Unit-2

Chapter-3

Development Processes and Organizations

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Figure 2-1 A wireless security alarm system control panel, one of Tyco's products.

- Tyco International is a leading manufacturer of sensors and controls, including home and industrial security systems.
- One of Tyco's products is the wireless security alarm system control panel shown in figure 2-1.
- Senior managers at Tyco wanted to establish a common product development process structure that would be appropriate for all of the many different operating divisions across the company.
- They also needed to create a product development organization that would allow Tyco to compete effectively in a variety of competitive business markets.
- Some of the questions Tyco faced were:
- What are the key product development activities that must be included in every project?
- What project milestones and review gates can be used to manage the overall development process by phases?
- Is there a standard development process that will work for every operating division?
- What role do experts from different functional areas play in the development process?
- Should the development organization be divided into groups corresponding to projects or to technical and business functions?

- This chapter helps to answer these and related questions by presenting a generic development process and showing how this process can be adapted to meet the needs of particular industrial situations.
- We highlight the activities and contributions of different functions of the company during each phase of the development process.
- The chapter also explains what constitutes a product development organization and discusses why different types of organizations are appropriate for different settings.

The Product Development Process

- A process is a sequence of steps that transforms a set of inputs into a set of outputs.
- Most people are familiar with the idea of physical processes, such as those used to bake a cake or to assemble an automobile.
- A ***product development process*** is the sequence of steps or activities that an enterprise employs to conceive, design, and commercialize a product.
- Many of these steps and activities are intellectual and organizational rather than physical.
- Some organizations define and follow a precise and detailed development process, while others may not even be able to describe their process.
- Furthermore, every organization employs a process at least slightly different from that of every other organization.
- In fact, the same enterprise may follow different processes for each of several different types of development projects.

A well-defined development process is useful for the following reasons:

Quality assurance:

- A development process specifies the phases a development project will pass through and the checkpoints along the way.
- When these phases and checkpoints are chosen wisely, following the development process is one way of assuring the quality of the resulting product.

Coordination:

- A clearly articulated development process acts as a master plan that defines the roles of each of the players on the development team.
- This plan informs the members of the team when their contributions will be needed and with whom they will need to exchange information and materials.

Planning:

- A development process includes milestones corresponding to the completion of each phase.
- The timing of these milestones anchors the schedule of the overall development project.

Management:

- A development process is a benchmark for assessing the performance of an ongoing development effort.
- By comparing the actual events to the established process, a manager can identify possible problem areas.

Improvement:

- The careful documentation and ongoing review of an organization's development process and its results may help to identify opportunities for improvement.

❑The generic product development process consists of six phases, as illustrated in Figure 2-2.

❑The process begins with a planning phase, which is the link to advanced research and technology development activities.

❑The output of the planning phase is the project's mission statement, which is the input required to begin the concept development phase and which serves as a guide to the development team.

❑The conclusion of the product development process is the product launch, at which time the product becomes available for purchase in the marketplace.

- One way to think about the development process is as the initial creation of a wide set of alternative product concepts and then the subsequent narrowing of alternatives and increasing specification of the product until the product can be reliably and repeatably produced by the production system.
- Note that most of the phases of development are defined in terms of the state of the product, although the production process and marketing plans, among other tangible outputs, are also evolving as development progresses.
- Another way to think about the development process is as an information-processing system.
- The process begins with inputs such as the corporate objectives, strategic opportunities, available technologies, product platforms, and production systems.
- Various activities process the development information, formulating specifications, concepts, and design details.
- The process concludes when all the information required to support production and sales has been created and communicated.

- A third way to think about the development process is as a risk management system.
- In the early phases of product development, various risks are identified and prioritized.
- As the process progresses, risks are reduced as the key uncertainties are eliminated and the functions of the product are validated.
- When the process is completed, the team should have substantial confidence that the product will work correctly and be well received by the market.

- Figure 2-2 also identifies the key activities and responsibilities of the different functions of the organization during each development phase.
- Because of their continuous involvement in the process, we choose to articulate the roles of marketing, design, and manufacturing.
- Representatives from other functions, such as research, finance, project management, field service, and sales, also play key roles at particular points in the process.

