Technology Transfer

Practical Issues of Technology Transfer in High-Tech Industrial Organizations

By Avan R. Jassawalla and Hemant C. Sashittal

Technology transfer, or the process by which ideas are translated into new products, requires high levels of cooperation among a diverse set of participants from R&D, production, marketing, and other functional groups. The human and organizational dimensions of technology transfer represent significant challenges to managers responsible for developing new products.

For most industrial organizations, rapid, successful introduction of new products based on cutting-edge technology, faster and cheaper than competitors, is more of a dream than a reality. The secrets of new product success, at least in part, lie in effective transfer of technology. Managing the process is inordinately challenging because it concerns complex human interactions and the interdependencies among its participants. Effective high-tech companies demonstrate a distinctive competence in integrating diverse organizational skills, and in harnessing the creativity and synergies that result from their interactions. On the other hand, poorly understood human and interpersonal issues—ineffective interfunctional communication and the lack of cooperation (commonly observed problems in modern organizations)—get in the way of effective transfer of technology.

To gain insights into some of the complex human interaction issues of technology transfer, we studied 10 high-technology based industrial organizations. All participating companies employed a proportionately large number of engineers and technically qualified individuals, had distinct R&D departments that required considerable capital outlays, faced a high degree of product obsolescence, and relied on new products based on new technology to remain competitive. The sample included manufacturers of radar systems, emissions control equip-

ment, electric and electronic components, medical diagnostic instruments, automobile transmission systems and components, electrical construction materials, jet engine cables and harnesses, single package cooling units, locomotive brake systems, and high-technology specialty metals.

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To gain multiple perspectives and diverse viewpoints, we conducted in-depth interviews with at least one manager directly involved in the technology transfer process from the R&D, production, and marketing functions from each company. We asked them to describe their relevant related activities, experiences, and interactions with others. Several cross-functional project team leaders (n=5) involved in technology transfer processes also were included in the study. The majority of the 40 managers we interviewed had spent 10 years or more in the industry (90 percent), and most had spent 10 years or more in their present company (70 percent).

Key learning

All participants recount the interpersonal rather than the technological dimensions

of technology transfer to be their most significant challenge. Similarly, managers from production and marketing groups report growing levels of involvement in converting new technologies into new products. Reciprocal interdependence among participants, cross-functional cooperation, and leadership are three of the key issues challenging survey participants.

Fostering Reciprocal Interdependence— Most of the managers we surveyed note that effective technology transfer is characterized by high levels of reciprocal interdependence between R&D, production, marketing, and other participants in the process. Reciprocal interdependence refers to a condition where participating functional groups are engaged in continuous exchange of inputs and outputs, hold equitable influence over technology transfer-related decision making, contribute equitably to tasks related to technology transfer, and feel equally dependent on each other for ensuring successful technology transfer outcomes. Explaining why feelings of interdependence are important, and why they characterize effective transfer of technology, managers note that the process is too complex to unfold smoothly without a high degree of shared enthusiasm and commitment from all participants. On the other hand, low levels of interdependence among participants are characterized by struggles for power and resources, which leads to distinctive agendas, turf-protection behavior, finger pointing, the domination of one functional group in technology transfer related decision making; and indifference and isolation of other functional groups, which results in a lack of concern for technology related outcomes. Both characteristics are associated with ineffective, sluggish technology transfer processes. Higher levels of cross-functional interactions and synergies, which are common features of effec-

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tive technology transfer processes, fail to occur when one functional group (usually R&D) dominates the process, or when other groups (production and marketing) are indifferent and fail to take ownership for new product outcomes.

The struggle for control and the indifference often originate from the natural task differentiation that exists in organizations; i.e., R&D develops new technology, production produces, and marketing connects the firm with customers. The differences in the ways functional groups define their roles in the organization create an erroneous view that each is self-standing, and not reciprocally linked with any other. Consider our finding that R&D groups view themselves as the principal owners of the technology transfer process, and that their influence on decision making overshadows that of other participants. On the other hand, we find production's influence on decision making uniformly and notably low, and marketing's influence only somewhat higher. Managers from six of the 10 firms recount, however, that marketing's stature in the technology transfer process, and its influence on technology transfer-related decision making has improved in recent years because of intensified competition and TQM programs that promote customer-oriented views in the organization. None of the companies in our sample share the ownership or the decision making power of the technology transfer process equally. Six of the 10 firms' marketing and production groups participate and contribute comparatively more to technology transfer-related tasks than in the other four firms. The R&D groups, however, clearly remain the first among equals.

