could be found by visiting experienced fellow employees. They have been able to provide the answer simply because they had been confronted with the same problem during their service to the department and found the answer by conducting their own research or by trial and error. Most of these findings were not documented. Therefore, when this occurs, the researchers always record the findings so they will be available in the future.

At the same time that the interdepartmental research scanning is going on, the researchers also perform a state-of-the-art search of the problem subject. Available for search and consultation are the experience, findings, and recommendations of others in TRB, the National Technical Information Service, Federal Highway Administration (FHWA) and U.S. Department of Transportation (DOT) publication program, FHWA National Evaluation and Experimental Program, FHWA Demonstration Projects, American Association of State Highway and Transportation Officials (AASHTO), and other state highway or transportation departments.

The researchers study the information in the literature to learn what research has been done in the area of the problem at hand. This takes time and is not easy. It is not often that one is able to find exactly what is sought in the literature. It happens, but not often.

Although one seldom finds exactly what one is seeking in the literature, it is almost always possible for an experienced researcher to use the literature to begin defining the scope of a research problem. Sometimes these findings of others can show what cannot be done or, at least, what has not yet been done; for example, preventing the accumulation of bird droppings on bridges. There is considerable material on this subject in the literature, but no completely satisfactory solution has been found.

Again, there may be much information available on a subject, but the researcher is then faced with deciding if the findings are applicable to a particular physical condition such as soil, temperature, rainfall, and elevation.

After the completion of this work, the research problem is presented to the Mississippi State Highway Research and Evaluation Committee for final review and comments before it is submitted to top management for funding consideration. The research and development engineers chair the Mississippi State Highway Research and Evaluation Committee. It is composed of the heads of most of our divisions and the three assistant chief engineers, plus a representative of the FHWA division office. The committee meets quarterly and can meet more often, if necessary. There is a wealth of technical and administrative experience available to aid the researchers in finally defining the scope of any particular research problem of interest to the department.

Having defined the project scope, and assuming that it meets the approval of the top management, the proposal is written, including the nuts and bolts of money, other personnel, equipment, and facilities. All that is necessary then is formal FHWA and Mississippi State Highway Department approval before work begins on the conduct of the actual research.

The FHWA, at least at the division level, and probably higher, has been in on the process almost from the beginning. As FHWA personnel do their job in the evaluation of the research proposal, certainly they also perform some function of scoping. However, the department's relationship with the FHWA, at all levels, has been outstanding and productive. All of Mississippi's research program is funded with Highway Planning and Research Program (HPR) funds, which means that the department almost always has to check with DOT every time a plan is proposed to do any research work. Only rarely is there a problem. For this, the FHWA people, at all levels, are due sincere thanks.

REFERENCE

The Texas Transportation Institute does research under two distinctly different contractual procedures: the research done through our Cooperative Research Program is for our state department of highways and public transportation and that done through the competitive proposal process has federal sponsorship. Let me begin by describing the management process for the contract research program. I will then try to draw some distinctions between this process and that used in the cooperative program.

As a general rule, transportation research takes on more of an interdisciplinary flavor each year. Research projects tend to be larger, and the number of different disciplines involved increases with the size and complexity of the problems being addressed.

**CONTRACT RESEARCH AT THE UNIVERSITY**

Interdisciplinary contract research in a university environment has special problems not shared by contract research firms on the outside or by those who conduct traditional grant research within the university. Contract research within the university must serve two masters. It must provide a usable product to the sponsor and also contribute to the educational objectives of the university. Without effective management and guidance, one of these objectives is often slighted. Research management at this level involves an evaluation of the research process as well as the product. In research evaluation, the appropriate questions appear to be the following:

1. Who should make the evaluation?
2. When should it be made?
3. What sort of things should be considered?

Evaluation, like project management itself, should be considered as a continuous process; however, there are really four times when a formal evaluation is necessary:

1. A "front-end" evaluation at the time the project is being considered,
2. A "start-up" evaluation at the time the project is initiated,
3. A "midterm" evaluation after the project is well under way, and
4. A "final" evaluation after the work is completed and a final report prepared.