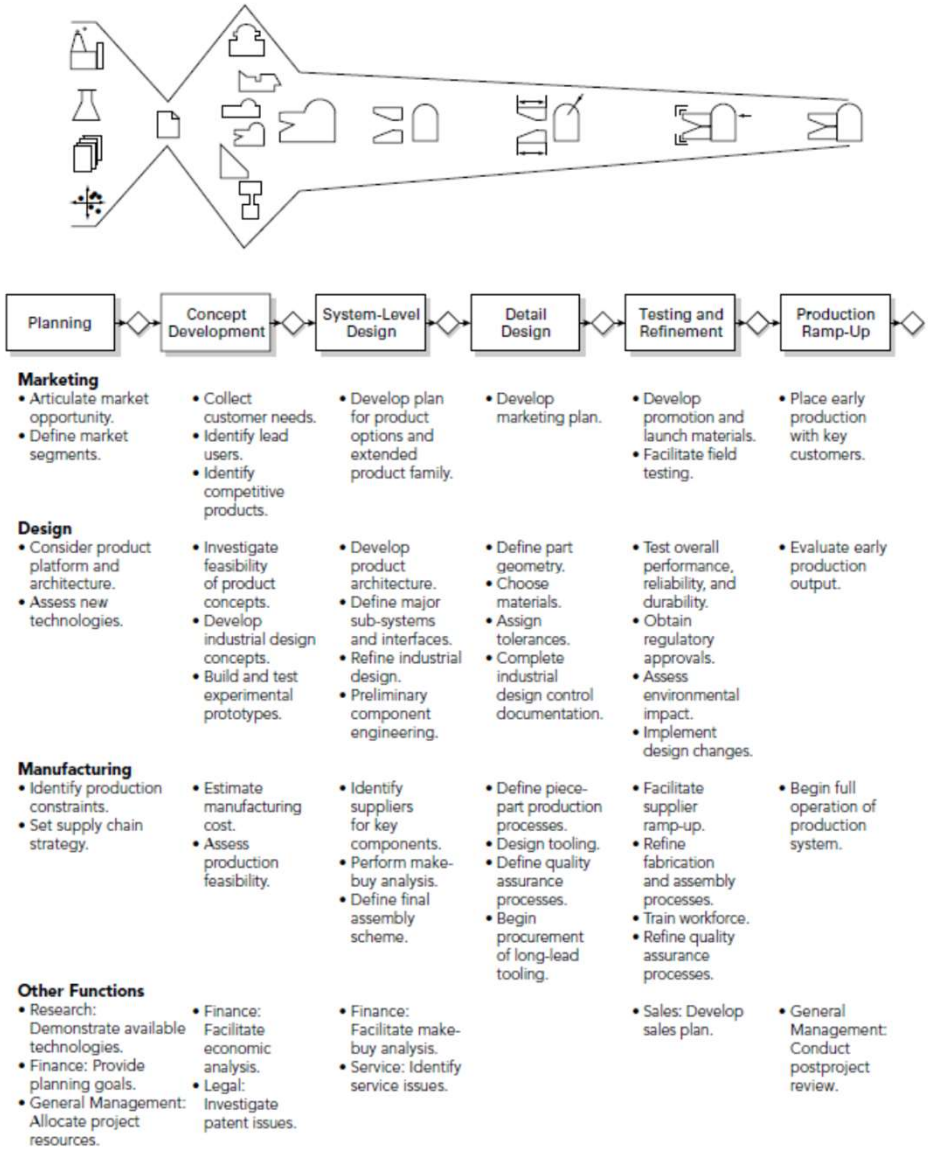

Figure 2-2 The generic product development process.

Six phases are shown, including some of the typical tasks and responsibilities of the key business functions for each phase.

The six phases of the generic development process are:

0. *Planning:*

- The planning activity is often referred to as "phase zero" because it precedes the project approval and launch of the actual product development process.
- This phase begins with opportunity identification guided by corporate strategy and includes assessment of technology developments and market objectives.
- The output of the planning phase is the project mission statement, which specifies the target market for the product, business goals, key assumptions, and constraints.

1. *Concept development:*

- In the concept development phase, the needs of the target market are identified, alternative product concepts are generated and evaluated, and one or more concepts are selected for further development and testing.
- A concept is a description of the form, function, and features of a product and is usually accompanied by a set of specifications, an analysis of competitive products, and an economic justification of the project.

2. *System-level design:*

- The system-level design phase includes the definition of the product architecture, decomposition of the product into subsystems and components, and preliminary design of key components.
- Initial plans for the production system and final assembly are usually defined during this phase as well.
- The output of this phase usually includes a geometric layout of the product, a functional specification of each of the product's subsystems, and a preliminary process flow diagram for the final assembly process.

3. *Detail design:*

- The detail design phase includes the complete specification of the geometry, materials, and tolerances of all of the unique parts in the product and the identification of all of the standard parts to be purchased from suppliers.
- A process plan is established and tooling is designed for each part to be fabricated within the production system.
- The output of this phase is the ***control documentation*** for the product—the drawings or computer files describing the geometry of each part and its production tooling, the specifications of the purchased parts, and the process plans for the fabrication and assembly of the product.
- Three critical issues that are best considered throughout the product development process, but are finalized in the detail design phase, are: materials selection, production cost, and robust performance.

4. *Testing and refinement:*

- The testing and refinement phase involves the construction and evaluation of multiple preproduction versions of the product.
- Early *(alpha)* prototypes are usually built with *production-intent* parts—parts with the same geometry and material properties as intended for the production version of the product but not necessarily fabricated with the actual processes to be used in production.
- Alpha prototypes are tested to determine whether the product will work as designed and whether the product satisfies the key customer needs.
- Later *(beta)* prototypes are usually built with parts supplied by the intended production processes but may not be assembled using the intended final assembly process.
- Beta prototypes are extensively evaluated internally and are also typically tested by customers in their own use environment.
- The goal for the beta prototypes is usually to answer questions about performance and reliability in order to identify necessary engineering changes for the final product.

5. *Production ramp-up:*

- In the production ramp-up phase, the product is made using the intended production system.
- The purpose of the ramp-up is to train the workforce and to work out any remaining problems in the production processes.
- Products produced during production ramp-up are sometimes supplied to preferred customers and are carefully evaluated to identify any remaining flaws.
- The transition from production ramp-up to ongoing production is usually gradual.
- At some point in this transition, the product is *launched* and becomes available for widespread distribution.
- A *postlaunch project review* may occur shortly after the launch.
- This review includes an assessment of the project from both commercial and technical perspectives and is intended to **identify ways to improve the development process for future projects.**

Concept Development: The Front-End Process

- Because the concept development phase of the development process demands perhaps more coordination among functions than any other, many of the integrative development methods are concentrated here.
- In this section we expand the concept development phase into what we call the *front-end process*.
- The front-end process generally contains many interrelated activities, ordered roughly as shown in Figure 2-3.
- Rarely does the entire process proceed in purely sequential fashion, completing each activity before beginning the next.
- In practice, the front-end activities may be overlapped in time and iteration is often necessary.
- The dashed arrows in Figure 2-3 reflect the uncertain nature of progress in product development.
- At almost any stage, new information may become available or results learned that can cause the team to step back to repeat an earlier activity before proceeding. This repetition of nominally complete activities is known as development ***iteration***.

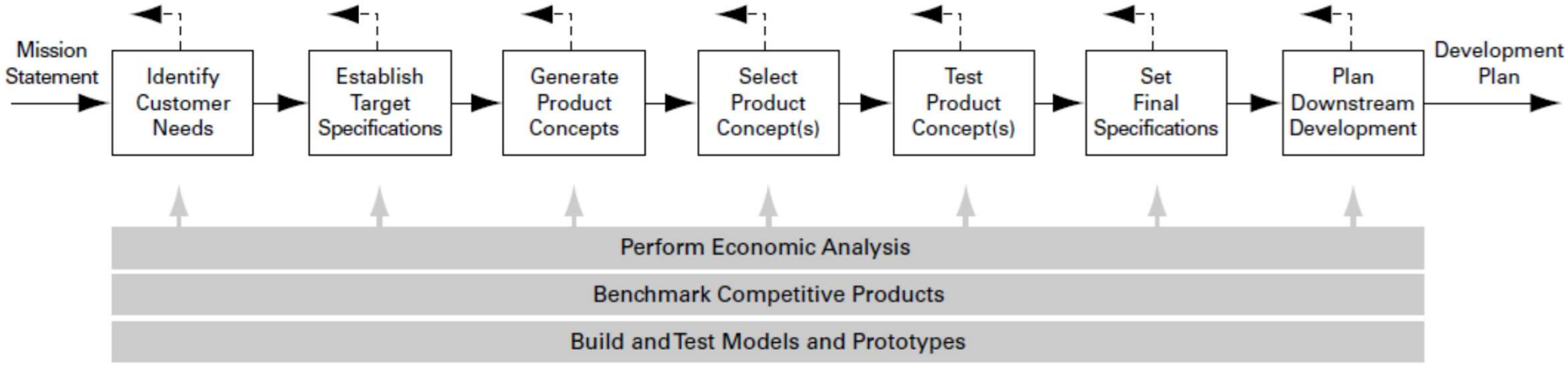

Figure 2-3 The many front-end activities comprising the concept development phase.

