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Cross-Functional Design Teams

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THE TERM *TEAMS* is used heavily in industry today, often with little more than a hope behind it. However, as companies strive for greater productivity and responsiveness to market changes, effective teams often play a central role in initiating organizational change. Such real teams may occur in any part of the business, but this article focuses on the particular issues arising in using teams in the product design process.

The most effective design teams generally involve a clearly delineated group of individuals who work full time on the specified project from its beginning until market introduction. The team comprises not only research and development professionals but also manufacturing and marketing members, and often members from quality, finance, or field service. These teams cut across traditional organizational boundaries, thus changing traditional reporting and decision-making relationships. Team members often report to the team leader for the duration of the project and are physically located together (co-located). Although these characteristics can increase productivity and responsiveness greatly, each also represents a major challenge in organizational change for most companies.

Specifically, such team characteristics encourage the use of generalists as team members, thus creating challenges in incorporating specialists, such as materials engineers or scientists. This article provides special coverage on alternative roles for such specialists whose expertise is essential to the success of the project but whose involvement with the team may violate some of the above characteristics.

Background: The Changing Role of Product Design and Development in Industry

Most manufacturing companies today are under heavy pressure to succeed, even to survive. Service industries have taken a dominant role in commerce, much manufacturing has moved offshore, and many manufactured goods, especially materials, have become commodities. In addition, environmental and product liability issues complicate manufacturing operations. All of this is occurring with a rising tempo, as evidenced by market shifts and other external demands that occur ever more frequently.

The Growing Importance of New Products. Senior managers often see new products as the key to coping with this chaotic environment. New products promise higher profit margins, opportunities to avoid commodity product status by creating market niches and added value, and an avenue for revitalizing the corporate image. New products are no longer just something done in research and development but have become central to the plans of the corporation. Many business leaders go beyond this by deciding to use new product development as the keystone in a broader plan of fundamental improvements in how their companies operate.

An Emphasis on Productivity and Responsiveness. Two thrusts come from these management desires:

- A requirement for consistently successful new products in a less predictable environment
- A requirement to obtain these products ever more quickly while using fewer financial and human resources

Design, or more broadly, development, teams have an effect on the product success requirement, but increasingly they are being considered essential to achieving productivity and time-to-market goals. This optimism regarding teams is well founded: many stories have appeared in trade and business magazines and research journals describing how cross-functional teams have brought new products to market far more quickly and inexpensively than more traditional organizational approaches to product development

As discussed in a later section, a team is not the answer to every development project, but teams have demonstrated their power to improve development effectiveness dramatically. This article covers the characteristics of such teams, how to staff and organize them, and the critical role of specialists, such as materials specialists, in working with such teams.

Types of Teams

Team is a heavily used and abused term in the workplace today. Any identifiable group of workers is generally labeled a team, and teams form in the sales, accounting, and research departments and from the factory floor to the executive suite. Seldom does calling a group a team change the way in which work gets done.

Effective teams can exist anywhere in the organization, but teams that deliver superior performance exhibit certain characteristics (Ref 1):

- A small (fewer than ten), well-defined group with complementary skills
- A meaningful purpose, specific goals, and agreement on concrete operating principles for reaching the goals
- Mutual accountability for results and joint ownership of work products

Teams and Meetings. Katzenbach and Smith (Ref I) distinguish teams that make or do things from those that recommend things or ones that run or manage things. Product development teams are of the type that do things, and it is essential to recognize that the doing gets done mostly between team meetings. Development team meetings are to assess what got done, solve problems, and set plans for doing the next work. Although meetings are an essential tool of teams, if the team equates itself with meetings and depends on meetings to get work done, progress will be slow. In effective teams, meetings tend to be highly spontaneous and largely transparent. These teams demand far more of their members than just participating in scheduled meetings.

Special Characteristics of Cross-Functional Development Teams. Three traits of product development make development teams particularly challenging ones to set up and manage: (a) most of those involved are professional knowledge workers; (b) a broad range of professional skills is needed, including engineering, science, marketing, manufacturing, and finance; and (c) innovation is an uncertain activity. Although some exceptions exist (Ref 1,2), most of the team literature treats simpler situations, such as assembly plant operations or mortgage application processing. Consequently, the literature is of limited use here; this article relies more on tools that the author and his colleagues have seen work well in other product development settings.

