

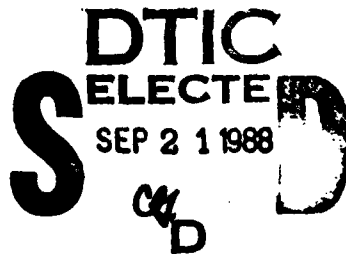
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**US Army Corps of Engineers**  
**The Hydrologic Engineering Center**

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# **Technology Transfer of the Corps' Hydrologic Models**



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# TECHNOLOGY TRANSFER OF THE CORPS' HYDROLOGIC MODELS

Arlen D. Feldman\*

## I. INTRODUCTION

The Hydrologic Engineering Center's, HEC, experiences in transferring hydrologic engineering software to the profession are presented in this paper. It describes several of the HEC's technology transfer activities and the ingredients of successful technology transfer. The paper also discusses several of HEC's successes and failures in technology transfer.

Three main activities are the essence of HEC's service to the Corps: research, technical assistance, and training, see Figure 1. The HEC's research activity is very applications oriented to the problems of the Corps' field offices. In those research activities, the HEC tries to develop generalized techniques to solve specific field problems. Then, those generalized methodologies or software can be applied to similar problems in other areas of the country. The research activities are most often performed in combination with technical assistance projects for the District offices. The first priority in HEC's technical assistance to field offices is for those projects related to the research needs. Thus, the research results are put to a practical field use as soon as they are developed. Research innovations are oftentimes developed right on that field project.

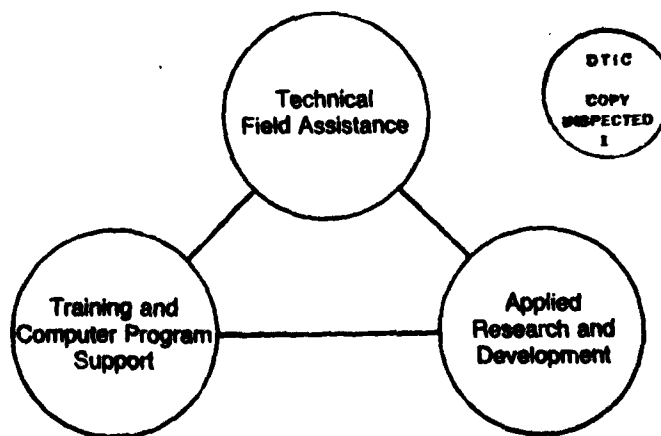


Figure 1. Activities of HEC

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\*Chief, Research Division, Hydrologic Engineering Center, U.S. Army Corps of Engineers, 609 Second Street, Davis, CA 95616. Presented at the Corps' S1 Remote Sensing Symposium, Galveston, Texas, November 1987.

Technology transfer occurs during those technical assistance projects and in training courses which make use of the results. HEC presents formal courses through the Corps training program; students receive the benefits of both the research and the technical assistance programs in those courses (Bonner, 1984). Thus, the district personnel attending the training courses, the districts seeking technical assistance, and the research community are all interlinked.

The HEC seeks to bridge the gap between university-type basic research, and the practical needs of the Corps. Oftentimes the research results from the universities require practical testing before implementation at the field engineering level. As a result of trying to bridge this gap, HEC is often accused of being too practical by the academics, and too theoretical by the districts.

## II. HEC TECHNOLOGY TRANSFER ACTIVITIES

There are five activities the HEC undertakes to perform its technology transfer: formal training; workshops; seminars; field implementation; and continuing support. The formal training is that of the Corps-wide short-course program. Those training courses evolve from work over the years on subjects of general need by the Corps' field offices. Oftentimes the formal training courses begin as seminars or workshops. Workshops are an informal or preliminary training course to meet a particularly timely field need. If there is enough need on a Corps-wide basis, the workshop becomes a part of the formal training program.

The earliest part of the technology transfer program often begins with a seminar. The seminars are an effort to bring together state-of-the-art technology and the needs of the Corps' field offices. Experts from universities, private industry, Corps offices and other Federal offices discuss their latest capabilities. Those capabilities are presented to a selected group of Corps field office representatives. The field offices also make presentations describing their particular hydrologic engineering problems. The intent of the seminar is to bring about a free exchange of ideas between the technology developers and the users.

The field implementation of the developed technology is an all-important link in its success. The HEC works closely with district and division offices to incorporate the newly developed technology directly within their operations (Johnson, 1981). This often involves HEC engineers working directly in the field offices. HEC and field personnel set up, test, and run the technology, e.g., a particular software program. Field implementation also includes the district personnel coming to HEC for more intensive training. The final ingredient of a successful technology transfer is the continuing support of the developed products. The HEC has maintained a software support service over the years to assist users of its computer programs. This continuing support or user service consists of direct responses to user inquiries by telephone or in writing. This continuing support is essential to the successful implementation of the computer programs. As a technology becomes more widespread and mature, the user support can be provided by other offices with the appropriate expertise.