The concept development process includes the following activities:

Identifying customer needs:

- The goal of this activity is to understand customers' needs and to effectively communicate them to the development team.
- The output of this step is a set of carefully constructed customer need statements, organized in a hierarchical list, with importance weightings for many or all of the needs.

Establishing target specifications:

- Specifications provide a precise description of what a product has to do.
- They are the translation of the customer needs into technical terms.
- Targets for the specifications are set early in the process and represent the hopes of the development team.
- Later these specifications are refined to be consistent with the constraints imposed by the team's choice of a product concept.
- The output of this stage is a list of target specifications. Each specification consists of a metric, and marginal and ideal values for that metric.

Concept generation:

- The goal of concept generation is to thoroughly explore the space of product concepts that may address the customer needs.
- Concept generation includes a mix of external search, creative problem solving within the team, and systematic exploration of the various solution fragments the team generates.
- The result of this activity is usually a set of 10 to 20 concepts, each typically represented by a sketch and brief descriptive text.

Concept selection:

- Concept selection is the activity in which various product concepts are analyzed and sequentially eliminated to identify the most promising concept(s).
- The process usually requires several iterations and may initiate additional concept generation and refinement.

Concept testing:

- One or more concepts are then tested to verify that the customer needs have been met, assess the market potential of the product, and identify any shortcomings that must be remedied during further development.
- If the customer response is poor, the development project may be terminated or some earlier activities may be repeated as necessary.

Setting final specifications:

- The target specifications set earlier in the process are revisited after a concept has been selected and tested.
- At this point, the team must commit to specific values of the metrics reflecting the constraints inherent in the product concept, limitations identified through technical modeling, and trade-offs between cost and performance.

Project planning:

- In this final activity of concept development, the team creates a detailed development schedule, devises a strategy to minimize development time, and identifies the resources required to complete the project.
- The major results of the front-end activities can be usefully captured in a *contract book*, which contains the mission statement, the customer needs, the details of the selected concept, the product specifications, the economic analysis of the product, the development schedule, the project staffing, and the budget.
- The contract book serves to document the agreement (contract) between the team and the senior management of the enterprise.

Economic analysis:

- The team, often with the support of a financial analyst, builds an economic model for the new product.
- This model is used to justify continuation of the overall development program and to resolve specific trade-offs between, for example, development costs and manufacturing costs.
- Economic analysis is shown as one of the ongoing activities in the concept development phase.
- An early economic analysis will almost always be performed before the project even begins, and this analysis is updated as more information becomes available.

Benchmarking of competitive products:

- An understanding of competitive products is critical to successful positioning of a new product and can provide a rich source of ideas for the product and production process design. Competitive *benchmarking* is performed in support of many of the front-end activities.

Modeling and prototyping:

- Every stage of the concept development process involves various forms of models and prototypes.
- These may include, among others: early "proof of- concept" models, which help the development team to demonstrate feasibility; "form only" models, which can be shown to customers to evaluate ergonomics and style; spreadsheet models of technical trade-offs; and experimental test models, which can be used to set design parameters for robust performance.

Adapting the Generic Product Development Process

- The development process described by Figure 2-2 and 2-3 is generic, and particular processes will differ in accordance with the unique context of the firm and the challenges of any specific project.
- The generic process is most like the process used in a *market-pull* situation: a firm begins product development with a market opportunity and then uses whatever available technologies are required to satisfy the market need (i.e., the market "pulls" the development decisions).
- In addition to the market-pull process outlined in Figure 2-2 and 2-3, several variants are common and correspond to the following: *technology-push* products, *platform* products, *process-intensive* products, *customized* products, *high-risk* products, *quick-build* products, and *complex systems*.
- Each of these situations is described below.
- The characteristics of these situations and the resulting deviations from the generic process are summarized in Figure 2-4.

Process Type	Description	Distinct Features	Examples
Generic (Market-Pull) Products	The team begins with a market opportunity and selects appropriate technologies to meet customer needs.	Process generally includes distinct planning, concept development, system-level design, detail design, testing and refinement, and production ramp-up phases.	Sporting goods, furniture, tools.
Technology-Push Products	The team begins with a new technology, then finds an appropriate market.	Planning phase involves matching technology and market. Concept development assumes a given technology.	Gore-Tex rainwear, Tyvek envelopes.
Platform Products	The team assumes that the new product will be built around an established technological subsystem.	Concept development assumes a proven technology platform.	Consumer electronics, computers, printers.
Process-Intensive Products	Characteristics of the product are highly constrained by the production process.	Either an existing production process must be specified from the start, or both product and process must be developed together from the start.	Snack foods, breakfast cereals, chemicals, semiconductors.
Customized Products	New products are slight variations of existing configurations.	Similarity of projects allows for a streamlined and highly structured development process.	Motors, switches, batteries, containers.
High-Risk Products	Technical or market uncertainties create high risks of failure.	Risks are identified early and tracked throughout the process. Analysis and testing activities take place as early as possible.	Pharmaceuticals, space systems.
Quick-Build Products	Rapid modeling and prototyping enables many design-build-test cycles.	Detail design and testing phases are repeated a number of times until the product is completed or time/budget runs out.	Software, cellular phones.
Complex Systems	System must be decomposed into several subsystems and many components.	Subsystems and components are developed by many teams working in parallel, followed by system integration and validation.	Airplanes, jet engines, automobiles.

Figure 2-4 Summary of variants of generic product development process.

Technology-Push Products

- In developing technology-push products, the firm begins with a new proprietary technology and looks for an appropriate market in which to apply this technology (that is, the technology "pushes" development).
- Gore-Tex, an expanded Teflon sheet manufactured by W. L. Gore Associates, is a striking example of technology push.
- The company has developed dozens of products incorporating Gore-Tex, including artificial veins for vascular surgery, insulation for high-performance electric cables, fabric for outerwear, dental floss, and liners for bagpipe bags.
- Many successful technology-push products involve basic materials or basic process technologies.
- This may be because basic materials and processes are deployed in thousands of applications, and there is therefore a high likelihood that new and unusual characteristics of materials and processes can be matched with an appropriate application.