One insight from this experience in helping clients set up development teams is that the organizations doing best at it are those that have already tried other kinds of teams. They simply have a greater appreciation for the difficulties involved and the training required.

Staffing a Development Team

Much like a cooking recipe, this "recipe" first lists the ingredients (the staffing issues) and then moves on to directions for combining them (the organizational issues).

The Team Leader. Choosing a team leader is the most important decision management will make in setting up a development team. Two criteria should guide the choice. One is that, because product development amounts to an obstacle course, the leader must be strong enough to figure out how to overcome the obstacles and work the existing system. The second is that the leader must operate from a business perspective, not a particular functional perspective, such as engineering or marketing.

If the team leader cannot deal effectively with the obstacles, then management must step in, which destroys the team's value and morale. Similarly, if the leader operates from a particular functional perspective, other functional managers will step in to ensure the participation of their function, again undermining the team's integrity. Neither of these situations provides the high-quality problem-solving and decision-making infrastructure desired.

In addition, a leader should have a strong, customer-centered vision of the product and sense of project direction. This is crucial in providing the leader with a touchstone for making the countless daily decisions that can deflect the team from its course. Leadership, then, is the ability to transform this vision into action.

Clearly, another essential requirement is a leader with excellent people skills, including communication (listening and providing ongoing performance feedback), conflict management, and the ability to influence others throughout the organization. A key part of people skills is giving credit and exposure to team members, rather than the leader accepting it.

From Which Department? For highly technical products, it is natural to choose a technical person as team leader. It seems that only a technical person will understand the design adequately. Others, with a longer view, might argue that only a marketer could provide the customer-focused guidance needed for marketplace success. Similarly, manufacturing might make a case for a manufacturing person as leader because a manufacturable product is essential.

Unfortunately, all of this discussion misses the point. No company has enough candidates for the demanding team leader job, so no company can afford to restrict its search to one function. Besides, the qualified person is someone who thinks and operates as a general manager, not a functional specialist.

Team Members. While much has been written about leaders and leadership, little guidance is available on selecting team members. Kelley (Ref 3) makes the point that the criteria for selecting team members are remarkably similar to those for team leaders. In particular, a development team needs self-starters able to work without supervision and individuals who will present their thoughts independently. Groupthink is dangerous on a development team, and the best defense is team members with the strength of conviction to present contrary views.

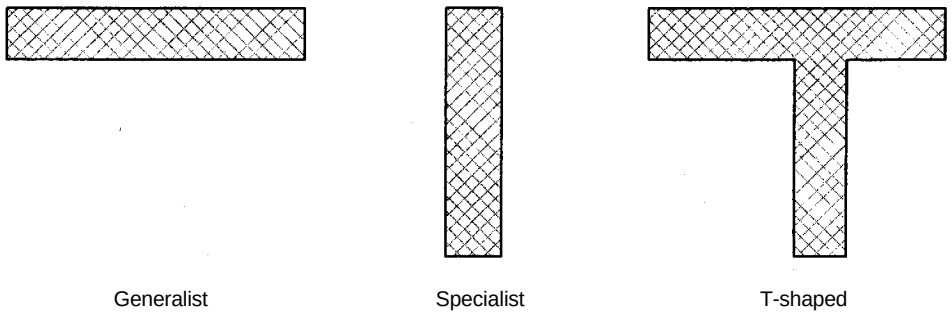

Fig. 1 T-shaped individual. The horizontal direction portrays breadth of experience, and vertical indicates depth of specialization.

Another key criterion is a willingness to share information and credit. A member who tries to build his or her own self-worth by withholding information or credit is disastrous on a development team.

Generalists Versus Specialists. In the development of sophisticated products, the tendency is to think of using highly specialized people who can contribute that something extra that will yield a competitive success in the marketplace. Usually, the recognition, compensation, and promotion systems of a company reinforce this bias toward specialists.

