responsibility, and proximity. For the IBM projects studied, however, in no case was the proximity of a development laboratory to a research laboratory an important factor for technology transfer. Being close was convenient and saved money, but no transfer failed because of distance (Cohen et al., 1979, p. 15).

In thinking about the transfer of technology we must be careful not to give sole weight to technical and rational criteria. The following true story makes the point. In India, an agricultural team convinced a farmer to use some new seeds. The results were dramatic. Production was 10 times as great. In evaluating the event, the farmer was asked for comments. To the amazement of the questioner, he indicated he was not planning to use the seed again. "Why?" asked the city-raised Indian agricultural engineer. "Because I have no room to store that much extra production, my cows can't eat the plants that are left on the field after the crop is harvested, and I have no way to get that much production to market." In other words, the engineer had used productivity as the *only* criterion, not taking into account social and collateral activities associated with the crop.

11.12 TECHNOLOGY TRANSFER STRATEGY

After reviewing all that has been written about the subject, one may feel a little overwhelmed by the many requirements necessary to transfer technology effectively. Trying to get several individuals to do some specific tasks for tech transfer, trying to get support from to management, trying to get the necessary financial resources, and then anticipating all the problems (e.g., "hedgers," and the like) make tech transfer seem like a difficult, if not an impossible, task. Because of the uncertainty associated with each step and because of the difficulties in finding the necessary people and resources on a timely basis, successful tech transfer may seem like an elusive dream. In practice, rarely does anyone have all the resources available for tech transfer except for those special projects that are necessary for the survival of the organization.

More often than not, technology moves from research and development to the user in small increments. The size of the transfer effort varies. For some large projects, resources required for effective tech transfer may indeed be extensive. For most projects, the tech transfer effort may have to be accomplished within existing resources, by fending off the skeptics who are opposed or simply reluctant to accept new technology and without all the support mechanisms at high levels of the organization.

No grand scheme or all-encompassing formula for tech transfer is offered and none seems obvious. Based on the considerable practical experience of the authors in moving technology from a research organization to the user community, and after reviewing some of the insightful suggestions made by others, the following approach may allow one to develop a strategy in response to the unique requirements of the organization—its history, its culture, and its technology. A generalized tech transfer strategy development plan is depicted in Figure 11.1, and a description of major activities of this plan follows. To understand this