- The generic product development process can be used with minor modifications for technology-push products.
- The technology-push process begins with the planning phase, in which the given technology is matched with a market opportunity.
- Once this matching has occurred, the remainder of the generic development process can be followed.
- The team includes an assumption in the mission statement that the particular technology will be embodied in the product concepts considered by the team.
- Although many extremely successful products have arisen from technology-push development, this approach can be perilous.
- The product is unlikely to succeed unless (1) the assumed technology offers a clear competitive advantage in meeting customer needs, and (2) suitable alternative technologies are unavailable or very difficult for competitors to utilize.
- Project risk can possibly be minimized by simultaneously considering the merit of a broader set of concepts that do not necessarily incorporate the new technology.
- In this way the team verifies that the product concept embodying the new technology is superior to the alternatives.

Platform Products

- A platform product is built around a preexisting technological subsystem (a technology *platform*).
- Examples of such platforms include the Intel chipset in a personal computer, the Apple iPhone operating system, and the blade design in a Gillette razor.
- Huge investments are made in developing such platforms, and therefore every attempt is made to incorporate them into several different products.
- In some sense, platform products are very similar to technology-push products in that the team begins the development effort with an assumption that the product concept will embody a particular technology.
- One difference is that a technology platform has already demonstrated its usefulness in the marketplace in meeting customer needs.
- The firm can in many cases assume that the technology will also be useful in related markets.
- Products built on technology platforms are much simpler to develop than if the technology were developed from scratch. For this reason, and because of the possible sharing of costs across several products, a firm may be able to offer a platform product in markets that could not justify the development of a unique technology.

Process-Intensive Products

- Examples of process-intensive products include semiconductors, foods, chemicals, and paper.
- For these products, the production process places strict constraints on the properties of the product, so that the product design cannot be separated, even at the concept phase, from the production process design.
- In many cases, process-intensive products are produced in very high volumes and are bulk, as opposed to discrete, goods.
- In some situations, a new product and new process are developed simultaneously.
- For example, creating a new shape of breakfast cereal or snack food will require both product and process development activities.
- In other cases, a specific existing process for making the product is chosen in advance, and the product design is constrained by the capabilities of this process.
- This might be true of a new paper product to be made in a particular paper mill or a new semiconductor device to be made in an existing wafer fabrication facility.

Customized Products

- Examples of customized products include switches, motors, batteries, and containers.
- Customized products are slight variations of standard configurations and are typically developed in response to a specific order by a customer.
- Development of customized products consists primarily of setting values of design variables such as physical dimensions and materials.
- Templates for specifying customized products may be provided with online design tools.
- When a customer orders a new product, the firm executes a structured design and development process to create the product to meet the customer's needs.
- Such firms typically have created a highly detailed development process involving a well defined sequence of steps with a structured flow of information (analogous to a production process).
- For customized products, the generic process is augmented with a detailed description of the specific information-processing activities required within each of the phases.
- Such development processes may consist of hundreds of carefully defined activities and may be highly automated.

High-Risk Products

- The product development process addresses many types of risk.
- These include technical risk (Will the product function properly?), market risk (Will customers like what the team develops?), and budget and schedule risk (Can the team complete the project on time and within budget?).
- High-risk products are those that entail unusually large uncertainties related to the technology or market so that there is substantial technical or market risk.
- The generic product development process is modified in high-risk situations by taking steps to address the largest risks in the early stages of product development.
- This usually requires completing some design and test activities earlier in the process.
- For example, when there is great uncertainty regarding customer acceptance of a new product, concept testing using renderings or user-interface prototypes may be done very early in the process in order to reduce the market uncertainty and risk.
- If there is high uncertainty related to technical performance of the product, it makes sense to build working models of the key features and to test these earlier in the process.
- Multiple solution paths may be explored in parallel to ensure that one of the solutions succeeds.
- Design reviews must assess levels of risk on a regular basis, with the expectation that risks are being reduced over time and not being postponed.

Quick-Build Products

- For the development of some products, such as software and many electronics products, building and testing prototype models is such a rapid process that the design-build-test cycle can be repeated many times.
- In fact, teams can take advantage of rapid iteration to achieve a more flexible and responsive product development process, sometimes called a *spiral product development process.*
- Following concept development in this process, the system-level design phase entails decomposition of the product into high-, medium-, and low-priority features.
- This is followed by several cycles of design, build, integrate, and test activities, beginning with the highest-priority items.
- This process takes advantage of the fast prototyping cycle by using the result of each cycle to learn how to modify the priorities for the next cycle.
- Customers may even be involved in the testing process after one or more cycles.
- When time or budget runs out, usually all of the high- and medium priority features have been incorporated into the evolving product, and the low-priority features may be omitted until the next product generation.

Complex Systems

- Larger-scale products such as automobiles and airplanes are complex systems comprising many interacting subsystems and components.
- When developing complex systems, modifications to the generic product development process address a number of system-level issues.
- The concept development phase considers the architecture of the entire system, and multiple architectures may be considered as competing concepts for the overall system.
- The system-level design phase becomes critical.
- During this phase, the system is decomposed into subsystems and these further into many components.
- Teams are assigned to develop each component. Additional teams are assigned the special challenge of integrating components into the subsystems and these into the overall system.
- Detail design of the components is a highly parallel process in which the many development teams work at once, usually separately.
- Managing the network of interactions across the components and subsystems is the task of systems engineering specialists of many kinds.
- The testing and refinement phase includes not only component and system integration, but also extensive testing and validation at all levels.

Product Development Process Flows

- The product development process generally follows a structured flow of activity and information flow.
- This allows us to draw *process flow diagrams* illustrating the process, as shown in Figure 2-5.
- The generic process flow diagram (a) depicts the process used to develop market-pull, technology-push, platform, process-intensive, customized, and high-risk products.
- Each product development phase (or stage) is followed by a review (or gate) to confirm that the phase is completed and to determine whether the project proceeds.
- Quick-build products enable a spiral product development process (b) whereby detail design, prototyping, and test activities are repeated a number of times.
- The process flow diagram for development of complex systems (c) shows the decomposition into parallel stages of work on the many subsystems and components.
- Once the product development process has been established within an organization, a process flow diagram is used to explain the process to everyone on the team.