Unfortunately, specialists create several difficulties on a team, including scheduling problems, lack of commitment to the project, and lack of a solid understanding of project objectives and customer desires. Therefore, the bias in selecting team members should swing toward generalists who have a firm grasp of the job to be done and can be engaged for the duration of the project. The ideal member is the so-called T-shaped individual, one who has depth in a crucial area but is also able and willing to handle many other jobs, often under the direction of others, when their specialty is not needed (see Fig. 1).

Figure 2 is a staffing chart for a simple product developed by a company preferring specialists. Each bar represents one individual on the team, and the height of the bar indicates this individual's degree of dedication to the project, that is, the number of hours he or she spent on it compared against the total number of hours possible for the duration of the project. Specifically, five people on the tail end of the chart are purchasing specialists, each permitted to purchase only a specific commodity.

The company represented in Fig. 2 has moved toward generalists. It uses fewer members on a team, but each is involved at a high level of dedication. Communication, coordination, and commitment have improved accordingly.

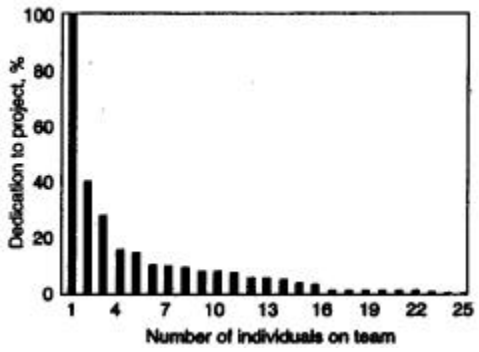

Fig. 2 Staffing diagram for a project that depended on many specialists, most of whom contributed less than 10 percent of their time to the project. Source: Ref 4

Clearly, the specialist-generalist issue applies to a materials specialist whose expertise may be needed for a small portion of the project.

Team Selection Process. To enhance commitment to the project, team members should have a say in whether or not they want to be on a team; in essence, they should volunteer (Ref 4, p 127–128).

Normally, the team leader recruits team mombeta after management recruits the leader. Recruiting team members is a negotiating process between the team leader and management because management will be unable to release certain members requested by the leader.

Suppliers on the Team. To leverage their resources, manufacturers are turning increasingly to suppliers to provide larger portions of their products. Also, there is a trend toward forming strong alliances with a few key suppliers rather than working with many at arms length to avoid being held hostage by a single supplier.

Product development is not as far along as production in making these transitions, but the changes are definitely occurring in product development as well. What this means for product development is that supplier personnel are joining their customers' development teams just as if they were employees of the customer. This practice has become routine for automobile manufacturers where suppliers are involved at many different levels (Ref *5).*

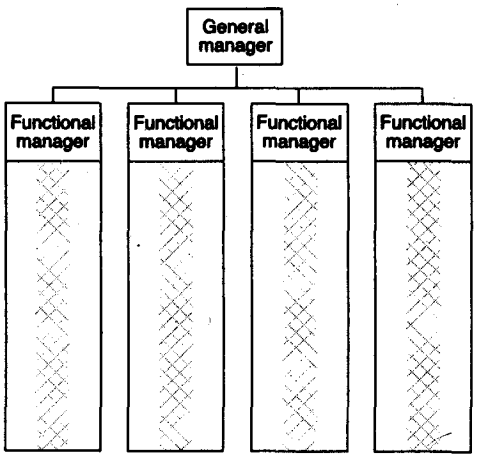

Fig 3 A functional organization, in which authority rests with the functional managers. Source: Ref 4

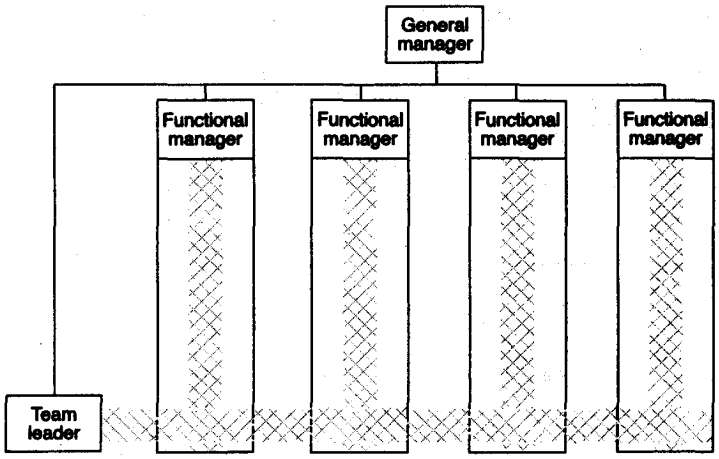

Fig 4 A balanced matrix, where the team leader and functional managers have equal authority over team members. Source: Ref 4

Suppliers should be considered as team members when they have essential technical expertise to contribute, when their parts are critical to the cost or schedule of the product, or when the customer's design of a part will affect the supplier's ability to produce it reliably.

