include an innovation climate survey or the number of new ideas generated monthly.
6. Compare these data with benchmarked data and work toward continuous improvement. For example, if specific functions are consistently lacking in team meetings, seek to rectify this; if there is mismatch between product attributes and customer requirements, focus on increasing voice of the customer research.
7. As specific metrics are improved significantly, these can be replaced with new metrics.
8. The overall goal is to improve the organization's processes and practices that have been proven to lead to greater product innovation success.

7.12.4 Benchmarking and continuous improvement

Learning and continuous improvement is essential for ongoing success in product innovation. A sound understanding of the strengths and weaknesses of product innovation processes and practices within the organization provides an excellent basis for applying the learning for other organizations, from literature and from professional networking. Appendix 1.1 presents a questionnaire that provides the basis for organizational analysis of current product innovation processes and practices. Completion of this questionnaire by representatives from across the organization provides an excellent basis for cross-functional discussion and leads to stronger cross-functional cooperation in continuous improvement in the organization's product innovation processes and practices.

7.13 IN SUMMARY

This chapter focuses on the role of product innovation management. It is divided into three sections:

SECTION 1
What is product innovation and what is the role of product innovation management?

SECTION 2
What is the product life cycle and how is product innovation managed through this life cycle?

SECTION 3
What are some of the key tools for managing product innovation and how can product innovation be improved through application of appropriate performance metrics?

SECTION 1: What is product innovation?

- Product innovation has been defined as "the creation and subsequent introduction of a good or service that is either new or an improved version of previous goods or services."
- The scope of product innovation — from strategy direction through portfolio management, from individual project management to commercialization — implies a high degree of complexity. It is influenced by a wide range of inputs and variables.
- The role of managing product innovation can lie with a range of job titles, from the CEO of small to medium sized companies, VP of innovation in large companies, product innovation manager, brand manager, product manager, and more. Currently, the role of product manager is growing in prominence around the world.
- The job of a product manager is to discover a product that is valuable, usable, and feasible. The role of a product manager lies at the intersection of business decisions, user experiences, and technology.
- A product manager is not a project manager. Project managers manage the process of creating a project or service. Product managers commercialize solutions to solve customer problems and/or meet a market need/demand.
- The principles and fundamentals of product innovation are common across most industries and product types. Differences lie in the specific strategies, processes, and tools applied. The key to successful product innovation management is to understand the basic principles and fundamentals, and recognize and implement "fit for purpose" strategies, processes, and tools for the specific organization.

SECTION 2: Managing the product life cycle

- Most products have a life cycle which follows the stages of introduction, growth, maturity, and decline.
- In general, product life cycles have become shorter over recent years, placing greater pressure on organizations to develop new products and to regenerate existing ones.
- Product management in terms of all elements of the marketing mix — product, price, promotion, and distribution — are determined by the stage of a product's life cycle.
- Product managers have a key role in guiding products through the life cycle.
- In the early stages of the product life cycle, the "diffusion of innovation" is very important. This is the process by which new innovations are accepted and begin to achieve market success. Products need to navigate the chasm between the introduction stage and growth stage.

SECTION 3: Key tools for product innovation management

- Assessment of project feasibility — in terms of development, manufacturability, market demand, competition, sustainability, and regulations — is a key component of the innovation management role.
- Financial analysis and reporting is a critical element of feasibility analysis. Techniques including basic product costing, return on investment, discount cash flow, payback period, and the application of sensitivity analysis are essential elements of the innovation management toolbox.

- A sound understanding of the principles and application of project management is vitally important. Complementing the New Product Development Professional (NPDP) certification with the Project Management Professional (PMP) certification is ideal.
- Product innovation performance metrics: Measuring and reporting on the outcomes of product innovation is essential to demonstrating the return on investment.
- Although the application of performance metrics for reporting is extremely important, their application to continuous improvement in product innovation processes is even more important to the long-term growth of an organization.
- A sound knowledge of the best practices for product innovation and regular benchmarking, both internal and external, is essential to high-performing product innovation management.

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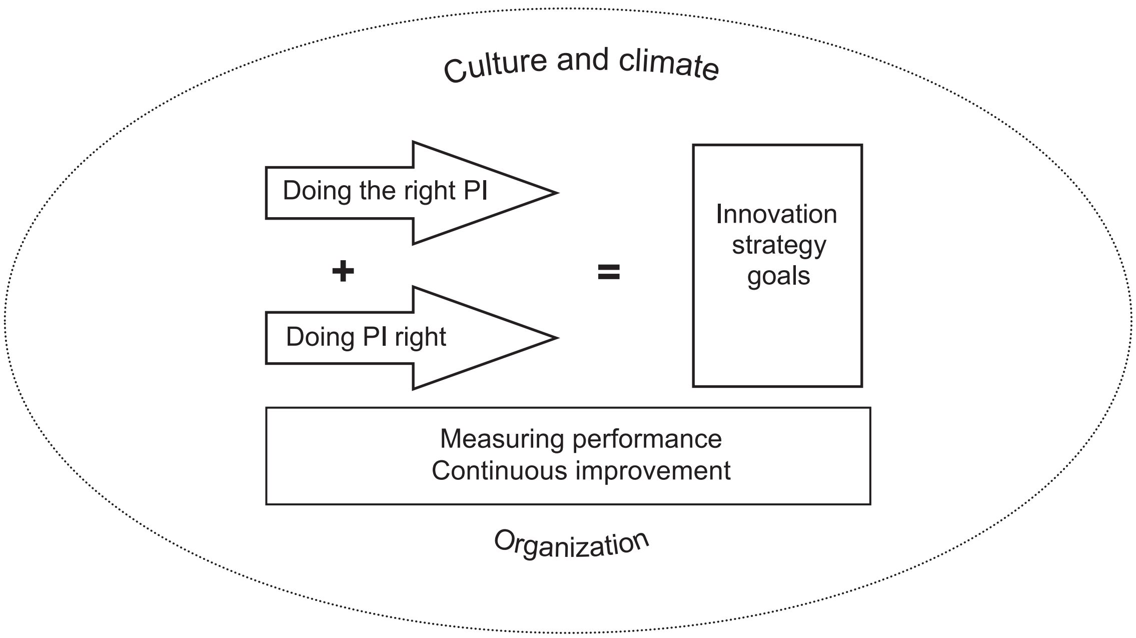
APPENDIX 7.1
A questionnaire for evaluating an organization's new product innovation management practices and processes

Introduction

This self-evaluation questionnaire is designed to focus on the key areas which define success in product innovation management. Although reasonably comprehensive, the questionnaire is not intended to completely cover all issues that need to be addressed to achieve a high level of product innovation performance. It is intended that the questions will encourage an organization to critically examine its product innovation management, its strengths, weaknesses, and opportunities for improvement.



A model for product innovation performance

Completing the questionnaire

1. Respond to each question by circling a number from 0 to 5 in the associated box.

1	2	3	4	5

Not at all   Always

2. In the summary section at the end of the questionnaire, add the scores for each major section. Briefly describe how the overall performance of **product innovation** could be improved and what specific areas to focus on.

3. There is no optimal or target score for this questionnaire. It is designed to encourage organizations to critically evaluate how they do new product innovation. It also provides an excellent basis for identifying specific metrics that will lead to improved product innovation outcomes.

SECTION 1 DOING THE RIGHT PRODUCT INNOVATION

1.1	Our company has a well-developed overall business strategy.	1 2 3 4 5
1.2	This strategy is well communicated and understood by all staff.	1 2 3 4 5
1.3	Product innovation is an integral and clearly identified element of the overall company strategy.	1 2 3 4 5
1.4	The company strategy provides a clear context for an NDP which defines the approach and direction for all product innovation.	1 2 3 4 5
1.5	Our company has a product innovation strategy which provides a comprehensive direction for all aspects of product innovation including: • Expected contribution to company growth targets; • Product emphasis; • Market emphasis; • Product innovation risk profile; • Intellectual property strategy; • Core internal capability; • Use of external capability.	1 2 3 4 5
1.6	The product innovation strategy provides clear and meaningful direction for prioritization of all product innovation projects.	1 2 3 4 5
1.7	The product innovation strategy is widely communicated and understood by all company staff.	1 2 3 4 5
1.8	All staff involved in an product innovation project can articulate the strategic relevance of that project.	1 2 3 4 5
1.9	The product innovation strategy is supported by a technology plan.	1 2 3 4 5
1.11	Our company has a well-developed process for technology planning and roadmapping.	1 2 3 4 5
1.12	Our company has a formal set of criteria for project selection which is rigorously applied.	1 2 3 4 5
1.13	Our company has a process for project prioritization to ensure best utilization of finance and resources.	1 2 3 4 5
1.14	Our company has a well-defined framework for defining the optimal product innovation portfolio.	1 2 3 4 5
1.15	Our company has an ongoing process for product portfolio analysis which is used to regularly review the product innovation portfolio.	1 2 3 4 5

SECTION 2 DOING PRODUCT INNOVATION RIGHT

2.1	A detailed stakeholder analysis is carried out at the beginning of the NDP project	1 2 3 4 5
2.2	Regular stakeholder input is sought throughout the product innovation process	1 2 3 4 5
2.3	All elements of the 4Ps (product, price, promotion, and place) are integrated into the product innovation process from an early stage.	1 2 3 4 5
2.4	Clear criteria are used for the selection of product innovation projects.	1 2 3 4 5
2.5	A well-defined selection process, involving all key parties, is used for all product innovation projects.	1 2 3 4 5
2.6	A well-defined product concept is developed early in the product innovation process. This is communicated to, and agreed upon, by all key parties.	1 2 3 4 5
2.7	A sound project plan is developed, involving all key parties and including key activities, timelines, resourcing, and budgeting.	1 2 3 4 5
2.8	Key project roles are defined before the project begins. These may include the project leader, key team members, and an overall senior management steering committee.	1 2 3 4 5
2.9	A business case is developed early in the product innovation process including an estimated return on investment based on sound estimates of target market and sales potential, manufacturing and marketing costs, and capital investment.	1 2 3 4 5
2.10	A well-defined process is used for all product innovation projects. Although not necessarily the same for all projects, it is fit for the specific purpose. The process is clearly understood and followed by all parties involved.	1 2 3 4 5
2.11	The product innovation process includes clear go/no-go decision points, or gates, with well-defined deliverables required for each gate.	1 2 3 4 5
2.12	Go/no-go decisions are taken seriously — with projects being approved to proceed, re-directed, or concluded.	1 2 3 4 5
2.13	Review meetings are carried out at the end of all product innovation projects. Learnings from these review meetings are used to bring about continuous improvement.	1 2 3 4 5

SECTION 3 CULTURE, CLIMATE, AND ORGANIZATION

3.1	Senior management is very supportive of product innovation.	1 2 3 4 5

3.2	Our chief executive regularly demonstrates support for product innovation through: • Reference to it in company presentations; • Recognition of product innovation success; • Leading initiatives for product innovation improvement; • Leading committee for portfolio management; • Active involvement in steering committees for highly significant projects.	1 2 3 4 5
3.3	Our company regularly carries out climate surveys.	1 2 3 4 5
3.4	Dimensions which are important to creativity and innovation are included in the climate survey.	1 2 3 4 5
3.5	Results from the climate survey are actively used to improve the company's performance.	1 2 3 4 5
3.6	Our company has a well-organized plan for appointment and development of product innovation capability.	1 2 3 4 5
3.7	This plan focuses on a balance of core, internal capability, and external sourcing.	1 2 3 4 5
3.8	This capability plan is based on the company's product innovation strategy and technology plan.	1 2 3 4 5
3.9	Our company has a clearly defined set of core values, which are used in the recruitment of new staff.	1 2 3 4 5
3.10	Our company has clear guidelines and processes for recognition and reward of individual contributions to product innovation.	1 2 3 4 5
3.11	Our company has clear guidelines and processes for recognition and reward of team contributions to product innovation.	1 2 3 4 5
3.12	Product innovation project teams are made up of a cross-section of company functions.	1 2 3 4 5
3.13	Involvement in the product innovation team is clearly identified as part of an individual's overall roles and responsibilities.	1 2 3 4 5
3.14	Members of product innovation project teams are involved in the project from start to finish.	1 2 3 4 5