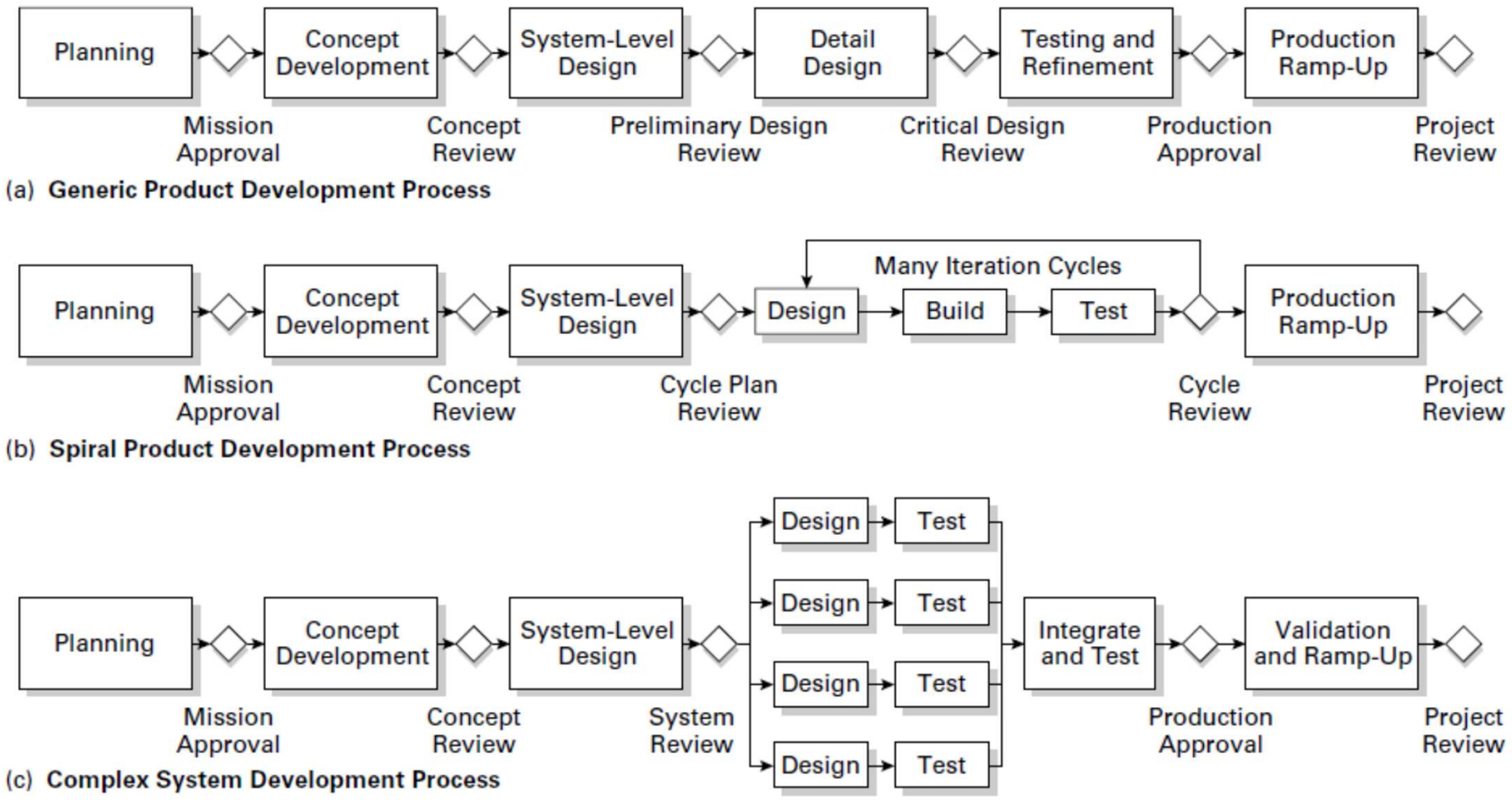

Figure 2-5 Process flow diagrams for three product development processes.

The Tyco Product Development Process

- Tyco is primarily a market-pull enterprise.
- This means that Tyco generally drives its development projects based on a perceived market need and utilizes new or established technologies to meet that need.
- Its competitive advantage arises from highly effective marketing channels worldwide, strong brand recognition, a large installed base of equipment, and an ability to integrate new technologies into its product lines.
- For this reason, the technology-push process would not be appropriate.
- Most Tyco products are assembled from components fabricated with relatively conventional processes such as molding, machining, and electronics assembly.
- Products are generally customized for a particular customer in the final sales and installation processes, so the development process at Tyco is primarily aimed at creation of new models of products, rather than at the customization of existing models.

- Tyco therefore established a common product development process similar to the generic phased process.
- The resulting Tyco Rally Point process flow is illustrated in Figure 2-6.
- Note that there are nine phases in the Rally Point process, with six of the phases (from concept definition to process verification) comprising the fundamental product development process activities.
- Each phase is followed by a critical review (called a Rally Point), which is required to gain approval to proceed to the next phase.
- The primary goal and key activities of each phase as well as the business function responsible for each activity are shown in Figure 2-7.

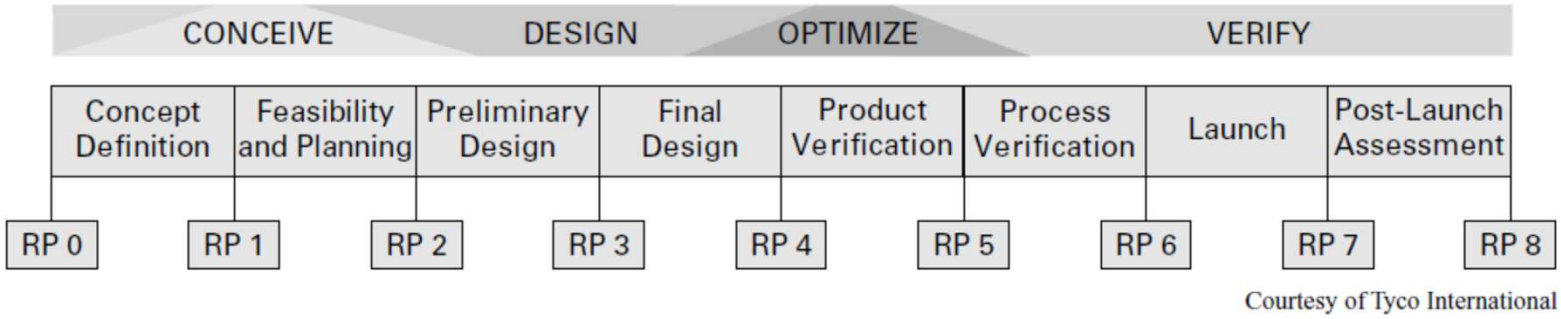

Figure 2-6 Tyco's Rally Point product development process includes nine distinct phases and review gates.

