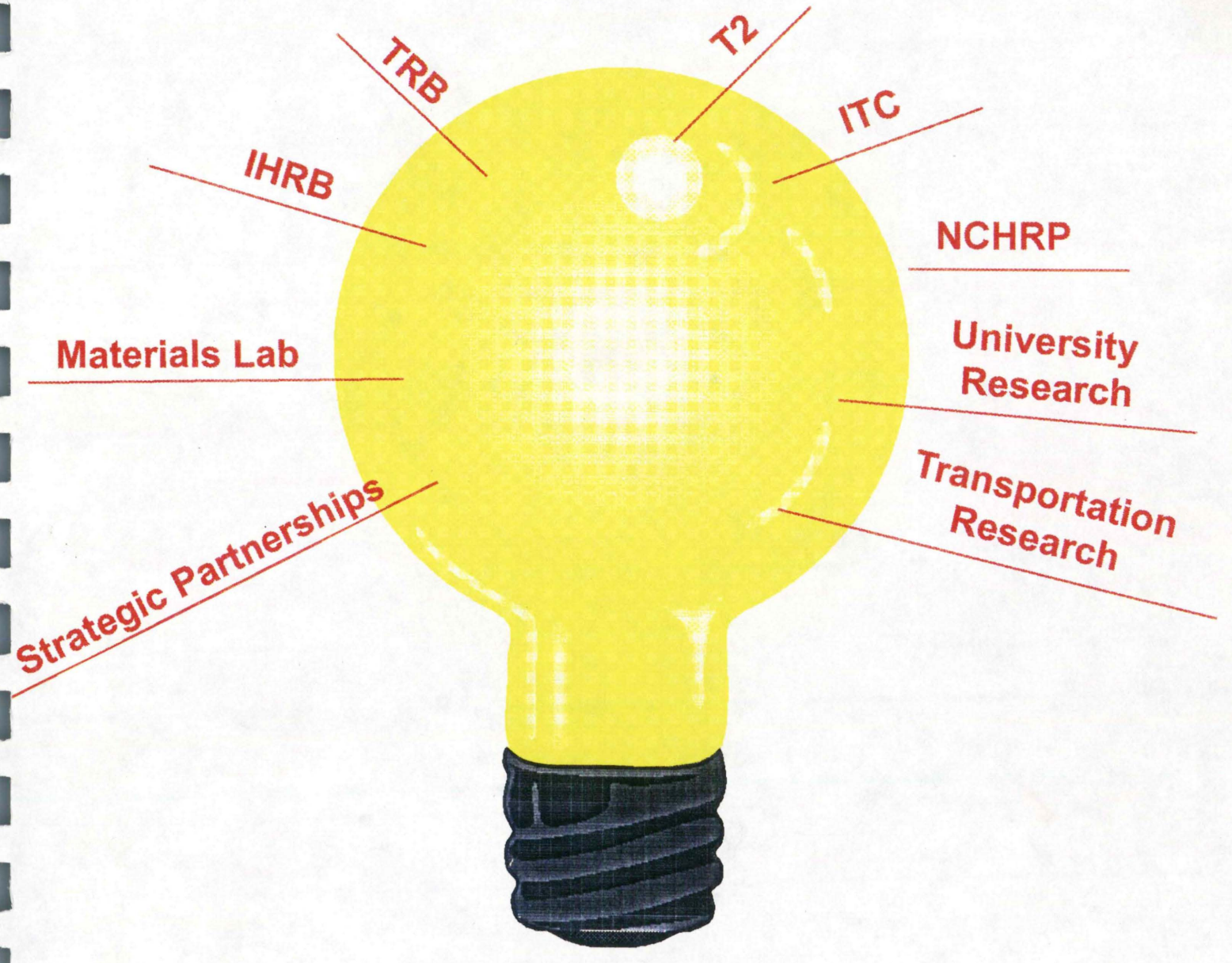
Report to Management Team on Research



By the
Research Review Team
May, 1994

gpc30120

Employee Transition Team: Report On Research

Contents

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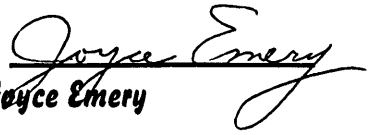

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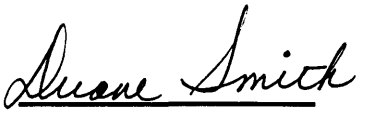

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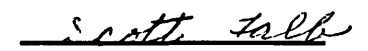

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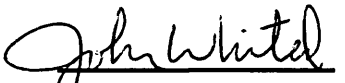

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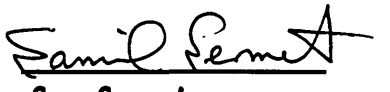

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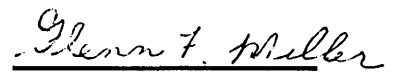


Glenn Miller

Section One: Statement of Purpose

The organization is changing to meet the needs of a horizontally managed environment. Activities that make up Research need to be aligned to support this effort. This report builds on the theme that the Department has initiated many of the activities that create a successful transportation research program. This examination is viewed by the employee team as an opportunity to build on this success to improve and strengthen the research process.

Maintain an integrated research program by focusing on the expansion of knowledge to improve the service of the Department.

Section Three: Guiding Principles

Contribute towards an environment which fosters a spirit of exploration and growth for the organization and individual.

Work with all shareholders to provide a common basis for understanding problems and pursuing solutions.

Search for opportunities to use the "systematic innovation" approach while relying on managed evolution, innovative thinking and technological advancements to improve processes.

Program initiatives focusing on fulfilling Departmental needs in a timely and effective manner.

Create opportunities to foster alliances with outside groups.

Communicate progress/results of program initiatives effectively.

Section Four: Research Milestones

Origins of DOT

At the direction of the Governor, the state Office of Planning and Programming drafted the Iowa law reorganizing the then Iowa State Highway Commission (ISHC) into the Iowa Department of Transportation (DOT). At the time there was considerable discussion whether the new organization should be modal or functional in character. There were serious concerns that the Iowa DOT should represent all modes of transportation, but retain centralized administration and planning and research activities.

This change to a DOT in Iowa was following a national pattern where the several federal transportation agencies were incorporated under the umbrella of the U.S. DOT. National transportation research activities were widening in scope to support the unified transportation environment. The Iowa Highway Research Board followed this national trend.

The Governor's plan for the organization included a planning and research function that would include research needs of all modes of transportation. ISHC research was concentrated on highway research and other research for the continued improvement of highway systems and of their operation.

The new organization needed to retain the highway research, while at the same time incorporating research for all modes. The workable compromise was the inclusion of materials, engineering and operational research into the Highway Division and the establishment of a new research activity in the Planning and Research Division. Similar changes regarding research were reflected on the national scene.

The new organization faced rather large changes with the restructuring of the railroad industry, where main lines and branch lines were abandoned and scrapped. Restructuring also occurred in the rubber-tired passenger and freight service, and continues today in all modes of transportation. Transportation research has expanded in its attempt to serve all modes. It included cooperative research with the railroad industry to try to find a cheaper, yet effective Iowa ballast product for branch line to replace rock material hauled form long distances; with aeronautics to find more effective pavements for runways and taxiway and for lighting needs; and for government automation.

Transportation research continues to widen in breadth and scope to fill the needs of the public.

People and Offices

With the establishment of the Iowa Highway Research Board (IHRB) in 1949, the Iowa State Highway Commission embarked on a formal research program. Mark Morris, traffic engineer, was appointed by Chief Engineer Fred White to serve as the director of Highway Research. There are no records to indicate that any additional staff was assigned.

Stephen Roberts was named research engineer in 1960. Additional staff of one engineer, one technician and a part-time secretary were assigned. The Research Office was assigned to the Planning Division. The primary function of the office was to administer the activities of the IHRB and make whatever field investigations could be accomplished by the staff.

In July 1975 the responsibility for these research activities was transferred from the Planning Division to the Highway Division and assigned to the Office of Materials. The logic behind this decision was that since a new laboratory facility had just been constructed, and since the primary type of research being pursued was highway-related it made sense to physically move the research operation into the new facility where efficiencies dealing with facilities, equipment and other resources could best be realized. It functions that way today.

General transportation research is presently under the direction of the Transportation Research Office in the Planning and Research Division. The office directs transportation research activity and monitors a number of contract research projects. Staff reductions have limited the scope of these activities.

Outcomes

Iowa, with the Iowa State Highway Commission and subsequent Iowa Department of Transportation, has a history of innovations by employees from its origins in 1904. Some of these innovations are the result of ingenuity of our work force not satisfied with presently available machines or processes; others are the result of traditional research resulting in a practical application. They are considered as milestones in our history, and some have been listed:

Iowa State Highway Commission
Proportioning materials by weight
Mud jack or mud pump
Slip-form paver
Tapered inlet culverts
Aluminum I-Beam bridge
"No Passing Zone" sign
Prestressed steel I-Beam bridge
Machine finished bridge decks
Photo/file technique

Slip-in bituminous oil distributor and hopper spreader boxes
Iowa method of bridge deck repair and surfacing
Full depth, no-base, hot-mixed asphalt cement concrete
Continuously reinforced paving without transverse steel
Recycling asphalt concrete while meeting environmental regulations
Flowable mortar alternative to bridge replacement
Reducing transverse cracking in hot-mix asphalt pavement
X-ray evaluation of carbonate aggregate for portland cement concrete (PCC) pavement
Design criteria for integral abutment bridges
Iowa fast track concrete pavement
Video evaluation of highway drainage systems
Image analysis of PCC and AC pavements using SEM images
Scanning electron microscope invesitgation of PCC pavement deterioration
Vacuum evaluation of PCC pavement joints
Highway advisory radios/traveler information stations
Iowa Rail Commodity Study
Automated process to count aircraft
Iowa track evaluation vehicle
Assessment and placement of Iowa DOT's maintenance garages
Weigh-in-motion
Update photo/video logging vehicle

Section Five: Existing Research Program

The information provided should not be viewed as a complete list of research activities. Many innovations occur as a natural exchange while discovering better ways to get the job done. Rather, view this information as a review of research areas that typically are thought of when describing the research program at DOT.

The research process gets started from ideas generated from Department staff, persons outside, or through a cooperative effort to support a program requirement. Once started, it may be managed by Department or program staff from other institutions. The level of direction and/or participation affects how effectively results will be transferred, and for the satisfaction with the program as a method to provide workable solutions.

When the Department contributes funding, whether by initiating a specific study or providing a "guaranteed" amount per year as matching funds, the nature of the partnership depends on the policies governing each individual program.

OFFICE OF MATERIALS RESEARCH SECTION

Staff

The Director of the Office of Materials supervises the Research Section. General daily supervision of research activities is under the direction of the research engineer (transportation engineer 2). In addition to the research engineer, the staff includes two transportation engineer associates, one materials technician 4 and a secretary 1 (shared with another section). This relatively small staff puts an emphasis on teamwork to accomplish the research responsibilities.

Funding

In general, funding for the formal research projects (HR-1 to 500) recommended by the Iowa Highway Research Board comes from the Primary Road Research Fund, the Secondary Road Research Fund and the Street Research Fund. All of these funds are restricted to use for highway-related research. Since FY 92, $750,000 of uncommitted funds from the Primary Road Fund have been authorized annually for the Primary Road Research Fund. No Primary Road Research Fund balance is carried forward. Any portion of the $750,000 authorization that is not spent returns to the Primary Road Fund.

The Secondary Road Research Fund was established in 1949 and is currently set forth in the Code of Iowa as:

> 310.34 Secondary road research fund.
>
> Notwithstanding any law to the contrary, the department is hereby authorized to set aside each year not to exceed one and one-half percent of the

receipts in the farm-to-market road fund in a fund to be known as the secondary road research fund.
[C50, 54, 58, 62, 66, 71, 73, 75, 77, 79, 81, §310.341

310.35 Use of fund.

The secondary road research fund shall be used by the department solely for the purpose of financing engineering studies and research projects which have as their objective the more efficient use of funds and materials that are available for the construction and maintenance of secondary roads, including bridges and culverts located thereon.
[C50, 54, 58, 62, 66, 71, 73, 75, 77, 79, 81, §310.351

For many years, the 1.5% has been set aside for the Secondary Road Research Fund, and in recent years has provided $750,000 to $800,000 annually for research projects. once funds have been set aside for the Secondary Road Research Fund, they must be used for engineering studies or research projects.

The Street Research Fund was established in 1989 and is currently set forth in the Code of Iowa as:

312.3A Street research fund.

Prior to the allocation to the cities under section 312.3, subsection 2, the department is authorized to set aside each year two hundred thousand dollars from the street construction fund of the cities in a fund to be known as the street research fund. The street research fund shall be used by the department solely for the purpose of financing engineering studies and research projects which have as their objective the more efficient use of funds and materials that are available for the construction and maintenance of city streets, including city street bridges and culverts. The research projects and engineering studies authorized shall be conducted in cooperation with the city engineers. On or before January 31 each year the department shall file a report with the governor, state transportation commission, city engineers, chief clerk of the house of representatives, and secretary of the senate showing the work

accomplished and projects undertaken under this section. 89 Acts, ch 293, §14

Any remaining balance in the Street Research Fund is carried forward into the next fiscal year.

These three sources provide funding for more than $1,500,000 of highway-related research annually. Funding for some projects is from all three funds if the research will be a potential benefit to all three jurisdictions.

Salaries and expenses of the general office operation are funded through the Office of Materials budget.

Iowa Highway Research Board

The Iowa Highway Research Board was established in 1950 to assist the Iowa DOT in a progressive and productive research program. It has always functioned well and been a definite asset to the Iowa DOT. It functions essentially the same as when it was established in 1950, except that two engineers employed by municipalities were added. The Iowa DOT Policy and Procedure 420.01 for the Iowa Highway Research Board is attached as Appendix A1. The current board membership is attached as A2.

Research Projects

The research projects funded by the primary street funds can address any aspect of design, construction, maintenance, management or materials for highways. The projects can be conducted by a county, a city, a university, a consultant or the Iowa DOT, depending on the type of research. The Research Section maintains records on all of the highway-related research. A research project numbering identification has been established to facilitate record keeping.