SECTION 4 METRICS

4.1	Performance measures (metrics) are required by senior management to demonstrate the value of product innovation investment.	1 2 3 4 5
4.2	These metrics are soundly based on well documented information and provide a reliable valuation of product innovation investment.	1 2 3 4 5
4.3	A comprehensive suite of product innovation metrics is used to address the key areas identified for improvement.	1 2 3 4 5

4.4	Metrics cover all aspects of product innovation and not just those directly related to the product innovation department.	1 2 3 4 5
4.5	Senior management demonstrates a commitment to the implementation of the product innovation metrics and to ensuring their application to product innovation improvement.	1 2 3 4 5
4.6	Product innovation metrics are clearly linked to the performance and development framework within our company.	1 2 3 4 5
4.7	Product innovation metrics are used as a basis for continuous improvement and are taken seriously across all functions and levels of management.	1 2 3 4 5
4.8	Product innovation metrics are changed from time to time according to specific areas identified for improvement.	1 2 3 4 5

SECTION 5 SUMMARY

5.1 Total scores

Doing the right product innovation	/75
Doing product innovation right	/65
Product innovation metrics	/40
Culture, climate, and organization	/70
TOTAL	/250

5.2 Areas of strength and weaknesses

5.3 Opportunities for improvement

5.4 Strategies for improvement

APPENDIX 7.2 APPLICATION OF PRODUCT INNOVATION PRINCIPLES ACROSS VARIOUS PRODUCT CATEGORIES

Domain / Product	Fast moving consumer goods (FMCG)	Consumer durables	Consumer electronics	Software	Pharmaceutical
Strategy planning All businesses benefit from a clearly defined strategic direction that informs the role and contribution of product innovation. The underlying processes and tools for strategic planning are common across product categories. Major differences occur in the level of product innovation investment and marketing strategies employed.	Strategy is largely influenced by creating demand at the consumer level. Margins are often low, resulting in low product innovation investment.	Strategy is largely influenced by product differentiation — either on price or features. Margins are typically higher than FMCG, with higher investment in product innovation and emphasis on technology.	Strategy is largely influenced by product differentiation based on technical features and functionality. Higher profit margins provide for higher investment in product innovation with a stronger focus on technology.	As a generalization, software innovation is based on iterative improvements in features and functionality with a strong technology underpinning.	The pharmaceutical industry is based very much on long-term development and intellectual property protection. Strategic planning is heavily reliant on fore-sighting, long-term R&D planning, and pro-active intellectual property planning.
Portfolio management A key tool for optimizing resource allocation. All businesses, irrespective of product or service focus, benefit from sound portfolio practices where the tools and processes are similarly applied.	The balance of the product innovation portfolio is generally strongly focused to “me too” products with low investment and low risk. There is also a strong emphasis on existing markets.	The balance of the product innovation portfolio will vary according to the nature of the consumer durables. Where technology is a strong contributor to consumer demand, the portfolio will be slanted toward higher investment in higher-risk products.	Technology plays an important role in most consumer electronics products. Depending on the strategy adopted by the organization — prospector, analyzer, defender, reactor, etc., a product innovation portfolio will be developed to reflect the implied technology, market, and risks.	Where Agile and Lean are the preferred processes in the software industry, portfolio management is often applied at multiple levels: At the business level addressing the overall products and categories; At the program level addressing a portfolio of projects; And at the project level, addressing priority of the backlog in features improvement.	The long timeframe for pharmaceutical product innovation implies criteria in portfolio management that focus on risk vs. reward, return on investment, and value of intellectual property.
Product innovation process All types of businesses and products benefit from some form of disciplined product innovation process. But there is a significant difference in the specific process or processes adopted. This largely depends on existing market knowledge, speed-to-market and risk.	FMCG companies generally have a sound understanding of market needs. The innovation costs and risk of failure are generally low. Speed to market is essential. All point to an Agile oriented, short Stage-Gate process.	Development time for consumer durables is traditionally shorter than for FMCG. Cost of development and risks of failure are higher. All of which point to the need for a more rigorous Stage-Gate type process.		As with most product categories there is a range of software products. These range from software that impacts significantly on product performance (possibly impacting human health), to software app development or functionality enhancement. The former requires significantly greater investment and associated risk, pointing to a hybrid Stage-Gate, Agile process, while the latter almost certainly points to an Agile process.	The risks involved in pharmaceutical innovation, together with associated regulatory requirements, demand several stages in development with a number of decision points — all pointing to several Stage-Gate processes.

Domain / **Product**	**Fast moving consumer goods (FMCG)**	**Consumer durables**	**Consumer electronics**	**Software**	**Pharmaceutical**
Culture and teams It is well accepted across all industries and organizations that people are the most important asset. Creating the right culture and establishing high performing teams is essential to product innovation success.	A positive innovation culture across the entire organization is essential. Cross-functional teams lead to greater success, with lightweight and functional teams being most prevalent.	A positive innovation culture across the entire organization is essential. Cross-functional teams lead to greater success, with lightweight teams being most prevalent.	A positive innovation culture across the entire organization is essential. Cross-functional teams lead to greater success, with lightweight and heavyweight teams being most prevalent, depending on specific challenges of the project.	A positive innovation culture across the entire organization is essential. A strong focus on Agile teams — generally short-term, cross-functional groups that are dedicated to the team for the duration of the project.	A positive innovation culture across the entire organization is essential. Cross-functional teams lead to greater success. The scope of pharmaceutical innovation may require a number of specialized teams with integration through a core cross-functional group. New-to-company product innovation will often use autonomous teams.
Design tools Utilizing appropriate design tools is a critical element of successful product innovation. A core set of tools that have application across product categories — ideation, user-centered design, concept design, etc. And tools that apply to specific products.	Specific tools include: • Sensory evaluation • Mixture design in the food industry • Formulation	Specific tools include: • Computer aided design (CAD) • Failure mode and effects analysis (FMEA) • Quality function deployment (QFD) • Design for manufacturing and assembly (DFMA)	Specific tools include: • PCB design • Rapid prototyping • User interface (UI) design • User experience (UX) design	Specific tools include: • A wide range of generic and proprietary tools including binary compatibility analysis, code review, debugging. documentation generation. GUI interface generation, source code editing.	Specific tools include: • Rational drug design • Computer-aided drug design • Structure-based drug design • Clinical trialling • ADMR (adsorption, distribution, metabolism and excretion)
Market research Market research techniques are widely used across all industries and product categories. The specific tools used will depend on the stage of the innovation process and the level of confidence required in the results.	Speed to market and current market knowledge normally preclude the use of extensive surveys and market testing. Focus groups and lead user panels are most commonly used to inform concept development and user acceptance testing. Specialized FMCG products such as sport supplements may use online interest groups.	Market research will largely depend on the type of product and its novelty. So for washing machines, lead user panels may be most appropriate throughout the innovation process. Whereas for sporting goods, the use of social media through online interest groups. High-end consumer durables such as automobiles may require more extensive market testing.	Tools used will depend very much on the type of product and the target market. Mainstream products such as TVs may rely of regular feedback from customers — either directly or online — as a means of market research forming the basis for product improvements. Specialized products such as game consoles may benefit from lead user input from the specific target market.	In the case of B2B (business to business) software products, customer site visits may be the preferred form of market research to better understand user needs. For standard consumer apps, online feedback through social media provides the best form of market research and input for product enhancements. Alpha and beta testing are also commonly used.	Often, the end consumer of a pharmaceutical is not the primary source of product requirements. The target market is more often the medical profession. Secondary research through medical journals and conference proceedings are useful. Direct contact with medical practitioners throughout the innovation process is essential. And clinical trials will ultimate define product efficacy.
Product innovation management	The principles and fundamentals of product innovation are common across most industries and product types. Differences lie in the specific strategies, processes, and tools applied. The key to successful product innovation management is to understand the basic principles and fundamentals and recognize and implement "fit for purpose" strategies, processes, and tools for the specific organization.				

Practice questions: Product innovation management

1. Jane is the product manager for a toy manufacturing and marketing company. The company has just embarked on developing a new product targeted at children between 8 and 12 years of age. Jane has just completed an early stage feasibility analysis of the product profitability potential. She has completed a comprehensive survey of the potential market; has examined the company's technical capability with respect to design and manufacture; has discussed the company's ability to market the new product with the marketing manager; and has developed an extensive spreadsheet to analyze the profit potential under different scenarios. What important consideration has Jane failed to take into account?
   A. Support from senior management.
   B. The company's manufacturing capability.
   C. The export market potential.
   D. The time to market.

2. You need to estimate the sales potential of a new product to determine its overall financial feasibility. Your sales manager estimates there is a 40% chance of achieving sales of 500,000 units and a 60% chance of selling 1,000,000 units. What sales potential would you use in your feasibility analysis?
   A. 600,000 units.
   B. 700,000 units.
   C. 800,000 units.
   D. 900,000 units.

3. Jane is establishing her own company to manufacture and market a novel range of sports clothes for children aged 8 to 12 years of age. In applying for a loan from her bank, she has been told that she needs to estimate the required working capital. Why is working capital so important to Jane in the establishment of her new business?
   A. It tells her how much money she has to invest in her new business.
   B. It provides an indication of the new business' potential to pay off its short-term financial liabilities.
   C. It provides a sound basis for calculating the return on investment of the new business.
   D. It provides a basis for how much money she should seek to borrow from the bank.

4. In which of the following scenarios is it most important to use net present value rather than payback period for financial analysis of a new product's potential?
   A. A high level of capital expenditure is required, the product has a long potential life cycle, and interest rates are high.
   B. A low level of capital expenditure is required, the product has a long potential life cycle, and interest rates are high.
   C. Potential profitability is high, the product has a long life cycle, and interest rates are low.
   D. Potential profitability is high, the product has a short life cycle, and interest rates are high.

5. Product management actions taken during the product life cycle are first determined by which of the following?
   A. Life cycle assessment.
   B. Sustainability plans.
   C. Product, price, promotion, and place.
   D. Phase of the product's life cycle.

6. In the introduction stage of the product life cycle, which of the following product pricing strategies is most commonly used?
   A. Penetration pricing.
   B. Skimming pricing.
   C. Either A or B.
   D. Competitive pricing.

7. What type of consumer is most likely to purchase a product in its introduction stage?
   A. Laggards.
   B. Early adopters.
   C. Innovators.
   D. Early majority.

8. Jack is a product manager responsible for a product that has clearly entered the decline stage of its life cycle. What strategy should Jack adopt?
   A. Seek to reduce costs and continue to sell to a loyal market.
   B. Rejuvenate the product by adding new features and finding new users.
   C. Discontinue the product.
   D. Any of A, B, or C.

9. In the management of a product portfolio, it is important to:
   A. Have a good mix of products across the introduction, growth, and maturity stages of the product life cycle.
   B. Focus strongly on products in the introduction and growth stages of the product life cycle.
   C. Place significant emphasis on the product in the maturity stage of the product life cycle.
   D. Place significant emphasis on products in the growth and maturity stages of the product life cycle.

10. A product manager is charged with launching a new product. She decides on initially launching into a specific market segment and then, on the basis of achieving penetration into this segment, to roll the product out progressively to more segments. This approach to launching a new product is called a:
    A. Rollout strategy.
    B. Beachhead strategy.
    C. Market testing.
    D. Market expansion.