Clearly, many different levels of supplier involvement are possible. It is important to be flexible in molding each circumstance to fit the requirements. When supplier involvement is planned, the previously covered concerns about specialists should be kept in mind. A few key suppliers involved heavily are better than many involved superficially.

Organizing a Development Team

Every organization has its formal organization depicted on the organization chart. Each also has an informal organization, the linkages by which things actually get done, decisions get made, and information flows. These systems have evolved over time to serve the primary needs of the firm. Due to need and tradition, most of these organizational structures are vertically (functionally) oriented. Although this vertical structure may be best for many corporate activities, it does not work well for developing innovative new products, which require heavy horizontal information flow.

Fortunately, corporate organizational structures are becoming more horizontal as firms delayer, decentralize, empower workers, and move toward team-based activity. The increasing emphasis on new products encourages this shift. However, the growing need for new products is outpacing changes in inertia-bound organizational structures. Usually, this suggests a bias toward structures for product development that are more horizontal and team based than the familiar ones. The change will require some organizational inventing and pioneering. Such organizational innovation is far more likely to take root if it is planned and set up before initiating a project.

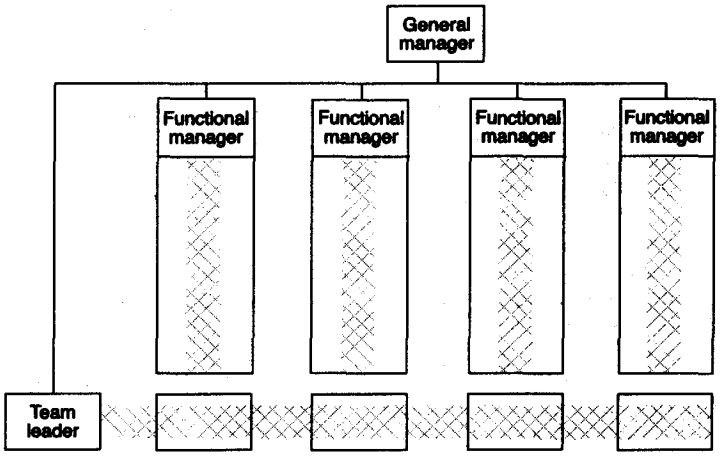

Fig. 5 A separate project organization, in which members report solely to the team leader. Source: Ref 4

Products of today are often complex, which means a development team must incorporate several types of technical expertise. Consider something as commonplace as a telephone set. Developing a new one requires electrical, mechanical, and software engineers, acoustics and materials experts, industrial design and ergonomics, and manufacturing process expertise. In addition, marketing, purchasing, and finance will be key participants. Thousands of decisions lie ahead, and thousands of problems await solutions. For the set to be a commercial success, the developers must reach delicate cross-functional balances repeatedly.

The present task is to provide an environment, that is, a team, to address such cross-functional problems and decisions quickly and effectively. Without such a team, the more vertical communication infrastructure in a company is likely to degrade the quality of the new product, add to its cost, and delay it.

Candidate Organizational Forms. It is helpful to think of the possible organizational forms as spanning a spectrum, from the functional one (strongly vertical) in Fig. 3, through the balanced matrix (Fig. 4), to the separate project shown in Fig. 5. The critical parameter that varies in these charts is the degree of control and influence the team leader has over individuals on the team compared with that held by the functional managers. In Fig. 3, there is no team leader, so all decisions flow through functional managers. In the balanced matrix, the team leader and functional managers hold equal power over team members. In Fig. 5, the team leader has unquestioned authority over those assigned to the project.