The formal research and development projects are established as described in Iowa DOT Policy and Procedure 420.02, which is attached B1. Projects numbered HR-1 (initiated in 1950) through HR-367 (initiated in 1993) are a series of projects formally recommended by the Iowa Highway Research Board (Attachment B2). They are approved by Iowa DOT staff action and funded by the Primary Road Research Fund, Secondary Road Research Fund and the Street Research Fund. They may also use federal funds.

Projects numbered HR-501 (initiated in 1973) through HR556 (initiated in 1993) are a series to evaluate experimental features in federally funded primary, secondary or urban construction projects (Attachment B3). In some cases there are no additional funds for the evaluation; in other cases the FHWA will grant funds for the evaluation.

The series of research projects HR-1001 (initiated in 1974) through HR-1062 (initiated in 1993) includes demonstration projects, special FHWA contracts, national pooled-fund projects and other specially funded research projects (Attachment B4).

There is also a HR-2000 series that was established for files to assist in recordkeeping on research conducted by others, subjects that may be of future interest, or very informal research activities.

Monitoring, Testing and Evaluation

The Office of Materials Research Section monitors the progress and status of all formal, 500 series and 1000 series projects. Many of the formal research projects are conducted by Iowa State University. On some of these projects Research Section personnel will assist the research by drilling "cores" or evaluating performance using special Iowa DOT equipment. The secondary road research coordinator will assist by conducting testing and evaluation of secondary research projects.

Most of the testing and evaluation of 500 series experimental feature projects is conducted by Research Section personnel. This includes crack, patch and rut depth surveys and also coring, friction testing and smoothness testing.

Many of the research projects are evaluated for a number of years (often 5 years). Research Section personnel compile the annual data in project files and often compare experimental sections with conventional sections.

Final Reports

Research Section personnel write many final reports so permanent records of research activities and conclusions are available to anyone who is interested. An effort is made to ensure that a final report is prepared on formal 500 series and 1000 series research projects conducted by other agencies. A supply of final reports are retained in the Research Section and distributed when requests are received.

An extensive library of Transportation Research Board (TRB) reports are on file in the Research Section, and extra copies of many TRB reports are available.

Materials Laboratory Research (MLR Program)

In addition to the research administered by the Materials Research Section, there are additional studies carried out solely within Materials or in conjunction with other offices. Staffing to conduct these studies comes from within the various testing sections of the laboratory. Typically, 5-10 such studies are done each year. They normally involve materials evaluations and result in specification or procedural changes.

Strategic Highway Research Program (SHRP)

The $150 million SHRP project is now completed. The task of implementing research results remains. Additional personnel training, equipment acquisition and data evaluation is being done to assess which of the 130 products and processes coming out of this program are applicable to Iowa.

OFFICE OF TRANSPORTATION RESEARCH

Staff

The office was created in the mid-1970s. The acting director of the Office of Economic Analysis currently supervises and provides administrative support to the Office of Transportation Research. The office has four permanent positions: one is vacant (office director); and one position has been assigned half-time to work on bridge and pavement management systems, with the remaining time spent on research projects. Two staff positions support ongoing research activities and provide support services. The office also supports a graduate work study program.

Funding Staff

Over 50% of the office director's salary is funded by State Planning & Research (SPR) funds. State funds are used to support the remaining staff salaries. Staff salaries are usually used as in-kind match for many of the federal research programs that are initiated.

Project Funding

Several methods are used to initiate work:

1. Respond to federal requests for proposals.
2. Direct contact with FHWA (Washington, D.C./Region) Program Management.
3. Iowa Highway Research Board.
4. Support from other office budgets.
5. SPR Fund (The 1991 Intermodal Surface Transportation Efficiency Act requires the state spend at least 0.25 %(SPR) for research.)

Services

Statistical and problem-solving support to Department offices and divisions in these specific and general areas:

Pavement Management
18 KIPs
Friction Review Committee
Statistical Sampling/Surveys
Statistical Model Building
Statistical Exploration of Data
Statistical Quality Control

Coordinate the University Transportation Center Program (UTC) and Local Technology Transfer Program (LTAP).

The UTC program is federally sponsored, with FHWA and FTA providing half of the financial support. These federal funds are then matched dollar-for-dollar by support from non-federal sources as private industry, universities, and state and local government. The Department supports part of the match (up to $350,000), based on projects identified as

topics of interest to the Department. The program is now completing its sixth year.

The LTAP program began in January 1983. The objective of the program is to provide for the transfer of technology to local government agencies involved in providing transportation services, as well as in public transportation. An advisory group meets regularly to provide input on the program and the delivery system and a close liaison is maintained with Iowa State University and FHWA. Initially the program was funded 100% by FHWA in the amount of $125,000 annually. In 1986 it required a 50% match. The local match was provided by IHRB. The program expanded by adding federal Section 402 dollars to fund a Safety Circuit Rider Program. (This idea received a national award). Recently the program focus has also begun to address small urban area issues. Evaluations of the LTAP program, both from the users and from FHWA, have been excellent. The program format is constantly evaluated on the basis of the evaluator's comments.

Monitor, coordinate, administer and evaluate the Intelligent Vehicle Highway System (IVHS) Program.

Enterprise is a multi-state consortium interested in various IVHS research and development initiatives on a joint participation bases. The partners in this process include Arizona, Colorado, Michigan, Minnesota, North Carolina, Washington, along with FHWA, Transport Canada, Ontario and the Dutch Ministry of Transport. Iowa is a member of this group and is working to develop several advanced technical projects and improve the communication and knowledge of its members on IVHS topics of all types. Several proposals have been submitted for consideration in response to FHWA's IVHS Program Solicitation.

IVHS-CVO Automated Fuel Mileage Operational Test/Iowa DOT (lead organization) submitted a proposal in cooperation with Minnesota DOT, Wisconsin DOT, ITC, Rockwell, Rand McNally, ATA Foundation and state trucking associations. The proposal was competitively selected for funding and the project is currently underway.

Research Projects

Projects start from a client base and a problem to solve. While applying technology is part of the process, many times it becomes transferring the information in a manner that fits the situation. Topics currently underway include:

Videologging van/side camera & Global Positioning System; Remote sensing and RF transducer/automate collection of roadway data.

Research Relationships

Many formal and informal relationships exist within the Department that help coordinate research needs and get the work done. At the same time, research needs in a number of offices could be enhanced through more effective coordination. The status is one in which there are many effective research relationships in various areas of DOT which need to be extended by some systematic method to achieve better coverage throughout the agency.

Although this section serves primarily to describe the existing research program, various issues are mentioned which will be developed in greater detail in later sections of this report.

Figure 1, "Existing Iowa DOT Research Relationships," illustrates schematically the more formal relationships, particularly those described earlier in this section. If the minor and less formal relationships were added, lines would cover the diagram. One might wonder how gaps could exist. However, unless DOT personnel have direct dealings with programs involving the Iowa Highway Research Board or the Iowa Transportation Center, the awareness of these areas as resources for research strategies and potential collaboration is generally low. This would seem particularly true for non-highway and non-engineering related research needs. Certain fields within transportation historically have been "on their own," so to speak, with regard to research. Current reorganization directions, such as toward an intermodal agency, suggest complementary changes in patterns of research relationships could be beneficial.

Research problems are becoming increasingly complex in terms of problem definition, interdisciplinary and inter-jurisdictional requirements for conducting studies, and the skills required to implement new knowledge, techniques and technological innovations. It is becoming increasingly common now for research ideas to be generated by committees, for research studies to be conducted by interdisciplinary teams of experts, and for implementation of results to require effort worthy to be called a project in and of itself.

Given the dynamic situation which already exists today, research relationships within the Department are already changing. Those changes can only be effective enough and rapid enough if research needs are regarded as important by management, with a view toward total integration into the fabric of how we do work and conduct business.

Existing Iowa D.O.T. RESEARCH Relationships

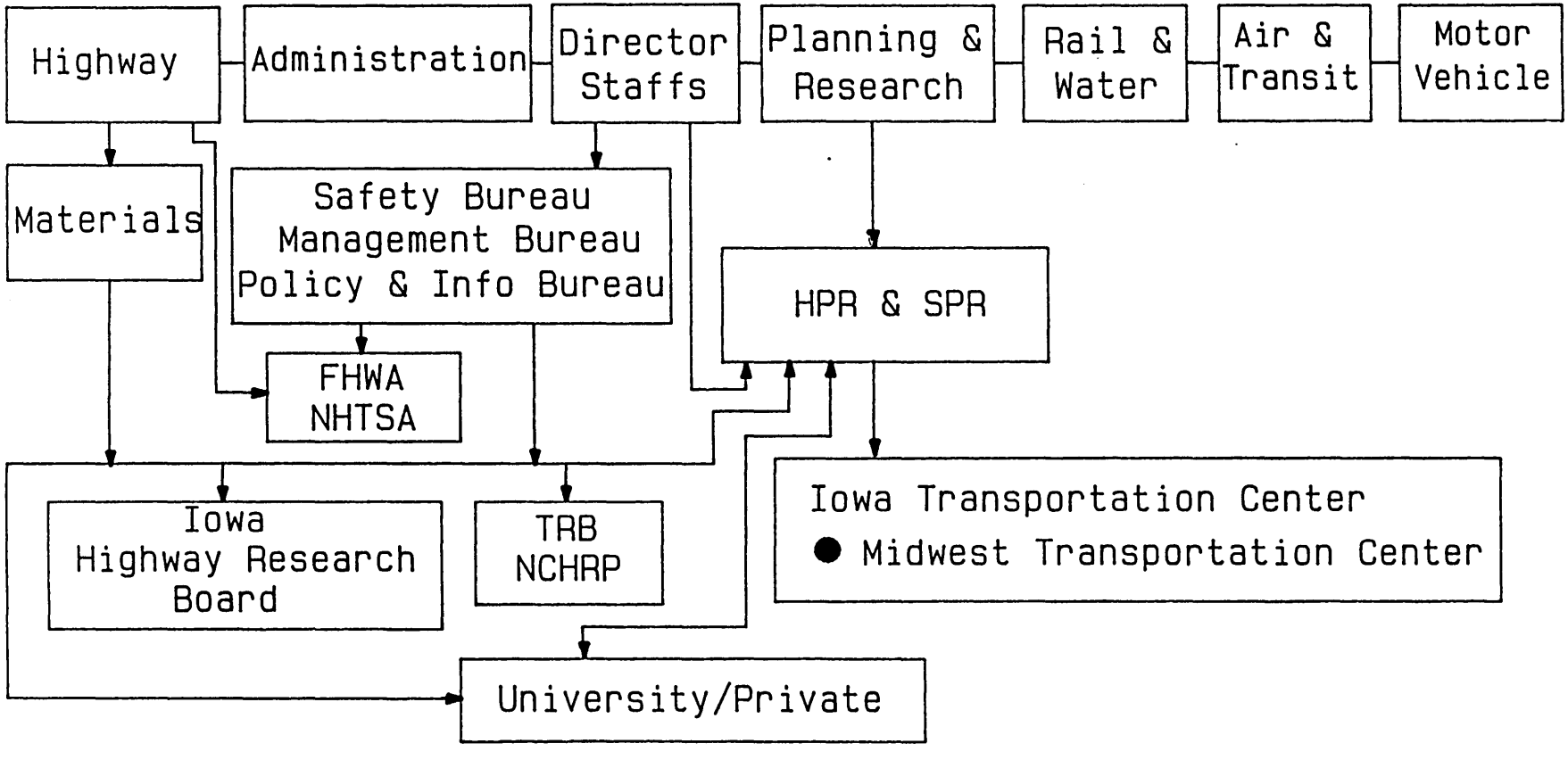


FIGURE 1

* Every Division does some research internally

Idea/Problem Process

Figure 2 looks at the Department from the standpoint of how research ideas now flow through the system. Assume in the top box, "Problem or Idea," that an idea has been generated by an individual, group or committee. As it develops into a research proposal and eventually into a funded research activity, there are three routes it can go within the Department. One is to work through the research staff, which presently is located with the Planning and Programming Division (left column). Another is to go to the Highway Research Board (middle column). Each of these two options gives the idea-generators access to DOT staffers with extensive experience and expertise in the management of research activity.

The final option is for the individuals or group originating the idea to handle it on their own, either by assigning DOT resources to it or by finding funding and expertise on the outside.

For any given research problem or idea, one of the three options will be the most effective and efficient. Currently, there is not much help selecting an option. Most people with research ideas take whatever path they are most familiar with instead of looking for the best match to their research needs.

Another aspect of the current idea/problem process is how research ideas are generated in the first place. Under conditions existing in the Department today, there is much variability concerning whether individuals and groups are encouraged to think innovatively, whether their ideas are listened to, or whether they are aware of resources they could use to develop their concepts, judge feasibility and initiate a proposal or an experiment of their own. Examples of successes are numerous--but they are still more the exception than the norm.