Answers to practice questions: Product innovation management

1. B	6. C
2. C	7. B
3. B	8. D
4. A	9. A
5. D	10. B

NPDP GLOSSARY

This glossary contains terms used in this book. It is a subset of the full PDMA glossary and is intended as specific support for NPDP certification.

A/B testing: A form of multivariate research designed to test and compare two samples or variables. Other forms of multivariate testing, such as conjoint analysis, involve two or more variations and variables.

Agile product development: An iterative approach to product development that is performed in a collaborative environment by self-organizing teams.

Alliance: Formal arrangement with a separate organization for purposes of development, and involving exchange of information, hardware, intellectual property, or enabling technology. Alliances involve shared risk and reward (e.g., co-development projects). (See also Chapter 11 of *The PDMA HandBook 2nd Edition*).

Alpha test: Pre-production product testing to find and eliminate the most obvious design defects or deficiencies, usually in a laboratory setting or in some part of the developing organization's regular operations, although in some cases it may be done in controlled settings with lead customers. See also beta test and gamma test.

Analyzer: An organization that follows an imitative innovation strategy, where the goal is to get to market with an equivalent or slightly better product very quickly once someone else opens up the market, rather than to be first to market with new products or technologies. Sometimes called an imitator or a "fast follower."

Applications development: The iterative process through which software is designed and written to meet the needs and requirements of the user base, or the process of enhancing or developing new products.

Acquisition effort: The extent to which your product or service is accessible to your customer.

Adjourning: The stage of a project team's work on the project is complete. In product innovation projects, the product is launched and turned over to standard business operations.

Architectural innovation: Combines technological and business disruptions. A well-quoted example is digital photography, which caused significant disruption for companies such as Kodak and Polaroid.

Architecture: See product architecture.

ATAR (Awareness-Trial-Availability-Repeat): A forecasting tool that attempts to mathematically model the diffusion of an innovation or new product.

Attribute testing: A quantitative market research technique in which respondents are asked to rate a detailed list of product or category attributes on one or more types of scales (such as relative importance, current performance, and current satisfaction with a particular product or service) for the purpose of ascertaining customer preferences for some attributes over others, to help guide the design and development process. Great care and rigor should be taken in developing the list of attributes, and it must be neither too long for the respondent to answer comfortably nor too short such that it lumps too many ideas together at too high a level.

Audit: When applied to new product development, an audit is an appraisal of the effectiveness of the processes by which the new product was developed and brought to market. (See Chapter 14 of *The PDMA ToolBook 1*.)

Augmented product: The core product, plus all other sources of product benefits, such as service, warranty, and image.

Augmented reality (AR): Similar to VR; whereas VR replaces the participant's real world with an entirely separate reality, AR overlays elements of a new reality into the participant's present environment.

Autonomous team: A completely self-sufficient project team with very little, if any, link to the funding organization. Frequently used as an organizational model to bring a radical innovation to the marketplace. Sometimes called a tiger team.

Awareness: A measure of the percent of target customers who are aware that the new product exists. Awareness is variously defined, including recall of brand, recognition of brand, recall of key features or positioning.

Balanced portfolio: A collection of projects where the proportion of projects in specific categories is selected according to strategic priorities.

Balanced Scorecard: A strategic management performance metric used to identify and improve various internal business functions and their resulting external outcomes.

Bass model: A tool used to forecast sales of an innovation, new technology, or a durable good.

Benchmarking: A process of collecting process performance data, generally in a confidential, blinded fashion, from a number of organizations to allow them to assess their performance individually and as a whole.

Benefit: A product attribute expressed in terms of what the user gets from the product rather than its physical characteristics or features. Benefits are often paired with specific features, but they need not be.

Best practice: Methods, tools, or techniques that are associated with improved performance. In new product development, no one tool or technique assures success; however, a number of them are associated with higher probabilities of achieving success. Best practices likely are at least somewhat context specific. Sometimes called effective practice.

Best practice study: A process of studying successful organizations and selecting the best of their actions or processes for emulation. In new product development, it means finding the best process practices, adapting them, and adopting them for internal use. (See Chapter 36 in the *PDMA HandBook 2nd Edition*, Chapter 33 in *The PDMA HandBook,* Griffin, "PDMA Research on New Product Development Practices: Updating Trends and Benchmarking Best Practices," *JPIM,* 14:6, 429-458, November, 1997, and "Drivers of NPD Success: The 1997 PDMA Report," PDMA, October, 1997.)

Beta test: A more extensive test than the alpha test, performed by real users and customers. The purpose of beta testing is to determine how the product performs in an actual user environment. It is critical that real customers perform this evaluation, not the organization developing the product or a contracted testing organization. As with the alpha test, results of the beta test should be carefully evaluated with an eye toward any needed modifications or corrections.

Big data: A collection of large and complex data from different instruments at all stages of the process which go from acquisition, storage, and sharing, to analysis and visualization.

Bottom up portfolio selection: Starts first with a list of individual projects, and through a process of strict project evaluation and screening, ends up with a portfolio of strategically aligned projects.

Brainstorming: A group method of creative problem-solving frequently used in product concept generation. There are many modifications in format, each variation with its own name. The basis of all of these methods uses a group of people to creatively generate a list of ideas related to a particular topic. As many ideas as possible are listed before any critical evaluation is performed. (See Chapters 16 and 17 in *The PDMA HandBook 2nd Edition.*)

Brand: A name, term, design, symbol, or any other feature that identifies one seller's good or service as distinct from those of other sellers. The legal term for brand is trademark. A brand may identify one item, a family of items, or all items of that seller.

Brand development index: Sales of your brand compared with its average performance in all markets.

Break-even point: The point in the commercial life of a product when cumulative development costs are recovered through accrued profits from sales.

Breakthrough projects: These projects strive to bring a new product to the market with new technologies, depart significantly from existing organizational practices, and have a high level of risk.

Bubble diagram: Visual representation of a product portfolio. Typically, a bubble diagram shows projects on a two-dimensional X-Y plot. The X and Y dimensions relate to specific criteria of interest (for example, risk and reward).

Business analysis: An analysis of the business situation surrounding a proposed project. Usually includes financial forecasts in terms of discounted cash flows, net present values, or internal rates of returns.

Business case: The results of the market, technical, and financial analyses, or up-front homework. Ideally defined just prior to the "go to development" decision (gate), the case defines the product and project, including the project justification and the action or business plan. (See Chapter 21 of *The PDMA HandBook 2nd Edition.*)

Business Model Canvas (BMC): A strategic management and Lean startup template for developing new or documenting existing business models. It is a visual chart with elements describing an organization's or product's value proposition, infrastructure, customers, and finances.

Business-to-business: Transactions with non-consumer purchasers such as manufacturers, resellers (distributors, wholesalers, jobbers, and retailers, for example), institutional, professional, and governmental organizations. Frequently referred to as industrial businesses in the past.

Buyer: The purchaser of a product, whether or not they will be the ultimate user. Especially in business-to-business markets, a purchasing agent may contract for the actual purchase of a good or service, yet never benefit from the function(s) purchased.

Cannibalization: That portion of the demand for a new product that comes from the erosion of the demand for (sales of) a current product the organization markets. (See Chapter 34 in *The PDMA HandBook 2nd Edition.*)

Capacity planning: A forward-looking activity that monitors the skill sets and effective resource capacity of the organization. For product development, the objective is to manage the flow of projects through development such that none of the functions (skill sets) creates a bottleneck to timely completion. Necessary in optimizing the project portfolio.

Carbon credits: By a simple cost of goods calculation, the indirect cost from externalities (effects of a product or service on other people than the producer and user) are not reflected. This can be CO_2, but also social impact. Integrating all externalities in your (shadow) price gives the real price.

Cash cows: Products that have a high share of a market and low overall growth.

Centers of excellence: A geographic or organizational group with an acknowledged technical, business, or competitive competency.

Certification: A process for formally acknowledging that someone has mastered a body of knowledge on a subject. In new product development, the PDMA has created and manages a certification process to become a New Product Development Professional (NPDP).

Champion: A person who takes a passionate interest in seeing that a particular process or product is fully developed and marketed. This informal role varies from situations calling for little more than stimulating awareness of the opportunity to extreme cases where the champion tries to force a project past the strongly entrenched internal resistance of organization policy or that of objecting parties. (See Chapter 5 in *The PDMA ToolBook 1st Edition.*)

Charter: A project team document defining the context, specific details, and plans of a project. It includes the initial business case, problem and goal statements, constraints and assumptions, and preliminary plan and scope. Periodic reviews with the sponsor ensure alignment with business strategies. See also Product Innovation Charter.

Chasm: A critical part of the product life cycle occurs near the beginning — after introduction, but before growth has fully kicked in.

Checklist: A list of items used to remind an analyst to think of all relevant aspects. It finds frequent use as a tool of creativity in concept generation, as a factor consideration list in concept screening, and to ensure that all appropriate tasks have been completed in any stage of the product development process.

Circular economy: An economy that is restorative and regenerative by design, and which aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles.

Cluster sampling: The population is divided into clusters and a sample of clusters is taken.

Collaborative product development: When two organizations work together to develop and commercialize a specialized product.

Co-location: Physically locating project personnel in one area, enabling more rapid and frequent decision-making and communication among them.

Commercialization: The process of taking a new product from development to market. It generally includes production launch and ramp-up, marketing materials and program development, supply chain development, sales channel development, training development, training, and service and support development. (See Chapter 30 of *The PDMA HandBook 2nd Edition.*)

Competitive intelligence: Methods and activities for transforming disaggregated public competitor information into relevant and strategic knowledge about competitors' position, size, efforts, and trends. The term refers to the broad practice of collecting, analyzing, and communicating the best available information on competitive trends occurring outside one's own organization.

Concept: A clearly written and possibly visual description of a new product idea that includes its primary features and consumer benefits, combined with a broad understanding of the technology needed.

Concept generation: The processes by which new concepts, or product ideas, are generated. Sometimes also called idea generation or ideation. (See Chapters 15 and 17 in *The PDMA HandBook 2nd Edition.*)

Concept screening: The evaluation of potential new product concepts during the discovery phase of a product development project. Potential concepts are evaluated for their fit with business strategy, technical feasibility, manufacturability, and potential for financial success.

Concept statement: A verbal or pictorial statement of a concept that is prepared for presentation to consumers to get their reaction prior to development.

Concept engineering: A customer-centered process that clarifies the "fuzzy front end" of the product development process with the purpose of developing product concepts. The method determines the customer's key requirements to be included in the design and proposes several alternative product concepts that satisfy these requirements.

Concept testing: The process by which a concept statement is presented to consumers for their reactions. These reactions can either be used to permit the developer to estimate the sales value of the concept or to make changes to the concept to enhance its potential sales value. (See Chapter 6 in *The PDMA HandBook 2nd Edition.*)

Concurrent engineering (CE): When product design and manufacturing process development occur concurrently in an integrated fashion, using a cross-functional team, rather than sequentially by separate functions. CE is intended to cause the development team to consider all elements of the product life cycle from conception through disposal, including quality, cost, and maintenance, from the project's outset. Also called simultaneous engineering. (See Chapter 30 of *The PDMA HandBook 1st Edition.*)

Conjoint analysis: A market research technique in which respondents are systematically presented with a rotating set of product descriptions, each containing a rotating set of attributes and levels of those attributes. By asking respondents to choose their preferred product and/or to indicate their degree of preference from within each set of options, conjoint analysis can determine the relative contribution to overall preference of each variable and each level. The two key advantages of conjoint analysis over other methods of determining importance are: 1) the variables and levels can be either continuous (e.g., weight) or discrete (e.g., color), and 2) it is just about the only valid market research method for evaluating the role of price, i.e., how much someone would pay for a given feature. (See Chapter 18 of *The PDMA HandBook 2nd Edition.*)

Consumer: The most generic and all-encompassing term for an organization's targets. The term is used in either the business-to-business or household context and may refer to the organization's current customers, competitors' customers, or current non-purchasers with similar needs or demographic characteristics. The term does not differentiate between whether the person is a buyer or a user target. Only a fraction of consumers will become customers.

