CHAPTER 24

Human Systems Integration and New Product Development

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24.1 INTRODUCTION

This chapter focuses on the nature of human systems integration (HSI) within new product development (NPD), primarily in the private sector. The discussions in this chapter draw upon experiences in product domains ranging from aviation to appliances, computers to communications, and drugs to data warehouses. Hundreds of new product planning engagements form this experience base.

It is essential at the outset to note that few, if any, of these experiences involved explicit use of the phrase "human systems integration." While human-related issues are often primary in NPD, this set of issues and how they are addressed are rarely labeled "HSI." However, as this chapter delineates in some detail, the HSI philosophy permeates much of NPD.

24.1.1 Overarching Design Objectives

The primary emphasis in this chapter is on human-related issues in NPD, how these issues interact with other issues, and how inherent trade-offs can be addressed. Elsewhere (Rouse, 1991, 2000a), I have argued that these issues and trade-offs are driven by three overarching design objectives:

- Enhancing human abilities
- Overcoming human limitations
- Fostering human acceptance

Enhancing human abilities dictates that humans' capabilities in the roles of interest be identified, understood, and cultivated. For example, people tend to have excellent pattern

Handbook of Human Systems Integration, Edited by Harold R. Booher.
ISBN 0-471-02053-2

recognition abilities. NPD should take advantage of these abilities—for instance, by using displays of information that enable users to respond on a pattern recognition basis rather than requiring more analytical evaluation of the information.

Overcoming human limitations requires that limits be identified and appropriate compensatory mechanisms devised. A good illustration of an apparent human limitation is the occasional exhibition of behaviors deemed to be "human errors." Humans are fairly flexible information processors, which is usually important to successful system operation. However, this flexibility can lead to innovative behaviors that are erroneous in the sense that undesirable consequences are likely to occur. Such "errors" often reflect a mismatch between the requirements of an unforeseen situation and humans' natural inclinations.

One way of dealing with this problem is to eliminate innovations, perhaps via interlocks and rigid procedures. However, this is akin to the proverbial "throwing out the baby with the bath water." Instead, mechanisms are needed to compensate for undesirable consequences without precluding innovations. Creatively addressing this need may provide considerable market advantage if done well.

Fostering human acceptance dictates that stakeholders' preferences and concerns be explicitly considered in the design process. This requires, of course, that stakeholders be identified and their concerns, values, and perceptions be assessed. Ideally, this will provide a basis for delighting primary stakeholders and gaining the support of secondary stakeholders.

These three overarching objectives lead to design attributes that potentially affect achieving these objectives for each class of stakeholder. The resulting multiattribute, multistakeholder nature of design problems can be quite difficult to address. This is further complicated by typical NPD contexts where there are no contractual requirements and constraints. There are only markets for which you may or may not correctly assess project needs and devise appropriate solutions. As discussed later in this chapter, the nature of risks in such environments is quite different from typical public system design and development efforts.

24.1.2 Human Systems Integration of New Product Development

Before pursuing HSI for NPD in more depth, it is useful to consider briefly HSI *of* NPD. Many of the methods and tools discussed in this chapter resulted from taking this perspective (Cody et al., 1995; Rouse and Boff, 1998a). Specifically, many of the concepts presented in this chapter emerged from focusing on enhancing designers' abilities, overcoming designers' limitations, and fostering designers' acceptance.

This series of studies included observations, interviews, and other data collection involving hundreds of designers over roughly 10 years. Overall, conclusions of these studies are presented in terms of typical design environments, common design challenges, and implications for design methods and tools. Later discussions of methods and tools illustrate direct benefits of the knowledge gained from these studies.

Two aspects of typical NPD environments are of particular note. First, are the pervasive and substantial impacts of market/business drivers on the technology/design envelope. Consequently, design issues, including HSI, are often highly influenced by the competition-determined, cost-sensitive business environment. The primary goals are to win the competition and make a profit rather than design a perfect product.

The second and related environmental factor is the inherent multiattribute, multi-stakeholder, time-pressured, information-rich problem solving and decision making.

Consequently, most design decisions are framed and made much too quickly to allow for model building and experimentation. There is little time to peruse archival information that might result in a better product.

Two design challenges are common. First is the need to understand high-impact uncertainties in terms of probability distributions of impacts and criteria for decision making. Expected values are not adequate when uncertainties are large. Design solutions need to function, and the investment needed to create such functionality needs to make sense—for plus and minus 2 to 3 sigma of the distributions of uncertain variables.

The second challenge concerns the difficulty of cross-disciplinary representation, manipulation, and (quasi-) optimization of problems, requirements, and solutions. Often, several of the multiple stakeholders in NPD involve the various disciplines contributing to creating design solutions. The abilities to seamlessly integrate the perspective of these different disciplines are often central to design success.

Considering design methods and tools, these studies indicated the importance of spiral discovery, prototyping, and evaluation processes versus traditional waterfall approaches. The practice of freezing requirements and then procuring solutions results in many immediately obsolete design solutions. Much more flexibility and adaptability are needed to consistently create competitive new products in the private sector.

A second methods and tools consideration relates to the need for targeted, specialized tools rather than monolithic approaches with, ideally, compatible representations and information flows across component tools. This conclusion recognizes the reality that there is not and will not be a "megamodel" that crosses all issues and disciplines, accessing all the world's data. Instead, frameworks that include a range of targeted tools are much more likely to be valued.

This brief tangent into HSI *of* NPD provides some philosophical underpinnings of the remainder of this chapter. Not only does HSI need to address abilities, limitations, and preferences of systems operators and maintainers; but, whatever prescriptions for HSI that we advocate have to be feasible for the humans that do HSI work, that is, designers. Thus, we should be "willing to take our own medicine."

24.1.3 Chapter Overview

The next section provides a fairly detailed comparison of private- and public-sector product/system development, primarily to explicate the significant differences between these sectors and the implications for how HSI issues are framed and addressed in NPD. This sets the stage for consideration of NPD management processes, both in terms of general multistage decision processes and more HSI-specific human-centered design. Methods and tools for supporting these processes are next discussed. Finally, best practices relative to product realization processes are summarized.

24.2 PRIVATE VERSUS PUBLIC DEVELOPMENT

The primary differences between product development in the private and public sectors are elaborated in Table 24.1. In this section, these differences are first elaborated and then an overarching explanation is offered for why these differences are manifested.

Both the private and public sectors are driven by customers' needs and desires, but the level of specificity relative to these needs and desires differs substantially. In the public

TABLE 24.1 Comparison of Private- and Public-Sector Product/System Development

Comparison	Private Sector	Public Sector
Driving force	Market needs and opportunities	Procurement plans and budgets
Competition	Continued new offerings and players	Little once production contract won
Customers	Many potential sales opportunities	Few potential sales opportunities
Customers' requirements	Typically researched and inferred	Publicly specified
Customers' budgets	Seldom openly available	Publicly available information
Production runs	Often very large	Usually relatively small
Product life cycles	Usually relatively short	Often very long
Risks	Usually borne by developer	Usually borne by customer
Rewards	Determined by marketplace	Controlled by customer
Sales of new offerings	Brand and relationship loyalty key	Usually competitively bid

sector, procurement plans and budgets are publicly available information[1]—customers' intentions are quite explicit, often many years in advance, although political factors can derail these plans. In the private sector, needs and opportunities must be inferred from buying patterns and possibly technology trends—customers' intentions may be only vaguely articulated and very open to change. Hence, the market uncertainties in the private sector are substantially greater than in the public sector.