Important points on this spectrum occur between the illustrated ones. For example, between the charts displayed in Fig. 3 and 4 is a so-called lightweight team leader form, in which a team leader exists but has less clout than the functional managers. This is a popular and often dangerous form because organizations have moved to it from the functional form, thinking they have arrived at teams but not realizing that they really need to take more steps. Lightweight teams are often impotent, as the label suggests, and the

leader often becomes frustrated. Between Fig. 4 and 5 is the heavyweight team leader form, a powerful one used by Honda, among others.

Figures 4 and 5 illustrate another key point. The team leader reports to a general manager, not to a functional manager, such as the vice president of engineering. Recall the earlier discussion about the team leader functioning as a general manager so that he or she would integrate the viewpoints of all functional managers. If the team leader reports to a functional manager, the project will take on the orientation of that function. The other functional managers will get involved to inject their opinions, bringing back the shortcomings of the functional form.

Selecting the Best Form for a Project. Every organizational form has its pros and cons. For example, the functional form is superior for maintaining consistency between products in a company's product line. But it is poor at facilitating communication across the functions involved in developing an innovative new product. Conversely, the separate project form excels at such cross-functional communication but is weak in cross-project coordination. The balanced matrix provides some of both but introduces potential conflicts because individuals on the team essentially have two equal bosses tugging at them.

The solution to this dilemma is to choose the form with strengths that most closely match the primary objectives of a particular project, then recognize the shortcomings of the chosen form, and put compensating mechanisms in place to handle them. For example, many firms introduce cross-functional project communication into the functional form by having weekly team meetings. (The earlier warning about trying to run a team through meetings should be noted.)

A consequence of this approach to organizational design is that each project will have its own structural form based on the specific objectives of that project. This makes the organization chart more complex but enables each project to use the most effective organizational tools available.

In general, a form closer to the separate project should be used for innovative, new-to-the-world products, and more functionally oriented forms should be used for more routine product upgrades (Ref 6).

There is nothing magical about the terminology used here, for instance the *heavyweight team leader* form. Other jargon is used, such as *core teams.* What really matters is how members are involved day-to-day, which is the next topic.

Full-Time, End-to-End Involvement. Another important characteristic of effective development teams is that, to the greatest extent possible, each member serves from the beginning of the project to its end and is involved full time for that period. Handoffs from person to person or from department to department mean breaks in the continuity of vital information. Engineers, according to a stereotype that is partially true, often want to redesign whatever they receive from someone else.

Full-time involvement (also called dedication) translates into higher commitment and accountability and into greater focus on key objectives of the project, such as the desires of key customers. By using full-time people, fewer people can handle the project, with the benefit that communication becomes far simpler. If a full-time member cannot be justified, their role should be defined carefully (Ref 4, p 142).

Full-time, end-to-end involvement is much easier to accomplish with generalists. This is one benefit of using generalists on a team, as discussed earlier.

The first person to be dedicated full time for the duration of the project should be the team leader. Part-time involvement in this key position is particularly ineffective.

The Power and Difficulties of Co-Location. Once a leader is selected, team members are recruited, an organizational form is chosen, and the degree of dedication expected from each member is established, then the last decision to be made is where to locate this crew. The basic choices are to leave members in the place where they were before the team formed or to physically locate them close together; this latter choice is called co-location.

The argument for co-location is that product development, especially for highly innovative products, requires a great deal of cross-functional communicating, problem solving, and decision making. Placing the participants close together simplifies these activities greatly. Project focus and easy access to project-related materials, such as products of the competitors, are additional advantages.

Figure 6 illustrates the basic case for co-location. These data from several research and development sites show how likely individuals are to communicate about technical matters, depending on their separation. Note that the "knee" of the curve is at about 10 m (30 ft), which suggests that there is great value in having team members close enough to overhear conversations of one another.

Thus, true co-location means that team members are within conversational distance, not just in the same building or on the same floor. As discussed earlier, this team includes members from marketing and manufacturing, not just the research and development portion of the team. In the author's experience in working with over a hundred product development teams, this type of co-location is a powerful tool to shorten development cycle time dramatically.