Consumer market: The purchasing of goods and services by individuals and for household use (rather than for use in business settings). Consumer purchases are generally made by individual decision-makers, either for themselves or others in the family.

Consumer need: A problem the consumer would like to have solved. What a consumer would like a product to do for them.

Consumer panels: Groups of consumers in specific sectors, recruited by research companies and agencies, who are used as respondents to answer specific research questions relating to product testing, taste testing, or other areas. Most often, they are a specialist panel who take part in numerous projects. Consumer panels are particularly useful for short, quick surveys, where the emphasis is on a sample of those with specialist knowledge rather than a representative sample of the general population.

Contingency plan: A plan to cope with events whose occurrence, timing, and severity cannot be predicted.

Continuous improvement: The review, analysis, and rework directed at incrementally improving practices and processes. Also called Kaizen.

Continuous innovation: A product alteration that allows improved performance and benefits without changing either consumption patterns or behavior. The product's general appearance and basic performance do not functionally change. Examples include fluoride toothpaste and higher computer speeds.

Convergent thinking: Associated with analysis, judgement, and decision-making. It is the process of taking a lot of ideas and sorting, evaluating, analyzing the pros and cons, and making decisions.

Cooperation (team cooperation): The extent to which team members actively work together in reaching team level objectives.

Copyright: The exclusive and assignable legal right, given to the originator for a fixed number of years, to print, publish, perform, film, or record literary, artistic, or musical material.

Core Benefit Proposition (CBP): The central benefit or purpose for which a consumer buys a product. The CBP may come either from the physical good or service, or from augmented dimensions of the product. See also value proposition. (See Chapter 3 of *The PDMA ToolBook 1st Edition.*)

Core competence: That capability at which an organization does better than other organizations, which provides them with a distinctive competitive advantage and contributes to acquiring and retaining customers. Something that an organization does better than other organizations. The purest definition adds, "and is also the lowest cost provider."

Corporate culture: The "feel" of an organization. Culture arises from the belief system through which an organization operates. Corporate cultures are variously described as being authoritative, bureaucratic, and entrepreneurial. The organization's culture frequently impacts the organizational appropriateness for getting things done.

Corporate strategy: The overarching strategy of a diversified organization. It answers the questions of "in which businesses should we compete?" and "how does bringing in these businesses create synergy and /or add to the competitive advantage of the organization as a whole?".

Creativity: "An arbitrary harmony, an expected astonishment, a habitual revelation, a familiar surprise, a generous selfishness, an unexpected certainty, a formable stubbornness, a vital triviality, a disciplined freedom, an intoxicating steadiness, a repeated initiation, a difficult delight, a predictable gamble, an ephemeral solidity, a unifying difference, a demanding satisfier, a miraculous expectation, and accustomed amazement." (George M. Prince, *The Practice of Creativity,* 1970.) Creativity is the ability to produce work that is both novel and appropriate.

Criteria: Statements of standards used by decision- makers at decision gates. The dimensions of performance necessary to achieve or surpass for product development projects to continue in development. In the aggregate, these criteria reflect a business unit's new product strategy. (See Chapters 21 and 29 of *The PDMA ToolBook 2nd Edition.*)

Critical path: The set of interrelated activities that must be completed for the project to be finished successfully can be mapped into a chart showing how long each task takes, and which tasks cannot be started before which other tasks are completed. The critical path is the set of linkages through the chart that is the longest. It determines how long a project will take.

Critical path scheduling: A project management technique, frequently incorporated into various software programs, which puts all important steps of a given new product project into a sequential network based on task interdependencies.

Critical success factors: Those critical few factors that are necessary for, but don't guarantee, commercial success. (See Chapter 1 of *The PDMA HandBook 2nd Edition.*)

Cross-functional team: A team consisting of representatives from the various functions involved in product development, usually including members from all key functions required to deliver a successful product, typically including marketing, engineering, manufacturing/operations, finance, purchasing, customer support, and quality. The team is empowered by the departments to represent each function's perspective in the development process. (See Chapters 9 and 10 in *The PDMA HandBook 2nd Edition* and Chapter 6 in *The PDMA ToolBook 1.*)

Crossing the chasm: Making the transition to a mainstream market from an early market dominated by a few visionary customers (sometimes also called innovators or lead adopters). This concept typically applies to the adoption of new, market-creating, technology-based products and services.

Crowdsourcing: The practice and use of a collection of tools for obtaining information, goods, services, ideas, funding, or other input into a specific task or project from a large and relatively open group of people, either paid or unpaid, most commonly via technology platforms, social media channels, or the Internet.

Culture: The shared beliefs, core values, assumptions, and expectations of people in the organization.

Customer: One who purchases or uses an organization's products or services.

Customer needs: Problems to be solved. These needs, either expressed or yet to be articulated, provide new product development opportunities for the organization. (See Chapter 14 in *The PDMA HandBook 2nd Edition.*)

Customer site visits: A qualitative market research technique for uncovering customer needs. The method involves going to a customer's work site, watching as a person performs functions associated with the customer needs your organization wants to solve, and then debriefing that person about what they did, why they did those things, the problems encountered as they were trying to perform the function, and what worked well. (See Chapters 15 and 16 of *The PDMA HandBook 2nd Edition.*)

Cycle time: The length of time for any operation, from start to completion. In the new product development sense, it is the length of time to develop a new product from an early initial idea for a new product to initial market sales. Precise definitions of the start and end point vary from one organization to another, and may vary from one project to another within the organization. (See Chapter 12 of *The PDMA HandBook 2nd Edition.*)

Dashboard: A typically color-coded graphical presentation of a project's status or a portfolio's status by project resembling a vehicle's dashboard. Typically, red is used to flag urgent problems, yellow to flag impending problems, and green to signal projects on track.

Data: Measurements taken at the source of a business process.

Database: An electronic gathering of information organized in some way to make it easy to search, discover, analyze, and manipulate.

Decision tree: A diagram used for making decisions in business or computer programming. The "branches" of the tree diagram represent choices with associated risks, costs, results, and outcome probabilities. By calculating outcomes (profits) for each of the branches, the best decision for the organization can be determined.

Decline stage: The fourth and last stage of the product life cycle. Entry into this stage is generally caused by technology advancements, consumer or user preference changes, global competition, or environmental or regulatory changes. (See Chapter 34 of *The PDMA HandBook 2nd Edition.*)

Defenders: Organizations that stake out a product turf and protect it by whatever means, not necessarily through developing new products.

Deliverable: The output (such as test reports, regulatory approvals, working prototypes, or marketing research reports) that shows a project has achieved a result. Deliverables may be specified for the commercial launch of the product or at the end of a development stage.

Delphi: A technique that uses iterative rounds of consensus development across a group of experts to arrive at a forecast of the most probable outcome for some future state.

Demographic: The statistical description of a human population. Characteristics included in the description may include gender, age, education level, and marital status, as well as various behavioral and psychological characteristics.

Derivative projects: Spin-offs from other existing products or platforms. They may fill a gap in an existing product line, offer more cost-competitive manufacturing, or offer enhancements and features based on core organization technology. Generally, they are relatively low risk.

Design for assembly: Simplifies the product design to reduce the cost of assembly in the manufacturing process. An assembly is defined as a combination of parts and components needed to manufacture a product. This view includes all the working activities during and after production.

Design for the environment: The systematic consideration of environmental safety and health issues over the product's projected life cycle in the design and development process.

Design for excellence: The systematic consideration of all relevant life cycle factors, such as manufacturability, reliability, maintainability, affordability, testability, etc., in the design and development process.

Design for functionality: Functionality determines the final performance of a product. It allows for the intended behavior of the elements of design or their combination. DFF implies considerations such as design for safety (coffeemakers), design for simplicity (platform design), and design for redesign (product variants or derivatives).

Design for maintenance: Design decisions regarding the selection of materials, assemblies, parts, devices, and components determine the maintainability or the capacity of the system to be inspected, restored, and serviced when components fail as they reach their operational life. During the design stages, design for maintenance should facilitate executing corrective and preventive maintenance.

Design for production: Aims to minimize product costs and manufacture times while maintaining specified quality standards. A successful manufacturing process depends on the following factors:
- Rate: flow of materials, parts, components through the system.
- Cost: materials, labor, machines, equipment, tooling.
- Time: supply times, inventory flows, processing times, machine set-up times.
- Quality: Lost functions and deviations from the target.

Design for recycling: Design for recycling (DFR) accounts for the use of materials that allow for reusing or reprocessing production waste, products, and parts of products. The methods for DFR center on reusing products and reprocessing products.

Design for serviceability: Focuses on the ability to diagnose, remove, or replace any part, component, assembly, or subassembly of a product while performing service repairs and troubleshooting.

Design for Six Sigma: The aim of DFSS is to create designs that are resource efficient, capable of exceptionally high yields, and are robust to process variations.

Design for usability: Evaluates the functionality, serviceability, maintainability, ease of operation, reliability, safety, aesthetics, operating context and environment, and customizability of the concept system. Overall, DFU should be intrinsically connected to the product and manufacture design process.

Design specifications: Where the concept statement provides a qualitative presentation of the product concept's benefits and features, the product design specifications provide the quantitative basis for further design and manufacture.

Design thinking: A creative solving approach — or more completely, a systematic and collaborative approach to identify and creatively solve problems.

Design validation: Product tests to ensure that the product or service conforms to defined user needs and requirements. These may be performed on working prototypes or using computer simulations of the finished product.

Development: The functional part of the organization responsible for converting product requirements into a working product. Also, a phase in the overall concept-to-market cycle where the new product or service is developed for the first time.

Development teams: Teams formed to take one or more new products from concept through development, testing, and launch.

Discontinuous innovation: Previously unknown products that establish new consumption patterns and behavior changes. Examples include microwave ovens and cellular phones.

Discounted Cash-Flow (DCF) analysis: One method for providing an estimate of the current value of future incomes and expenses projected for a project. Future cash flows for a number of years are estimated for the project, and then discounted back to the present using forecast interest rates.

Dispersed teams: Product development teams that have members working at different locations, across time zones, and perhaps even in different countries.

Disruptive innovation: Requires a new business model but not necessarily new technology. So, for example, Google's Android operating system potentially disrupts companies like Apple.

Distribution (physical and channels): The method and partners used to get the product (or service) from where it is produced to where the end user can buy it.

Divergent thinking: The process of coming up with new ideas and possibilities without judgement, without analysis, and without discussion. It is the type of thinking that allows for free-association, "stretching the boundaries," and thinking of new ways to solve difficult challenges that have no single, right, or known answer.

Early adopters: For new products, these are customers who, relying on their own intuition and vision, buy into new product concepts very early in the life cycle. For new processes, these are organizational entities that were willing to try out new processes rather than just maintaining the old.

Embodiment design: The stage of the design process that starts from the concept definition and continues to develop the design based on technical and economic criteria to reach the detail design stage, which leads to manufacturability.

Emotional design: Is based on eliciting the moods and feelings of consumers that allow for designing positive emotional associations and a feeling of trust in the product, and thus improve its usability.

Emotional intelligence: Comprised of self-management components and of elements directed toward managing relationships.

Empathy analysis: Involves the capacity to connect with and understand customers deeply and have a direct emotional connection with them.

Enhanced new product: A form of derivative product. Enhanced products include additional features not previously found on the base platform, which provide increased value to consumers.

Entrepreneur: A person who initiates, organizes, operates, assumes the risk, and reaps the potential reward for a new business venture.