It is, however, very important to recognize the possibility that well-documented and communicated requirements for public systems can nevertheless be ill-conceived. Such a starting point provides ample opportunities for cost overruns, schedule slippages, and much finger pointing. Ensuring that requirements are well-founded is important to successful HSI in all domains, whether private or public (Sage and Rouse, 1999).

Winning a public-sector contract to provide products and systems often assures a long stream of revenues, perhaps decades in the case of defense systems. In the private sector, new offerings and players emerge more frequently and customers may switch to these providers if the costs/benefits are better. Thus in the private sector, winning provides only temporary advantage. On the other hand, losing results is only a temporary disadvantage. Thus, overall private-sector market relationships are much more responsive to change than in the public sector.

There are usually only a few possible customers for public systems. If, for instance, the Federal Aviation Administration does not buy your air traffic control system, to whom else can you sell this system? As another example, if the U.S. military does not buy your defense system, there are unlikely to be many foreign military sales. In contrast, the private sector typically has many potential customers, ranging from 20 to 30 airlines that buy commercial aircraft to millions of people who buy automobiles and computers.

Public-sector customers' requirements are usually quite specific and publicly available. All potential providers compete to offer the most cost-effective way to meet these requirements. Private-sector vendors have to research and infer requirements, often because customers do not really know what they want—hence, market research such as described by Blattberg et al. (1994) is pursued. As a result, alternative solutions tend not to have the same functions and features. Eventual winning solutions may have significant competitive advantages due to proprietary functionality, performance characteristics, etc.

Budgetary information is publicly available for public-sector customers. Thus, providers know what spending is expected and when this spending is projected. Information on private-sector customers' budgets is seldom openly available. In fact, there may be no budget items in many areas. Sales of products in the private sector may, therefore, depend on arguing the costs/benefits of possible solutions and, in effect, creating needs that were not previously perceived.

Public-sector production runs tend to be relatively small, typically ranging from hundreds (e.g., aircraft) to thousands (e.g., small defense systems). In contrast, production runs of hundreds of thousands to millions are not uncommon in the private sector. This enables amortization of research and development (R&D) costs over many more units. It also results in significantly greater cost savings as providers move down production learning curves. Consequently, prices for private-sector products tend to decrease, often as quality also improves.

The product life cycles for public-sector products tend to be quite long, with many defense systems, for example, remaining in use for several decades. The private sector often experiences product life cycles as short as a few months to as long as a few years. The provider who gets to market first, and makes it down the production learning curve the fastest, tends to capture market share and realize the best margins. Of course, there is also the risk of getting to market too quickly, or getting there with the wrong sets of functions and features.

The risks associated with creation of public-sector products and systems are usually assumed by the customer—who often is the only customer. In the private sector, such risks are assumed by the developers of the product. If they are too early, too expensive, or off target in terms of functions and features, they must accept the consequences.

Those who accept risks often earn the greatest rewards. Thus, public-sector profit margins are often quite modest and explicitly controlled by customers. Private-sector profits are determined by the marketplace and are typically not visible to customers, at least not in terms of profit per unit. Of course, if this were not the case, then private-sector product developers would be unlikely to accept the inherent risks.

Sale of new offerings in the public sector usually involves an open competitive bid, despite superior past performance, service, etc. Brand and relationship loyalty provides much more advantage in the private sector, often resulting in sales of new offerings without competition. In fact, loyalty may be such that customers no longer even consider the possibility of alternative ways to meet their needs.

The impact of the differences summarized in Table 24.1 can be considered in the context of a typical product/system life-cycle model such as shown in Figure 24.1 (Patterson, 1999; Sage, 1995). New product development in the private sector involves much more early uncertainty and risk, particularly in terms of market and competitive factors rather than technology. Thus, more effort and time are invested in concept definition, requirements analysis, and conceptual design, partly because concepts and requirements must be evaluated to ensure likely market acceptance. If, for example, a product has major usability deficiencies, private-sector markets cannot be, in effect, forced to buy the product until these deficiencies are remedied.

Across the whole product life cycle, private-sector NPD usually involves many more hypotheses and tests, regularly trying to catch bad ideas quickly—"bad" meaning things that will not sell or may sell but lead to warranty or product liability problems.

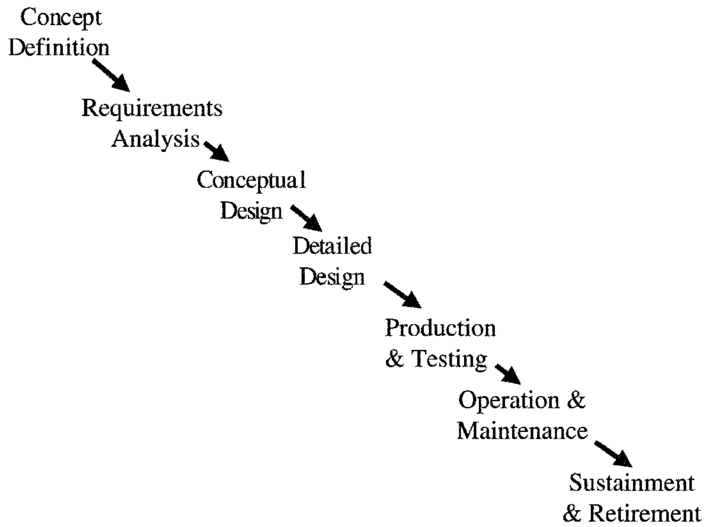

Figure 24.1 Elements of simplified product/system life cycle.

Consequently, there is much more reliance on "spiral" models of development (Boehm, 1988), rather than the "waterfall" model depicted in Figure 24.1. The requirements analysis, conceptual design, detailed design, and production and testing phases of the life cycle are repeated relatively quickly, each time learning and refining the product concept to improve the design and spiral toward a good design.

Best practices for public-sector system development do include evolutionary waterfall models and spiral models [Sage, 1995, 1999; U.S. Department of Defense (DoD), 1996], often discussed in terms of integrated product and process development (IPPD). Thus, public system developers are often well aware of many, and perhaps most, of NPD best practices. Unfortunately, complications of procurement processes, as well as political processes, can extend and distort life cycles in ways that undermine the benefits of these practices.

Faster development processes, as well as less customer control, result in private-sector products evolving much more quickly. This enables faster technology upgrades and insertion of new technologies. Lessons learned in operations and maintenance are quickly fed back to the evolution of new releases of the product or, more appropriately, the evolving product family. Consequently, private-sector products and systems are much more likely to include the latest, leading-edge technologies.

This blessing for private-sector customers comes with the curse—for developers—of greatly reduced sustainability of competitive advantage. Substantial revenues for spare parts and maintenance of decades-old products and systems are rare in the private sector. Competitive displacement of older technologies tends to be merciless in all but near-monopoly private-sector markets (e.g., commercial aviation). Thus, products usually cannot be viewed as "loss leaders" for downstream recurring revenues.

One very major exception to this assertion involves products where there are substantial ongoing service components. Automobile maintenance is a good example where innovations in products are, to a great extent, intended to attract and retain buyers who will avail themselves of the ongoing services for the products. Thus, in this case, the automobile dealer does not have to make very large margins on the initial product sale.

Summarizing the distinctions drawn in this section, private-sector NPD differs from public-sector product/system development in terms of uncertainties, risks, and rewards. Private sector NPD involves much greater uncertainty and many more risks. However, the *potential* rewards are much greater, due to both large unit volumes and much greater profits per unit.