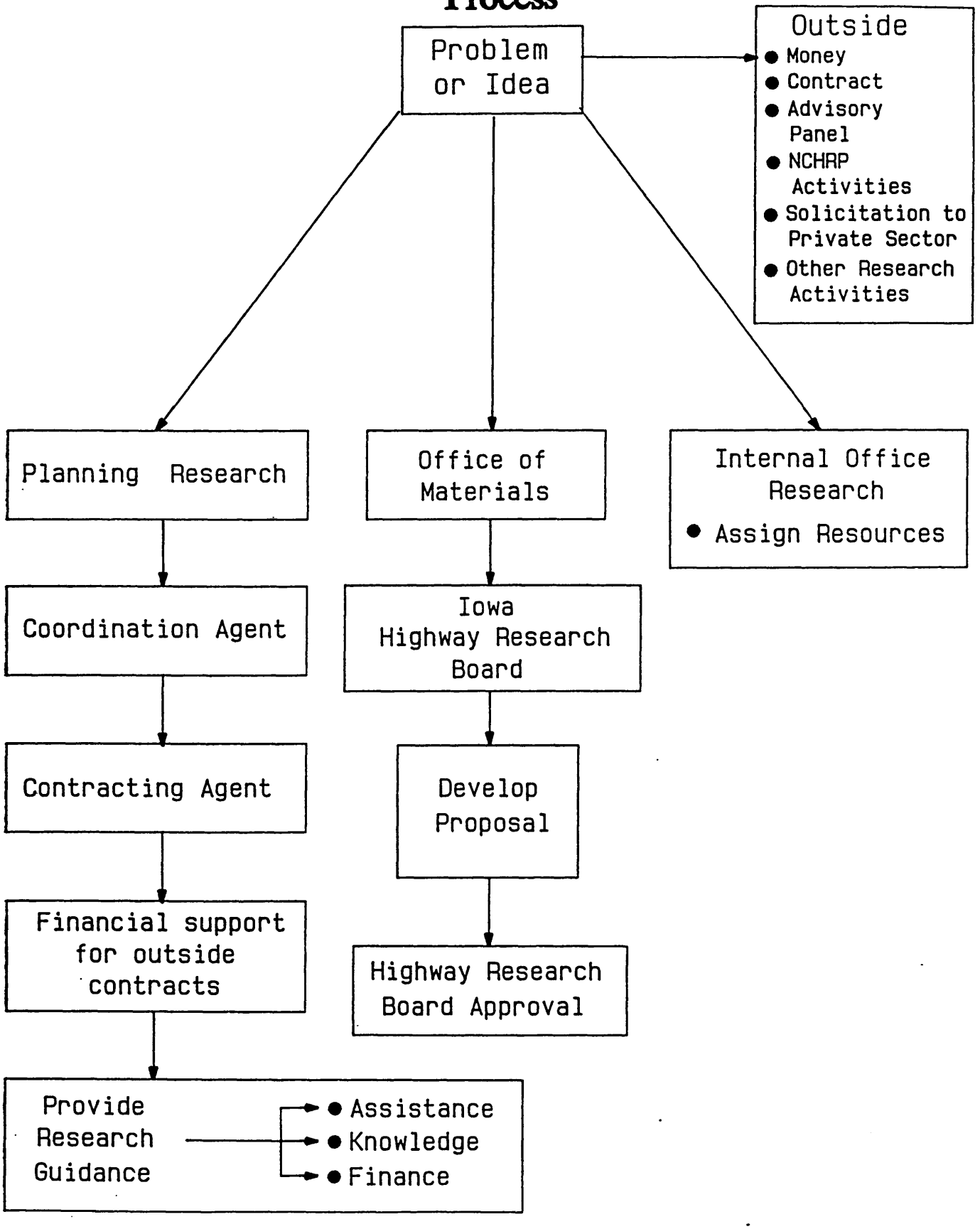
The research idea/problem process will flourish if employees have opportunities for creative thinking and brainstorming, have access to persons who are conduits to research activity, and are made to feel a part of the cycle of research and implementation. These cultural aspects of the Department's research activity are making inroads with the advent of quality management techniques. These techniques are bringing valuable experiences to workers who previously had little say in how they did their work.

At the same time, the other end of the spectrum should not be ignored. Many of the Department's research problems must be solved at the most sophisticated levels. Regardless of who conducts the research or where it is done, persons internal to the department must be capable of understanding the problem, managing and evaluating the research activity, and implementing the results. That now requires, and will continue to require, a certain level of expertise with the Department.

Finally, it must be remembered that the pursuit of excellence and further integration of research into the fabric of the Department require the stimulation of ideas from without as well as from within. In the past, the DOT maintained leadership status among transportation agencies by involvement in national associations and committees and through collaboration with research partners. Senior staff have leadership roles via committee appointments and through presentation of papers at regional and national meetings.

FIGURE 2

Existing Idea/Problem Process



These connections matter; they make a difference. As senior staff continue to leave the agency, it might be well to encourage broader participation by Department staff, and at earlier stages in their careers.

Hopefully, this description of the existing research program has revealed why pride in past research achievements is well deserved, but also why change is needed here just as in other areas of the department.

Section Six: Changing The Research Mind-Set

Elements For Change

In the past, the Department has organized itself to conduct and sponsor research but has not taken the next step to ensure rapid implementation. Eventually, innovations seep into some level of practice, it's the pace at which full acceptance is reached that returns the largest pay back. Too often, especially with contract research, the research report is the final step of the effort to cause change. If management feels that the job is done when the report is written in simple language and sent to relevant personnel, implementation is still far from certain.

Research is a tool used to help assess and limit the level of risk when carrying out change. Recognizing that research is merely one aspect of an "innovative process," a system needs to be devised to assure rapid acceptance of new technologies and ideas. Some components of an "innovative process" include the following observations listed below. At first glance it may appear there are issues that may be inconsistent with each other; but, the role of management is to provide balance and guidance so these issues do not become destructive.

1. Management must be directly involved in the implementation loop.

2. A well-defined strategic plan known and understood by everyone is required.

3. An innovation effort must include all sources of change, of which internal research is only one.

4. Change can be an interesting feature of daily operational work that can make the work creative and challenging.

5. Change can be hastened deliberately by properly organizing for it.

6. Change can be resented if urged upon personnel abruptly.

7. Operational people have too many daily crises, problems and aggravations to be solely responsible for adopting changes.

8. Ability to initiate and respond immediately to partnerships is necessary.

9. Trained personnel to implement and track developing technology are needed.

10. A central role in coordinating all research activities is desirable.

Main-Stream Research Results

Implementation of innovations should be viewed as the goal, and research is merely a part of the process. An innovation process should encompass the following:

1. All personnel should be part of the innovative process.

2. Recommendations for change should be submitted to management and be part of the innovative process.

3. Proposed innovations should provide practical solutions to its sponsoring division/office.

4. Creative thinkers need to be assigned to an innovation group.

The innovation group identified in item four would be responsible for using technology/new ideas/new processes to improve the effectiveness of the DOT. The following guidelines are proposed:

1. Responsibility for innovations should be vested in an individual and/or group who manages the process on a regular basis.

2. The innovation group must include people with backgrounds that enable an evaluation of all the sources of innovations including:
    a. In-house research
    b. External source research
    c. Innovative practices of other agencies
    d. Creative ideas for development projects

3. The innovation group must include full-time personnel who can encourage and help operational groups in adopting innovations.

4. The innovation group must recognize that the selling of change is best accomplished by involving at the outset those who must eventually implement change. Also an important role management provides is to make certain that the chance for positive change will not be overlooked. A climate for change should be part of the Department's common practice.

5. The innovation group must be able to delineate:
    a. Problems that have been solved elsewhere.
    b. Solutions that need research to be set in motion.
    c. Problems that need long-range research and high funding.
    d. The differences among the three types of issues.

6. The innovations group must realize that operational personnel are constantly upgrading their procedures and that research is not the sole source of change. The ideal attitude is that everyone must be alert to beneficial change, but that the innovations group has the responsibility to bring beneficial change opportunities to the attention of the operational groups.

Integrate BEST (Building Excellence In Services and Transportation)

It is important to recognize and support the steps taken by the Department to implement a quality improvement strategy. In order for the Department to undertake quality research, a positive environment is necessary. This starts with a commitment to continued improvement in the quality of everything we do. ll managers need to create an organizational environment that generates continuous improvement for systems of production and service. This requires a continued investment in understanding how things work.

The key players in research need to be champions, facilitators, enablers and providers of resources, not merely controllers or individuals who are primarily focused on everyday activity. Both management and employees must create ownership and share in the responsibility to maintain and create trust and confidence throughout the process. All employees need to understand the relationship of their work product to others' work, and decision-making should be accomplished at the most appropriate level of the Department. All employees must be encouraged and positively recognized for their ideas and suggestions whether they are successful or unsuccessful.

Goals, targets or standards should be developed jointly with employees. These tools should be used by the Department to evaluate its processes and not its employees.

Section Seven: Role of Iowa Transportation Center

Background

Iowa State University was one of the earliest institutions (1862) established in the movement to create an educational system whose aim was to promote "liberal and practical education...in the several pursuits and professions of life." Over the years, ISU and the Department have and continue to share development of many pioneering concepts for the transportation community.

A program announced in 1982 by FHWA provided an opportunity to focus attention on the importance of transferring the results of research. Iowa DOT and Iowa State University Engineering Extension Service submitted a proposal to establish a Technology Transfer Center. The Iowa proposal was one of 10 selected to participate in the FHWA-sponsored program the following year. This program was funded at 100% by FHWA through September 1986. The program has subsequently been funded with a 50% match of local and state funds.

In 1987 the U.S. DOT established the University Transportation Center Program. The focus of the program is on long-term applied research that spans all transportation modes. After a competitive selection process, the U.S DOT selected Iowa's proposal for Region 7 to carry out the program. The Midwest Center mission is to attract the best talent to the study of transportation and to develop new strategies and approaches that effectively address transportation issues.

The Technology Transfer and the Midwest Center contracts provided the basis to support an ongoing formal transportation program. The Iowa Transportation Center was created to provide an organized focal point for transportation interests on campus, enabling individuals, government and industry to gain access to university-based educational services, intellectual resources and specialized technical facilities and services.

Value to the Department

The Iowa DOT has a unique opportunity to supplement and enhance the Department's research program. A long-term working partnership can provide an environment supported by confidential deliberation, program flexibility and trust.

The commitment displayed in the past by each organization has created an environment for a strategic partnership to emerge. Several scenarios could be successfully implemented but the following approach adds immediate value to both organizations.

Identify areas of common interest. Some areas to be explored further include:

National and regional transportation issues

Practical applications of emerging technologies

Training for knowledge jobs

Building coalitions with public-private sectors

Apply Iowa Transportation Center strengths to support research objectives:

Can facilitate the team concept to reach a specific goal.

Support from a full range of experts with ability to access a rapidly changing technical base.

Ability to view issues in a technology-neutral environment.

Offers a different perspective.

Flexible program environment.

This concept of mutual alignment supports the Department's self-interest in developing staff with knowledge skills capable of initiating, evaluating and directing research activities.

The Department research needs or interests will not always coincide with academic pursuits. The purpose of a strategic partnership is to build on the common areas of each institution.

Section Eight: Issues

In reviewing the research at the DOT, several issues have surfaced through the course of the investigation. They have been divided into four areas: communication and coordination; process; implementation; and review/evaluation.

Communication and Coordination

There seems to be a lack of general knowledge of the research process by those not directly involved. Task group members were not aware of all the research activities within the Department. Although the various components of our research program, IHRB, TRB and NCHRP, have well established structures and procedures in regard to funding and selection of research projects, this information is not widely known among all the potential research shareholders.

This lack of horizontal communication, across departmental lines, seems to have a marked affect on level of knowledge of the research program. Those not directly involved in the administration of these research components often have a limited understanding of the process outside their own sphere of operations. While access to these research programs are readily available, there is a lack of operational knowledge as to available funding, technical expertise and the various selection processes. This has prevented the full utilization of these assets by all potential users. All of the shareholders do not seem to be aware of the research infrastructure nor understand its use.

While there is widespread dissemination of some research (IHRB), with more than 200 copies distributed both internally and externally, the results of other research activities are not as well known. Often the applicability of these activities is not fully appreciated due to this lack of a coordinated communication system.

Another issue that pertains to communication and coordination deals with the management of our electronic informational systems. With the rapid technological changes that are taking place, especially in the research field, some type of data management system must be in place to ensure the compatibility of research components and the availability of results in useable formats among all shareholders. While data collection technologies are essential, the challenge is to integrate these informational technologies so that the individual parts are made more useful by contributing to the whole.

Process

While there are policies dealing with some components of our research program, IHRB and Transportation Research, there is no department-wide policy addressing the subject of research. The people responsible for these research components are very well versed in how the research is organized, funded, reported and distributed. However, this knowledge is often limited to their own operational areas. There are many diverse research interests, but no overall agency focus or administration dealing with how the components are used to benefit the Department as a whole. The development of a agency-wide policy should not only document the process, but provide a conceptual framework that would assist relevant decision makers in developing a research program that supports Departmental objectives.

There is some concern with the role of the Iowa Transportation Center/Midwest Center and our research program. ITC have become a very good source of professional assistance, but the scope of their activities needs to be defined in regard to an overall Department research policy.

Implementation

Once research has been undertaken and completed, how are the results utilized? Given that the research results has been successfully communicated, the potential user must accept the ideas presented and must be able to put them in practice. There are questions regarding the utilization and implementation of completed research within the agency. While much effort is devoted to conducting research, in many cases the process of implementation is often not a high priority. The implementation procedures for the SHRP program provide good documentation on how SHRP products come through the DOT and are reviewed. This same type of implementation process should be examined for other research activities.

Review and Evaluation

Other questions raised during the study concerned the need for review and evaluation of research that has been completed. The research components do contain a level of performance measurement, but there aren't any equivalent overall performance measures for the research program. While this process could take on a variety of roles, depending on how its function is defined, it should provide an analytical framework for the evaluation of research projects. The effectiveness of any research program should be measured on its contribution to overall Department objectives.

Summary of Research Issues

Communication & Coordination
- External Relationships
- Knowledge of Process
- Funding Sources
- Technical Expertise
- Activities/Results
- Agency Focus
- Data Management

Process
- Access
- Funding Priority
- Availability of Technical Expertise
- Conduct of Research
- Documentation
- Department-wide Focus
- Programming
- Relationship With Iowa Transportation Center
- Administration

Implementation
- Use of Results
- Barriers

Review and Evaluation

Section Nine: Options

Overview

There are several elements which are common to all of the options. The following paragraphs will explain these common elements.

Policy Steering Committee

The Policy Steering Committee is envisioned to be a division-level responsibility and will provide continuity of the research program and delineate the course to be followed. Duties of this group include guidance (figure out what's right), eliminate project over-control while enforcing standards, and establishing financing.

Division-level Responsibility

The Policy Steering Committee would interact with the Research staff by route of a division-level responsibility. The division-Level responsibility would be one of three: the Chief Engineer's Office, the Project Development Director or the Planning and Programming Director. The perspective that research is an agency-wide resource is viewed as part of the existing work assignments already contained in these divisions. The division-Level responsibility would also coordinate and be responsible for TRB and NCHRP activities.