Rally Point Phase	0. Project Registration	1. Concept Definition	2. Feasibility and Planning	3. Preliminary Design	4. Final Design	5. Product Verification	6. Process Verification	7. Launch	8. Post-Launch Assessment
Primary Goal	Define project and business unit needs	Develop project concept and charter	Create product description	Create preliminary detailed design	Detail and optimize design	Demonstrate product performance	Demonstrate process performance	Launch product	Identify lessons learned
Marketing and Sales	Identify customers and market size Describe competitive features and benefits Identify target cost and price	Capture voice of the customer Analyze customer needs Document customer needs	Develop marketing and sales plans Create phase-in and phase-out plans	Review concepts with customers		Initialize field trials	Complete field trials Finalize training plans	Finalize pricing and sales forecasts Complete sales and service training	Solicit customer feedback and satisfaction ratings Measure sales vs. forecast Complete phase-in and phase-out
Engineering	Identify project risks	Identify critical-to-quality specs Develop and select concepts Update project risks	Create functional specification and performance metrics Review concept selection Define product architecture Assess technical failures modes	Conduct a preliminary design review Build and test alpha prototypes Assess product failure modes	Freeze hardware and software design Complete engineering documentation Draft technical documentation Secure beta prototypes	Finalize design documentation Complete beta prototype and field testing Apply for regulatory approvals	Obtain regulatory approvals	Finalize product metrics	
Quality Assurance			Create preliminary test plan		Test beta prototypes for robustness	Complete quality assurance testing	Conduct process verification testing		
Manufacturing				Begin manufacturing process development Conduct a preliminary manufacturing process review	Finalize bill of materials (BOM) Develop manufacturing control plans	Update manufacturing control plans	Run manufacturing pilots Finalize manufacturing control plans		Register obsolete and scrap products
Purchasing				Create a supplier participation matrix Assess suppliers for certification	Identify long lead-time items		Verify supply chain readiness		
Legal		Search patents	Identify trade compliance issues	Identify potential patents	Prepare patent applications	Assure trade compliance			
Financial	Prepare preliminary business case	Refine business case	Complete financial package						Monitor return on investment
Project Management	Identify project timing, resources, and capital Prepare RP0 checklist & submit for approval	Assess team capabilities/skills Identify development team members Select a Rally Point process variant Prepare RP1 checklist & submit for approval	Plan integrated product development schedule Assign a project manager Update RP1 deliverables Prepare RP2 checklist & submit for approval	Update RP1-2 deliverables Prepare RP3 checklist & submit for approval	Update RP1-3 deliverables Prepare RP4 checklist & submit for approval	Update RP1-4 deliverables Prepare RP5 checklist & submit for approval	Update RP1-5 deliverables Prepare RP6 checklist & submit for approval	Finalize all deliverables Finalize launch plans and documentation Update RP1-6 deliverables Prepare RP7 checklist & submit for approval	Document best practices Prepare RP8 checklist & submit for approval

Figure 2-7 Key activities and the responsible functions comprising the Tyco Rally Point product development process.

- Although Tyco established Rally Point as its standard process, Tyco managers realized that this process would not be perfectly suitable for all Tyco development projects across all business units.
- Therefore one key activity in the concept definition phase is to select a Rally Point process variant if necessary.
- For example, some of Tyco's new products are based on existing technology platforms.
- To develop such derivative products, the team assumes the use of the existing technology platform during concept development.
- Also, some products are designed for specific customers as private-label variants of standard Tyco products.
- In these cases, a streamlined process known as Rally Point EZ is used.
- Nevertheless, the standard Rally Point product development process is the baseline from which a particular project plan begins.

Product Development Organizations

- In addition to crafting an effective development process, successful firms must organize their product development staff to implement the process in an effective manner.
- In this section, we describe several types of organizations used for product development and offer guidelines for choosing among these options.

Organizations Are Formed by Establishing Links among Individuals

- A product development organization is the scheme by which individual designers and developers are linked together into groups.
- The links among individuals may be formal or informal and include, among others, these types:

• ***Reporting relationships:*** Reporting relationships give rise to the classic notion of *supervisor* and *subordinate.* These are the formal links most frequently shown on an organization chart.

• ***Financial arrangements:*** Individuals are linked by being part of the same financial entity, such as a business unit or department within a firm.

• ***Physical layout:*** Links are created between individuals when they share the same office, floor, building, or site. These links are often informal, arising from spontaneous encounters while at work.

- Any particular individual may be linked in several different ways to other individuals.
- For example, an engineer may be linked by a reporting relationship to another engineer in a different building, while being linked by physical layout to a marketing person sitting in the next office.
- The strongest organizational links are typically those involving performance evaluation, budgets, and other resource allocations.

Organizational Links May Be Aligned with Functions, Projects, or Both

- Regardless of their organizational links, particular individuals can be classified in two different ways: according to their *function* and according to the *projects* they work on.

✓A function (in organizational terms) is an area of responsibility usually involving specialized education, training, or experience.

✓The classic functions in product development organizations are marketing, design, and manufacturing.

✓Finer divisions than these are also possible and may include, for example, market research, market strategy, stress analysis, industrial design, human factors engineering, process development, and operations management.

❑Regardless of their functions, individuals apply their expertise to specific projects.

❑In product development, a project is the set of activities in the development process for a particular product and includes, for example, identifying customer needs and generating product concepts.

- Note that these two classifications must overlap: individuals from several different functions will work on the same project.
- Also, while most individuals are associated with only one function, they may contribute to more than one project.
- Two classic organizational structures arise from aligning the organizational links according to function or according to projects.
- In *functional organizations,* the organizational links are primarily among those who perform similar functions.
- In *project organizations,* the organizational links are primarily among those who work on the same project.

- For example, a strict functional organization might include a group of marketing professionals, all sharing similar training and expertise.
- These people would all report to the same manager, who would evaluate them and set their salaries.
- The group would have its own budget and the people may sit in the same part of a building.
- This marketing group would be involved in many different projects, but there would be no strong organizational links to the other members of each project team.
- There would be similarly arranged groups corresponding to design and to manufacturing.