### III. INGREDIENTS OF SUCCESSFUL TECHNOLOGY TRANSFER

There are several ingredients for successful technology transfer. The first of which is that a need exists. Either the user recognizes that the need exists or the need is recognized by the R&D activity. There are different risks involved depending upon how the need is perceived. If the user identifies the need, then there is much less risk both to the user and the R&D activity. If the R&D lab identifies the need, there is more risk to successful field implementation. In this case, the lab must sell the technology; i.e., convince the field office that the new technology assists performing their duties better than they are able to do without it.

The success of the technology transfer will greatly depend upon the resources of the user and the resources of the R&D lab. The management (in the field, in the labs, and in the general organization) is also a key element in the success of the technology transfer. One consideration for user resources is whether the user plans to develop an in-house capability or to contract. In either event the user must have a firm grasp on the technology. The only difference in doing the work by contract is that the user need not develop production resources.

In order for the user to effectively assimilate the technology, they must comprehend the technology, they must have the capacity to absorb the technology, and they must have the ability to apply the technology. The management resources of the user are key ingredients in the successful implementation of the technology. The local management must support new ideas and must be willing to take a risk in their implementation. These managers must be able to see, that is, be confident in, the long-term benefits to be derived from the technology.

The resources of the R&D lab, i.e., the experts, are also extremely important to the technology transfer. Those resources are important for the development of the technology as well as its implementation into the field setting. The management of the R&D activity must be flexible to take on new directions as directed by the field problems. They must support the innovation of their staff in developing the technology. The management must be innovative in their financing to carry over the R&D activities during difficult financial times. As mentioned previously, the lab and especially the technical experts need to be good salesmen to represent their products effectively to the field offices.

It is essential that the experts do not oversell the technology early in its development. They should let the technology grow as it begins to speak for itself through successful applications. The smallest successful application of a new product is the best recommendation there can be for the technology.

In order to be creditable salesmen, the experts must have a sound technical ability; and that ability must be very evident to the field office. The experts need to be patient and understanding in order to appreciate fully the problems of the field personnel. They must see how the field personnel view the particular problems being solved. In order to implement this

technology, the researchers also have to be good teachers. They teach the new users the capabilities and applicability of their products; then, they must follow-up to "make it work." The follow-up support and maintenance of the products are essential to the viability of the technology.

#### IV. ORGANIZATIONAL RESOURCES

The organization, i.e., the Corps of Engineers management, must be willing to fuel the development of the technology. The Corps does this now through their R&D program. It was very gratifying to hear the strong support for remote sensing technology expressed by the Chief of Engineers, General Heiberg, in his keynote address to this symposium. The organization must take special care to encourage a field application of the developing technology. That is, don't let the technology developers drift off by themselves to the so-called "ivory tower." In fact, the organization should require these field applications as the justification of continuing the technology development.

The organization should establish specific elements within its organization to support the technology that's created (Peters, 1980). There is no surer death for new technology than failure to support what is created. The Corps R&D labs and offices usually provide that support. If new technology comes from outside of the normal R&D laboratory system, then the organization must ensure that some elements within the lab, or within another part of the organization, are available to nurture and apply that new technology.

Demonstration projects often help to develop new technology. Such demonstration projects are usually at a larger scale and must seek funding from the general organization. In the case of the major demonstration projects, oftentimes there is such a large investment in the project that it almost always "succeeds" from the institutional stand point, but it may not accomplish much. Thus, it is especially important to involve the field offices so the technology development and application have a firm basis. Without the field implementation, such demonstration projects would find it difficult to be truly successful. With the field application and involvement, the technology can be successfully demonstrated and transferred.

#### V. GIVE TECHNOLOGY A HOME

It is essential to give a good home to the newly developed technology. The HEC has found this to be especially true of its software which has developed over the years (Eichert, 1983). That software can be likened to a person in many respects. During the software's infancy it needs much guidance to correct its errors and steer it to the correct solution. During its teenage years, the technology needs further guidance so the maturing technology is not misapplied. Also, as the technology receives more widespread application, new requirements for the software often occur. The key point is: software is a dynamic technology that must be corrected and developed throughout its life. During the adult years of the software, the organizational support must be there to answer the user's questions and continue to update the technology to the state-of-the-art.