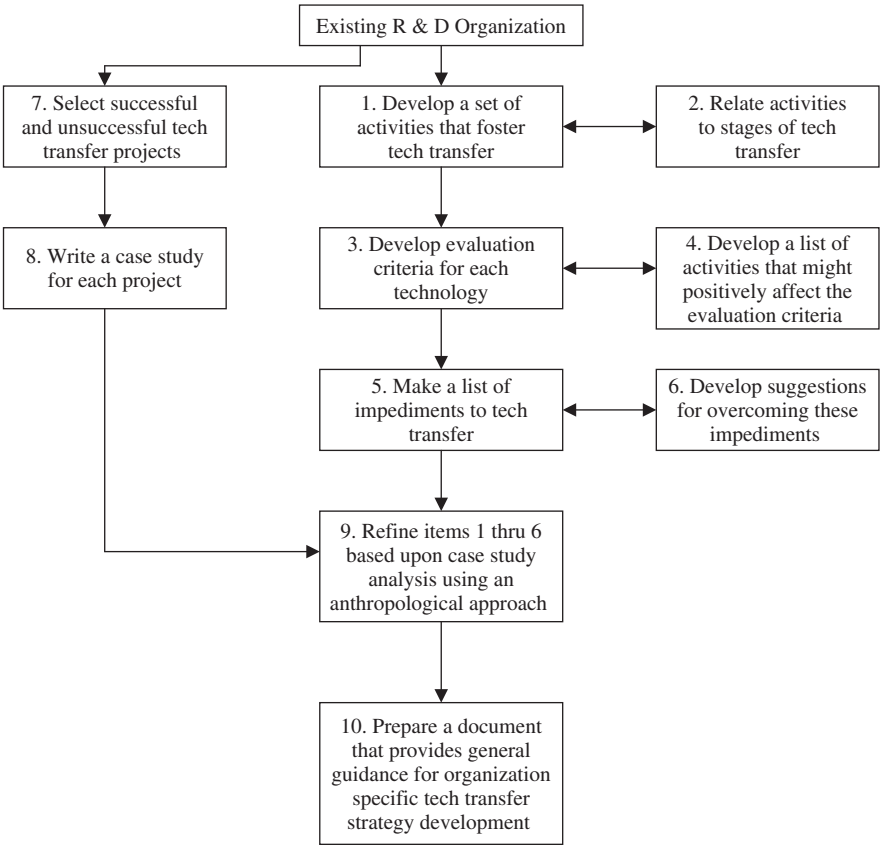

Figure 11.1. Technology Transfer Strategy Development Plan

approach clearly and to operationalize the concept, real research project execution and actual organizational experiences are needed. Hypothetical examples cannot easily convey the organizational and individual behavior contexts that effect tech transfer. Where possible, some examples are presented, although these examples may not be applicable to all cases.

1. Tech Transfer Activities and Documents

Based upon the knowledge of the R&D staff and the user community, prepare a preliminary list of tech transfer activities and documents that foster or enhance technology transfer. For larger and more complex projects, this list preparation may require extensive interviews; for smaller projects, telephonic information from selected participants would be sufficient. The general approach of allocating resources based on the size and complexity of the project and, indeed, based on the availability of resources is the prudent course of action. (Discussion material

presented earlier in this chapter could be used as a guide for this and other activities that follow.)

Some examples of tech transfer activities and documents are:

- User involvement in research project identification
- User involvement in research program execution
- Sponsor at high levels
- Effective information brochures, audiovisuals, and so on
- User manual
- Design criteria
- Patents
- Licensing for manufacture
- Operation and maintenance document
- Support center for training and the like
- Hot line to respond to questions
- Demonstration projects
- Successful implementation for selected users

2. Activities and Tech Transfer Stages

Relate these activities to the five tech transfer stages or steps (knowledge, persuasion, decision, implementation, confirmation) discussed earlier. Use some relevance scale. As an example, using a matrix, activities having the most relevance to a given stage could be rated A, those with least relevance could be rated C, and others without relevance could be left blank.

3. Technology Evaluation Criteria

It must be recognized that, fundamentally, the ability to transfer a new technology is limited by its utility. Utility encompasses such items as relative advantage, marketability, economic feasibility, and user acceptability. Trying to push a new technology that is marginally utilitarian will result in failure in the end. At times one must deal with a technology in which considerable R&D resources have been invested and which seems utilitarian to the R&D community, but which the user community judges to be of marginal utility. It is a poor strategy for the R&D community and its top management zealously to push marginally useful technology without making a genuine effort to understand and to overcome the user community's objections. Not only is the effort likely to fail, but it could adversely affect future worthwhile efforts. In such situations, it would be prudent to recall that the focus of tech transfer is supposed to be on marketing the product rather than selling it. Thus, user needs and preferences should be given

proper consideration. Emphasis then should be on activities (discussed earlier) that enhance user acceptance, though this is not always an easy course of action.

A list of evaluation criteria should be developed. Based on the discussion of characteristics of innovation and key issues in technology transfer, a suggested list follows:

Relative Advantage. To what degree is the innovation more advantageous to existing technologies? Does it reduce cost, save time, or improve quality?

Compatibility. To what degree is the innovation compatible with existing values, experiences, capabilities, felt needs, and organizational and cultural settings?

Complexity. To what degree is the innovation complex and difficult to adopt by the users? What degree of specialized training is required before the innovation can be adopted? What specialized equipment is needed?

Trialability. To what degree can the innovation be tried on a limited basis?

Observability. To what degree can the advantages of the innovation be easily communicated to decision-makers and users?

Technical Understanding. To what degree does the research personnel fully understand the main technology?

Resource Requirement. What level of resources is required to implement the new technology? Is this resource requirement compatible with previous user experiences? Is the capital needed for the new technology available?

Advanced Development Concepts. Are the research activities going to continue to debug problems and further supplement the technology?

Growth Potential. Does the technology have a potential for growth and product applicability? Will the new technology overcome "stretching" of existing technology capabilities?

Advocate. Are there advocates at higher levels and at user level?