These differences strongly affect how HSI issues are pursued. Human-related concerns—such as the possibility of creating products with wrong function/feature sets or products with major usability problems—receive substantial attention because the consequences to the developer are so substantial. On the other hand, concerns such as long-term health and safety considerations receive much less attention, mostly because they do not affect near-term sales but also due to discounting of long-term impacts in general.

To a great extent, differences in addressing HSI issues are determined by who suffers the consequences of being wrong. Public-sector product/system development projects are typically sold before development begins; thus, the sale does not depend on how HSI issues are addressed, although it may depend on having a plan for addressing these issues. In contrast, private-sector products/systems are sold after they are developed; customers who are not satisfied with how HSI concerns have been addressed can simply choose not to make purchases. In general, things get done when sales are dependent on them!

The differences summarized thus far are related to both the nature of products and systems created in the private and public sectors and to inherent dissimilarities between these sectors. Figure 24.2 suggests an overarching explanation for these differences. A large percentage of NPD in the private sector involves creating standard products (solutions) for a relatively homogeneous market (stakeholders) that only has scrutiny over the end product. In contrast, a large portion of systems developed in the public sector, for which HSI has received the most attention, involve tailored solutions for which there are a wide range of stakeholders—users, customers, employees, politicians, etc.—who

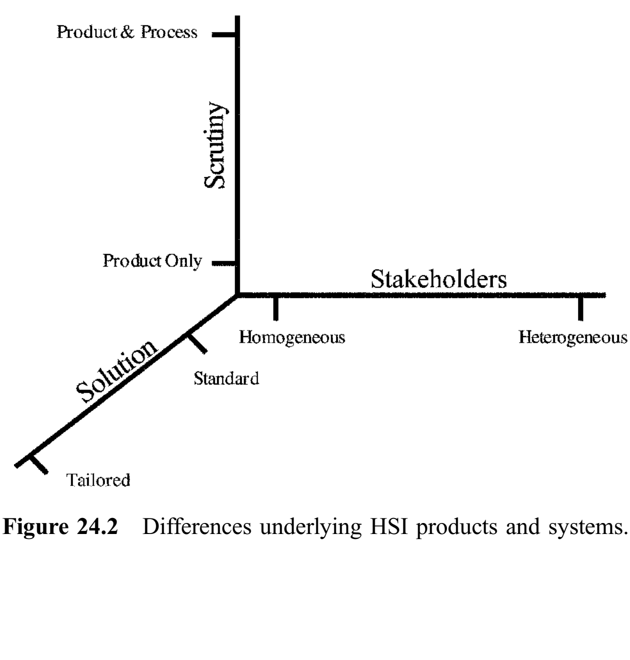

Figure 24.2 Differences underlying HSI products and systems.

have considerable scrutiny over both system characteristics and the process whereby the system is designed and developed.

As a consequence, many NPD best practices are difficult to implement in the public sector, despite the fact that practitioners are well aware of these practices. For example, it is often the case that the military end user (the warfighter) will dictate design decisions, including design changes that adversely affect budget and schedule. Congress may, for instance, preempt design changes that would adversely affect developers in favored congressional districts. And, of course, the whole federal procurement process can complicate and extend the acquisition process in ways in direct opposition to NPD best practices.

It is also useful to note that private-sector system development efforts involving tailored solutions for heterogeneous stakeholders who have considerable scrutiny of both product and process can encounter some, if not all, of the same difficulties encountered in the public sector. For example, Fryer (1999) reports that at least 90 percent of enterprise resource planning (ERP) projects end up late or over budget, often taking 6 to 7 years or more to realize positive returns. This tends to result in rather large "expectations gaps," often created by vendors of ERP systems. Thus, dissimilarities between the private and public sectors provide only a partial explanation of the differences summarized in Table 24.1.

24.3 PRODUCT MANAGEMENT PROCESSES

The uncertainties and risks associated with NPD in the private sector result in many more concepts being pursued than eventually make it to the marketplace. The ratio of initial ideas to market innovations through the product development "funnel" ranges from 3,000 : 1 (Stevens and Burley, 1997) to 10,000 : 1 (Nichols, 1994). Statistics for particular companies commonly reflect 200 to 300 funded projects for each product eventually introduced to the market.

24.3.1 Multi-Stage Decision Processes

Companies who manage this winnowing process with firm "go/no-go" decision points perform much better than those who are more ad hoc in their approach. Cooper (1998) has pioneered the formalization of multistage decision processes for making these decisions. An example of a multistage decision process is depicted in Figure 24.3.

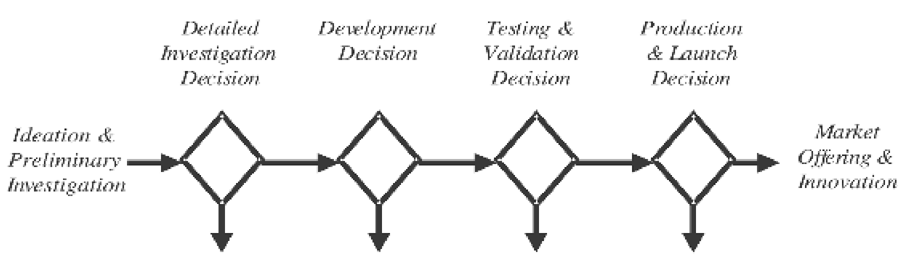

Figure 24.3 Typical multistage decision process for new product development.

At each stage, NPD projects must pass specified criteria to move on to the next stage. Not passing these criteria results in projects being killed, shelved, or possibly retained at the earlier stage. Of great importance, project managers know exactly what the criteria are for each stage long before having to satisfy these criteria.

Investment levels increase substantially with each stage, adding significant potential value to the concepts being pursued by projects. The stages are designed to eliminate projects where the value added downstream will not justify the costs. The criteria change with each stage, shifting emphasis from strategic relevance and technical feasibility to economic return and risk management. For attributes that are relevant across stages, "hurdle rates," or decision thresholds, increase with each stage.

Investments in all the projects in the funnel are managed as portfolios (Cooper et al., 1998–2000). Plots of returns versus risks are typically used to represent portfolios, where return might be represented as net present value (NPV) or net option value (NOV), and risk might be characterized as the probability that NPV or NOV falls below some criterion, for example, zero (Rouse, 2000b). A common goal is to create an "efficient" portfolio such that each project in the portfolio has the minimum risk for a given level of return or the maximum return for a given level of risk. However, other nonfinancial criteria, for example, "strategic criticality," may result in elements of portfolios that are inefficient from a purely financial perspective.

The nature of multistage decision making just depicted results in many more "failures" than experienced for public systems. The vast majority of all ideas do not make it to applications. However, these nonsuccesses are viewed as simply part of the process of bringing new products to market.

Put differently, NPD in the private sector is much less risk averse than in the public sector. Emphasis is on assessing and managing risks rather than eliminating them. Of course, the consequences of risks are spread across many companies. In the public sector, the government absorbs most risks and nonsuccesses can result in endless scrutiny. Further, companies who develop products and systems for the public sector face the risk that their one and only customer will no longer be able to justify an acquisition, resulting in substantial loss of revenue although seldom significant loss of capital.

24.3.2 Human-Centered Design

Human-centered design (HCD) is a multistaged process focused on HSI aspects of NPD (Rouse, 1991, 2000a). The HCD concept emerged from the recognition that product success usually depends on the support of a range of stakeholders beyond the users of the product, hence the phrase human-centered rather than user-centered design. Relative to commercial aircraft, this idea is captured by the expression, "Pilots may fly 'em, but they don't build 'em or buy 'em." Thus, designing an aircraft cockpit to ensure pilot (user) acceptance does not at all guarantee that the airlines will want to buy this aircraft, that the airframe manufacturers will want to produce it, or that the regulatory authorities will certify its use. Human-centered design is a process of ensuring that the concerns, values, and perceptions of all stakeholders in a design effort are considered and balanced.