Comparing the four firms where R&D clearly dominates the technology transfer process, with the six firms that share some of the power with the marketing and production groups yields interesting insights. For instance, in the former firms, R&D makes a strong attempt to control the process, often at the expense of technology transfer efficiency. They don't cooperate with other functional groups. They micromanage and impose bureaucratic mechanisms such as checklists and guide-

lines on other participants and demand strict adherence. They obstruct the formation of cross-functional project teams and insist on appointing a member of their own group as the leader when one is formed. They consciously keep the production group out of the technology transfer-related decision making process.

R&D's de facto ownership of the process, and its view of production and marketing as support groups ,functions not only to consolidates its own power as the chief orchestrator, but it also alienates other participants who withhold cooperation after their ideas are shot down and initiatives discounted.

A cross-functional team leader representing the R&D function explains why his company's production group is given only a limited role on project teams, ". . . Yes we do (cooperate with the production group) on my product, although not as much as I think we should. And that is because, personally, I question whether they have the expertise to do the job. The production engineering manager is a good organizer. He knows the product fairly well. He's getting better, but I don't know that he has the necessary technical knowledge about our product to have a meaningful dialogue . . . If I say we're going to do the pilot build on this date, he'll make the arrangements, he'll do everything that has to be done in manufacturing. but I don't know about his technical ability."

According to this employee, the manufacturing group is good at doing their end of things, but they're not very active as far as contributing to the design and development of the product.

Clearly, the problems lie not only in R&D's views and behaviors. A common refrain of the production function is that while R&D can build anything once, manufacturing it on a large scale, fast and cheap, is the real challenge. Additionally, and regardless of how they view themselves, we find that other functional groups tend to view production groups as owners of the current business, and hence not particularly concerned with anticipated new products. Similarly, marketing and sales take exclusive ownership of market related constituents, and view them-

selves as the customers' voice in the organization. These compartmentalized views about who owns what often get in the way of developing reciprocally interdependent relationships. Additionally, we find that this problem of ownership is greatly exacerbated by:

- the R&D groups' high stature as bodies engaged in esoteric pursuits of pure science and their resulting reluctance in viewing others as their equals;
- engineering/inventor run firms that view marketing (and sales) as superfluous activities until increasing competition and declining revenues directly threaten the bottom line; and
- upper management's often empty rhetoric on cross-functional cooperation, without visible attempts to affect changes within the organization.

We find a clear pattern in the events that lead to improvements in marketing and production groups' stature in technology transfer-related decision making. The concern with equitable distribution of power and reciprocal interdependence is raised when competitors offer cheaper, more effective substitutes, and customers switch suppliers. The interest in customer-driven technology transfer processes, efficiency, and cost-driven production deepens within organizations. R&D groups are pressured into involving marketing because they speak for customers, and involving production because they speak for production efficiencies and manufacturability of new designs.

We find that real power sharing, and feelings of reciprocal interdependence occur when:

- Change is initiated at the top, and

senior management displays both by proclamation and deeds that all functional groups are equally important for accelerated, efficient technology transfer processes;
- From the initial stages of the process, not only are all functional groups involved

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in decision making, a higher degree of concern is shown toward meeting customer needs and raising production efficiencies;
- Participants are cross-functionally trained and formally educated/trained in the human and interpersonal dynamics of working in teams;
- Collaborative activities are encouraged and rewarded; and
- Spatial distances are shrunk to reduce perceptual differences—the diverse sets of participants are located in the same facility.

The Nature of Cross-functional Cooperation—All of the managers we studied highlight the virtues of cross-functional cooperation, and its importance in accelerating the technology transfer process. Although managers are fairly unequivocal in their convictions, we find that because some companies demonstrate low, some demonstrate medium, and some demonstrate high levels, the sampled firms exhibit a clear continuum of cross-functional cooperation; and the actual level of cross-functional cooperation, on average, is quite low.

Two of the companies in our sample have notably low levels of cross functional cooperation. Each functional group within those two companies works in isolation and hands off its output over the wall to the next group. R&D orchestrates the linear work flow, and involves other functional

groups as needed, one at a time. The compartmentalized structure and distinct interdepartmental boundaries breed differences in people's mindsets, and result in low levels of interaction among participants.

Several insights emerge from our analysis of how firms organize for the cross-functional cooperation entailed by transfer of technology. For instance, eight of the 10 firms use some form of teamwork to manage the technology transfer-related decision making and work flow. One uses a partnership team between marketing and R&D, and one uses a concurrent engineering team with representatives from the technical functions such as R&D, production engineering, and production. Three firms have recently instituted cross-functional teams for technology transfer, two report considerable experience with cross-functional teams, and one firm employs cross-functional teams for most complex organizational initiatives. Managerial descriptions of these structural arrangements belie two erroneous assumptions. They assume that increasing marketing's and production's involvement in the technology transfer-related decision making guarantees high levels of cross-functional cooperation. They also assume that the formation of cross-functional teams, in and of themselves, guarantees increased cross-functional cooperation.