Ethnography: A descriptive, qualitative market research methodology for studying the customer in relation to his or her environment. Researchers spend time in the field observing customers and their environment to acquire a deep understanding of the lifestyles or cultures as a basis for better understanding their needs and problems. See customer site visits. (See Chapter 15 in *The PDMA HandBook 2nd Edition.*)

Eye tracking: A specialized form of sensory testing that uses specialized tools, including connected headsets or goggles, measuring where people look and for how long. The equipment tracks and reports where participants look first, second, third, etc., and provides a visual scan overlaid on an image of the object tested. It is used to answer questions on consumers' reactions to various stimuli, online products and services, websites, apps, images of products, packaging, and messaging. It is widely used in software, retail product packaging, marketing, and advertising.

Factor analysis: A process in which the values of observed data are expressed as functions of a number of possible causes in order to find which are the most important.

Factory cost: The cost of producing the product in the production location including materials, labor, and overhead.

Failure rate: The percentage of an organization's new products that make it to full market commercialization, but which fail to achieve the objectives set for them.

Feasibility analysis: The process of analyzing the likely success of a project or a new product.

Feature: The solution to a consumer need or problem. Features provide benefits to consumers. A handle (feature) allows a laptop computer to be carried easily (benefit). Usually, any one of several different features will be chosen to meet a customer need. For example, a carrying case with shoulder straps is another feature that allows a laptop computer to be carried easily.

Feature creep: The tendency for designers or engineers to add more capability, functions, and features to a product as development proceeds than were originally intended. These additions frequently cause schedule slip, development cost increases, and product cost increases.

Feature roadmap: The evolution over time of the performance attributes associated with a product. Defines the specific features associated with each iteration/generation of a product over its lifetime, grouped into releases (sets of features that are commercialized).

Field testing: Product use testing with users from the target market in the actual context in which the product will be used.

Financial success: The extent to which a new product meets its profit, margin, and return on investment goals.

First-to-market: The first product to create a new product category or a substantial subdivision of a category.

Focus groups: A qualitative market research technique where 8 to 12 market participants are gathered in one room for a discussion under the leadership of a trained moderator. Discussion focuses on a consumer problem, product, or potential solution to a problem. The results of these discussions are not projectable to the general market.

Forecast: A prediction, over some defined time, of the success or failure of implementing a business plan's decisions derived from an existing strategy. (See Chapter 23 of *The PDMA HandBook 2nd Edition.*)

Forming: The first stage in team formation, where most team members are positive and polite. Some are anxious, as they haven't fully understood what the team will do.

Function: 1) An abstracted description of work that a product must perform to meet customer needs. A function is something the product or service must do. 2) Term describing an internal group within which resides a basic business capability such as engineering.

Function Analysis System Technique (FAST): A technique that builds on the results of a functional analysis. The purpose of FAST is to illustrate and provide insights on how the product system works in order to identify malfunctions, incoherence in the sequencing of operations, or operational flaws. The technique allows visualization of the cause-effect relationship among the functions in a product to enhance understanding of how it works.

Functional team: The project is divided into functional components with each component assigned to its own appropriate functional manager. Coordination is either handled by the functional manager or by senior management.

Fuzzy front end: The messy "getting started" period of product development, when the product concept is still very fuzzy. Preceding the more formal product development process, it generally consists of three tasks: strategic planning, concept generation, and, especially, pre-technical evaluation. These activities are often chaotic, unpredictable, and unstructured. In comparison, the subsequent new product development process is typically structured, predictable, and formal, with prescribed sets of activities, questions to be answered, and decisions to be made. (See Chapter 6 of *The PDMA HandBook 2nd Edition.*)

Gamma test: A product use test in which the developers measure the extent to which the item meets the needs of the target customers, solves the problem(s) targeted during development, and leaves the customer satisfied.

Gantt chart: A horizontal bar chart used in project scheduling and management that shows the start date, end date, and duration of tasks within the project.

Gap analysis: Carried out in product development to determine the difference between expected and desired revenues or profits from currently planned new products if the corporation is to meet its objectives.

Gate: The point at which a management decision is made to allow the product development project to proceed to the next stage, to recycle back into the current stage to better complete some of the tasks, or to terminate. The number of gates varies by organization. (See Chapter 21 in *The PDMA HandBook 2nd Edition.*)

Gatekeepers: The group of managers who serve as advisors, decision-makers, and investors in a Stage-Gate® process. Using established business criteria, this multifunctional group reviews new product opportunities and project progress, and allocates resources accordingly at each gate. This group is also commonly called a product approval committee or portfolio management team.

Greenwashing: When an organization or organization spends more time and money claiming to be "green" through advertising and marketing than actually implementing business practices that minimize environmental impact.

Growth stage: The second stage of the product life cycle, marked by a rapid surge in sales and market acceptance for the good or service. Products that reach the growth stage have successfully "crossed the chasm."

Heavyweight team: An empowered project team with adequate resourcing to complete the project. Personnel report to the team leader and are co-located as practical.

Hurdle rate: The minimum return on investment or internal rate of return percentage a new product must meet or exceed as it goes through development.

Idea: The most embryonic form of a new product or service. It often consists of a high-level view of the envisioned solution needed to solve the problem identified by a person, team, or organization.

Idea generation (ideation): All of those activities and processes that lead to creating broad sets of solutions to consumer problems. These techniques may be used in the early stages of product development to generate initial product concepts, in the intermediate stages for overcoming implementation issues, in the later stages for planning launch, and in the post-mortem stage to better understand success and failure in the marketplace. (See Chapter 17 in *The PDMA HandBook 2nd Edition.*)

Implementation team: A team that converts the concepts and good intentions of the "should-be" process into practical reality.

Implicit product requirement: What the customer expects in a product, but does not ask for, and may not even be able to articulate.

Incremental improvement: A small change made to an existing product that serves to keep the product fresh in the eyes of customers.

In-depth interviews: A qualitative research method that involves conducting longer intensive interviews probing and exploring a specific topic, one on one, with individual participants. The research gathers detailed insights, perspectives, attitudes, thoughts, behaviors, and viewpoints on a problem, idea, program, situation, etc.

Information: Knowledge and insight, often gained by examining data.

Initial screening: The first decision to spend resources (time or money) on a project. The project is born at this point. Sometimes called idea screening.

In-licensed: The acquisition from external sources of novel product concepts or technologies for inclusion in the aggregate NPD portfolio.

Innovation: A new idea, method, or device. The act of creating a new product or process. The act includes invention as well as the work required to bring an idea or concept into final form.

Innovation-based culture: A corporate culture where senior management teams and employees work habitually to reinforce best practices that systematically and continuously churn out valued new products to customers.

Innovation steering committee: The senior management team or a subset of it responsible for gaining alignment on the strategic and financial goals for new product development, as well as setting expectations for portfolio and development teams.

Innovation strategy: Provides the goals, direction, and framework for innovation across the organization. Individual business units and functions may have their own strategies to achieve specific innovation goals, but it is imperative that these individual strategies are tightly connected with the overarching organizational innovation strategy.

Integrated Product Development (IPD): A philosophy that systematically employs an integrated team effort from multiple functional disciplines to effectively and efficiently develop new products that satisfy customer needs.

Intellectual property (IP): Information, including proprietary knowledge, technical competencies, and design information, which provides commercially exploitable competitive benefit to an organization.

Internal rate of return (IRR): The discount rate at which the present value of the future cash flows of an investment equals the cost of the investment. The discount rate with a net present value of 0.

Internet of Things (IoT): The interconnection via the Internet of computing devices embedded in everyday objects, enabling them to send and receive data.

Intrapreneur: The large-organization equivalent of an entrepreneur. Someone who develops new enterprises within the confines of a large corporation.

Introduction stage: The first stage of a product's commercial launch and the product life cycle. This stage is generally seen as the point of market entry, user trial, and product adoption.

ISO 9000: A set of five auditable standards of the International Organization for Standardization that establishes the role of a quality system in an organization and which is used to assess whether the organization can be certified as compliant to the standards. ISO 9001 deals specifically with new products.

Journal of Product Innovation Management: The premier academic journal in the field of innovation, new product development, and management of technology. The journal, which is owned by the PDMA, is dedicated to the advancement of management practice in all of the functions involved in the total process of product innovation. Its purpose is to bring to managers and students of product innovation the theoretical structures and the practical techniques that will enable them to operate at the cutting edge of effective management practice. Website: www.pdma.org/journal.

Journey maps: A representation as a flowchart of all the actions and behaviors consumers take when interacting with the product or service.

Kaizen: A Japanese term meaning “change for the better” or “continuous improvement.” It is a Japanese business philosophy regarding the processes that continuously improve operations and involve all employees.

Kano method: Used to identify customer needs and latent demands, determining functional requirements, developing concepts as candidates for further product definition, and analyzing competitive product or services within a product category.

Kansei engineering: Used to identify the relevant design elements (color, size, and shape) embedded in a product as determinant of user preference.

Launch: The process by which a new product is introduced into the market for initial sale. (See Chapter 30 of *The PDMA HandBook 2nd Edition.*)

Lead users: Users for whom finding a solution to one of their consumer needs is so important that they have modified a current product or invented a new product to solve the need themselves because they have not found a supplier who can solve it for them. When these consumers’ needs are portents of needs that the center of the market will have in the future, their solutions are new product opportunities.

Lean product development (LPD): The Lean approach to meet the challenges of product development. Lean product development is founded on the fundamental Lean methodology initially developed by Toyota (the Toyota Production System, or TPS).

Lean startup: An approach to building new businesses based on the belief that entrepreneurs must investigate, experiment, test, and iterate as they develop products.

Learning organization: An organization that continuously tests and updates the experience of those in the organization, and transforms that experience into improved work processes and knowledge that is accessible to the whole organization and relevant to its core purpose.

Life cycle assessment: A scientific method for analysis of environmental impacts ($CO2$ footprint, Water footprint, etc.).

Lightweight team: New product team charged with successfully developing a product concept and delivering to the marketplace. Resources are, for the most part, not dedicated, and the team depends on the technical functions for resources necessary to get the work accomplished.

Line extension: A form of derivative product that adds or modifies features without significantly changing the product functionality.

Manufacturability: The extent to which a new product can be easily and effectively manufactured at minimum cost and with maximum reliability.

Manufacturing design: The process of determining the manufacturing process that will be used to make a new product. (See Chapter 23 of *The PDMA HandBook 1st Edition.*)

Manufacturing test specification and procedure: Documents prepared by development and manufacturing personnel that describe the performance specifications of a component, subassembly, or system that will be met during the manufacturing process, and that describe the procedure by which the specifications will be assessed.

Market penetration: The percentage of your target market that you have reached at least once in a specific period of time.

Market research: Information about the organization’s customers, competitors, or markets. Information may be from secondary sources (already published and publicly available) or primary sources (from customers themselves). Market research may be qualitative in nature, or quantitative. See entries for these two types of market research.

Market segmentation: Market segmentation is defined as a framework by which to subdivide a larger heterogeneous market into smaller, more homogeneous parts. These segments can be defined in many ways: demographic (men vs. women, young vs. old, or richer vs. poorer), behavioral (those who buy on the phone vs. the Internet vs. retail, or those who pay with cash vs. credit cards), or attitudinal (those who believe that store brands are just as good as national brands vs. those who don't). There are many analytical techniques used to identify segments — such as cluster analysis, factor analysis, or discriminate analysis. But the most common method is simply to hypothesize a potential segmentation definition and then to test whether any differences that are observed are statistically significant. (See Chapter 13 of *The PDMA HandBook 2nd Edition.*)

Market share: An organization's sales in a product area as a percent of the total market sales in that area. Sales may be for the organization, a brand, a product, etc.

Marketing mix: Comprises the basic tools that are available to market a product. The market mix is often referred to as the 4 Ps — Product, Price, Promotion, and Place.