Stakeholders and their roles in the success of a product or system often include:

- Users—use solutions
- Customers—buy solutions

- Technical—evaluate and possibly regulate solutions
- Providers—invest in creating solutions
- Suppliers—provide elements of solutions
- Maintainers—troubleshoot and repair solutions
- Distributors—sell and deliver solutions

Some of these stakeholders represent several other stakeholders. For example, providers include functional stakeholders such as marketing, sales, finance, engineering, manufacturing, etc.

An overarching principle of HCD concerns the need to delight primary stakeholders and gain the support of secondary stakeholders to have a successful product or system. This reflects the need to convince the user stakeholder to want the solution, the customer stakeholder to buy the solution, and so on. Within the private sector, customers cannot typically be forced to accept a solution by a procurement function. Thus, all stakeholders have to want the solution or at least not argue against its purchase.

The HCD approach provides a framework for pursuing this principle. The core of this framework involves a set of measurement issues that are progressively addressed within a four-phase process. In the remainder of this section, relevant portions of this overall framework are presented.

What do successful products and systems have in common? The fact that people buy and use them is certainly a common attribute. However, sales are not a very useful measure for designers[2]. In particular, using *lack* of sales as a way to uncover poor design choices is akin to using airplane crashes as a method of identifying design flaws; this method works, but the feedback provided is a bit late.

The question, therefore, is one of determining what can be measured early that is indicative of subsequent poor sales. In other words, what can be measured early to find out if the product or system is unlikely to fly? If this can be done early, it should be possible to change the characteristics of the product or system to avoid the predicted failure.

The overall HCD methodology involves seven classes of measures. However, only three of these classes are useful for differentiating private-sector and public-sector approaches to HSI: viability, acceptability, and validity. The other four classes of measures (i.e., testing, verification, demonstration, and evaluation) are similarly addressed in both domains, at least for those organizations that employ leading-edge design methods and tools.

Measures of viability, acceptability, and validity emphasize quite different issues than measures related to testing, verification, demonstration, and evaluation. In fact, viability, acceptability, and validity are the driving issues in HCD. Thus the *last* concern is, "Does it run?" The *first* concern is, "What matters?" or "What constitutes benefits and costs?" Viability, acceptability, and validity are defined as follows:

- *Viability* Are the benefits of system use sufficiently greater than the costs? While this question cannot be answered empirically prior to having a design, one can determine how the question is likely to be answered. How do stakeholders characterize benefits? Are they looking for speed, throughput, an easier job, or appealing surroundings? What influences their perceptions of these characteristics? How do stakeholders characterize costs? Is it simply purchase price or do costs include maintenance and perhaps training? Are all the costs monetary?

- *Acceptability* Do organizations/individuals use the system? This is also a question that cannot be answered definitively prior to having the results of design. However, one can determine in advance the factors that are likely to influence the answer. Most of these factors relate to the extent to which a product or system fits into an organization's philosophy, technology, work practices, etc. Also important can be the extent to which successful adoption of the product involves substantial organizational change.
- *Validity* Does the product or system solve the problem? This, of course, leads to the question, What is the problem? How would you know if the problem was solved or not solved? The answer depends on how stakeholders perceive their problems. Quite possibly, they perceive an effectiveness or efficiency shortfall rather than a need for a new product or system.

These three broad classes of measurement issues are addressed in HCD using an overall approach to measurement that balances the allocation of resources among the issues of concern at each stage of design. This approach integrates intermediate measurement results in a way that provides maximal benefit to the evolution of the design product. This is accomplished by embedding measurement in an NPD process involving the following four phases:

- *Naturalist Phase* This phase involves researching market needs, that is, understanding the domains and tasks of stakeholders from the perspective of individuals, the organization, and the environment. This understanding not only includes people's activities but also prevalent values and attitudes relative to productivity, technology, and change in general. Evaluative assessments of interest include identification of difficult and easy aspects of tasks, barriers to and potential avenues of improvement, and the relative leverage of the various stakeholders in the organization.
- *Marketing Phase* Once one understands the domain and tasks of current and potential stakeholders, as well as their needs and desires, one is in a position to conceptualize alternative products or systems to support these people. Product concepts can be used for evaluative market research in the sense of determining how users react to the concepts. Stakeholder's reactions are needed relative to validity, acceptability, and viability. In other words, one wants to determine whether or not people perceive a product concept as solving an important problem in an acceptable way and at a reasonable cost.
- *Engineering Phase* One is now in a position to begin trade-offs between desired conceptual functionality and technological reality. Most traditional research, development, test, and evaluation occur in this phase. Technology development will usually have been pursued prior to and in parallel with the naturalist and marketing phases. This will have at least partially ensured that the product concepts shown to stakeholders will be technologically and economically feasible. However, one now must be very specific about how desired functionality is to be provided, what performance is possible, and the time and dollars necessary to provide it.
- *Sales and Service Phase* As this phase begins, the product should have successfully been tested, verified, demonstrated, and evaluated. From a measurement point of view, the focus is now on validity, acceptability, and viability. It is also at this point that one ensures that implementation conditions are consistent with the assumptions under-

lying the design basis of the product or system. Also important is identification of new market opportunities. This information is compiled by sales people in the process of selling solutions and by service people in the process of providing ongoing support.

Table 24.2 illustrates typical measures of viability, acceptability, and validity and shows how these three classes of measurement issues should be organized or sequenced in the four phases. *Framing* an issue denotes the process of determining what an issue means within a particular context and defining the variables to be measured. *Planning* is concerned with devising a sequence of steps and schedule for making measurements. *Refining* involves using initial results to modify the plan or even rethink issues and variables. Finally, *completing* is the process of making outcome measurements and interpreting results. Elsewhere, I discuss a wide range of methods and tools for making the measurements associated with the four phases of HCD (Rouse, 1991, 2000a).

It is useful to note the philosophical compatibility of HCD as outlined here with the aforementioned integrated product and process development (Sage 1995, 1999; DoD, 1996), although IPPD tends to be most focused on the engineering phase of HCD. In general, HCD emphasizes very early, upstream involvement, where HSI problems are best avoided and continual, downstream involvement where problems can be remedied and new opportunities identified.

Table 24.2 provides a useful context in which to discuss typical measurement problems. There are two classes of problems of interest. The first class is *planning too late* where, for example, failure to plan for assessing acceptability issues can preclude measurement prior to putting a product into use. The second class of problems is *executing too early* where, for instance, product demonstrations are performed prior to resolving validity issues and potentially lead to negative initial impressions of a product or system—such impressions can later be difficult to change.

It is important to note the role of technology in the HCD process. As depicted in Figure 24.4, technology is pursued in parallel with the four phases of the design process. In fact, technology feasibility, development, and refinement often consume the greatest share of the resources in a product or system design effort. However, technology should not drive the design process. The HCD objectives should drive the process, and technology should support these objectives.

The HCD process was formulated to avoid HSI failures. In private sector NPD, such failures can lead to lack of product sales, substantial recall/warranty costs, and possible lawsuits. Meeting requirements may be a sufficient condition for technical success but is by no means sufficient for market success. The success of NPD in the marketplace depends on competitively enhancing human abilities, overcoming human limitations, and fostering human acceptance. The HCD approach provides a systematic means for achieving these ends.