Market Pull. To what degree is there a market pull?

External Pressures. To what degree are there external pressures (such as regulations, competitor development, and so on)?

A numerical or relative importance scale rating scheme can be developed to evaluate a new technology vis-à-vis such criteria.

4. Activities to Enhance Evaluation Criteria

The purpose of the evaluation criteria is not necessarily to determine whether the project should be tech transferred or not, but rather to see how the viability of the tech transfer can be improved. It would seem that if the evaluation criteria are used to make a "go or no-go" decision, there may be a natural, though unfortunate, tendency on the part of the researchers to be less objective about the criteria. In actual practice this is a crucial point and needs to be emphasized.

If, for example, the evaluation criteria show that the product (a new concept, process, system, or design) is not compatible with existing and past experiences, then the emphasis should be on how the innovation can be improved so that it becomes compatible.

5. Impediments to Tech Transfer

Make a list of impediments to tech transfer. This list should include organizational items, resource requirements, and general behavioral-related items. In the earlier part of this chapter, much information is provided on this topic and can be used to generate a list that can be supplemented, depending on organization experience and project characteristics.

6. Suggestions to Overcome Tech Transfer Impediments

For every impediment to tech transfer, it would be useful initially to develop suggestions for overcoming the impediment. As an example, if at the higher management level there is a tepid response concerning the immediate benefits from the new technology, showing evidence of tangible, intangible, and unexpected benefits should help. Some examples of such benefits that might accrue from tech transfer include:

- Improved quality of the product
- Increased market share due to improved quality
- Flexibility to use the new technology for purposes other than those intended at this time
- Strategic advantage over competitors if the new technology can provide the flexibility for necessary product lines
- Reduced time required to do the job; even though savings in time have already been used as a savings in cost, reduced time can often provide a crucial advantage (for instance, in a military tactical situation)

7. Selection of Successful and Unsuccessful Projects

Based on the past experience of the R&D organization, select a number of projects in which tech transfer was or was not successful. The number of projects selected would depend on the total domain, diversity, and resource availability of the study. A minimum of three of each type of project is recommended, with a higher number of successful ones when more than three projects are selected.

8. Case History

Prepare a case history for each project. The examples provided in the referenced IBM projects (Cohen et al., 1979) should prove useful.

9. Refine Items 1 through 6

After analyzing the cases, items 1 through 6 should be modified. Considerable effort would be involved in executing this activity. Input from R&D and user community personnel is needed. Emphasis here should be on doing qualitative, anthropological analysis. Quantitative analysis should be avoided unless sufficient quantifiable data are available.

10. Guidance Document for Tech Transfer

A guidance document should be prepared based on analysis performed to provide information for R&D performers. The focus of the document should be on flexible general guidance. Rigid, mandatory requirements will only be counterproductive. The document can provide a framework that allows R&D managers to develop policy and implement strategies that foster technology transfer. The format of the document and level of detail will depend on the nature of technology, characteristics of the R&D organization, and the user community among other things.

It needs to be recognized that not all research outputs can or should be pushed to tech transfer. This is because need and technology may change during the R&D process, and R&D may not be able to produce what was thought possible during the planning stages. This type of uncertainty in R&D results should be accepted if an organization is ever going to undertake challenging R&D projects. Not being able to transfer technology successfully should not be viewed as a loss or necessarily a poor investment in the unsuccessful R&D project. Projects with unsuccessful tech transfer records can be useful as building blocks for future related research activities. There could be other unintended benefits to ongoing research efforts, though the links may seem less obvious at the time.

11.13 SUMMARY

In developing an effective management strategy for technology transfer, it is important to understand stages of technology transfer and fundamental issues and factors affecting adoption or rejection of new technologies. All these issues and factors that relate to the innovation itself, the adopter, and the organization are discussed in this chapter.

This chapter briefly describes tech transfer activities of the Agricultural Extension Service and NASA. The Agricultural Extension Service has been most successful in technology transfer of agricultural research to the farmer. Its work started in 1914. NASA has undertaken many activities in order to facilitate adoption of space technology for industrial and biomedical applications.

In the high-tech area, effective and timely technology transfer from research to manufacturing is essential to maintain a competitive position in this industry.