Marketing strategy: A process or model to allow an organization to focus limited resources on the best opportunities to increase sales and thereby achieve a unique competitive advantage.

Maturity stage: The third stage of the product life cycle, where sales begin to level off due to market saturation. It is a time when heavy competition, alternative product options, and (possibly) changing buyer or user preferences start to make it difficult to achieve profitability.

Metrics: A set of measurements to track product development and allow an organization to measure the impact of process improvements over time. These measures generally vary by organization, but may include measures characterizing both aspects of the process, such as time to market and duration of particular process stages, as well as outcomes from product development such as the number of products commercialized per year and percentage of sales due to new products.

Mindmapping: A graphical technique for imagining connections between various pieces of information or ideas. The participant starts with a key phrase or word in the middle of a page, then works out from this point to connect to new ideas in multiple directions — building a web of relationships.

Mission: The statement of an organization's creed, philosophy, purpose, business principles, and corporate beliefs. The purpose of the mission is to focus the energy and resources of the organization.

Multidimensional scaling (MDS): A means of visualizing the level of similarity of individual cases of a dataset (for example, products or markets).

Multifunctional team: A group of individuals brought together from the different functional areas of a business to work on a problem or process that requires the knowledge, training, and capabilities across the areas to successfully complete the work. See also cross-functional team. (See Chapters 9 and 10 in *The PDMA HandBook 2nd Edition* and Chapter 6 in *The PDMA ToolBook 1.*)

Multiple regression analysis: Often used in product innovation to analyze survey-based data. It provides detailed insight that can be applied to new products or improve products or services when there are any number of factors, key drivers, and product attributes that can impact the product's value proposition from the customer's point of view. It can be used to identify which variables have an impact on the topic of interest and is used to predict the value of a variable based on the known value of two or more other variables (predictors).

Multivariate analysis: Explores the association between one outcome variable (referred to as the dependent variable) and one or more predictor variables (referred to as independent variables).

Needs statement: Summary of consumer needs and wants, described in customer terms, to be addressed by a new product. (See Chapter 14 of *The PDMA HandBook 2nd Edition.*)

Net present value (NPV): The difference between the present value of cash inflows and the present value of cash outflows. NPV is used in capital budgeting to analyze the profitability of a projected investment or project.

Net promoter score: The likelihood someone would recommend your product or service to a friend.

Network diagram: A graphical diagram with boxes connected by lines that shows the sequence of development activities and the interrelationship of each task with another. Often used in conjunction with a Gantt chart.

New product: A term of many opinions and practices, but most generally defined as a product (either a good or service) new to the organization marketing it. Excludes products that are only changed in promotion.

New Product Development (NPD): The overall process of strategy, organization, concept generation, product and marketing plan creation and evaluation, and commercialization of a new product. Also frequently referred to as product development.

New product introduction (NPI): The launch or commercialization of a new product into the marketplace. Takes place at the end of a successful product development project. (See Chapter 30 of *The PDMA HandBook 2nd Edition.*)

New Product Development process (NPD process): A disciplined and defined set of tasks and steps that describe the normal means by which an organization repetitively converts embryonic ideas into salable products or services. (See Chapters 4 and 5 of *The PDMA HandBook 2nd Edition.*)

New Product Development Professional (NPDP): A New Product Development Professional is certified by the PDMA as having mastered the body of knowledge in new product development, as proven by performance on the certification test. To qualify for the NPDP certification examination, a candidate must hold a Bachelor's or higher university degree (or an equivalent degree) from an accredited institution and have spent a minimum of two years working in the new product development field.

New-to-the-world product: A good or service that has never before been available to either consumers or producers. The automobile was new-to-the-world when it was introduced, as were microwave ovens and pet rocks.

Non-product advantage: Elements of the marketing mix that create competitive advantage other than the product itself. These elements can include marketing communications, distribution, organization reputation, technical support, and associated services.

Norming: The third stage of team formation, when people start to resolve their differences, appreciate colleagues' strengths, and respect the leader's authority.

Open Innovation (OI): The strategy adopted by an organization whereby it actively seeks knowledge from external sources, through alliances, partnerships, and contractual arrangements, to complement and enhance its internal capability in pursuit of improved innovation outcomes. These innovation outcomes may be commercialized internally, through new business entities, or through external licensing arrangements.

Operations: A term that includes manufacturing but is much broader, usually including procurement, physical distribution, and, for services, management of the offices or other areas where the services are provided.

Opportunity: A business or technology gap that an organization or individual realizes, by design or accident, exists between the current situation and an envisioned future in order to capture competitive advantage, respond to a threat, solve a problem, or ameliorate a difficulty.

Organizational identity: Fundamental to the long-term success of an organization is a clear definition and understanding of what the organization stands for, why it exists.

Outsourcing: The process of procuring a good or service from someone else, rather than the organization producing it themselves.

Outstanding Corporate Innovator Award: An annual PDMA award given to organizations acknowledged through a formal vetting process as being outstanding innovators. The basic requirements for receiving this award are: 1) Sustained success in launching new products over a five-year time frame; 2) Significant organization growth from new product success; 3) A defined new product development process, that can be described to others; 4) Distinctive innovative characteristics and intangibles.

Payback: The time, usually in years, from some point in the development process until the commercialized product or service has recovered its costs of development and marketing. While some organizations take the point of full-scale market introduction of a new product as the starting point, others begin the clock at the start of development expense.

Perceptual mapping: A quantitative market research tool used to understand how customers think of current and future products. Perceptual maps are visual representations of the positions that sets of products hold in consumers' minds.

Performance measurement system: The system that enables an organization to monitor the relevant performance indicators of new products in the appropriate time frame.

Performance metrics: A set of measurements to track product development and to allow an organization to measure the impact of process improvement over time. These measures generally vary by organization but may include measures characterizing both aspects of process, such as time to market and duration of particular process stages, as well as outcomes from product development, such as the number of products commercialized per year and percentage sales due to new products.

Performing: The fourth stage of team formation when hard work leads, without friction, to the achievement of the team's goals. The team structures and processes, established by the leader, are working well.

Personas: Fictional characters built based on objective and direct observations of groups of users. These characters become "typical" users or archetypes, enabling developers to envision specific attitudes and behaviors toward product features.

PERT (Program Evaluation and Review Technique): An event-oriented network analysis technique used to estimate project duration when there is a high degree of uncertainty in estimates of duration times for individual activities.

PESTLE: A structured tool based on the analysis of Political, Economic, Social, Technological, Legal, and Environmental factors. It is particularly useful as a strategic framework for seeking a better understanding of trends in factors that will directly influence the future of an organization — such as demographics, political barriers, disruptive technologies, competitive pressures, etc.

Phase review process: A staged product development process in which first one function completes a set of tasks, then passes the information generated sequentially to another function, which in turn completes the next set of tasks, and then passes everything along to the next function. Multifunctional teamwork is largely absent in these types of product development processes, which may also be called baton-passing processes. Most organizations have moved from these processes to Stage-Gate® processes using multifunctional teams.

Pipeline (product pipeline): The scheduled stream of products in development for release to the market.

Pipeline management: A process that integrates product strategy, project management, and functional management to continually optimize the cross-project management of all development-related activities. (See Chapter 5 in T*he PDMA HandBook 1st Edition* and Chapter 3 in *The PDMA HandBook 2nd Edition.*)

Plant variety rights: An exclusive right to produce for sale and sell propagating material of a plant variety.

Platform product: The design and components that are shared by a set of products in a product family. From this platform, numerous derivative products can be designed. See also product platform.

Portfolio: Commonly referred to as a set of projects or products that an organization is investing in and making strategic trade-offs against. See also project portfolio and product portfolio.

Portfolio criteria: The set of criteria against which the business judges both proposed and currently active product development projects to create a balanced and diverse mix of ongoing efforts.

Portfolio management: A business process by which a business unit decides on the mix of active projects, staffing, and dollar budget allocated to each project currently being undertaken. See also pipeline management. (See Chapter 13 of *The PDMA ToolBook 1* and Chapter 3 of *The PDMA HandBook 2nd Edition.*)

Portfolio management team: See gatekeeper.

Portfolio rollout scenarios: Hypothetical illustrations of the number and magnitude of new products that would need to be launched over a certain time frame to reach the desired financial goals; accounts for success/failure rates and considers organization and competitive benchmarks.

Primary market research: Original research conducted by you (or someone you hire) to collect data specifically for your current objective.

Process champion: The person responsible for the daily promotion of and encouragement to use a formal business process throughout the organization. They are also responsible for the ongoing training, innovation input, and continuous improvement of the process.

Process managers: The operational managers responsible for ensuring the orderly and timely flow of ideas and projects through the process.

Process owner: The executive manager responsible for the strategic results of the NPD process. This includes process throughput, quality of output, and participation within the organization. (See Section 3 of *The PDMA ToolBook* for four tools that process owners might find useful, and see Chapter 5 of *The PDMA HandBook.*)

Product: All goods, services, or knowledge sold. Products are bundles of attributes (features, functions, benefits, and uses) and can be tangible, as in the case of physical goods; intangible, as in the case of those associated with service benefits; or can be a combination of the two.

Product and process performance success: The extent to which a new product meets its technical performance and product development process performance criteria.

Product approval committee: See gatekeeper.

Product architecture: The way in which functional elements are assigned to the physical chunks of a product and the way in which those physical chunks interact to perform the overall function of the product. (See Chapter 16 of *The PDMA HandBook 1st Edition.*)

Product backlog: A basis of Agile product development. The requirements for a system, expressed as a prioritized list of product backlog items. These include both functional and non-functional customer requirements, as well as technical team-generated requirements.

Product definition: Defines the product, including the target market, product concept, benefits to be delivered, positioning strategy, price point, and even product requirements and design specifications.

Product design specifications: All necessary drawings, dimensions, environmental factors, ergonomic factors, aesthetic factors, cost, maintenance that will be needed, quality, safety, documentation, and description. It also gives specific examples of how the design of the project should be executed, helping others work properly.

Product development: The overall process of strategy, organization, concept generation, product and marketing plan creation and evaluation, and commercialization of a new product. (See Chapters 19-22 of *The PDMA HandBook 1st Edition.*)

Product Development & Management Association (PDMA): A not-for-profit professional organization whose purpose is to seek out, develop, organize, and disseminate leading-edge information on the theory and practice of product development and product development processes. The PDMA uses local, national, and international meetings and conferences, educational workshops, a quarterly magazine *(Visions),* a scholarly journal published six times per year *(Journal of Product Innovation Management),* research proposal and dissertation proposal competitions, *The PDMA HandBook of New Product Development 1st and 2nd Editions,* and *The PDMA ToolBook 1 for New Product Development* to achieve its purposes. The association also manages the certification process for New Product Development Professionals. Website: www.pdma.org.

Product development portfolio: The collection of new product concepts and projects that are within the organization's ability to develop, are most attractive to the organization's customers, and deliver short- and long-term corporate objectives, spreading risk and diversifying investments. (See Chapter 13 in *The PDMA ToolBook 1* and Chapters 21 and 22 of *The PDMA HandBook 2nd Edition.*)

Product development process: A disciplined and defined set of tasks, steps, and phases that describe the normal means by which an organization repetitively converts embryonic ideas into salable products or services. (See Chapters 4 and 5 of *The PDMA HandBook 2nd Edition.*)

Product development team: That group of persons who participate in a product development project. Frequently each team member represents a function, department, or specialty. Together they represent the full set of capabilities needed to complete the project. (See Chapter 9 in *The PDMA HandBook 2nd Edition* and Chapter 6 in *The PDMA ToolBook 1.*)

Product discontinuation: A product or service that is withdrawn or removed from the market because it no longer provides an economic, strategic, or competitive advantage in the organization's portfolio of offerings. (See Chapter 28 of *The PDMA HandBook 1st Edition.*)

Product failure: A product that does not meet the objective of its charter or marketplace.