As we note, the most common precursors of marketing's and production's growing influence are senior management's directives forcing R&D to seek inputs from other functional groups. Very often, however, the involvement from other functional groups is mechanistic. Marketing and production groups go through the motions, provide the information R&D solicits, agree to meet more often, and perform more tasks. The increase in marketing's and production's involvement via cross-functional teams reinforces the assumption that teams create cooperation. The assumptions are erroneous, however, because unless R&D shares the power and responsibilities equitably, increased involvement does not improve cross-functional cooperation. In practice, having marketing and production go through the motions of involvement

does not result always in high levels of cross-functional cooperation. Our data show that about the only results that cross-functional teams can guarantee are increased frequency of meetings among participants and increased involvement of functional groups other than R&D. They do not guarantee, however, that participants will abandon narrow, compartmentalized views of the world and adopt holistic thinking, create feelings of joint

of technology transfer initiatives.

High levels of cooperation—a condition we call collaboration—refer to instances where the technology process benefits from the synergies of high cross-functional interactions. We find this condition occurring in four of the 10 firms in our sample. It is characterized by cross-fertilization of ideas, early involvement of all participants in decision making, and joint ownership of outcomes. We find that per-

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ownership, or engage in intense, synergistic interactions that characterize high levels of cross-functional cooperation. Increased involvement and teamwork, by themselves, rarely foster the changes that have to occur at the cerebral level, and in the attitudes and mindsets of participants, before higher levels of cross-functional cooperation can occur. Since the actual extent of cooperation varies widely among the firms that employ teamwork, we find the notion of a direct relationship between the two, tenuous at best.

We also find that uninterested participants can create a serious threat to cross-functional cooperation. While they are often included in technology transfer-related activities because of their technical expertise, they do not embrace the concept of joint ownership, make no attempt to participate in cross-fertilization of ideas, wait for instructions, and contribute as little as possible. The damper they cast on others' enthusiasm, and the resistance they raise suggest that they must either be educated and socialized to become better, more enthusiastic participants, or left out

ceptual and spatial boundaries between functional groups become permeable and fluid, and in one instance, disappear altogether. We also identify four features common to their technology transfer processes. First, the time and resources senior management devotes to technology transfer-related decision making indicate that it is an activity of paramount importance, and closely related to the firm's survival, growth, and profitability. We find that participants view this type of senior management commitment as the principal cue to guide their own behaviors in the technology transfer process. Second, most technology transfer-related decisions are decentralized. Cross-functional project teams are empowered to make most decisions on the class of issues that directly affect their involvement in the technology transfer process. Senior management provides cross-functional teams with unprecedented access to the information and resources necessary to implement their decisions. Third, senior management demonstrates a high degree of willingness to change, innovate, and adopt new work

flows and systems to accommodate the needs imposed by the new technology and new customer requirements. They send R&D and production personnel to visit customers with the sales force, assign marketing and R&D persons to the production floor during the pilot build, and support and fund innovative tools and techniques that foster higher levels of connectedness among participants.

One specially selected cross-functional team leader shares the innovative way his company used two-way radios to foster high levels of interaction among participants.

When it was time to implement a new product out on the production floor, he purchased two-way radios for all the major functions—something that had never been done at his company before. Initially, there was much skepticism from the employees. "It will not work, it can't work, we've never done that," were common complaints.

Now, the employees won't give up the radios. And the project couldn't have been completed in the condensed time frame without the use of the radios. "We were asked to do it one month early by our customer, and we did. One of the reasons we were able to do it was that all of the major functions had radios. They could talk to

greatly enhanced by the cues senior managers send when they decentralize technology transfer related decisions, and empower cross-functional teams.

Fostering Leadership—The clearest dichotomy in our sample relates to technology transfer processes inordinately dominated by R&D (n=4), and those that show a more equitable distribution of power among participants (n=6). We find that noteworthy differences exist in the way the two types of firms provide leadership for the technology transfer processes. For instance, when R&D dominates, we find that it either resists formation of cross-functional teams or it appoints its own representative as the leader of such teams. Appointed leaders are chosen for their technical competence, and not necessarily for their interpersonal and group interaction skills. Appointed leaders, we find, owe more allegiance to the R&D function than they do to the technology transfer process. They view other team members as unequal, less powerful, and less important participants. They also tend to view cross-functional teams as the principal means for expediting R&D's agenda and gaining compliance from other participants. Others on the team view appointed leaders as senior management's signal that they are less important, and tend to with-

exists within firms.