24.4 METHODS AND TOOLS

Design philosophies and frameworks are often adopted and utilized to the extent that methods and tools are available to support their use. This section outlines a variety of methods and tools commonly employed for NPD in the private sector. Also described are methods and tools specifically created to support HCD.

TABLE 24.2 Measures vs. Phases in Human-Centered Design

Attributes		Phase			
		Naturalist	Marketing	Engineering	Sales and Service
Viability	Benefits	Frame	Plan	Refine	Complete
	Performance improvements	Frame	Plan	Refine	Complete
	Quality improvements	Frame	Plan	Refine	Complete
	Etc.	Frame	Plan	Refine	Complete
	Costs	Frame	Plan	Refine	Complete
	Acquisition costs	Frame	Plan	Refine	Complete
	Operating costs	Frame	Plan	Refine	Complete
	Etc.	Frame	Plan	Refine	Complete
Acceptability	Matches operating philosophy	Frame	Plan	Refine	Complete
	Compatible with existing infrastructure	Frame	Plan	Refine	Complete
	Consistent with training practices	Frame	Plan	Refine	Complete
	Etc.	Frame	Plan	Refine	Complete
Validity	Meets technical specifications		Frame/plan	Refine/complete	
	Complies with relevant standards		Frame/plan	Refine/complete	
	Passes usability evaluation		Frame/plan	Refine/complete	
	Etc.		Frame/plan	Refine/complete	

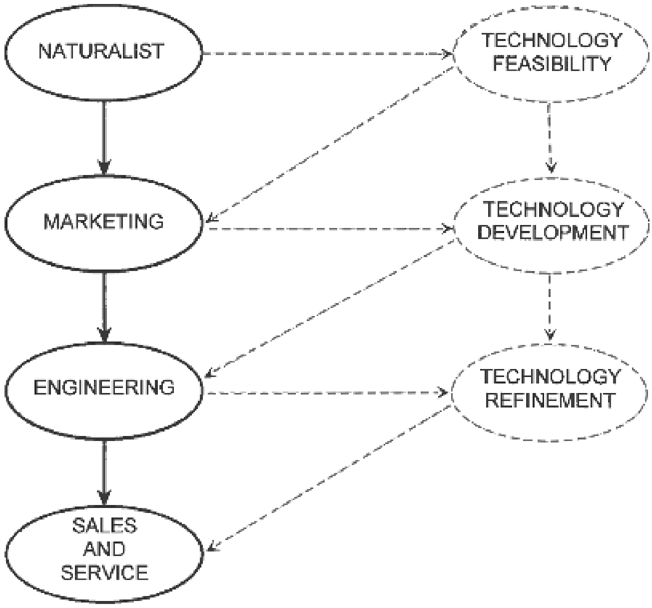

Figure 24.4 Role of technology in human-centered design.

24.4.1 Market Research

It should be apparent from the foregoing discussion that the private sector has to make much greater investments than the public sector in researching market needs, customer preferences, and possible product requirements. Private-sector markets do not publish their requirements. Indeed, these markets often do not know what they want until they see it.

There is a wide variety of methods and tools for market research, ranging from secondary sources such as newspapers, magazines, and the Internet, to information gathering via questionnaires, interviews, and prototyping (Rouse, 1991, 2000a). The various alternatives have advantages and disadvantages depending on the phase or stage of the product realization life cycle.

Many companies have in recent years created or purchased databases of customer characteristics and purchasing behaviors. They mine and model this data to form and test hypotheses regarding preferences and responses to, for example, alternative marketing programs (Blattberg et al., 1994). Gensch and colleagues (1990) discuss development of such models and present data that show the financial returns from making NPD decisions with the support of such models.

24.4.2 Product Lines and Platforms

Market research is used to drive choices of product functions and features that are likely to provide compelling value propositions to the stakeholders (Rouse, 2000b). Increasingly, such decisions concern product families rather than just "point" solutions. Thus, NPD involves systematic thinking about product lines (Brownsword and Clements, 1996), product platforms (Robertson and Ulrich, 1998), evolutionary architectures (Rouse, 1991), and the modularity needed to enable these families of products (Baldwin and Clark, 1997). This has been a common practice in the automobile industry for many decades. However, it is being extended to products such as software (Brownsword and Clements, 1996) and computers (Baldwin and Clark, 1997).

24.4.3 Product Evaluation

Despite extensive market research, it is still quite possible to create products that people find difficult to use. Many companies employ formal usability evaluation processes to minimize chances of significant difficulties (Henneman, 1999). Such evaluations are motivated by risks of difficult-to-use products not selling in the private sector and possible safety problems in both the private and public sectors.

Product evaluation usually continues after introduction to the marketplace and during ongoing sales and service. Such evaluative efforts typically focus on rapid remediation of problems and responses to competitive threats and opportunities. Of course, follow-up of products and systems in use is common in both private and public sectors. The difference in the private sector, however, is the speed with which opportunities can be converted to business advantages and profitable outcomes.

24.4.4 NPD Project Evaluation

An important contributor to NPD success is the nature of the design and development process. Best practices in this area are reviewed later in this chapter. Relative to methods and tools, it is nevertheless useful to mention at this point NewProd, an NPD project benchmarking tool [Cooper, 1985; Product Development Institute (PDI), 2000]. This software tool is used to evaluate proposals for new product initiatives. Several 0–1 scales are used to characterize NPD projects. These ratings are combined to create an overall score that is compared to the scores of roughly 200 actual, historical NPD projects to predict probability of success.

The obvious limitations of this tool include the idiosyncrasies of historical linkages and the focus on a single attribute—probability of success. A finer-grained characterization can be needed to diagnose and remediate project deficiencies. Later discussion considers other types of project attributes.

24.4.5 Decision Support Tools

There is a variety of decision support and project management tools available to support NPD (Rouse, 2000b). Most of these tools are quite general in nature, aimed at providing support in a wide range of decision-making situations or managing projects in general. As such, the advice and online help provided are not premised on particular types of decisions being addressed.

The Product Planning Advisor (PPA) was specifically developed to support HCD as outlined earlier [Enterprise Support Systems (ESS), 2000a].[3] This tool helps in developing and manipulating models of the form depicted in Figure 24.5. The purpose of such models is identification of products and systems that delight primary stakeholders and ensure the support of secondary stakeholders, while also assuring competitive advantages for those who invest in creating these products and systems.

The portion of Figure 24.5 labeled "What the Market Wants" relates to characterizations of stakeholders and their issues and concerns in terms of attributes related to viability,