Product family: The set of products that have been derived from a common product platform. Members of a product family normally have many common parts and assemblies.

Product Innovation Charter (PIC): A critical strategic document, the Product Innovation Charter (PIC) is the heart of any organized effort to commercialize a new product. It contains the reasons the project has been started, the goals, objectives, guidelines, and boundaries of the project. It is the "who, what, where, when, and why" of the product development project. In the Discovery phase, the charter may contain assumptions about market preferences, customer needs, and sales and profit potential. As the project enters the Development phase, these assumptions are challenged through prototype development and in-market testing. While business needs and market conditions can and will change as the project progresses, one must resist the strong tendency for projects to wander off as the development work takes place. The PIC must be constantly referenced during the Development phase to make sure it is still valid, that the project is still within the defined arena, and that the opportunity envisioned in the Discovery phase still exists.

Product life cycle: The four stages that a new product is thought to go through from birth to death: introduction, growth, maturity, and decline. Controversy surrounds whether products go through this cycle in any predictable way.

Product life cycle management: Changing the features and benefits of the product, elements of the marketing mix, and manufacturing operations over time to maximize the profits obtainable from the product over its life cycle. (See Chapter 33 of *The PDMA HandBook 2nd Edition.*)

Product line: A group of products marketed by an organization to one general market. The products have some characteristics, customers, and uses in common and may also share technologies, distribution channels, prices, services, and other elements of the marketing mix.

Product management: Ensuring over time that a product or service profitably meets the needs of customers by continually monitoring and modifying the elements of the marketing mix, including: the product and its features, the communications strategy, distribution channels, and price.

Product manager: The person assigned responsibility for overseeing all of the various activities that concern a particular product. Sometimes called a brand manager in consumer packaged goods organizations.

Product owner: Commonly used in Agile product development. The product owner is the single person who must have final authority representing the customer's interests in backlog prioritization and requirements questions.

Product platform: Underlying structures or basic architectures that are common across a group of products or that will be the basis of a series of products commercialized over a number of years.

Product portfolio: The set of products and product lines the organization has placed in the market. (See Chapter 13 of *The PDMA ToolBook 1.*)

Product positioning: How a product will be marketed to customers. Product positioning refers to the set of features and benefits that are valued by (and therefore defined by) the target customer audience, relative to competing products.

Product rejuvenation: The process by which a mature or declining product is altered, updated, repackaged, or redesigned to lengthen the product life cycle and in turn extend sales demand.

Product requirements document: The contract between, at a minimum, marketing and development, describing completely and unambiguously the necessary attributes (functional performance requirements) of the product to be developed, as well as information about how achievement of the attributes will be verified (i.e., through testing).

Product roadmap: Illustrates high-level product strategy and demonstrates how a product will evolve over time. It is essential to organizational alignment.

Product superiority: Differentiation of an organization's products from those of competitors, achieved by providing consumers with greater benefits and value. This is one of the critical success factors in commercializing new products.

Program manager: The organizational leader charged with responsibility of executing a portfolio of NPD projects. (See Section 4 of *The PDMA ToolBook 1* for four product development tools a program manager may find helpful.)

Project: A temporary endeavor undertaken to create a unique product, service, or result. (See *PMI-PMBOK Guide*).

Project decision making & reviews: A series of Go/No-Go decisions about the viability of a project that ensure the completion of the project provides a product that meets the marketing and financial objectives of the organization. Includes a systematic review of the viability of a project as it moves through the various phase Stage-Gates in the development process. These periodic checks validate that the project is still close enough to the original plan to deliver against the business case. (See Chapters 21 and 22 of *The PDMA HandBook 2nd Edition.*)

Project leader: The person responsible for managing an individual new product development project through to completion. They are responsible for ensuring that milestones and deliverables are achieved and that resources are utilized effectively. See also team leader. (See Sections 1 and 2 of *The PDMA ToolBook 1* for eight product development tools for project leaders.)

Project management: The set of people, tools, techniques, and processes used to define the project's goal, plan all the work necessary to reach that goal, lead the project and support teams, monitor progress, and ensure that the project is completed in a satisfactory way.

Project pipeline management: Fine-tuning resource deployment smoothly for projects during ramp-up, ramp-down, and mid-course adjustments.

Project plan: A formal, approved document used to guide both project execution and control. Documents planning assumptions and decisions, facilitates communication among stakeholders, and documents approved scope, cost, and schedule deadlines.

Project portfolio: The set of projects in development at any point in time. These will vary in the extent of newness or innovativeness. (See Chapter 13 in *The PDMA ToolBook 1* and Chapter 3 of *The PDMA HandBook 2nd Edition.*)

Project resource estimation: This activity provides one of the major contributions to the project cost calculation. Turning functional requirements into a realistic cost estimate is a key factor in the success of a product delivering against the business plan.

Project sponsor: The authorization and funding source of the project. The person who defines the project goals and to whom the final results are presented. Typically a senior manager.

Project strategy: The goals and objectives for an individual product development project. It includes how that project fits into the organization's product portfolio, who the target market is, and what problems the product will solve for those customers. (See Chapter 2 in *The PDMA HandBook 2nd Edition.*)

Project team: A multifunctional group of individuals chartered to plan and execute a new product development project.

Prospectors: Organizations that lead in technology, product and market development, and commercialization, even though an individual product may not lead to profits. Their general goal is to be first to market with any particular innovation.

Prototype: A physical model of the new product concept. Depending upon the purpose, prototypes may be non-working, functionally working, or both functionally and aesthetically complete.

Psychographics: Characteristics of consumers that, rather than being purely demographic, measure their attitudes, interests, opinions, and lifestyles.

Qualitative market research: Research conducted with a very small number of respondents, either in groups or individually, to gain an impression of their beliefs, motivations, perceptions, and opinions. Frequently used to gather initial consumer needs and obtain initial reactions to ideas and concepts. Results are not representative of the market in general nor projectable. Qualitative marketing research is used to show why people buy a particular product, whereas quantitative marketing research reveals how many people buy it. (See Chapters 14-16 of *The PDMA HandBook 2nd Edition.*)

Quality: The collection of attributes, which when present in a product, means a product has conformed to or exceeded customer expectations.

Quality assurance/compliance: Function responsible for monitoring and evaluating development policies and practices, to ensure they meet organization and applicable regulatory standards.

Quality-by-design: The process used to design quality into the product, service, or process from the inception of product development.

Quality control specification and procedure: Documents that describe the specifications and the procedures by which they will be measured which a finished subassembly or system must meet before judged ready for shipment.

Quality Function Deployment (QFD): A structured method employing matrix analysis for linking what the market requires to how it will be accomplished in the development effort. This method is most frequently used during the stage of development when a multifunctional team agrees on how customer needs relate to product specifications and the features that deliver those needs. By explicitly linking these aspects of product design, QFD minimizes the possibility of omitting important design characteristics or interactions across design characteristics. QFD is also an important mechanism in promoting multifunctional teamwork. Developed and introduced by Japanese auto manufacturers, QFD is widely used in the automotive industry.

Quantitative market research: Consumer research, often surveys, conducted with a large enough sample of consumers to produce statistically reliable results that can be used to project outcomes to the general consumer population. Used to determine importance levels of different customer needs, performance ratings of and satisfaction with current products, probability of trial, repurchase rate, and product preferences. These techniques are used to reduce the uncertainty associated with many other aspects of product development. (See Chapter 18 of *The PDMA HandBook 2nd Edition.*)

Radical innovation: A new product, generally containing new technologies, that significantly changes behaviors and consumption patterns in the marketplace.

Random sample: A subset of a statistical population in which each member of the subset has an equal probability of being chosen.

Reactors: Organizations that have no coherent innovation strategy. They only develop new products when absolutely forced to by the competitive situation.

Reposition: To change the position of the product in the minds of customers, either on failure of the original positioning or to react to changes in the marketplace. Most frequently accomplished through changing the marketing mix rather than redeveloping the product.

Resource matrix: An array that shows the percentage of each non-managerial person's time that is to be devoted to each of the current projects in the organization's portfolio.

Resource plan: Detailed summary of all forms of resources required to complete a product development project, including personnel, equipment, time, and finances.

Return on investment (ROI): A standard measure of project profitability, this is the discounted profits over the life of the project expressed as a percentage of initial investment.

Reverse engineering: The implementation of value analysis (VA) tear-down processes to formulate ideas for product improvement.

Risk: An event or condition that may or may not occur, but if it does occur will impact the ability to achieve a project's objectives. In new product development, risks may take the form of market, technical, or organizational issues. (For more on managing product development risks, see Chapters 8 and 15 in *The PDMA ToolBook 1* and Chapter 28 in *The PDMA HandBook 2nd Edition.*)

Risk acceptance: An uncertain event or condition for which the project team has decided not to change the project plan. A team may be forced to accept an identified risk when they are unable to identify any other suitable response to the risk.

Risk avoidance: Changing the project plan to eliminate a risk or to protect the project objectives from any potential impact due to the risk.

Risk management: The process of identifying, measuring, and mitigating the business risk in a product development project.

Risk mitigation: Actions taken to reduce the probability and/or impact of a risk to below some threshold of acceptability.

Risk tolerance: The level of risk that a project stakeholder is willing to accept. Tolerance levels are context specific. That is, stakeholders may be willing to accept different levels of risk for different types of risk, such as risks of project delay, price realization, and technical potential.

Risk transference: Actions taken to shift the impact of a risk and the ownership of the risk response actions to a third party.

Roadmapping: A graphical multistep process to forecast future market and/or technology changes, and then plan the products to address these changes.

Routine innovation: Builds on an organization's existing technological competencies and fits with its existing business models. Innovation is focused on feature improvement and new versions or models.

S-Curve (Technology S-Curve): Technology performance improvements tend to progress over time in the form of an "S" curve. When first invented, technology performance improves slowly and incrementally. Then, as experience with a new technology accrues, the rate of performance increase grows and technology performance increases by leaps and bounds. Finally, some of the performance limits of a new technology start to be reached and performance growth slows. At some point, the limits of the technology may be reached and further improvements are not made. Frequently, the technology then becomes vulnerable to a substitute technology that is capable of making additional performance improvements. The substitute technology is usually on the lower, slower portion of its own "S" curve and quickly overtakes the original technology when performance accelerates during the middle (vertical) portion of the "S."

Sales forecasting: Predicting the sales potential for a new product using techniques such as the ATAR (Awareness-Trial-Availability-Repeat) model.

Sales wave research: Customers who are initially offered the product at no cost are re-offered it, or a competitor's product, at slightly reduced prices. The offer may be made as many as five times. The number of customers continuing to select the product and their level of satisfaction is recorded.

Scamper: An ideation tool that utilizes actions verbs as stimuli. S – Substitute; C – Combine; A – Adapt; M – Modify; P – Put to another use; E – Eliminate; R – Reverse.

Scenario analysis: A tool for envisioning alternate futures so that a strategy can be formulated to respond to future opportunities and challenges. (See Chapter 16 of *The PDMA ToolBook 1.*)

Screening: The process of evaluating and selecting new ideas or concepts to put into the project portfolio. Most organizations now use a formal screening process with evaluation criteria that span customer, strategy, market, profitability, and feasibility dimensions.

Scrum: A term used in Agile product development. Arguably it is the most popular framework for implementing Agile. With scrum, the product is built in a series of fixed-length iterations, giving teams a framework for shipping software on a regular cadence.

Scrum-master: Commonly used in Agile product development. The facilitator for the team and product owner. Rather than manage the team, the scrum-master works to assist both the team and the product owner.

Scrum team: Commonly used in Agile product development. Usually made up of seven, plus or minus two, members. The team usually comprises a mix of functions or disciplines required to successfully complete the sprint goals (cross-functional team).

Secondary market research: Research that involves searching for existing data originally collected by someone else.