- A strict project organization would be made up of groups of people from several different functions, with each group focused on the development of a specific product (or product line).
- These groups would each report to an experienced project manager, who might be drawn from any of the functional areas.
- Performance evaluation would be handled by the project manager, and members of the team would typically be collocated as much as possible so that they all work in the same office or part of a building.
- New ventures, or "start-ups," are among the most extreme examples of project organizations: every individual, regardless of function, is linked together by a single project—the growth of the new company and the creation of its product(s).
- In these settings, the president or CEO can be viewed as the project manager.
- Established firms will sometimes form an autonomous "tiger team" with dedicated resources for a single project when special focus is required to complete an important development project.

- The *matrix organization* was conceived as a hybrid of functional and project organizations.
- In the matrix organization, individuals are linked to others according to both the project they work on and their function.
- Typically each individual has two supervisors, one a project manager and one a functional manager.
- The practical reality is that either the project or the function tends to have stronger links.
- This is because, for example, both functional and project managers cannot independently assign their shared staff, they cannot independently evaluate and determine the salaries of their subordinates, and both functional and project organizations cannot easily be grouped together physically.
- As a result, either the functional or the project organization tends to dominate.

- Two variants of the matrix organization are called the *heavyweight project organization* and *lightweight project organization* (Hayes et al., 1988).
- A heavyweight project organization contains strong project links.
- The heavyweight project manager has complete budget authority, is heavily involved in performance evaluation of the team members, and makes most of the major resource allocation decisions.
- Although each participant in a project also belongs to a functional organization, the functional managers have relatively little authority and control.
- A heavyweight project team in various industries may be called an *integrated product team* (IPT), a *design-build team* (DBT), or simply a *product development team* (PDT).
- Each of these terms emphasizes the cross-functional nature of these teams.

- A lightweight project organization contains weaker project links and relatively stronger functional links.
- In this scheme, the project manager is more of a coordinator and administrator.
- The lightweight project manager updates schedules, arranges meetings, and facilitates coordination, but the manager has no real authority and control in the project organization.
- The functional managers are responsible for budgets, hiring and firing, and performance evaluation.
- Figure 2-8 illustrates the pure functional and project organizations, along with the heavyweight and lightweight variants of the matrix organization.

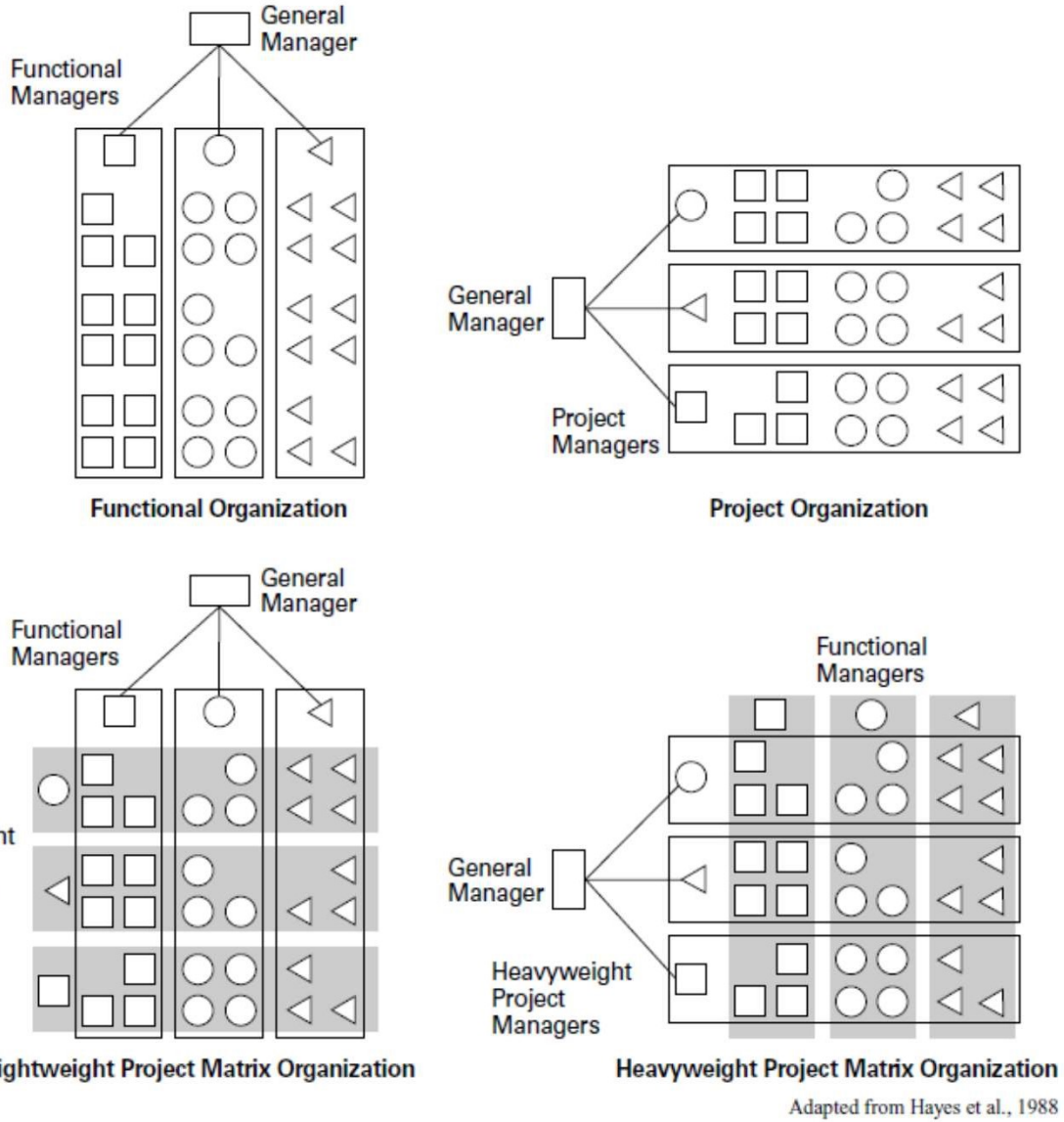

EXHIBIT 2-8 Various product development organizations. For simplicity, three functions and three projects are shown.

- Here, we refer to the *project team* as the primary organizational unit.
- In this context, the team is the set of all people involved in the project, regardless of the organizational structure of the product development staff.
- In a functional organization, the team consists of individuals distributed throughout the functional groups without any organizational linkages other than their common involvement in a project.
- In the other organizations, the team corresponds to a formal organizational entity, the project group, and has a formally appointed manager.
- For this reason the notion of a team has much more meaning in matrix and project organizations than it does in functional organizations.