Although the benefits of co-location are great, the resistance can be equally great in many organizations. Those who have tried it appreciate its benefits and would always use it again if effective project communication were critical. Many who have not tried it are skeptical, often due to personal reasons, such as lack of privacy; see Ref 4 (p 145–150, 271–272).

Co-Location Versus Electronic Team Linkages. The data in Fig. 6 are from Ref 7, which is over 20 years old. Many engineers in high-tech industries discount Fig. 6, asserting that modem electronic means of communication, for instance, faxes, e-mail, and videoconferencing, have superseded the need for physical co-location. Figure 6 suggests that the threshold (10 m, 30 ft) is so low that people are not willing to work very hard to communicate. If they have to take the effort to dial the phone, compose a message on their computer, or arrange a video-conference, they will instead just make this mini decision themselves. After a while, poor mini decisions pile up.

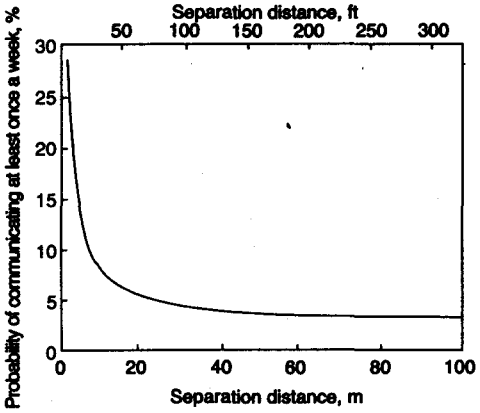

Fig. 6 Effect of separation distance on communication between team members. Communication is much more likely to occur if team members are located within about 10 m (30 ft) of one another. Source: Ref 7

Electronic communications have two other shortcomings. One is that they are not very fast; the inherent delays in phone tag and its e-mail equivalent are commonplace. The more fundamental weakness is a lack of communication quality. The words themselves account for less than half of what a message communicates, most of the communication being attributed to intonation, body language, and timing. To various extents, all of the electronic media filter out this vital information. Even the current resolution of videoconferencing fails to pick up many clues.

Electronic media certainly have their value, but their limitations diminish their ability to facilitate rapid, effective team progress. Being aware of the limitations will help the team to compensate for them.

The Role of Rewards and Other Motivators. Many researchers and authors have addressed the effectiveness of motivators, such as compensation, recognition, and promotion in improving corporate productivity. This is a difficult subject about which to be definitive, and much of the available material is contradictory. However, two general observations apply to cross-functional development teams.

One is that these systems ultimately have to come into alignment with the behavior desired of the team, or the team will revert to traditional ways of operating. For example, if the culture punishes mistakes, then the behavior change sought, learning from mistakes and getting beyond mistakes quickly, will not occur. The new products developed by the team will not likely be very innovative in such a risk-averse environment. Similarly, if team cooperation is the desired outcome, individuals should not be rewarded.

Second, substantial dependence on rewards to achieve results is likely to backfire. In the

author's experience, clients who focus on rewards usually have other, more fundamental difficulties, such as overbearing top management, and superficial fixes with rewards will not overcome the fundamental issue. In the end, team members must be motivated intrinsically by an interest in the work itself, and extrinsic motivators will have limited effect. For a sobering view of this subject, see Ref 8.

The Specialist's Role on a Development Team

An assumption underlying this article is that the reader is probably a materials specialist or manager who is reading it concerning their involvement on a cross-functional development team. Thus, the specialist's role needs specific attention here.

Balancing Team Needs with the Specialist's Needs. The dilemma of the specialist was covered earlier: the specialist's expertise is often needed to provide the technical product innovativeness essential to marketplace success, but the specialist introduces several complications in managing a high-performance development team. Thus, the specialist's role is one of those organizational design factors that should be resolved by first satisfying the major project objectives, then identifying known weaknesses in the specialist's role, and compensating for these. This means that the best solution is likely to differ every time.

The Specialist on a Weak Team. A weak team, for example, a functional organization or a lightweight team leader form, is really just a variety of specialists being guided by functional managers. Consequently, technical specialists fit into these forms quite naturally, but they also contribute to all of the shortcomings of these forms.