The home for technology support must have staff with sufficient technical expertise to meet the users demands (Feldman, 1983). They provide support in three different ways: assess the applicability of software to different technical problems; provide program usage guidance and results interpretation; and correct errors and make modifications to the software. Oftentimes the users can only describe a particular technical problem hoping the support center will determine the best solution (e.g., computer program). Here, the support center must be well aware of a variety of technologies and be able to advise the user accordingly. When the user is applying the software, they need telephone access to the support center for specific information about how to use the software.

The last function of the support center is to correct errors in the technology (software). Almost every major new application of software requires some modification or error correction. The original software was developed to solve a particular problem; but, when it's applied to new and different problems, often the combinations of various capabilities do not work correctly.

An important means for the technology support center to communicate with its users is a newsletter. The HEC newsletter communicates information about new developments and error corrections in its software. When users discover errors or problems with the software, all known users of the program are so advised. So, either through these advisory notices and/or the newsletters, all of the users are made aware of the changes.

## VI. SUCCESSFUL TECHNOLOGY TRANSFER

The most successful type of technology transfer is the automation of already accepted techniques. This was the case for most of HEC's rainfall-runoff models and river hydraulics models. This is also true of the flood frequency computation methods and the flood damage computations methods. In those cases, commonly used, well accepted, techniques were simply automated into a computer program. In this case, the developer doesn't have to fight the battle of a new technique. Two other examples of successful technology transfer are the development of HEC's water control software and the development of two-dimensional hydrodynamics software. These technologies branch out from the readily accepted techniques category into the use of new technologies. The water control software technology is a combination of previously accepted techniques and new technologies to communicate, display and analyze information.

The two-dimensional hydrodynamics technology is a new technology which was not possible with the past computational techniques. It requires the speed of modern digital computers. The theory of the hydrodynamics is well established, but the numerical approximations to make the computations feasible are new. In the case of the two-dimensional hydrodynamics, the HEC began with small applications in the field offices. The field engineers received training through direct application. Eventually the new technology became part of the regular formal training program.

Technology such as the two-dimensional hydrodynamics requires special user expertise. It's not a technology that any person who once ran a water surface profile can use. There is some discussion in the general literature whether such sophisticated technology should be transferred to the field engineers. Many people believe that such sophisticated technology should remain in the hands of the experts for application. There is some comparison here with the Corps' remote sensing program. Should the specialized image classification and remote sensing analysis techniques be transferred into the field offices, or should they remain within the specialized expertise of the R&D labs?

#### VII. FAILURES OR LIMITED-SUCCESS OF TECHNOLOGY TRANSFER

There are several aspects of technology and user/expert situations which may limit the success of technology transfer. If the technology is beyond the capability of the user, there is no chance that there can be effective use of the technology. As in the case of the computer software, it doesn't make any difference how sophisticated the model is, it's the expertise of the person applying the model that is most important.

Another pitfall of successful technology transfer is that the new technology requires doing business in a different way. That is, not doing the business in an accepted manner both in a technical sense and in the organizational sense. If a new technology requires different elements of the organization to interact, the organization must exert an extra effort to make it successful. This is more difficult than selling new technology to users within a single organizational unit.

The geographic information systems (GIS) technology proposed for the expanded floodplain management studies faced these organizational types of problems. The GIS approach requires the front-end development of a large database by several different organizational entities within a district office (Webb and Davis, 1978). It also required a significant effort from computer management to develop the database (also known as grid cell databank).

Insufficient support for a new technology will certainly doom it to failure; there were already several points made in this regard. Thus, the organization should establish a home to support the new technology. Successful technology transfer occurs when the field is involved throughout the development of the new technology. If the field does not participate, the new product will not be mature enough to be successfully transferred to the field. Lastly, there is the age-old problem of the researcher: be sure there is a problem to solve before developing the technology. If a new technology does a job better but is more costly and does more than is necessary, then, the user will have little incentive to make use of that technology.

#### VIII. SUMMARY

Technology transfer at the Hydrologic Engineering Center takes place in its research, technical assistance and training activities. The interlinkage of these activities is important both to the development and to the transfer of technology. HEC's five main technology transfer activities (formal



training, workshops, seminars, field implementation, and continuing support) were described in relation to those main activities.

Ingredients for successful technology transfer were illustrated. High quality technical expertise is, of course, necessary for successful technology development and transfer; but, it is not sufficient. Successful technology transfer also requires organizational and managerial resources to open a receptive environment for the new technology. And, most importantly, new technology must be given a home and a firm support base. Continued support and development of new technology is necessary to keep it viable.

New technology will either go unused or, worse yet, be misused without successful technology transfer. The best technology (e.g., computer program) in the hands of an inexperienced user is not an advancement. The user must understand how the new technology relates to (simulates) the physical process being analyzed. Without that, the results are meaningless.

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