External Resources

External resources have been identified as an input to the research effort. The potential contributing entities include private ventures with industry, associations with universities and staff, coordination with the efforts of other states or governmental entities, and advisory groups which would be assembled on a project-by-project basis. The main emphasis at this point in time is the growing relationship with Iowa State University's Transportation Center. This venture will help identify and focus on areas of common interest, apply the Iowa Transportation Center's strengths in support of Department research objectives, will facilitate developing Department knowledge and skills, and provide other outlet avenues for applying research programs into day to day operations.

Expert Focus Teams

The expert focus teams are specifically identified because some members would be selected from DOT staff. This assignment would have an impact on their normally assigned duties. The committee wanted to make a positive statement about this element. The assignments given to the expert focus teams need to be made with the acknowledgement that: individuals are committing a significant amount of time; they have the background or desire to expand their knowledge on a specific topic; they can fully participate throughout the process and they will be recognized for their efforts. The experience gained will build a multi-discipline team that can benefit from technical expertise found outside the Department.

There currently are plenty of stories around about the ways innovative ideas get (often inadvertently) stifled. One of the most popular goes like this: "An employee comes up with an idea, on the job, that he/she thinks could really help the way things get done. The employee explains the idea to a supervisor. The supervisor says to the 'offending' employee, 'That sounds like it might be a good idea. Why don't you write up a formal proposal on that. Tell me what changes we would need to make, who we would have to coordinate with, what other areas it would affect, who we need to have sign off on it, what it would cost, and how we could pay for it.' No doubt, in most cases, the supervisors is pleased that the idea came up and is trying to give the employee full reign to 'run with it.' But it is also quite likely that the employee is overwhelmed with everything that would need to be done and probably has no idea where to turn for help or answers. It looks like an impossible task, or worse yet, like he/she is being punished for coming up with the idea. So this employee does what generations of employees have done before; quietly shelves the idea and goes back to work."

The expert focus team concept will encourage more involvement in the research process. They serve as a conduit for getting information about ongoing research, research possibilities and research funding sources out to the divisions and transportation centers and bring information on research needs in from the divisions and transportation centers, but they can also serve as innovation mentors and a resource for:

Idea development
Proposal writing
Knowledge of the research process
Funding source knowledge
System interaction

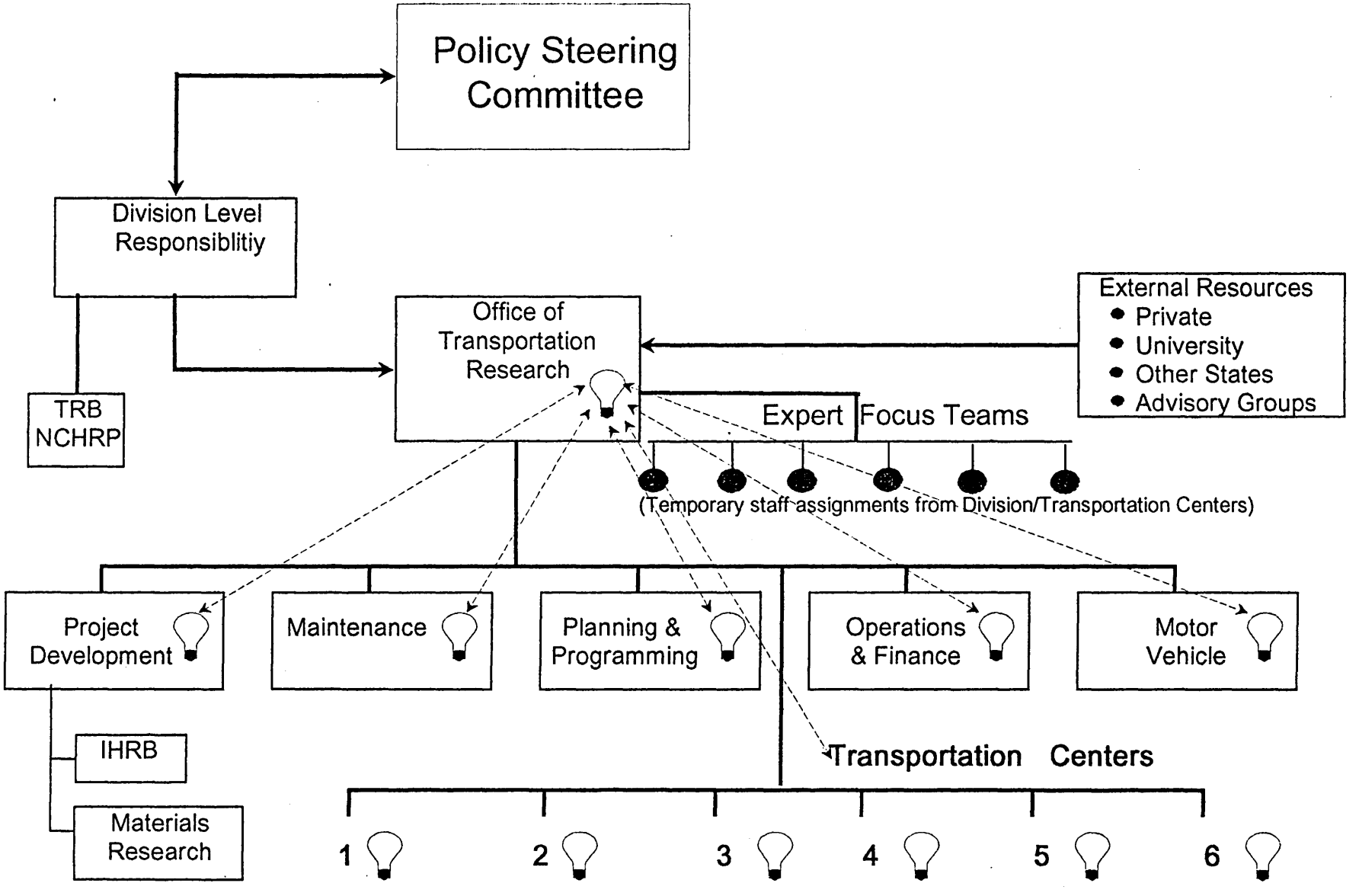
However, the structure of the expert focus team concept will be in direct contrast to a centralized, hierarchical organization structure. Since the main goal of the expert focus team will be to do whatever it takes to achieve results, the traditional government bureaucracy viewpoint--based on carefully ordered rules, procedures and hierarchy--may need to be adjusted.

Light Bulbs

Five of the seven divisions and the six transportation centers would be directly associated with research activities. The "light bulb" graphic is used to illustrate a two-way free flow of ideas between the divisions/transportation centers and the Transportation Research staff. This concept will be critical to the overall effectiveness of the research efforts and successful accomplishments.

Research Operational Flow Chart
Option 1

April 20, 1994



Option One

Project Development would retain the Iowa Highway Research Board (IHRB) and Materials Research responsibilities, along with the current staffing.

The nucleus that draws all of these varied elements into a productive, coordinated effort is the Transportation Research staff. Here lies the responsibility for the research projects: to solicit communications to and from the divisions/transportation centers; to assemble the expert focus teams; to draw from the external resources; and to interact with TRB and NCHRP as directed while progressing forward on the path that has been delineated by the division-level responsibility and the Policy Steering Committee.

Observations:

1. Requires the Transportation Research staff be held responsible for communicating information relative to funding sources for research and how they can be utilized.

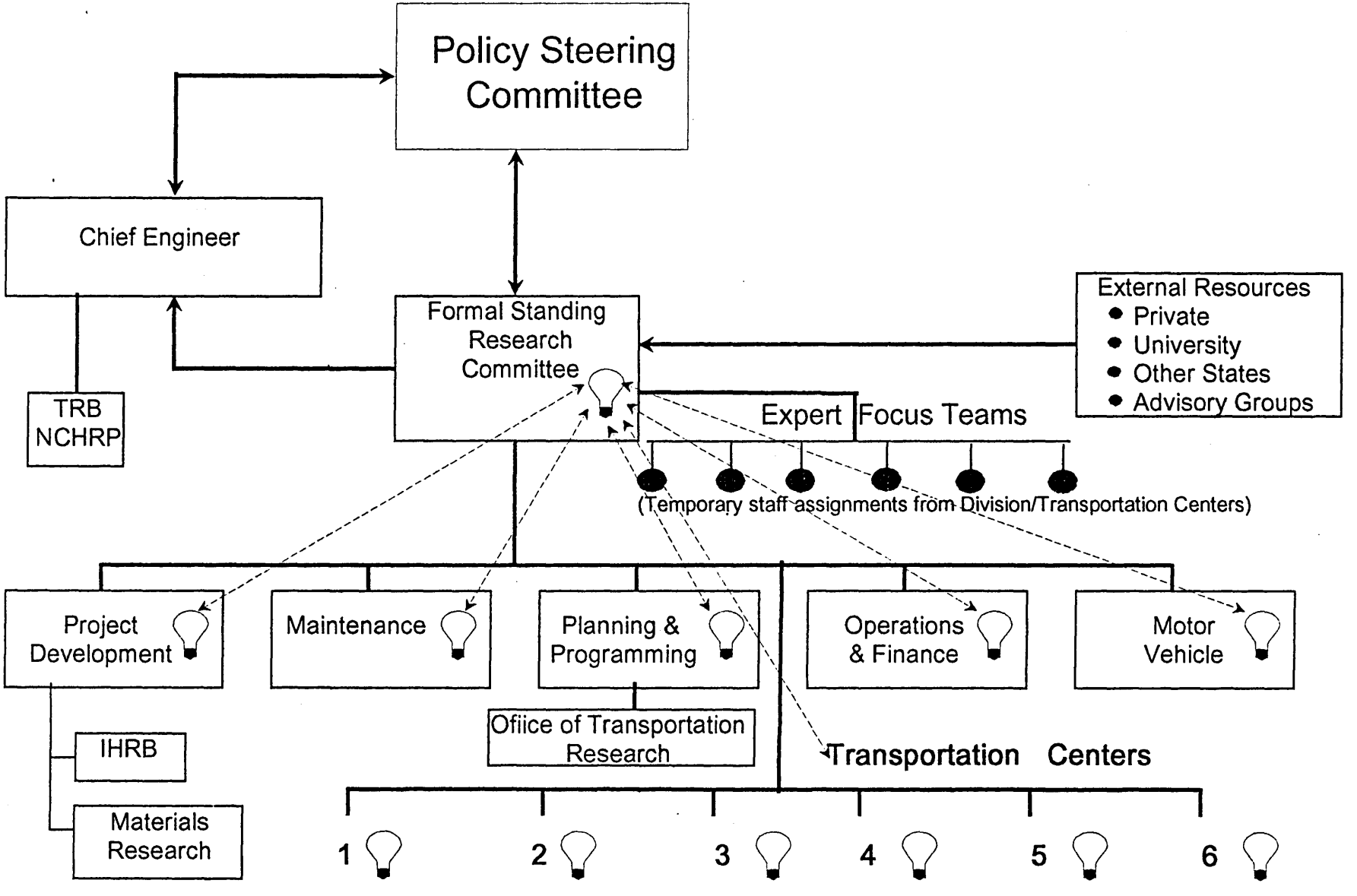
2. Encourages a much broader base for input to the research program, and will facilitate, to a much greater degree, the implementation of applied research projects.

3. Provides for the continuity of existing programs.

4. Maintains the effectiveness of the various research operations that are presently in place; i.e., Iowa Highway Research Board, Materials Research, and Transportation Research.

Research Operational Flow Chart
Option 2

April 20, 1994



Option Two

Option Two provides for the establishment of a Standing Research Committee. The committee would consist of divisional and transportation center representatives and be chaired by the Chief Engineer. It would function in a manner similar to the present Specifications Committee. It is anticipated that the FHWA and the Iowa Transportation Center would have some representation, as well.

The Standing Research Committee would serve to discuss research activities of interest; serve as a clearinghouse for national, regional and state research; provide an understanding of funding sources for research, etc. The committee would also serve to direct and coordinate the various research activities within the Department. While answerable to the Chief Engineer, direction would also come from the Policy Steering Committee (which presumably would include the Chief Engineer).

Project Development would retain the Iowa Highway Research Board (IHRB) and Materials Research responsibilities, along with the current staffing. Planning and Programming would retain the Office of Transportation Research. This concept is the same as in Option One.