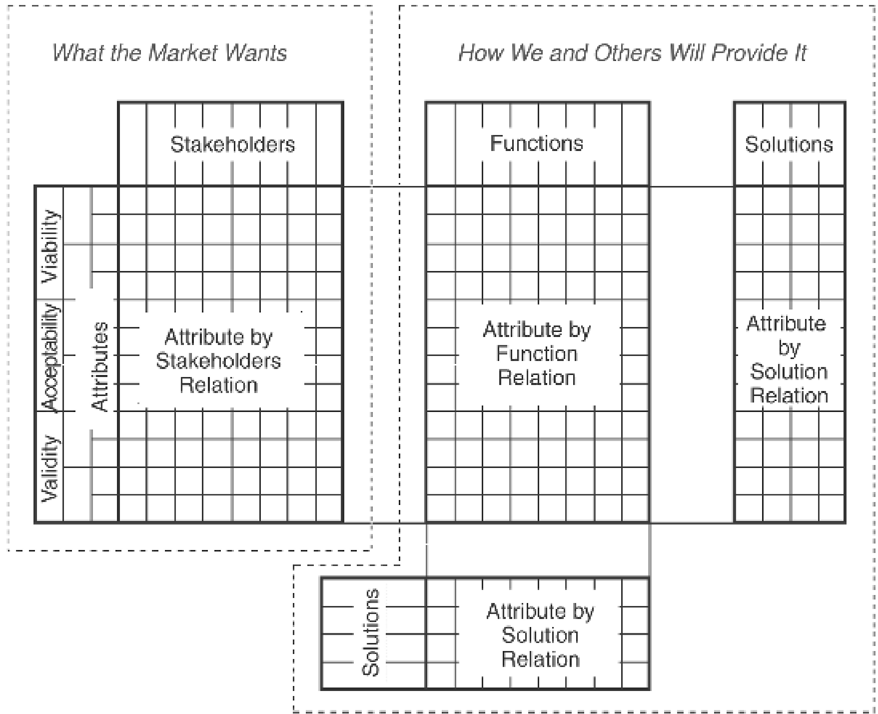

Figure 24.5 Multistakeholder, multiattribute product planning framework.

acceptability, and validity. The cells of this matrix include stakeholders' utility functions that map attributes to relative preferences. Each cell relates to one stakeholder and one attribute.

The portion labeled "How We and Others Will Provide It" includes characterizations of product and system functionality as they relate to attributes of interest to stakeholders. The elements of the functions versus attributes matrix include ratings of the strength of relationships—either positive or negative—between functions and attributes. This representation is similar to quality function deployment (Hauser and Clausing, 1988), albeit much simplified. This enables providing users of PPA with product improvement advice in terms of functional improvements most likely to support achieving relative competitive advantage.

Solutions are "composed" of collections of functions, as indicated in the lower matrix in Figure 24.5. This often includes both solutions provided—or being entertained—by users of PPA and solutions provided or potentially provided by competitors. This enables competitive analyses and positioning of potential market offerings relative to competitors, possibly with different competitors in different market segments.

The right-most matrix in Figure 24.5 represents solutions versus attributes. The cells of this matrix include the attribute values for each solution. These values may be based on empirical measurements, market requirements, or stakeholder perceptions. In the latter case, multiple attributes may be needed to characterize differences among different stakeholders' perceptions of particular variables.

Summarizing, the overall characterization in Figure 24.5 involves an object-oriented model—in terms of the underlying software—of the multistakeholder, multiattribute nature of how multifunction solutions compete for stakeholders' perceptions of value and, hopefully, influence their subsequent purchase decisions. The PPA helps to both create such models and manipulate these models to determine the most competitive market offerings.

The representation summarized in Figure 24.5 underlies the PPA shown in Figure 24.6. Use of this tool begins with defining goals of the NPD effort, which usually includes both market and organizational goals. The second through fourth steps, as well as associated substeps, involve defining the rows and columns of the matrices depicted in Figure 24.5.

The fifth step, "Assess Solutions," enables using the underlying models to calculate the expected utility of the alternative solutions, for each or all solutions, attributes, and stakeholders. A "How to Improve?" feature within this step performs sensitivity analyses relative to each attribute, rank orders attributes by impact on overall utility, and provides guidance on the functions needing attention to achieve improvements. A "What If?" feature enables assessing the impacts of particular combinations of attribute values, stakeholder preferences, and relative stakeholder importance.

Typical use of PPA involves initial representation of one or two stakeholders, attributes, etc., and subsequent "growing" of representations via insights gained from sensitivity and "What If?" analyses. This approach is much more useful than attempting to "complete" a model before performing analyses, which tends to result in overly complex models from which intuitions can be difficult to glean.

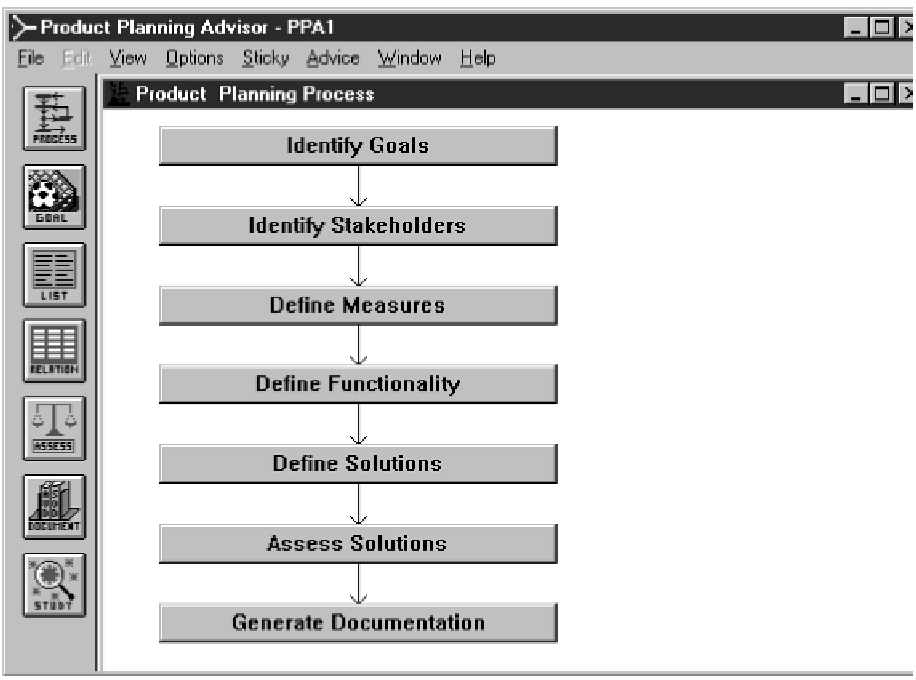

Figure 24.6 Product planning advisor (ESS, 2000a).

The following examples of how PPA has been used illustrate the ways in which this tool is applied and the types of insights that are gained. In particular, these examples depict trade-offs across stakeholders and how the impacts of assumptions can be explored. It is important to note that while these three examples show how NPD teams reached counterintuitive conclusions, use of PPA does not always result in such conclusions.

Digital Signal Processor Members of the NPD team began this effort convinced that they already knew the best function/feature set with which to delight the market. The marketing manager, however, insisted that they test their intuitions using PPA. After developing the models in Figure 24.5 and using them for competitive analyses, the team concluded that assumptions regarding stakeholders' preferences for three particular attributes, as well as the values of these attributes, were critical to the original intuitions being correct. Attempts to support these assumptions by talking with stakeholders, especially end users and customers, resulted in the conclusions that all three assumptions were unsupportable. The team subsequently pursued a different product concept.

Automobile Engine A team working on new emission control systems decided to evaluate an earlier technology investment using PPA. The team members compared the chosen approach to four other candidates that had been rejected with the earlier decision. Development and use of the models shown in Figure 24.5 resulted in the conclusion that the chosen approach was the worst among the five original candidates. This surprising conclusion led to an in-depth exploration of the assumptions built into their PPA models. This exploration resulted in further support for these assumptions. Reviewing these results, the team leader realized that the earlier decision had not fully considered the impact of the alternatives on the manufacturing stakeholder. The earlier choice had been of high utility to customers and other stakeholders but very complex to manufacture. As a result of this insight, a new approach was adopted.