Segmentation: The process of dividing a large and heterogeneous market into more homogeneous subgroups. Each subgroup, or segment, holds similar views about the product, and values, purchases, and uses the product in similar ways. (See Chapters 3 and 4 of The PDMA HandBook.)

Senior management: That level of executive or operational management above the product development team that has approval authority or controls resources important to the development effort.

Sensitivity analysis: A calculation of the impact that an uncertainty might have on the new product business case. It is conducted by setting upper and lower ranges on the assumptions involved and calculating the expected outcomes. (See Chapter 16 of *The PDMA ToolBook 1.*)

Sensory testing: A quantitative research method that evaluates products in terms of the human sensory response (sight, taste, smell, touch, hearing) to the products tested.

Services: Products, such as an airline flight or insurance policy, which are intangible or at least substantially so. If totally intangible, they are exchanged directly from producer to user, cannot be transported or stored, and are instantly perishable. Service delivery usually involves customer participation in some important way. Services cannot be sold in the sense of ownership transfer, and they have no title of ownership.

Simulated test market: A form of quantitative market research and pre-test marketing in which consumers are exposed to new products and to their claims in a staged advertising and purchase situation. Output of the test is an early forecast of expected sales or market share, based on mathematical forecasting models, management assumptions, and input of specific measurements from the simulation.

Six Sigma: A level of process performance that produces only 3.4 defects for every one million operations.

Six thinking hats: A tool developed by Edward de Bono which encourages team members to separate thinking into six clear functions and roles. Each role is identified with a color-symbolic "thinking hat."

Social media: Computer-mediated tools that allow people, companies, and other organizations to create, share, or exchange information, ideas, and pictures/videos in virtual communities and networks.

Specification: A detailed description of the features and performance characteristics of a product. For example, a laptop computer's specification may read as a 90 megahertz Pentium, with 16 megabytes of RAM and 720 megabytes of hard disk space, 3.5 hours of battery life, weight of 4.5 pounds, with an active matrix 256 color screen.

Sponsor: An informal role in a product development project, usually performed by a higher-ranking person in the organization who is not directly involved in the project, but who is ready to extend a helping hand if needed, or provide a barrier to interference by others.

Sprint: A term used in Agile product development. A set period of time during which specific work has to be completed and made ready for review.

Stage: One group of concurrently accomplished tasks, with specified outcomes and deliverables, of the overall product development process.

Stage-Gate® process: A widely employed product development process that divides the effort into distinct time-sequenced stages separated by management decision gates. Multifunctional teams must successfully complete a prescribed set of related cross-functional tasks in each stage prior to obtaining management approval to proceed to the next stage of product development. The framework of the Stage-Gate® process includes work-flow and decision-flow paths and defines the supporting systems and practices necessary to ensure the process's ongoing smooth operation.

Staged product development activity: The set of product development tasks commencing when it is believed there are no major unknowns and that result in initial production of salable product, carried out in stages.

Standard cost: See factory cost.

Star products: Products that command a significant market share in a growing overall market.

Storming: The stage in team formation where people start to push against the boundaries established. This is where many teams fail. Storming often starts where there is a conflict between team members' natural working styles.

Storyboarding: Focuses on the development of a story, possibly about a consumer's use of a product, to better understand the problems or issues that may lead to specific product design attributes.

Strategic balance: Balancing the portfolio of development projects along one or more of many dimensions such as focus vs. diversification, short vs. long term, high vs. low risk, extending platforms vs. development of new platforms.

Strategic fit: Ensures projects are consistent with the articulated strategy. For example, if certain technologies or markets are specified as areas of strategic focus, do the projects fit into these areas?

Strategic partnering: An alliance or partnership between two organizations (frequently one large corporation and one smaller, entrepreneurial organization) to create a specialized new product. Typically, the large organization supplies capital and the necessary product development, marketing, manufacturing, and distribution capabilities, while the small organization supplies specialized technical or creative expertise.

Strategic priorities: Ensures the investment across the portfolio reflects the strategic priorities. For example, if the organization is seeking technology leadership, then the balance of projects in the portfolio should reflect this focus.

Strategy: The organization's vision, mission, and values. One subset of the organization's overall strategy is its innovation strategy.

Stratified sampling: The population is divided into strata according to some variables that are thought to be related to the variables that we are interested in. A sample is taken from each stratum.

Support projects: Can be incremental improvements in existing products or improvements in manufacturing efficiency of an existing product. Generally they are low risk.

Sustainable development: Development which meets the needs of current generations without compromising the ability of future generations to meet their own needs.

Sustainable innovation: The process in which new products or services are developed and brought to commercialization and in which the characteristics of sustainable development are respected from the economic, environmental, and social angle, in the sourcing, production, use, and end-of-service stages of the product life cycle.

Sustaining innovation: Does not create new markets or value networks but only develops existing ones with better value, allowing companies to compete against each other's sustaining improvements.

SWOT Analysis: Strengths, Weaknesses, Opportunities, and Threats Analysis. A SWOT analysis evaluates an organization in terms of its advantages and disadvantages vs. competitors, customer requirements, and market/economic environmental conditions.

Tangible product: The physical and aesthetic design features that give the product its appearance and functionality.

Target market: The group of consumers or potential customers selected for marketing. This market segment is most likely to buy the products within a given category. These are sometimes called prime prospects.

Task: The smallest describable unit of accomplishment in completing a deliverable.

Team: A small number of people with complementary skills who are committed to a common purpose, with a clear set of performance goals and approach, for which they hold themselves mutually accountable.

Team leader: The person leading the new product team. Responsible for ensuring that milestones and deliverables are achieved, but may not have any authority over project participants. (See Sections 1 and 2 of *The PDMA ToolBook* for eight product development tools for team leaders.)

Technology-driven: A new product or new product strategy based on the strength of a technical capability. Sometimes called solutions in search of problems.

Technology foresighting: A process for looking into the future to predict technology trends and the potential impact on an organization.

Technology roadmap: A graphic representation of technology evolution or technology plans mapped against time. It is used to guide new technology development or technology selection in developing new products.

Technology S-curve: The life cycle that applies to most technologies — embryonic, growth, and maturity stage.

Technology strategy: A plan for the maintenance and development of technologies that supports the future growth of the organization and aids the achievement of its strategic goals.

Technology transfer: The process of converting scientific findings from research laboratories into useful products by the commercial sector. May also be referred to as the process of transferring technology between alliance partners.

Test marketing and market testing: Market testing in its most general definition covers the research methods for all products, new or existing, tested under in-market conditions for the purpose of reducing the risks of launch or expansion failure, and includes test marketing methods. Where test marketing focuses on reducing risks for new product launches, market testing can also be defined more narrowly to mean testing the expansion of an existing product to a new market for the purpose of reducing the risk of a failed expansion strategy.

Time to market: The length of time it takes to develop a new product from an early initial idea for a new product to initial market sales. Precise definitions of the start and end point vary from one organization to another, and may vary from one project to another within the organization. (also called Speed to Market).

Top down portfolio selection: Also known as the strategic bucket method, relies on starting with strategy and placing significant emphasis on project selection according to this strategy.

Total Quality Management (TQM): A business improvement philosophy that comprehensively and continuously involves all of an organization's functions in improvement activities.

Trade secrets: Information related to IP that is retained confidentially within an organization.

Trademark: A symbol, word, or words legally registered or established by use as representing an organization or product.

Triple constraint: The combination of the three most significant restrictions on any project: scope, schedule, and cost. The triple constraint is sometimes referred to as the project management triangle or the iron triangle.

Triple bottom line: Reports an organization's performance against three dimensions: Financial, social, environmental.

TRIZ: The acronym for the Theory of Inventive Problem Solving, which is a Russian systematic method of solving problems and creating multiple-alternative solutions. It is based on an analysis and codification of technology solutions from millions of patents. The method enhances creativity by getting individuals to think beyond their own experience and to reach across disciplines to solve problems using solutions from other areas of science.

TURF analysis: Total Unduplicated Reach and Frequency (TURF) analysis has its roots in media scheduling and is used in product innovation and product management to understand and maximize the market potential of product lines and product platforms, especially when multiple choices and repeat purchases are involved over a product's life cycle.

Unarticulated customer needs: Those needs that a customer is either unwilling or unable to explain.

Usage and purchase intent: The extent to which someone says they will use or purchase your product or service.

User: Any person who uses a product or service to solve a problem or obtain a benefit, whether or not they purchase it. Users may consume a product, as in the case of a person using shampoo to clean their hair or eating a potato chip to assuage hunger between meals. Users may not directly consume a product, but may interact with it over a longer period of time, like a family owning a car, with multiple family members using it for many purposes over a number of years. Products also are employed in the production of other products or services, where the users may be the manufacturing personnel who operate the equipment.

User experience (UX): In current vernacular, UX is often associated with interface design, human factor design, etc., and while those are definitely a part of the user experience, UX ultimately comes down to understanding the customer.

Value: Any principle to which a person or organization adheres with some degree of emotion. It is one of the elements that enter into formulating a strategy.

Value-added: The act or process by which tangible product features or intangible service attributes are bundled, combined, or packaged with other features and attributes to create a competitive advantage, reposition a product, or increase sales.

Value proposition: A short, clear, and simple statement of how and on what dimensions a product concept will deliver value to prospective customers. The essence of "value" is embedded in the trade-off between the benefits a customer receives from a new product and the price a customer pays for it. (See Chapter 3 of *The PDMA ToolBook 1.*)

Virtual reality (VR) testing: A growing segment of the market research field, conducted using specialized equipment including a headset and/or gloves with tracking sensors that create three-dimensional (3D) simulations and enable participants to interact in a realistic environment.

Virtual team: Dispersed teams that communicate and work primarily electronically may be called virtual teams.

Vision: An act of imagining, guided by both foresight and informed discernment, that reveals the possibilities as well as the practical limits in new product development. It depicts the most desirable future state of a product or organization.

Vitality index: The sales of new products as defined by the business divided by the sales of all products for a given product line or department during a designated period.

Voice of the Customer (VOC): A process for eliciting needs from consumers that uses structured in-depth interviews to lead interviewees through a series of situations in which they have experienced and found solutions to the set of problems being investigated. Needs are obtained through indirect questioning by coming to understand how the consumers found ways to meet their needs, and, more important, why they chose the particular solutions they found. (See Chapter 11 of *The PDMA ToolBook 1.*)

Waste: Any activity that utilizes equipment, materials, parts, space, employee time, or other corporate resource beyond minimum amount required for value-added operations to ensure manufacturability. These activities could include waiting, accumulating semi-processed parts, reloading, passing materials from one hand to the other, and other non-productive processes. The seven basic categories of waste that a business should strive to eliminate are overproduction, waiting for machines, transportation time, process time, excess inventory, excess motion, and defects.

Waterfall process: A sequential design process used in software development processes, in which progress is seen as flowing steadily downward (like a waterfall) through the phases of conception, initiation, analysis, design, construction, testing, production/implementation, and maintenance.

Willingness to pay: The highest price a customer says they will definitely buy your product or service.

Whole product: A product definition concept that emphasizes delivering all aspects of a product which are required for it to deliver its full value. This would include training materials, support systems, cables, how-to recipes, additional hardware/software, standards and procedures, implementation, applications consulting — any constitutive elements necessary to assure the customer will have a successful experience and achieve at least minimum required value from the product.

Workplan: Detailed plan for executing the project, identifying each phase of the project, the major steps associated with them, and the specific tasks to be performed along the way. Best practice workplans identify the specific functional resources assigned to each task, the planned task duration, and the dependencies between tasks. See also Gantt chart.

BODY OF KNOWLEDGE INDEX

This index contains some of the terms used in this book, including the glossary. While not all-encompassing, we have attempted to capture some of the major terms to allow readers to search for major topic areas more easily.