Whatever the organizational form, a chronic weakness of highly specialized technical people on development projects is that they often have little contact with the customer for which they are designing. They need to get into the field rather than rely on filtered information from others. For example, a plastics specialist working on a new type of plastic body panel resin for automobiles should spend time in body shops, car wash establishments, and shopping mall parking lots to see firsthand just how cars get used and abused.

The Specialist on a Strong Team. The specialist's role dilemma is most evident in the stronger team forms. Fortunately, there are options for how the specialist can contribute to the team.

Joining the Team Option. If the specialist's expertise constitutes a major contribution to the project, this person should be a regular, dedicated, co-located member of the team for at least most of the development and testing. The specialist should be a T-shaped individual, as discussed earlier, to justify end-to-end, full-time involvement. Limited involvement would mean that this person will be gone when problems associated with his or her design choices begin to appear later.

Expert Contributor Option. This is a popular middle ground, but it must be treated with care to get a quality, responsive contribution from the specialist. This individual is not a member of the team (trying to include such associates to help them feel more involved will simply dilute the significance of the team).

Therefore, a regular member of the team acts as a liaison to the specialist, and clear objectives, deliverables, and due dates are established for each task. The liaison should monitor progress closely, watching for slippage due to the specialist's other activities or lack of understanding of project goals. The specialist must spend enough time with the team that he or she can experience firsthand what the team is about. Team meetings may not be the place for specialists to get this direct exposure.

The expert contributor option simply provides a contracted deliverable, much like a supplier's, and should be managed accordingly.

Expert Advisor Option. An expert advisor acts as a consultant to the project and is expected to deliver competent professional advice, based on one's field of expertise. It is the team's responsibility, not the specialist's, to be sure this advice fits with team objectives and to identify contextual shortcomings in it. For example, if an automotive plastics specialist suggests a certain resin, it is the team's responsibility to ascertain that this resin is suitable for Siberia and Saudi Arabia, where they may intend to sell their cars.

If the specialist's advice is critical to the success or schedule of the project, then the specialist's participation should be arranged in advance.

Conclusions

Unlike much of the other material covered in the *ASM Handbook*, this article covers subjects without a strong scientific basis. There are few firm rules, and the best solution will depend greatly on the specific circumstances involved. Much of the supporting evidence is anecdotal, as in the case of co-location, for example.

However, this does not mean that there are no preferred solutions. Some solutions are far more powerful and effective than others, so it is definitely worth struggling with the issues to find the solution that works best in a specific situation. Individuals forming a design team should form their objectives, analyze the existing data to select an approach, and then *do something.* In making progress, action is preferable to inaction.

Initial team "experiments" should be operated on a manageable scale where the risk is reasonable, and they should involve the most enthusiastic people to initiate change. See Ref 4, Ch 15, for further information on making such changes. Results should be monitored, and adjustments should be made on an ongoing basis. See Ref 9.

For more detailed coverage of the material in this article, see Ref 4, especially Ch 7 and 8.

REFERENCES

1. J.R. Katzenbach and D.L Smith, *The Wisdom of Teams*, Harper Business, 1993
2. G.M. Parker, *Cross-Functional Teams*, Jossey-Bass, 1994
3. R.E. Kelley, In Praise of Followers, *Harvard Business Review*, Vol 66 (No. 6), Nov-Dec 1988, p 142–148
4. P.G. Smith and D.G. Reinertsen, *Developing Products in Half the Tine*, Van Nostrand Reinhold, 1995
5. R.R. Kamath and J.K. Liker, A Second Look at Japanese Product Development, *Harvard Business Review*, Vol 72 (No. 6), Nov-Dec 1994, p 154–170
6. E.M. Olson, O.C. Walker, and R.W. Ruekert, Organizing for Effective Product Development: The Moderating Effect of Product Innovativeness, *Journal of Marketing*, Vol 59 (No. 1), Jan 1995, p 48–62
7. T.J. Allen, *Managing the Flow of Technology*, The MIT Press, 1977, p 239
8. A. Kohn, *Punished by Rewards: The Trouble with Gold Stars, Incentive Plans, A's, Praise, and Other Bribes*, Houghton Mifflin, 1993
9. P.G. Smith, Your Product Development Process Demands Ongoing Improvement, *Research-Technology Management*, Vol 39 (No. 2), March-April 1996, p 37–44