Medical Imaging System An NPD team had developed an advanced concept for medical imaging that members argued would enable their company to enter a very crowded market, where a couple of brand name companies currently dominated. They used PPA to assess the market advantages of their concept relative to the offerings of the market leaders. Initial results showed a considerably greater market utility for their potential offering. Attention then shifted to the likely reactions of the market leaders to the introduction of this advanced product. The team's expectation was that the leaders would have to invest in 2 years of R&D to catch up with the new technology embodied in their offering. However, using the "How to Improve?" feature for PPA models of the competitors' offerings resulted in the conclusion that the best strategy for the market leaders was to reduce prices significantly. The team had not anticipated this possibility—someone said, "That's not fair!" This caused the team to reconsider the firmness of its revenue projections, in terms of both number of units sold and price per unit.

These three examples serve to illustrate types of human-related issues in NPD. The first example depicted the impact of unsupportable assumptions regarding the preferences of primary stakeholders. The next example showed how the concerns of a secondary stakeholder could affect the attractiveness of a solution. The last example demonstrated how the likely reactions of competitors impact the possible market advantages of a product or system. Taken together, these three examples clearly illustrate how a human-centered orientation helps to avoid creating solutions that some stakeholders may want but other stakeholders will not buy.

24.4.6 Summary

This section has discussed selected methods and tools for NPD in the private sector. These methods and tools are also applicable in the public sector. However, due to the differences between these domains, as summarized in Table 24.1, these methods and tools are much more important elements of risk reduction for private-sector NPD. In particular, when the risks of product failure fall completely on developers, there is strong motivation to employ methods and tools that will help in gaining understanding of these risks and evaluate alternative approaches to managing risks.

24.5 BEST PRACTICES

Thus far, several NPD methods and tools have been discussed that are judged by many as best practices. Multistage decision processes are pervasive among new product developers, and spiral development processes are also quite common. The HCD concept exploits these concepts for HSI-intensive design contexts.

Market research, often involving compilation of extensive databases, is also key to NPD. The notion of product lines and platforms enabling evolutionary product families is also common, as are formal product evaluation processes. Evaluation of NPD projects is often framed by the particular nature of the multistage decision process employed.

The PPA represents an instance of a structured decision framing and decision-making process. Many research studies have shown that such structured processes tend to result in well-informed decisions with better outcomes (Rouse, 2000b). It is important to emphasize, however, that such tools are best used to guide decision making, *not* dictate decisions.

Beyond these practices, there has been a wealth of studies of the utility of alternative new product realization processes, as well as various characteristics of these processes (Balachandra and Friar, 1999; Cooper, 1999; Rosenau, 1996; Rouse, 2000b, Rouse and Boff, 1998b). The foci of these studies generally fall in categories of project characteristics, project management practices, organizational characteristics, and individual characteristics. The remainder of this section provides a brief review of the highlights of the findings of these many studies.

24.5.1 Project Characteristics

Not surprisingly, the nature of a NPD project influences its likely success (Rouse and Boff, 1998b). For example, Tatikonda and Rosenthal (2000) investigated the impacts on project success of technology novelty and project complexity. They found that technology novelty is strongly associated with poor unit cost and time-to-market results, and project complexity is strongly associated with poor unit cost outcomes. They also found that novel process technology presents more problems than novel product technology. With regard to project complexity, they found that the newness of project objectives is more problematic than other aspects of project complexity.

The implications of these findings need to include uncertainties of costs and time to market in financial valuations of novel and/or complex projects (ESS, 2000b; Rouse et al., 2000). These uncertainties might be included in Monte Carlo analyses focused on the probability distributions for projected returns. Risks could then be quantified in terms of, for instance, probability that net values are less than zero. Projects could then be compared in return versus risk portfolio plots.

A wide variety of other project characteristics have been the focus of numerous studies. Recent analyses of this wealth of studies have summarized the impacts of company characteristics, management practices, market characteristics, motivation/incentives, product/project characteristics, team skills/abilities, organizational structure, technologies involved, and time issues on various measures of NPD technical and/or market success (Rouse and Boff, 1998b; Rouse et al., 1998). This immense literature is quite rich, although it tends to rely heavily on subjective perceptions assessed via questionnaires and interviews. Nevertheless, the availability of such data for private-sector NPD efforts far exceeds that available for public-sector endeavors.

24.5.2 Project Management Practices

Beyond the inherent nature of NPD undertakings, project management practices can also impact likely success. Lester (1998) summarizes several practices found to be valuable for project management:

- Cross-functional teams are ideally suited for NPD assignments.
- NPD organizations should be focused on adding value to the efforts of NPD teams by helping, supporting, and guiding.
- The NPD process should provide strategy and fundamental operational guidelines.
- Teams and organizations are more effective if they share a common understanding of the NPD process.

Thus, to the extent that NPD projects are dominated by one or two disciplines, do not have clear strategic guidance and objectives, and do not employ commonly understood processes, the likely success of these projects may be compromised.

Regarding teams, McDonough (2000) reports the results of a survey of NPD professionals asking them about success factors in NPD. Almost all respondents employ cross-functional teams, with a primary motivation of improving time to market. Establishing clear, unchanging goals, team leadership, and cooperation were most frequently mentioned as the factors influencing team success. Thus, the mere presence of teams, without other factors being addressed appropriately, does not ensure success.

Jassawalla and Sashittal (2000) provide another view of NPD teams, particularly team leaders. Summarizing the literature on leadership of NPD teams, they conclude that effective team leaders should:

- Clearly communicate the organization's expectations.
- Foster high levels of communication.
- Create a climate that raises morale and energizes the team.
- Take responsibility for the team's goals.

- Guide and share burdens.
- Interface with key external constituents.
- Enjoy high levels of autonomy and support from superiors.
- Involve all functional groups from the initiating stages.
- Balance both technical and human interaction issues.
- Reduce destructive conflict.

Based on interviews of 40 managers in 10 high-tech companies, Jassawalla and Sashittal (2000) suggest that carefully selected team leaders endowed with high levels of autonomy be likely to:

- Ensure commitment.
- Build transparency.
- Function as facilitators.
- Strengthen human relations.
- Foster learning.

Lynn and colleagues (1998) discuss NPD teams and learning. They provide several suggestions for what teams can do to learn more. First, do not expect to get it right the first time, and do not fire the scouts who are exploring new territory. It is important to embrace new information and build on it. Finally, teams should be structured to learn. This involves both refining current ways of doing things and determining new procedures.

Tabrizi and Walleigh (1997) discuss three sets of practices that distinguish companies that are able to successfully launch next-generation products—gleaned from examination of 28 next-generation product projects at 14 leading high-tech companies. They conclude that practices surrounding product strategy are very important, including creating a clear map of the company's product stream for the next 2 years and using it to manage all aspects of the company's development activities, generating a seamless product strategy; that is, one that leaves no holes for competitors to exploit, and collecting, interpreting, and assimilating good information about the market.

With regard to project organization, Tabrizi and Walleigh (1997) emphasize being willing to turn the development of new-platform products over to business units created solely for that purpose, knowing how to choose the optimum number of NPD team members—with the right mix of skills—for product definition over the course of the product development process, and matching other product development resources—such as shifting workloads of engineers and marketers—to the cyclical demands of the process. When executing during the definition stage, they suggest tracking progress and sustaining urgency, developing early prototypes, and using development partnerships.

The representative set of studies discussed here make it quite clear that project management practices are central to success. The nature of NPD teams, how they are guided, and how progress is measured are central issues.