Choosing an Organizational Structure

- The most appropriate choice of organizational structure depends on which organizational performance factors are most critical to success.
- Functional organizations tend to breed specialization and deep expertise in the functional areas.
- Project organizations tend to enable rapid and effective coordination among diverse functions.
- Matrix organizations, being hybrids, have the potential to exhibit some of each of these characteristics.

The following questions help guide the choice of organizational structure:

How important is cross-functional integration?

- Functional organizations may exhibit difficulty in coordinating project decisions that span the functional areas.
- Project organizations tend to enable strong cross-functional integration because of the organizational links of the team members across the functions.

How critical is cutting-edge functional expertise to business success?

- When disciplinary expertise must be developed and retained over several product generations, then some functional links are necessary.
- For example, in some aerospace companies, computational fluid dynamics is so critical that the fluid dynamitists are organized functionally to ensure the firm will have the best possible capability in this area.

Can individuals from each function be fully utilized for most of the duration of a project?

- For example, a project may require only a portion of an industrial designer's time for a fraction of the duration of a project.
- In order to use industrial design resources efficiently, the firm may choose to organize the industrial designers functionally, so that several projects can draw on the industrial design resource in exactly the amount needed for a particular project.

How important is product development speed?

- Project organizations tend to allow for conflicts to be resolved quickly and for individuals from different functions to coordinate their activities efficiently.
- Relatively little time is spent transferring information, assigning responsibilities, and coordinating tasks.
- For this reason, project organizations are usually faster than functional organizations in developing innovative products.
- For example, consumer electronics manufacturers almost always organize their product development teams by project.
- This allows the teams to develop new products within the extremely short periods required by the fast-paced electronics market.

❖ Dozens of other issues confound the choice between functional and project organizations.

❖ Figure 2-9 summarizes some of the strengths and weaknesses of each organizational type, examples of the types of firms pursuing each strategy, and the major issues associated with each approach.

		Matrix Organization		
	Functional Organization	**Lightweight Project Organization**	**Heavyweight Project Organization**	**Project Organization**
Strengths	Fosters development of deep specialization and expertise.	Coordination and administration of projects is explicitly assigned to a single project manager. Maintains development of specialization and expertise.	Provides integration and speed benefits of the project organization. Some of the specialization of a functional organization is retained.	Resources can be optimally allocated within the project team. Technical and market trade-offs can be evaluated quickly.
Weaknesses	Coordination across different functional groups can be slow and bureaucratic.	Requires more managers and administrators than a non-matrix organization.	Requires more managers and administrators than a non-matrix organization.	Individuals may have difficulty maintaining cutting-edge functional capabilities.
Typical Examples	Customized products, where development involves slight variations to a standard design (e.g., motors, bearings, packaging).	Derivative products in many automobile, electronics, and aerospace companies.	New technology or platform projects in automobile, electronics, and aerospace companies.	Start-up companies. "Tiger teams" and "skunkworks" intended to achieve breakthroughs. Firms competing in highly dynamic markets.
Major Issues	How to integrate different functions (e.g., marketing and design) to achieve business goals.	How to balance functions and projects. How to simultaneously evaluate project and functional performance.		How to maintain functional expertise over time. How to share learning from one project to another.

Figure 2-9 Characteristics of different organizational structures.

Distributed Product Development Teams

- It is well established that a highly effective way to organize a product development team includes colocation of the team members at a single site.
- However, the use of modern communication technology and digital development processes allows even globally distributed project teams to be effective.
- Reasons to utilize product development team members located at multiple sites may include the following:

  - ✓ Access to information about regional markets.
  - ✓ Availability of technical expertise.
  - ✓ Location of manufacturing facilities and suppliers.
  - ✓ Cost saving through lower wages.
  - ✓ Outsourcing to increase product development capacity.

- Notwithstanding the importance of using the right team members regardless of location, firms implementing globally distributed product development have experienced many challenges due to the weaker ties between team members separated by great distances.
- This may result in an increased number of design iterations and more difficult project coordination, particularly when such teams are newly formed.
- Fortunately, organizations having years of experience with global project teams report that distributed projects do work more smoothly over time.

The Tyco Product Development Organization

- The primary functions involved in product development at Tyco are engineering, manufacturing, marketing, sales, purchasing, quality assurance, finance, legal, and project management (as listed in Figure 2-7).
- Each of these functions has a manager who reports to the general manager of the division.
- However, product development projects are led by project managers, with the resources for each project drawn from the functional areas.

- In terms of the variants described in Figure 2-8 and 2-9, product development at Tyco primarily takes place in projects strongly reflecting a traditional functional organization structure.
- Project leaders are given only indirect control of the functional resources assigned to their teams.
- As explained above, a functional structure generally sacrifices some project efficiency in favor of greater ongoing development of the functional skills.
- To address this concern, Tyco has created a highly effective project management function, with project leaders who know the Rally Point process and how to coordinate the activities across the functions.
- This organizational choice has indeed led to very good product development performance for Tyco while maintaining very strong functional capabilities.

- In recent years, Tyco has created new regional engineering centers at locations in high growth markets such as China and India.
- Engineers at these centers are able to support product development projects across multiple Tyco business units around the world.
- This arrangement improves project performance by augmenting any project team with additional technical resources on an as-needed basis, which is particularly helpful in the later stages of the Rally Point process.

Assignment

1. Diagram a process for planning and cooking a family dinner. Does your process resemble the generic product development process? Is cooking dinner analogous to a market-pull, technology-push, platform, process-intensive, customization, high-risk, quick-build, or complex system process?
2. Define a process for finding a job. For what types of endeavor does a well-defined process enhance performance?
3. What type of development process would you expect to find in an established company successful at developing residential air-conditioning units? How about for a small company that is trying to break into the market for racing wheelchairs?
4. Sketch the organization (in some appropriate graphical representation) of a consulting firm that develops new products for clients on a project-by-project basis. Assume that the individuals in the firm represent all of the different functions required to develop a new product. Would this organization most likely be aligned with functions, be aligned by projects, or be a hybrid?
5. What role does basic technological research play in the product development process? How would you modify Figure 2-3 to better represent the research and technology development activities in product development?
6. Is there an analogy between a university and a product development organization? Is a university a functional or project organization?
7. What is the product development organization for students engaged in projects as part of a product development class?
8. Is it possible for some members of a product development organization to be organized functionally, while others are organized by project? If so, which members of the team would be the most likely candidates for the functional organization?