Observations:

1. Provides a point of focus for various research programs.

2. Provides information on funding for research and how to access it.

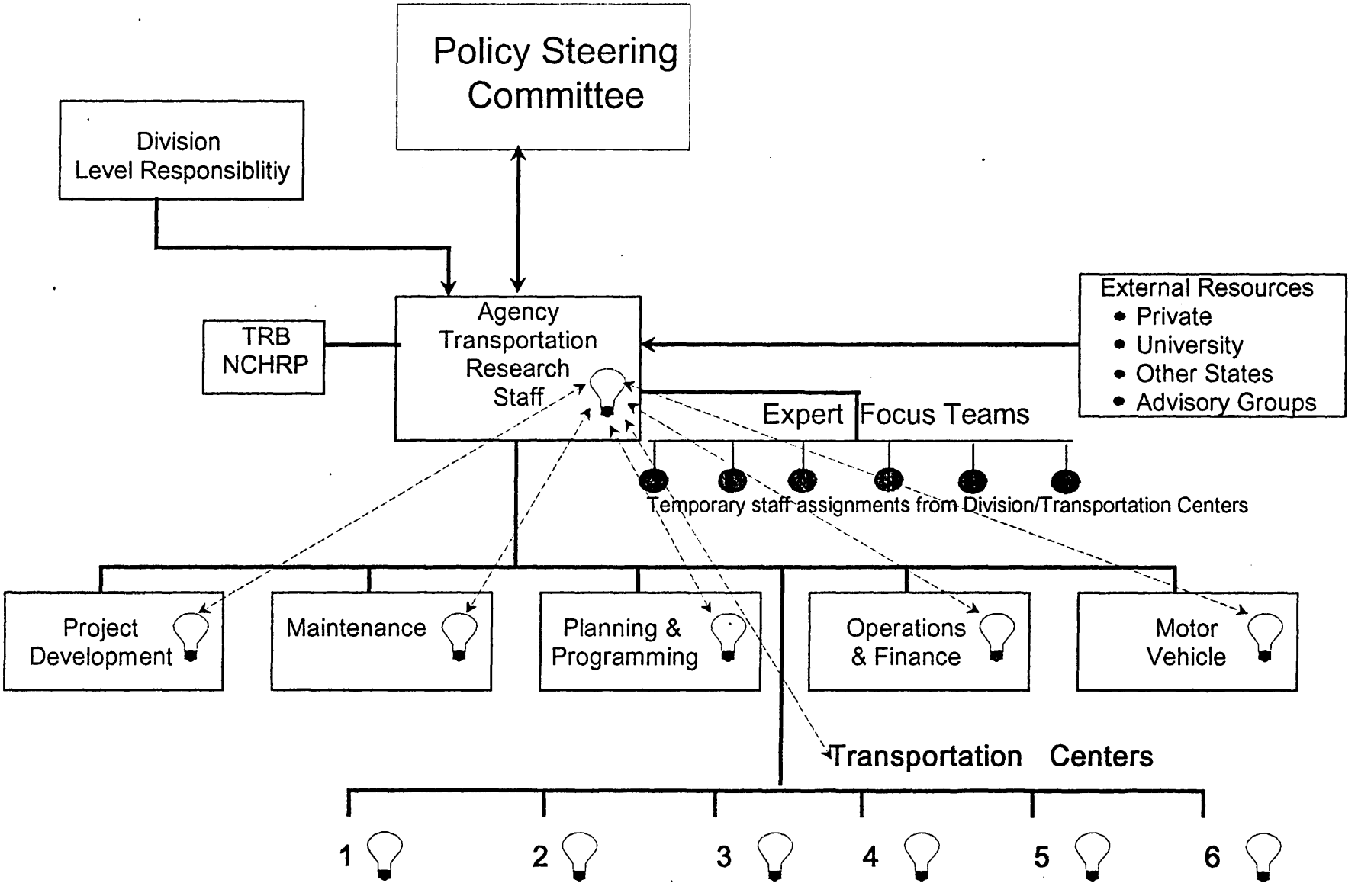
3. Maintains the effectiveness of the various research operations that are presently in place; i.e., Iowa Highway Research Board, Materials Research, Transportation Research.

4. Provides for the continuity of existing programs.

5. Provides for administrative oversight and for a high level of review of the direction research is taking.

Research Operational Flow Chart
Option 3

April 20, 1994



Option Three

The intent of Option Three is to incorporate all permanent and part-time research staff in one location. This could be an office in any division with division oversight related to normal work activities. However, the Policy Steering Committee would have specific input on the direction the research staff takes. This option, however, does not mean that all interaction among division and offices has ceased. All the liaison activities noted in previous options would still take place with representatives from the transportation centers and the divisions as noted on the chart. However, Option Three provides one focal point within the DOT for funneling research activities and one focal point for the management and responsibility of research activities within the DOT.

Observations:

1. Research activities are located in one office and everyone knows where to go for research interaction.

2. The agency Transportation Research staff would be current on all research activities as a result of combining into one office.

3. This option provides for one contact point for outside activities and interests which interface with research responsibilities.

4. Would have to combine current activities into one office.

Section Ten: Consensus Emerged on These Issues

Through the deliberations of the research team, consensus emerged on many issues. The breadth of that consensus is most clearly demonstrated in the wealth of similarities, when compared to the few differences, in the organizational options listed in Section Nine. These points of consensus coalesced into six basic areas: single agency-wide focus; effective communication system; open environment for fostering idea development; appropriate implementation strategies; strategic partnerships; and in-house expertise. A more complete description of these six areas follows:

1. A single agency-wide focus

   The organizational vehicle for this focus should reside in a Policy Steering Committee as described in Section 9. Functions this committee could facilitate to help create an agency-wide focus include:

   - Creating a formalized review process to help keep projects moving and evaluate the research results and direct research results toward tangible ends.

   - Directing the establishment of a mechanism for documentation of the system that takes an idea through research to implementation.

   - Providing the knowledge to obtain the resources n necessary to get ideas researched and results implemented.

2. Effective communication system

   Key elements of such a communication system should include easy access to the following:

   - Listing of research program opportunities and results.

   - The establishment of key focus areas developed from the strategic planning process.

   - Funding options.

   - Technical expertise.

   - Knowledge of process.

3. An open environment for idea development

   - The Department must maintain an unqualified commitment to the development of a TQM environment.

   This environment must include the following elements:

   - A system of continuous Department staff training.

   - Providing opportunities to encourage individual involvement.

   - Systemic encouragement of participation in finding solutions to problems.

   - Systematic support for a "can do" attitude.

   - Commitment to improve processes.

4. Appropriate implementation strategies

   This should:

   - Set timetables and allocate human, financial and technological resources.

   - Creates improved deployment of product.

   - Build public confidence in the Department's activities.

5. Strategic partnerships

   - Recognize what partnerships should be useful.

   - Create opportunities for partnership.

   - Expands the ability of the Department to extend the range of research capabilities.

   - Helps stretch scarce resources.

6. In-house capabilities

   - The Department should retain enough expertise in-house to sustain and manage its own programs, as well as be able to critically evaluate other research activities.

   - The experiences gained will allow the Department to put itself in position to manage evolutionary changes.

Section Eleven: Attachments

A. Iowa DOT Research History/Project Milestones

B. Office of Materials/Office of Transportation Research PPM

C. Guide to Understanding Research Jargon

D. Summary Information on Research Programs

E. TRB/NCHRP Organization Charts

F. Typical Reports from: TRB, NCHRP, IHRB, Internal Staff

G. Iowa DOT SHRP Product Implementation Process

H. Axioms of Research Utilization

I. Ten Rules of Effective Research

IOWA DOT RESEARCH HISTORY / PROJECT MILESTONES

IOWA HIGHWAY COMMISSION

The original organization of the Iowa State Highway Commission (ISHC) was unique - thus a probable "first". The Iowa Highway Commission (IHC) was originally founded by legislative action in 1904 as a function of the Ames College (Iowa State University) to provide a short course instruction to local authorities in the construction and maintenance of the roads. The Dean of Engineering Anson Marston was named a Commissioner along with the college's Dean of Agriculture C.F. Curtiss. The Commission at that time had no roads to construct or maintain. Dean Marston did pioneer work in analyzing loads on underground drainage pipe. Probably the greatest accomplishment by the IHC occurred when 1,030 miles of Portland cement concrete pavement was constructed in 1929-30 on the primary road system which consisted of 6,813 miles.

PROPORTIONING MATERIALS BY WEIGHT

The IHC persuaded two paving contractors to equip for proportioning their materials by weight rather than volume in about 1920. This was subsequently required by specification, has been recognized as superior, and is used almost universally.

MUD JACK OR MUD PUMP

The mud pump was developed first in Iowa by John Poulter, an ISHC employee in Mt. Pleasant. Poulter devised the mud pump to raise hydraulically a corner of the ISHC garage floor-at Mt. Pleasant. Poulter later sold his idea to Koehring Mfg. Co. and became a VP of the firm. While an employee of the ISHC, he first raised depressed pavement with the machine in the Burlington area in 1930.

SLIP-FORM PAVER

James W. Johnson of the ISHC developed the slip-form method of placing portland cement concrete (PCC) pavement around 1949. This procedure places highway pavements without the need for forms to support the vertical sides of the concrete, and is now used as a standard nationally and in many foreign countries.

TAPERED INLET CULVERTS

The use of tapered or flared end culvert inlets in 1952 to increase hydraulic capacity was the result of research conducted by the Iowa Highway Research Board. Flared ends are used where feasible in Iowa, and the use is spreading to other agencies and consultants. The use of bell jointed culverts in Iowa is a possible first.

ALUMINUM I-BEAM BRIDGE

The world's first aluminum girder highway bridge was built in 1958 over I-80 and I-35 north of Des Moines when structural steel could not be obtained. Although completely successful, cost factors are prohibitive.

"NO PASSING ZONE" SIGN

Iowa introduced the 'no passing zone' pennant in 1959. It was placed on the left shoulder of U.S. 30 across the state; the public's reaction was highly favorable, and within two years, the sign was in place over all of the paved primary system. It has subsequently been adopted and included in the National Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD).

PRESTRESSED STEEL I-BEAM BRIDGE

The first bridge with pretensioned steel beams was built in U.S. 6 in Pottawattamie County in 1961. The pretentioning was done by placing camber in the beam when the cover plates were welded to the beam.

MACHINE FINISHED BRIDGE DECKS

Iowa was certainly among the first, if the not the first, to require machine finishing of bridge decks. Smooth bridge decks were of concern to the entire highway industry in 1961. At the time, Iowa's Construction Engineer W. W. Wickham presented a paper at AASHTO in Detroit on machine finishing. The process created interest as a new approach, and has since become almost standard practice.

PHOTO/FILE TECHNIQUE

In 1962, the ISHC was first to develop a photo/file on the 10,000 mile primary road system.

SLIP-IN BITUMINOUS OIL DISTRIBUTOR AND HOPPER SPREADER BOXES

Bituminous distributors are generally mounted on trailers or trucks. The slip-in distributor, which is equipped with folding legs and can be skidded into a truck box,

eliminates the need for a trailer and provides the convenience of a truck mounted unit. It can be easily loaded and unloaded from the truck. The slip-in concept was developed by Chuck Huisman of the Iowa Maintenance Office about 1962. Hopper spreader boxes used for spreading aggregates and ice control abrasive were also developed in 1962 by Mr. Huisman, and are now standard equipment in state maintenance fleets.

IOWA'S METHOD OF BRIDGE DECK REPAIR AND SURFACING

In 1963, Iowa began experimental work that has resulted in what is widely known today as the Iowa Method of bridge deck repair. Nearly all concrete bridge decks eventually spill and delaminate on the surface above the reinforcing steel when ice control salts cause corrosion. A low water cement ratio, dense PCC was developed as a patching material. This mix is used for patching small areas or as a complete deck overly and as a thin lift resurfacing over PCC pavements. It has been found to be very successful on bridge decks, and less successful on pavements.

FULL DEPTH, NO BASE HOT MIXED ASPHALT CEMENT CONCRETE

A section of I-80 east of Iowa City built in 1964 is believed to be the first section of interstate with hot mixed asphalt cement concrete as the full depth of the pavement structure. There is no lower base or sub-base. This concept is now the industry standard.

CONTINUOUSLY REINFORCED PAVING WITHOUT TRANSVERSE STEEL

This was an Iowa 'first' used on I-80 in 1966. The method required the development of machinery to place the reinforcing steel in the concrete without the use of supports under it.
This method eliminated a great amount of hand labor, and is now widely used.

RECYCLING ASPHALT CONCRETE WHILE MEETING ENVIRONMENTAL REGULATIONS

Beginning with Kossuth County research on recycling asphalt concrete, the Iowa DOT made a commitment to encourage contractors to reuse recycled asphalt product. Iowa was one of the first to accomplish this and also meet EPA air pollution regulations.

FLOWABLE MORTAR ALTERNATIVE TO BRIDGE REPLACEMENT

On US 30 in Harrison County large culverts were placed beneath five short span bridges. Flowable mortar was used to fill the void between the bottom of the bridge

and the culvert. The old bridges were not removed. These were the first of many innovative flowable mortar cost-saving projects.

REDUCING TRANSVERSE CRACKING IN HOT MIX ASPHALT PAVEMENT
Jones County IA 64 research demonstrated that the temperature susceptibility of the asphalt cement was a major factor in the frequency of transverse cracking of asphalt pavement. Specifications requiring higher quality asphalt cement resulted in reduced cracking.

X-RAY EVALUATION OF CARBONATE AGGREGATE FOR PORTLAND CEMENT CONCRETE (PCC) PAVEMENT
X-ray diffraction testing at Iowa State University was used to evaluate new and existing aggregate sources and identify aggregate that would result in reduced PCC pavement longevity. The producers use this information for selective quarrying to supply aggregate that will result in extended longevity.

DESIGN CRITERIA FOR INTEGRAL ABUTMENT BRIDGES
Bridge expansion assemblies have been the cause of much deterioration resulting in increased maintenance and reduced life. Iowa State University Research has provided engineering and design criteria for use of longer integral abutment bridges.

IOWA FAST TRACK CONCRETE PAVEMENT
A portion of US 71 in Buena Vista County was paved with fast track PCC pavement using high early strength cement and insulated blanket accelerated curing. This initiated the use of Iowa Fast Track Concrete across the U.S. Some additional innovations have produced PCC pavement for city street intersections that were opened prior to the morning traffic rush after being placed during the night.

VIDEO EVALUATION OF HIGHWAY DRAINAGE SYSTEMS
Iowa was the first state to use video probes to inspect longitudinal edge drain installation and to monitor the condition and performance of older drains. The video inspections initiated specification changes and improved contractor workmanship. Video inspection has been initiated by many other states.

IMAGE ANALYSIS OF PCC AND AC PAVEMENTS USING SEM IMAGES
The proper amount and distribution of air voids are necessary to produce durable PCC pavement. Image analysis is a rapid, simple, inexpensive, computerized method of determining the air void distribution to verify the quality and expected longevity of PCC pavement.

SCANNING ELECTRON MICROSCOPE INVESTIGATION OF PCC PAVEMENT DETERIORATION

A low vacuum scanning electron microscope is being used to identify the initial cause of premature PCC pavement deterioration. By being able to ascertain the initial cause of the distress, appropriate specification changes can prevent reoccurrence of the problem.

VACUUM EVALUATION OF PCC PAVEMENT JOINTS

Iowa has developed a vacuum joint tester that will rate the quality of PCC pavement joint seals. This testing has demonstrated the importance of high quality workmanship in joint seal performance which is a factor in pavement longevity.

TRANSIT/CARPOOLING

Numerous studies involving fringe parking, transit patrons socioeconomic characteristics, vanpool insurance, interagency and interstate cooperation in transit areas, carpool matching techniques, and intercity airport transit were conducted.