There are also three classes of people who should be involved in these evaluations: (a) the research and university administration, (b) the research management, and (c) those who have technical responsibility for the conduct of the research.

Just who would be involved in each of these levels would vary from organization to organization and even from project to project, depending on the size, complexity, and number of different units or disciplines involved in the research. For simplicity, I will refer to the levels as administrative, management, and technical.

Now, as to what should be included in the evaluation—what questions should be asked and what assurances given—this, too, will vary with the time and level of evaluation.

Let us begin with a look at the front-end evaluation. This is primarily an administrative function and should be made at the time the research opportunity has progressed to the point of being given serious consideration but before a substantial investment has been committed to preparing a research proposal. At this stage the following administrative questions must be answered:

1. Does the research contribute to (or at least not detract from) the other academic processes of the university?
2. Will successful completion serve to enhance (or at least not detract from) the reputation and prestige of the university?
3. Does it offer an opportunity for faculty and student involvement?
4. What is the extent of the financial commitment required?
5. Is the research consistent with university policy with regard to such things as patents, publication rights, and secrecy?
6. Are there potential political impacts involved?

There is also a management evaluation that must be made concurrently. Here some questions may be the following:

1. Can we do it? Do we have the interested staff available? Is the funding adequate? Is the time period reasonable?
2. Do we have the physical facilities, offices, laboratories, and equipment necessary to conduct the research?
3. Are the technical expectations of the sponsor reasonable?

Now, assuming that the answers to all these questions have been favorable in the balance, that a proposal has been completed before the deadline, that it was judged technically acceptable by the sponsor, and finally, that you have had enough administrative flexibility and personal stamina to survive the rigors of contract negotiations, you finally have a contract. This may take anywhere from 2 to 18 months. After your principal investigator has regrouped the staff and they are ready to go to work on the project, it is time for the next evaluation.

The start-up evaluation is primarily a management review. Its purpose is to see that the proper institutional support is made available to accomplish the work and that the proper mechanisms are devised to ensure the continuity of the effort. Questions to be asked at this stage include:

1. Do you still have a logical work plan?
2. Are all the staff times available in the amounts called for in the work plan?
3. Are there changes to the staffing or work plans that need to be negotiated with the sponsor?
4. Are the committed facilities still available and adequate?

It is important to ask these questions again at this stage because of the time lag between the preparation of the proposal and the initiation of work. Since we all live in a dynamic society, people who are named in the proposal and are expected to be available for the initiation of a new research contract may no longer be available six months or a year later when the project is awarded.

If we are to assume that an average of 10 proposals are received in response to each request for proposal issued, a success ratio of about 1:10 would be expected for the proposing organizations. Our organization is very fortunate that we have experienced a success ratio of about 40 percent. That is, we have been successful
in receiving about 4 awards for every 10 proposals we submit in the competitive research field. Even with this higher ratio, however, we still face the problem of proposing to do more than twice as much work as we have staff capability to handle. This makes it imperative that the start-up evaluation be conducted in a rigorous manner and that project-life commitments be developed at that time.

The midterm evaluation is also basically a management review. Its purpose is to ensure that our original project team is functioning properly and that they are being provided with all the resources necessary to bring the research project to a successful conclusion. There is also a requirement to step back and make a technical evaluation at this stage. This is our last chance to ask questions such as

1. Is the proposed procedure still the favored approach, or have we found blind alleys and promising new avenues that should be discussed with the sponsor?
2. Are members of the research team staff technically competent and productive in this particular activity?
3. Has the staff developed a logical skeleton for the preparation of the draft report?
4. Is the project on schedule and within the budget? If not, what do we need to do to bring it back on track?

The final evaluation comes at the completion of the study. It is primarily a technical evaluation and is largely concerned with the final product—the final report. At this stage, the principal investigator and research management should have a debriefing as to how well the project team performed and what changes need to be made on future projects. Individual team members should be evaluated and special problems identified and recorded so that they can be considered on future projects.