24.5.3 Organizational Characteristics

Organizational characteristics beyond the nature of the NPD effort and project management practices can also impact likely success. For instance, Englund and Graham (1999) provide a compilation of good practices for top management. They assert that a successful top manager exhibits the following:

- Knows that projects without strategic emphasis often end in failure
- Develops an upper management team to oversee project selection
- Focuses on the goals of what an organization should do before limiting choices by considering only what the organization is capable of doing
- Works to develop a system of projects and links them to organizational strategy
- Guides the development of consistent criteria that are used to prioritize projects
- Selects projects based on comparative priority ranking contributions to strategy
- Reduces the total number of projects to minimize possible disruption
- Knows that a system of projects utilizes a common resource pool and that the pool may be abused without cooperation across the organization
- Develops a system to manage the resource pool and reward interdepartmental cooperation
- Allows unallocated capacity in a resource pool for emergencies and creativity
- Believes in the power generated by a learning organization
- Creates a model for linking projects to strategy and supports it with authenticity and integrity (p.64)

There can be significant interactions across the categories of variables discussed here. Swink's (2000) recently reported study provides a good illustration. This report presents the results of a survey of NPD projects across most manufacturing industries. Questions were focused on impacts of design integration (i.e., coordination of product and process design activities) and top management support of NPD projects. Design integration was found to be positively associated with higher design quality but not better financial performance. Design integration was also found to be a factor in achieving NPD time goals but only for projects with high technological innovation and/or high levels of uncertainty. Top management support was generally associated with better time-based performance, design quality, and financial performance. However, high levels of top management support were found to be ineffective in securing good financial performance with high levels of technological innovativeness. It is suggested that this might be attributed to managers' likely greater understanding of incremental versus disruptive innovation.

24.5.4 Individual Characteristics

The characteristics of NPD team members also impact projects. Perhaps no other aspect of such characteristics has been explored more than the role of champions. Markham and Griffin's (1998) study of almost 400 firms found the impact of champion support for projects tends to be indirect through program success, innovation strategy, process implementation, and program success. While champions significantly improve project performance, it is difficult to demonstrate any measurable overall effects at the company level, although positive effects are manifested through the just-mentioned mediating variables.

Another oft-discussed individual characteristic is entrepreneurship. Roberts (1991) studied high-tech entrepreneurs in several hundred companies over a 25-year period. Of particular interest are his conclusions regarding why entrepreneurs often encounter difficulty attracting investors to their NPD visions. Plans that inadequately reflect market issues and support for financial assumptions are typical shortfalls of NPD plans. Best practice approaches to NPD avoid such flaws.

Bhide (1996) notes that entrepreneurs' great ideas often do not lead to great performance. In discussing entrepreneurs' abilities to deal with people issues, he concluded that:

> When entrepreneurs neglect to articulate organizational norms and instead hire employees mainly for their technical skills and credentials, their organizations develop a culture by chance rather than by design. The personalities and values of the first wave of employees shape a culture that may not serve the founders' goals and strategies. Once a culture is established, it is difficult to change. (p. 129)

The roles of individual knowledge and skills in NPD have also received considerable attention. Mascitelli (2000) argues for taking advantage of the creative power of tacit knowledge to foster breakthrough innovations, defined in terms of creative and original market offerings. He suggests that breakthrough innovators, who are often highly capable generalists, tend to "see" solutions without the conscious ability to explain their visions. Their knowledge is, therefore, very difficult to codify and share—in other words, this knowledge is tacit. His suggested mechanisms for harnessing this tacit knowledge include:

- Engendering deep personal commitments—tacit knowledge flows from the pull of emotional commitment and deep personal involvement
- Using prototypes as catalysts for breakthrough thinking—enables a physically active approach to learning and experimentation
- Sharing tacit knowledge face-to-face—sharing relies more on showing than telling

The obvious implication is that managers need to support the development and maintenance of these mechanisms.

Thus championship, entrepreneurship, and knowledge and skills are individual characteristics that play important roles in NPD efforts. These characteristics can be both great strengths and substantial weaknesses, especially if the problematic aspects are not anticipated.

These findings for private-sector NPD are quite consistent with those of a much more modest study of determinants of success of public-sector R&D projects (Rouse and Boff, 1994). Senior managers from several military R&D organizations were asked to explain factors that differentiated past project successes from failures. The one factor upon which all interviewees agreed was the association of project success with the efforts of champions who displayed strong entrepreneurial orientations. It was often noted that the commitments of champions of successful projects approached irrationality in light of the organizational hurdles that had to be addressed and lack of monetary incentives and rewards for success.

24.5.5 Summary

It is beyond the scope of this chapter to provide a complete review of the wealth of studies of the types of factors and variables just discussed. Sources such as those noted earlier—

Balachandra and Friar (1999), Cooper (1999), Rosenau (1996), Rouse and Boff (1998b), and Rouse (2000b)—provide, collectively, a thorough review. In fact, the breadth and depth of this work are sufficient to warrant creation of "knowledge maps" of relationships among primary variables and the secondary variables that affect these relationships (Rouse et al., 1998).

It is useful to consider how the best practices outlined in this section might differ for private and public sectors. This immediately raises the question of the types of outcomes the best practices are intended to influence. In general, technical success and market success are the outcomes sought when attempting to identify potential best practices for private-sector NPD. This search for best practices involves finding those practices associated with the highest degrees of technical and market success.

Technical success in the private and public sectors is likely to be much more similar than is market success. Put in terms of HCD issues, validity is much more likely to be similar in two domains than are acceptability and viability. Thus, those private-sector best practices associated with maximizing technical success are likely to also be applicable in the public sector. In contrast, practices aimed at maximizing market success may not transition well, or even meaningfully, from private to public sectors.

In terms of HSI issues, the key distinction is between design practices that are indirectly regulated by market forces versus practices that are directly regulated by government dictates. In the former, HSI shortfalls are absorbed by the developer in terms of lost sales, warranty costs, etc. In the latter, HSI shortfalls are borne by the customers, often because they failed to specify or regulate some requirement or process.

24.6 CONCLUSIONS

This chapter has considered HSI issues in the context of private-sector NPD efforts where market considerations and profit motives drive design decisions. The characteristics of private versus public-sector product and system development were contrasted.

Product management practices were discussed in terms of multistage decision processes and HCD. Methods and tools considered included those for market research, product lines and platforms, product evaluation, NPD project evaluation, and product planning. Results of empirical assessments of best practices were summarized in terms of characteristics of projects, project management, organizations, and individuals.

Overall, competitive pressures, as well as providers having to absorb most risks, result in private-sector NPD being very sensitive to HSI issues. The possibilities of products not selling, having to be recalled, and leading to legal suits provide strong motivations for paying attention to and resolving HSI issues. On the other hand, for new, innovative products and services, the marketplace is often quite forgiving with regard to HSI limitations.

To the extent that public-sector products and systems are similar to private-sector offerings, one may be able to rely on similar competitive forces to ensure responsiveness to HSI issues. On the other hand, for public systems procurements that are sufficiently unique to require significant deviations from off-the-shelf, private-sector solutions, HSI compliance may have to be a regulatory requirement.

Overall, the issues in private- and public-sector NPD are quite similar. However, the motivations for pursuing and resolving these issues tend to be rather different. The HCD concept applies equally well in both domains, but the nature of the stakeholders—beyond users—is very different. Consequently, common practices tend to differ significantly, although one could quite reasonably argue for similar best practices.

NOTES

1. An obvious exception to this generalization concerns systems associated with national security where a "need to know" may be necessary to gain access to information. Those involved with proposing solutions inherently have this need.
2. One can clearly learn from baselines of previously successful products, especially if they are similar to the product currently being developed. However, the concern here is with assessing likely success as product development proceeds.
3. The author openly acknowledges a principal role in development of this software tool and an ongoing role in its application and sales.

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