AIR

The aircraft counting program was conducted by the office and most recently the requirement for manual evaluation of the aircraft counting tapes was replaced by using a pc with an artificial neural network. Studies on passenger satisfaction and evaluations of paved airport runways were also conducted.

RAIL

The 1% waybill study, which identified movement of goods within the state by rail and study on upgrading branch lines, was conducted by the office. The development of the track geometry car was overseen by the office.

ENERGY

Studies on diesel powered, hydrogen powered, and electric powered vehicles were made by the office. Evaluation of wind power was investigated. Energy conservation issues were studied for emergency conservation, driving attitudes, and grain transportation.

MOTOR VEHICLE DIVISION

Traveler information stations, highway advisory radios and highway emergency long-distance phone service were studied. Research was conducted on the transportation of nuclear materials within the state. Probable repurcussions of motor carrier deregulation in Iowa, cash flow for the Iowa victim reperation fund, and the

effectiveness of beads on paint and reflective sheeting for license plates were studied. Recommendations for staffing levels were developed for Motor Vehicle Enforcement using nonlinear regression statistical techniques. Specifications for weigh-in-motion for use in two new interstate scales were developed. Older drivers special needs were evaluated.

WEIGH-IN-MOTION

Iowa was a lead state in evaluation of bridge weigh-in-motion and low cost automatic weight and classification systems (AWACS) in the United States.

PHOTO/VIDEO LOGGING

Evaluation of the updated photologging system and conversion of the photologging system to laser disc video were accomplished by the office. Continued updates of the current system are being coordinated by the office.

MAINTENANCE GARAGES

The first computer models that used least distance calculations were used by the office to determine the most efficient relocation/consolidation of maintenance garages.

TRAFFIC SAFETY

The ability to tie accidents to base records data was accomplished by writing several fourth generation language computer programs in SAS. The Bureau of Safety was also involved in developing these programs. Over 2000 lines of SAS code was user developed in this project. Numerous safety studies were conducted by the office prior to creation of the Bureau of Safety.

MISCELLANEOUS STUDIES

Research on optimum placement of AWACS sites for truck weight estimation was conducted. Coordination of AWACS and SHRP sites was overseen by the office. Noise pollution and lighting studies were conducted. Surveys were done on various topics such as custodial services, older drivers, and Give 'Em a Brake.

Attachment B

Iowa Department of Transportation
POLICIES AND PROCEDURES MANUAL

Title	Policy No.
Research and Development Projects	420.02
Responsible Office(s)	**Related Policies & Procedures**
Office of Materials	300.02, 420.01
Effective/Revision Date(s)	**Approval(s)**
7/1/69/ 6-29-92	

Authority: Director of the Highway Division pursuant to Iowa Code sections 310.34 and 312.3A.

Contents: This policy describes the procedures for submission, funding and conduct of research and development projects using primary road research funds, secondary road research funds and street research funds.

Affected Offices: All

Policy and Procedure:

I. SUBMISSION

A. Any person, group or office may submit a suggestion or a problem for a research and development project to the Research Engineer in the Office of Materials.

B. The Research Engineer shall encourage submissions, assist in preparing problem statements or descriptions, present the problem to the Iowa Highway Research Board for review and action, and report the Board's action to those who submitted the problem.

C. After the Board approves a problem statement for a research and development project, a detailed research proposal with a proposed budget shall be prepared.

1. If the research is to be conducted by the Department, the Research Engineer will assist the person, group or office to prepare the research proposal.

2. If the research is to be conducted by an outside contractor, the contractor shall prepare the research proposal.

D. The Research Engineer shall review all research proposals and submit them to the Board for action.

II. APPROVAL

A. After the research proposal has been approved by the Board, the Research Engineer shall prepare a funding recommendation unless the proportion of primary road research funds, secondary road research funds and street research funds has been recommended by the Board, the Director of the Bureau of Operations, or the Director of the Office of Materials.

B. The Research Engineer shall forward the proposal and the funding recommendation for Staff Action approval.

C. With Staff Action approval for conduct of the research and expenditure of funds, the Research Engineer may approve an equipment purchase for a project conducted by the Department. The equipment must be essential for a specific research project and not in customary use by the Department.

Title	Policy No.
Iowa Highway Research Board	420.01
Responsible Office(s)	**Related Policies & Procedures**
Office of Materials	300.02, 420.02
Effective/Revision Date(s)	**Approval(s)**
7-1-69/ 6-29-92	

Authority: Director of the Highway Division

Contents: This policy describes the membership of the Iowa Highway Research Board, its duties and operations.

Affected Offices: Highway Division

Policy and Procedure:

I. ORGANIZATION OF BOARD

A. The Iowa Highway Research Board is an advisory board that assists the Department in the development and continuation of an effective, coordinated program of research and development in highway transportation.

B. The board is composed of thirteen members appointed with Staff Action approval, as follows:

1. Six county engineers, one from each of the six districts. County engineers are nominated by the Iowa County Engineers' Association.

2. Two city engineers, or engineers employed by a municipality. These engineers are nominated by the League of Iowa Municipalities.

3. Two engineers from the Colleges of Engineering, one from Iowa State University and one from the University of Iowa, as nominated by those institutions.

4. Three Department engineers nominated by the Director of the Highway Division.

C. For each board member an alternate is appointed to serve at the member's request when the member is unable to attend. The alternate is appointed by the same procedure as the board member.

D. The normal term for a member and an alternate is three years, beginning on January 1. However, when a vacancy occurs during a member's term, the person appointed shall serve the unexpired part of the term, beginning on the date of the appointment.

E. The Board shall annually select a chair and a vice-chair to serve beginning January 1. The Board shall hold regular meetings at times determined by the Board and shall establish the rules of procedure needed to perform its duties.

F. The Research Engineer, Office of Materials, shall serve as secretary of the board and shall perform the following duties:

1. Arrange for regular and special meetings called by the Board; keep the minutes and other records of the Board.

DIVISION/BUREAU	OFFICE
Planning and Research	Transportation Research
EFFECTIVE/REVISION DATE	APPROVAL(S)
5-25-76/ 7-19-83	

I. Purpose

To conduct, administer, and monitor research directed toward areas with high potential for improving transportation in Iowa. To provide consulting services for the Department, including statistical analysis and problem-solving through mathematical modeling.

II. Responsibilities

The Office of Transportation Research shall perform the following duties and responsibilities:

A. Conduct transportation mode research and operations research to support the divisions in reaching their objectives.

B. Maintain liaison with the Transportation Research Board and transportation research centers.

C. Monitor state, national, and international transportation research organizations identifying ideas involving technology transfer or research and apply these ideas to DOT operations through discussion with using divisions.

D. Maintain a library of current research papers and bibliographies for Department staff use.

E. Identify and evaluate modal improvement technologies applicable to transportation systems in Iowa and provide results to appropriate Department divisions.

F. Review and evaluate planning and programming procedures using statistical analysis techniques and cost-effectiveness criteria.

G. Provide statistical and problem-solving support to Department offices and divisions.

H. Manage contracts for demonstration programs and technical research investigations such as those sponsored by Urban Mass Transportation Administration, Federal Aviation Administration, Federal Railroad Administration, Federal Highway Administration, and Department of Energy.

Guide to Understanding Research Jargon

Research
A systematic controlled inquiry involving analytical and experimental activities which primarily seek to increase the understanding of underlying phenomena.

Applied Research
The study of phenomena relating to a specific known need in connection with the functional characteristics of a system, the primary purpose of this research is to answer a question or solve a problem.

Basic Research
The study of phenomena whose specific application has not been identified the primary purpose is to increase knowledge.

Technology Transfer
Activities that lead to the adoption of a new technique or product by users and involves dissemination, demonstration, training and other activities that lead to eventual innovation.

Development
Translation of basic or applied research results into prototype materials, devices, techniques or procedures for the practical solution of a specific problem.

Transportation Research Board (TRB)
A national research agency directed by a 30 member board to promote and publish unique and original research of national interest.

Transportation Research Information Services (TRIS)
Transportation Research Board maintained computerized storage and retrieval system for abstracts of ongoing and completed Research, Development and Technology (RD&T) activities.

National Cooperative Highway Research Program (NCHRP)
The cooperative RD&T program directed toward solving problems of national or regional significance identified by states and FHWA, administered by the TRB.

National Pooled Funded Study

RD&T study or activity expected to solve problems of regional significance, usually administered by a lead state in cooperation with other sponsoring states.

"Systematic Innovation" Peter F. Drucker, Managing for the Future - The 1990s and Beyond

"....consists in the purposeful and organized search for changes, and in the systematic analysis of the opportunities such changes might offer...."

Iowa Highway Research Board (IHRB)

A 13-member advisory board with county engineer, Iowa DOT, city engineer and university members to recommend research and receive reports for the Iowa DOT.

Materials Laboratory Research (MLR)

Iowa DOT research projects initiated and conducted by Materials Laboratory personnel with the State Material Engineer's approval either in the laboratory or at a field location.

FHWA Special Experimental Features (SEF) Projects

These are experimental projects that originate when the FHWA identifies an experimental feature in a construction project and requires a work plan for evaluation. Operations Research identifies these projects as HR-5XX.

Noncentralized Research

Is that research undertaken by various units of the department without special organizational framework. The individual operating unit (division, bureau, or district) initiates the project and authorization of funds as necessary. Active direction of the project often resides with the initiator. Often the cost is small that formal authorization of funds is not required and may not even be officially considered as research. Such investigations are expedient and usually are practical. They consist of applied or developmental research rather than basic research. if this research results in useable information it may be put to immediate use within the operation entity responsible for the research. If negative, very few will even know the research had taken place.

Centrally Located Research

The various units of the department conduct research which is programmed and assigned by the executive branch and coordinated by the research director. It provides a means of assessing the relative need of each proposed project and for including the most needed projects to obtain a balanced, continuing program. In practice, some of the small-sized investigations are done independently, although all of the larger projects requiring authorization of funds are part of the planned program.

Formal Research

Deals with those formal, self-contained, centrally operated units officially designated or recognized as research units in the department. These units are sometimes responsible for the whole program but may assign parts of it to outside agencies. It is distinguished from "joint research" by the pattern of its top management with its own staff and facilities.

Joint Research

Is that research conducted by organizations established and operated by "joint" effort and for mutual benefit. It does not preclude the operation of other research, either inside or outside of the department, but the joint research program may constitute a major research endeavor within the department.

Program Name: Iowa Highway Research Board

Program Coordination: Office of Materials

Funding Information: Source/State

Partners	Est. FY 94 $
Iowa DOT	$ 750 k
Secondary	1.2 m
Street	200 k

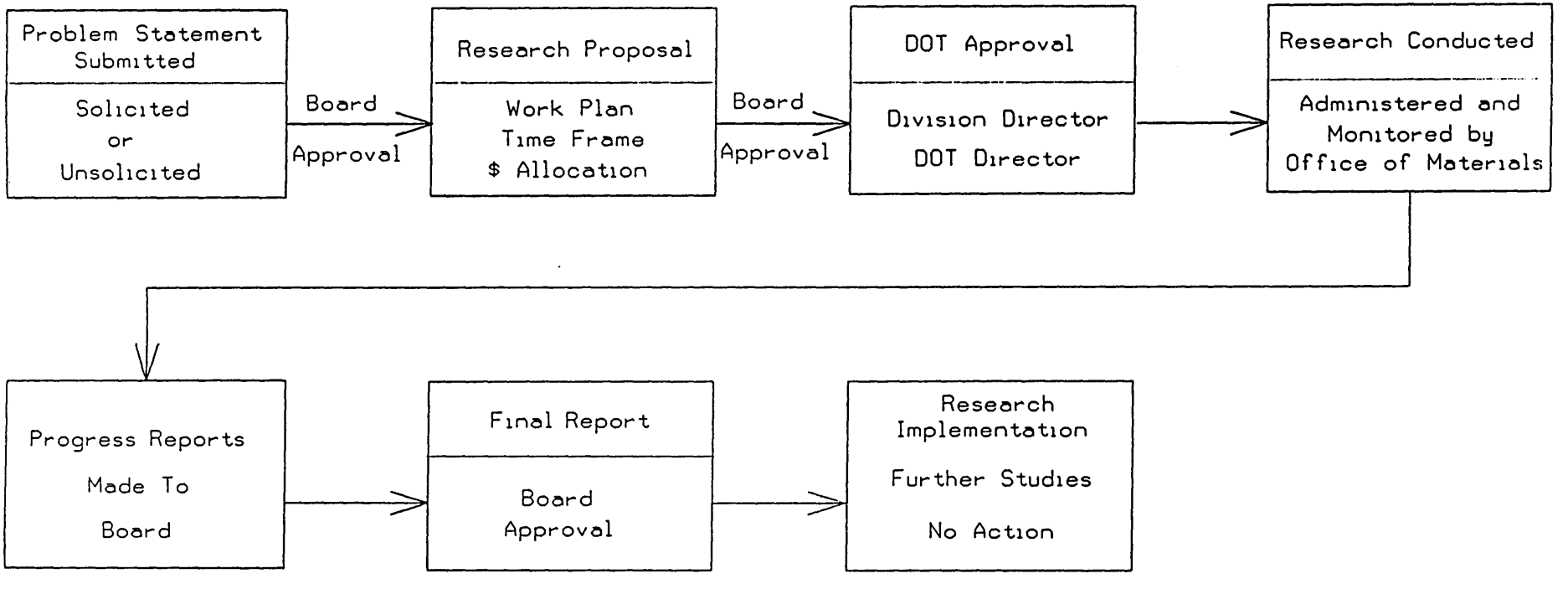
Program Summary: Proposals for research and development are reviewed by the Iowa Highway Research Board, and its recommendations are transmitted to the Director of the Highway Division and the Director of the Department of Transportation. Expenditure of funds for research and development is then authorized on an individual project basis.

These expenditures may be charged to the Primary Road Fund, Farm-to-Market Road Fund or the Street Research Fund, depending on which road system will benefit from the project. If more than one jurisdiction's roads share in the benefits, the costs are shared.