The last element of project management is concerned with preparation of the final report. Until the final report is prepared, neither the research administrator nor the sponsor really knows how effective the efforts of the principal investigator have been in completing the objectives of the study. Indeed, within the framework that most of us operate today, our research programs are largely product oriented and, like the consumer product manager, our final product is the means by which our entire organization is evaluated. In our case, the final product is the research report. The sponsoring agency generally has already identified the problem, has often defined the conceptual approach to its solution, and sometimes has even outlined a proposed work plan that can be modified only within narrow limits. The professional performance of the researcher, then, is evaluated almost totally on the efficiency in the conduct of the research as measured by his or her capability in reporting research results.

In this context, the research report assumes an importance much greater than its real contribution to the total research effort. It becomes the sole visible evidence of the quality and thoroughness of the work performed by the research organization. In order to ensure the quality of the final product, several years ago we established a series of report review teams to review each draft report prior to its finalization. This review team must answer three basic questions: Is the report technically sound, is it logical, and is it readable? The team is composed of three members. One member is from within the specific discipline or disciplines, one from the general field, and one from completely outside the field. For example, a report on freeway corridor control may be reviewed by a panel composed of a traffic engineer, a geometric design engineer, and an economist. The traffic engineer would evaluate technical quality; the geometric design engineer, the logical presentation; and the economist, the readability and the general sensibility question. Each member, of course, would also have responsibility for suggesting organizational and editorial changes that would improve the overall report.

As the report progresses through each stage of preparation by the principal investigator, it is reviewed by the program manager responsible for that area of research. At this stage most technical, organizational, and editorial revisions are made. A draft is then prepared for internal review. Three copies are submitted for concurrent review by the internal review team not less than 10 days prior to the date the report is due to be mailed to the sponsor.

Members of the review team are expected to complete their review within five days and submit their marked drafts back to the principal investigator. In instances where substantial comments are involved or major changes suggested, a review conference is held between the reviewers and the principal investigator. The principal investigator is expected to give full consideration to the comments received. He or she does not have to accept them all, but he or she is expected to give them professional consideration. Any irreconcilable differences between the reviewer and the author are called to the attention of the administration for further review.

We recognize that this is not a perfect solution and that the very nature of interdisciplinary contract research will make a perfect solution impossible to find. The time constraint alone is such that only a minimum amount of project effort can be devoted to the preparation of the final report. In no funded research programs that I am aware of is there a contractual provision for internal review prior to the submission of the draft report. The tendency seems to be toward larger projects, incorporation of additional disciplines in the research, and a reduced time period for the conduct of the work. Each of these makes report preparation more difficult and review more necessary. I would like to see at least a two-week internal review period incorporated into each contract to provide an opportunity for a realistic review prior to submitting the draft report to the sponsor.

THE COOPERATIVE RESEARCH PROGRAM

In closing, let me say a few words about the Cooperative Research Program that we have developed during the last 25 years or so with the Texas State Department of Highways and Public Transportation. In many ways the management of this program is more comprehensive but less formal and less complex than is the management of our contract research projects.

Over the years, our staff has developed a close working relationship with district engineers and division heads in the department. Each fall we begin a series of meetings in which the major problems of the department are identified and agreed on between our research staff and the responsible districts and divisions. Research problem statements are developed and priorities set by the four departmental area research committees.

In the winter of each year, these priority statements are presented by the area committees to the department's research and development committee and a departmentwide priority list is prepared. During the spring, individual research projects are then prepared
under the guidance of the department's research engineer. By the beginning of the summer, both we and
the department know the overall size of the next year's research program; its division into individual research
projects; the staff, laboratory, and other resource requirements; and the timing of the research activities.

Through the continuous interaction of our research staff with the field engineers and administrators of the
department, we are able to make most of the management evaluations informally and more thoroughly as
the program develops. Consequently, by the time the project is initiated, most of the questions concerning
staff, laboratories, work plans, and resources have already been answered.

I realize that it is not practicable to use this approach in contract research. I do feel, however, that
anything that will bring the researcher and those responsible for research initiation closer together in an
atmosphere that will promote a better understanding of the research problem areas, priorities, expectations,
and limitations would add greatly to the efficiency of research and allow us to deliver a better project at a
lower overall cost. It would also make the research project more realistic and easier to manage.