In the six firms where we find a more equitable distribution of power and higher levels of cross-functional cooperation, we find that the senior management in four firms carefully selects leaders that are technically competent and skilled at addressing the human interaction issues that confront teams. The role of selected leaders is particularly noteworthy because they champion cross-functional cooperation and provide the missing link between cross-functional teams and high levels of cross-functional cooperation. They greatly improve the effectiveness of cross-functional teams because they:

■ are cross-functionally trained, and reflect a comprehensive understanding of the divergent orientations and priorities that exist within teams;

■ have a clear sense of the relationship between high cross-functional cooperation and successful transfer of technology;

■ believe that improving interpersonal and group processes are key to accelerating technology transfer, and spend inordinate amount of energy and resources on improving interpersonal and group dynamics; and

■ encourage participants to change their thinking, adopt new, more holistic ways of defining their responsibilities, and appreciate the interdependent nature of their relationships with other functional groups.

Selected leaders hold weak functional group affiliations and actively prevent participants from reenacting the interfunctional rivalries and disagreements that exist in the macro-environment. The actions they take to improve team effectiveness include training members in team-building and conflict management skills, coaching and mentoring participants, and seeking innovative techniques to increase cross-functional cooperation.

Conclusion
A new generation of competitors and technology has forced high-tech firms to re-evaluate how they integrate their new technology with rapidly changing customer needs. At no other time has the emphasis on cross-functional collaboration

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The climate of trust is greatly enhanced by the cues senior managers send when they decentralize technology transfer related decisions, and empower cross-functional teams.

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each other," says the team leader.

Fourth, we find their organizational cultures characterized by trust. Notable elements of their organization include low levels of interfunctional rivalry, low resistance to change, and a widely held belief that other participants in the technology transfer process are technically competent and skilled in managing interpersonal relationships. The climate of trust is

hold cooperation. In such instances, we find that cross-functional teams strongly reflect the larger organizational culture and its interfunctional rivalries. Far from insulating the team from larger bureaucratic forces and creating a microcosm that spawns innovative, efficient technology transfer-related work flows, we find appointed leaders associated with teams that exacerbate the differentiation that

to accelerate technology transfer processes been stronger. Among most of the 10 organizations we studied, however, the rhetoric on sharing power, reciprocal interdependence, and cross-functional cooperation far exceeds what they actually affect in their technology transfer processes.

Integrating the diverse organizational experiences and skills and focusing on serving customers with new, cutting-edge products appears a lot easier when technology transfer-related decision-making power is equitably shared, strong feelings of reciprocal interdependence exist, the level of decentralization is high, and team leaders understand the human interaction issues of the process. Failure to understand these central features of technology transfer results in sluggish development of new products.

We also note the considerable interest in employing cross-functional teams because they promise efficient technology transfer-related work flows. The widespread adoption of this innovative structural mechanism reflects positively on companies, because it signals the realization that new technologies, new market conditions, and new customer needs require innovative ways of integrating functional groups, administering technology transfer-related decision making, and structuring work flows. Cross-functional teams, we find however, are catalysts and not causes of cross-functional cooperation. More often than not, cross-functional teams fail to deliver the technology transfer-related efficiencies they promise and fail to insulate participants from larger bureaucratic forces of the organization because managers are confused about what they can and cannot deliver. The adoption of cross-functional teams—in the absence of joint ownership, supportive leadership, high decentralization, and relatively free access to resources and information—fails to accelerate the technology transfer process.

For managers interested in stimulating their thinking and conducting an audit of their current technology transfer-related activities, we offer the following questions:

To what extent does senior management, with respect to the technology transfer process:

■ decentralize decision making?
■ provide participants with access to resources and information necessary to implement their independently derived decisions?
■ encourage (i.e., support with resources) participants to experiment with and adopt innovative ways of improving communications and structuring work flows?
■ mistake higher levels of involvement for cross-functional cooperation?
■ reflect in its proclamation and deeds, that the process is important, and a joint responsibility of all organizational members?

To what extent do the teams employed for transferring technology:

■ increase the feelings of reciprocal interdependence among participants?
■ deliver higher involvement versus higher cross-functional cooperation?
■ insulate team members from the regressive, bureaucratic forces of the larger environment (versus exacerbate them)?

To what extent are/do team leaders:

■ cross-functionally trained, technically competent, and skilled at managing interpersonal and group dynamics?
■ reflect an understanding of the divergent, sometimes conflicting interests, orientations, and priorities that exist among multiple participants in the technology transfer process?
■ take innovative actions to increase communication and coordination among participants?
■ encourage innovative, risk-taking behaviors from participants?
■ foster holistic thinking and joint ownership of decisions and outcomes?
■ coach, train, and mentor participants to increase cross-functional cooperation?

To what extent do participants in the technology transfer process:

■ believe that they are reciprocally interdependent with others?
■ feel powerless to influence the technology transfer process?
■ reflect a sense of shared ownership for technology transfer-related decisions and outcomes? To what extent are they disinterested participants?

■ enjoy equitable status in technology transfer-related decision making? ■

For further reading

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