IOWA HIGHWAY RESEARCH BOARD

Board Make-up - 6 County Engineers, 3 DOT Highway Division Engineers, 2 City Engineers
1 - ISU , 1 - University of Iowa -3 Year Terms

Annual Funding - Secondary Road Research Fund - 1.5% of Farm to Market Fund ($ 900,000 Approx.)
- Street Research Fund - ($ 200,000)
- Primary Research Fund - ($ 500,000 Approx.)
- Total - $ 1.6 Million



Typical Researchers Universities, Midwest Transportation Center, Counties, DOT, Consultants

Program Name: State Planning & Research (SPR)

Program Coordination: Planning & Programming

Funding Information (Research Component): Source/Federal (EARMARKED)

ISTEA/1991 Revised research funding to 25% of SPR. This amounted to $950,000 for FY 1994. Participation in Pooled Fund projects and general research is estimated at $1.2 million.

Program Summary: General Research

RF/Transponder Project
Crack/Patch Survey Equipment
Strategic Research Plan Phase 2
Video Van/Side Camera and GPS
Environmental Analysis Using GPS

Program Name: National Cooperative Highway Research Program (NCHRP)

Program Coordination: Office of Materials

Funding Information: Source/State
Estimated FY 1994
Iowa DOT share $186,000 (total U.S. program $15 million)

Program Summary: National Transportation Issues

Iowa participates in project development, selection and serves on advisory panels.

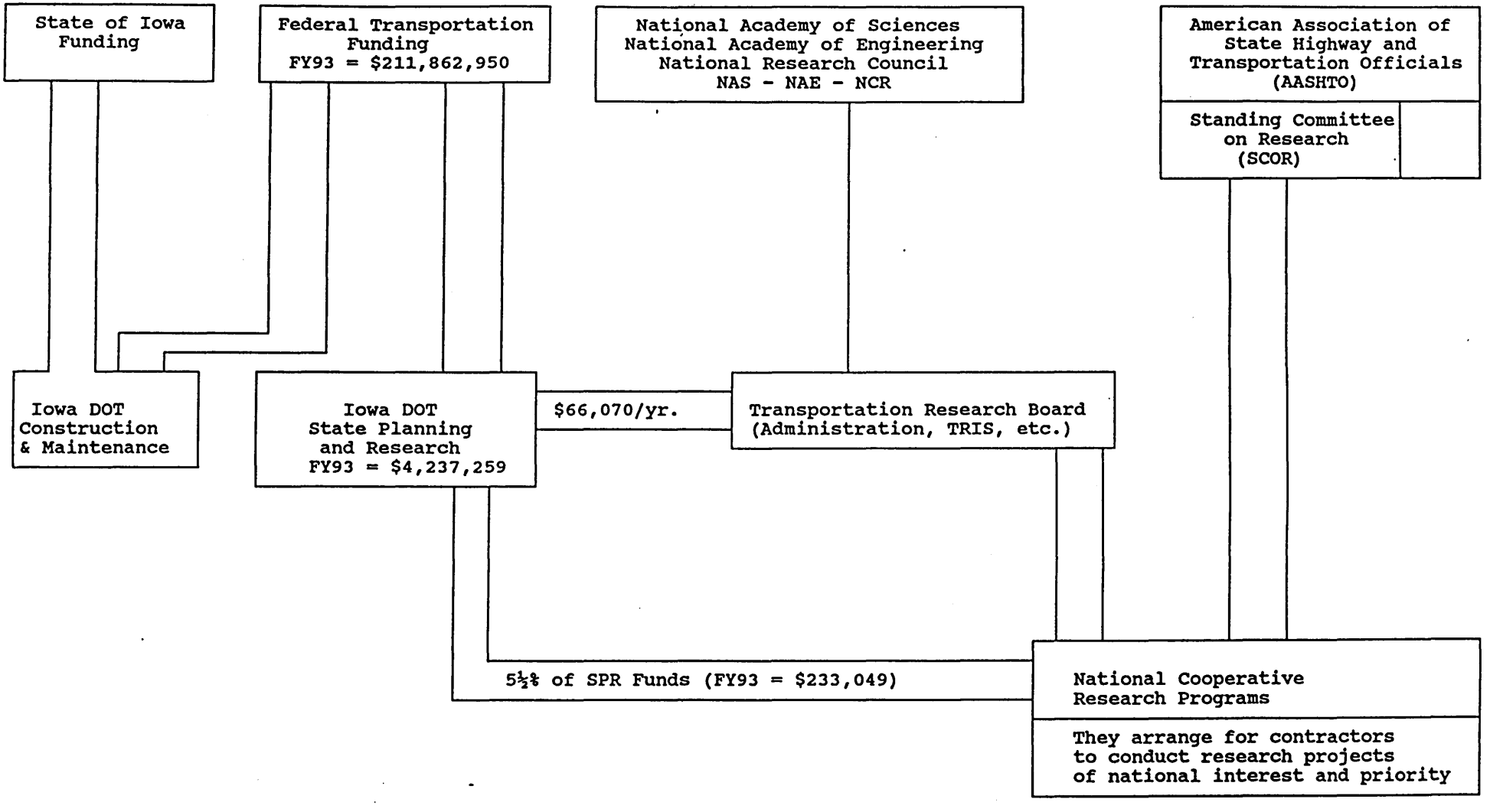
Program Name: Transportation Research Board (TRB)

Program Coordination: Planning and Programming

Funding Information: Source/State
Estimated FY 1994
Iowa DOT share $66,000 (total U.S. program $4 million)

Program Summary:
- Establish committee activities
- Hold meetings
- Public reports
- Information exchange
- On-line computer

NATIONAL RESEARCH RELATIONSHIPS



Program Name: ENTERPRISE (Pooled Fund Program)

Program Coordination: Office of Transportation Research

Funding Information: Source/State (HPR/SPR)
Estimated FY 1994
Iowa DOT share $75,000

ENTERPRISE is a multi-state pooled fund program. Members of this program include Arizona DOT, Colorado DOT, Iowa DOT, Michigan DOT, Minnesota DOT, North Carolina DOT, Washington DOT, Ontario Ministry of Transportation, Transport Canada, Dutch Ministry of Transport - Rijkswaterstaat, and Federal Highway Administration. This organization consists of an Executive Board, a Program

Program Summary: A group of technologies known as Intelligent Vehicle-Highway Systems (IVHS) program was recognized as a way to meet the goals identified in ISTEA 1991. The ENTERPRISE program is a forum for collaborative research, development and deployment ventures reflecting the interest of government entities and industrial groups. ENTERPRISE provides a way for member agencies to communicate and pursue IVHS projects that might be difficult to initiate on their own.

Program Name: Local Technical Assistance Program (LTAP)

Program Coordination: Office of Transportation Research

Funding Information:

Partners	Est. FY 1994
FHWA	$ 110 k
402 Program	40
IHRB (County)	46
(Street)	46
(Primary)	10
ISU	
	$ 277 k

Program Summary: The Local Technology Assistance Program (LTAP) is supported by the Iowa Transportation Center. The Center's operational plan is to achieve the objective of transferring technology to those involved in local transportation. During 1993, the Iowa LTAP program began to increase the amount of urban oriented programs. This includes providing traffic engineering and transportation planning training programs and services.

Products:

1. Compile and maintain mailing list
2. Publish quarterly newspaper and other publications
3. Provide technological reference material and information
4. Provide information and referral service
5. Conduct or arrange seminars and/or training sessions--some of the programs presented were:
   - Motor Grader Operator Training Program
   - Management for Street and Road Maintenance Supervisors
   - Local Road and Street Pavement Management (The Iowa State Pavement Management System)
   - Equipment Specification Development and Writing
   - Construction Inspectors Workshop
   - Roadside Design Guide Workshop
   - Excavation Safety
   - Sign Management Conference
6. Evaluate effectiveness of program
7. Highway Safety Circuit Rider
   - Flagger training
   - Accident location analysis
   - Sign needs analysis

Program Name: Federal 402 Highway Safety Program

Program Coordination: Governor's Traffic Safety Bureau, Department of Public Safety

Funding Information:

Estimated FY 1994		
NHTSA	402	$2 M
FHWA	402	$150 K

Program Summary: Priority program areas: alcohol, seat belts, community programs, traffic engineering, youth programs. Priority geographical areas based on accident history. Emphasis on programs rather than on research or studies.

Products: Public information campaigns, safety program grants to cities counties, and other state agencies, statewide safety conference, police traffic safety checkpoints, drug recognition expert training for law enforcement, safety circuit rider, traffic

Program Name: Traffic Safety Improvement Program

Program Coordination: Office of Program Management

Funding Information:	Source	Match	Program Totals
	RUTF	.005	$3.5M/year

Program Summary: Projects initiated by any city, county, or IDOT regarding:
- site specific traffic operation improvements
- replacement of obsolete traffic control devices
- safety research, studies, or public information initiatives (all lumped under "studies")

Proposals are selected by Review Board, Transportation Commission Approval

Examples:
- $500,000 to Coralville to widen U.S. 6 from First Avenue to Clear Creek Bridge (site specific)
- $27,000 to Grinnell for materials to replace obsolete traffic control device equipment at four locations (traffic control device)
- $40,000 for accident data entry; $50,000 for Operation Lifesaver; $25,000 for work zone training (all studies sponsored by IDOT)

Program Name: University Transportation Center/Midwest Transportation Center

Program Coordination: Office of Transportation Research

Funding Information: Iowa DOT FY 1994 estimated dollars ($350 k) is used to match a 50/50 basis with U.S. DOT dollars.

Program Summary: The Midwest Transportation Center's theme focuses on transportation strategies to support a region undergoing major economic and social changes.

Program Name: Strategic Partnerships/IVHS Rockwell

Program Summary: The objective is to establish a basis for a partnership directed toward common interest areas that apply advanced technology to solve critical issues in the Department.

1. An IVHS-CVO operational test has been approved and is currently underway.

2. Quality Functional Deployment (QFD) for road maintenance vehicles.

Program Name: ADHOC Research Items
Federal 403 Highway Safety Program

Program Coordination: U. S. DOT, Washington, D.C.

Program Summary: RFPs, Invitations for Cooperative Agreements solicit proposals as determined by U.S. DOT priorities.

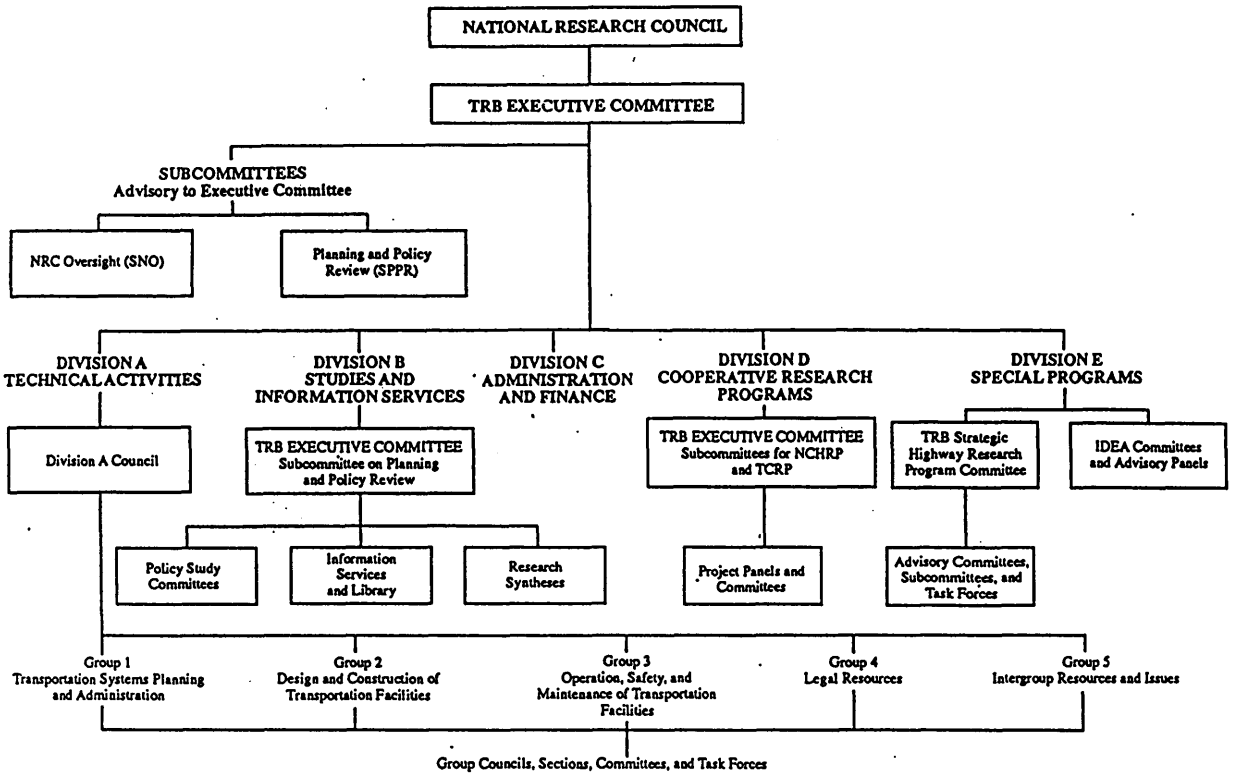


FIGURE 2 Committee and task force structure.

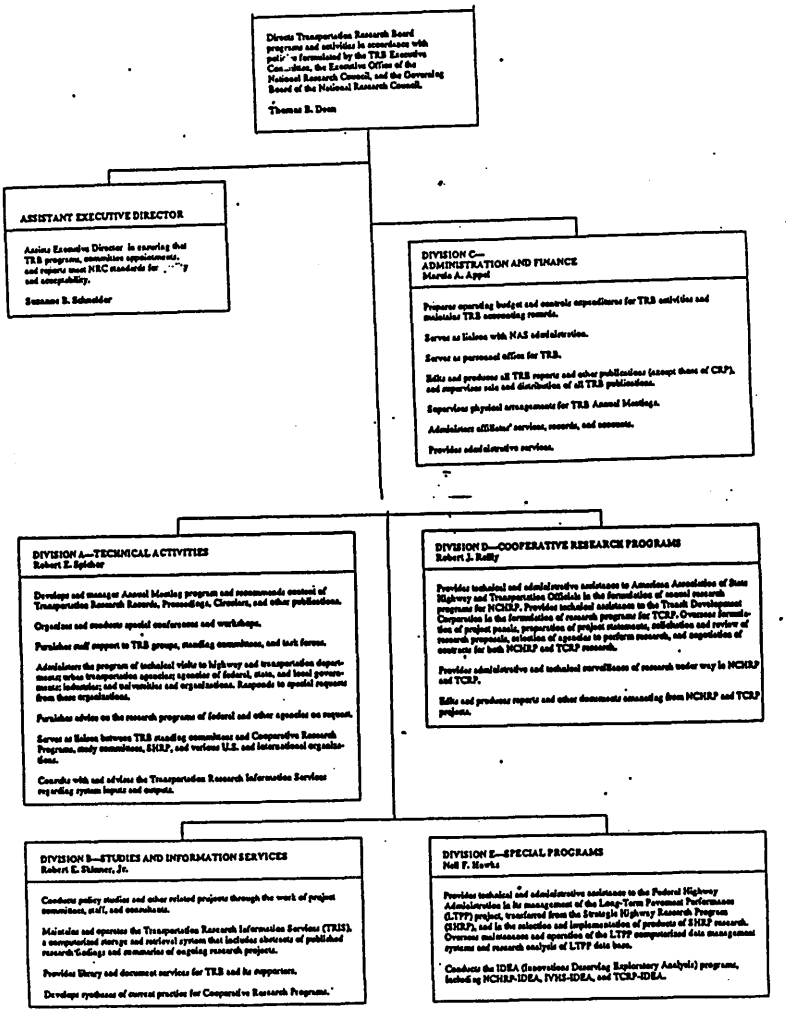


FIGURE 1 Staff organization and responsibilities.

TRANSPORTATION RESEARCH

RECORD

No. 1395

Planning and Administration

Finance, Taxation, Pricing, Economic Analysis, Socioeconomics, Education, and Management

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

National Cooperative Highway Research Program

NCHRP Synthesis 182

Performance and Operational Experience of Truck-Mounted Attenuators

A Synthesis of Highway Practice

Transportation Research Board
National Research Council

NATIONAL COOPERATIVE
HIGHWAY RESEARCH PROGRAM REPORT

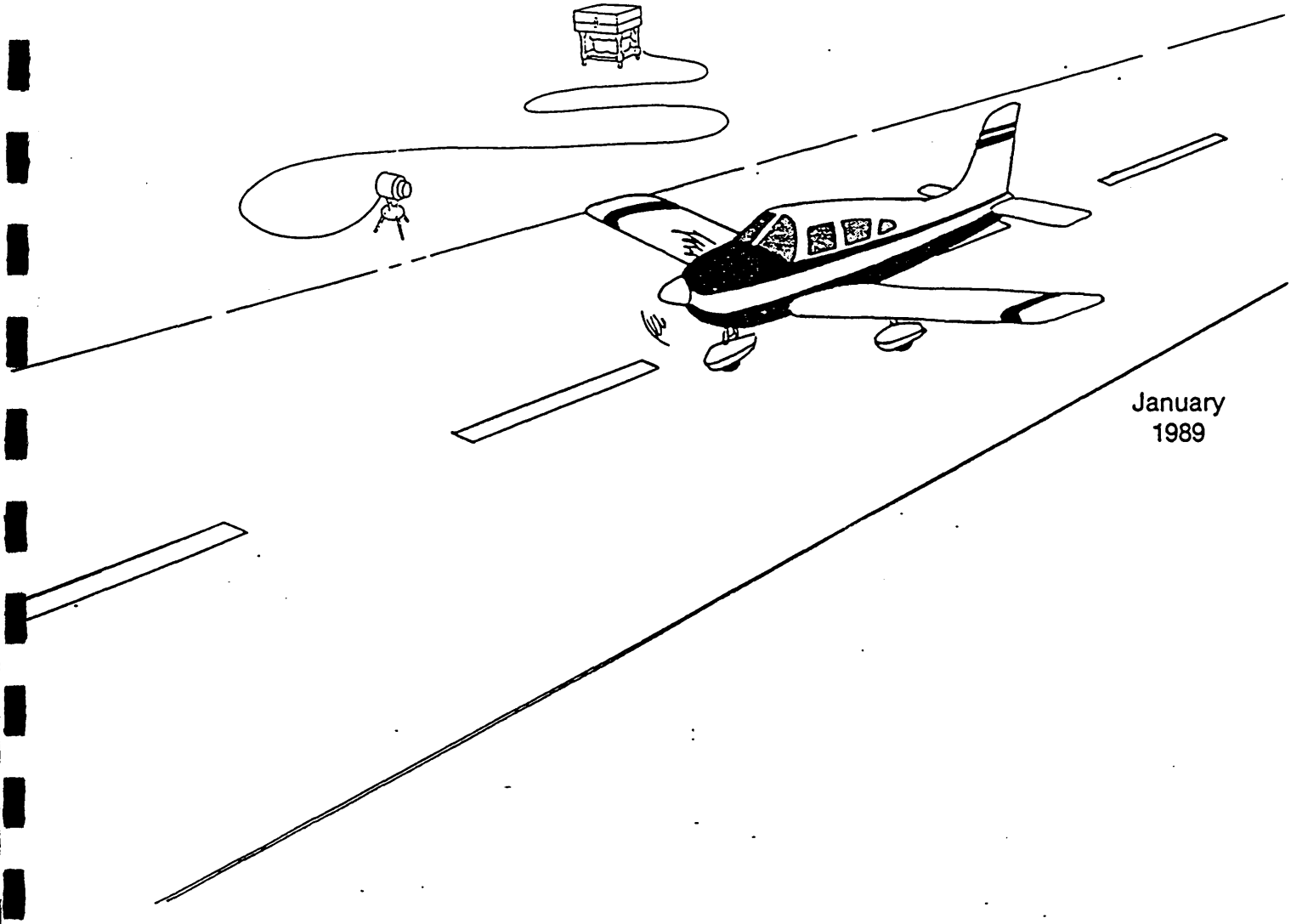
304

DETERMINING DETERIORATED AREAS IN PORTLAND CEMENT CONCRETE PAVEMENTS USING RADAR AND VIDEO IMAGING

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

Iowa Department
of Transportation
Planning & Research
Division
Office of Transportation
Research

IOWA AUTOMATED AIRCRAFT ACTIVITY COUNTING 1987-1988

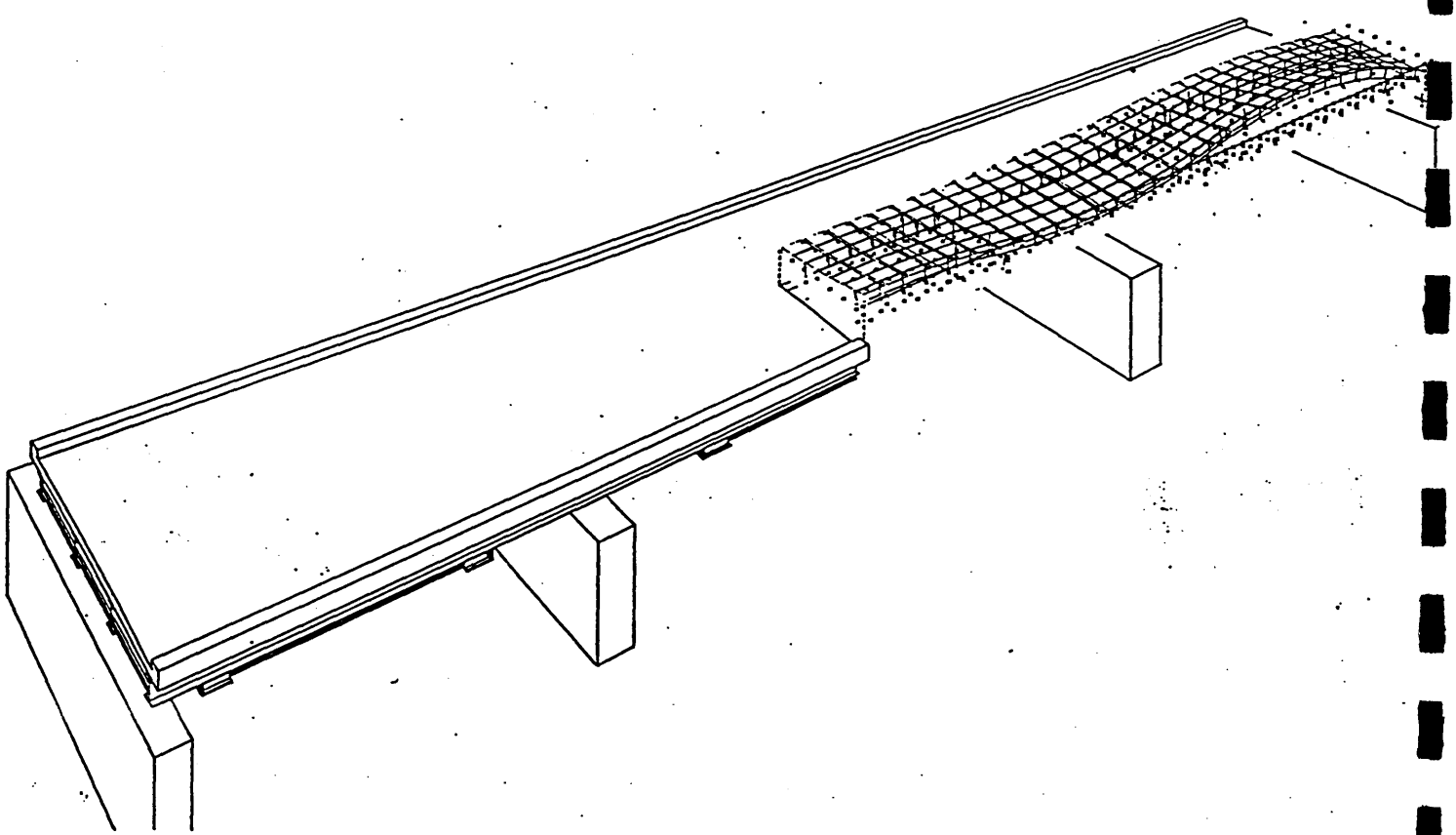


January
1989

K. F. Dunker F. W. Klaiber F. K. Daoud W. E. Wile

Strengthening Existing Continuous Composite Bridges

Sponsored by the Highway Division, Iowa Department of Transportation, and the Iowa Highway Research Board



engineering research institute
Iowa State University

Iowa Department of Transportation

Correlation of the IJK Roadmeter to the International Roughnes

Final Report for MLR-91-5

March 1992

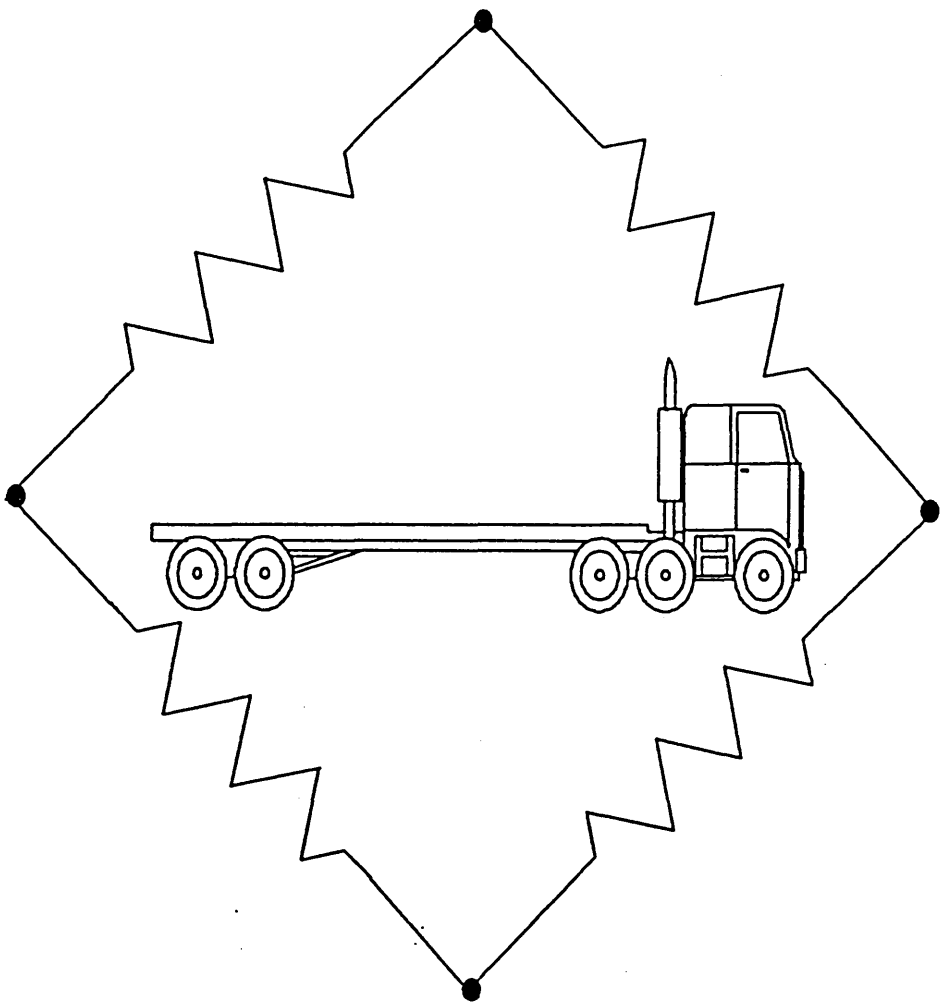
Highway Division
Iowa Department of Transportation

U.S. Department
of Transportation

Federal Highway
Administration

Pavement Instrumentation

Demonstration Project
Division



DTFH71-86-621-Ia-19

Sept. 1992

Iowa Department of Transportation
Iowa Highway Research Board
Project HR 293

EFFECTS C
HEAT STRAIGHTENING
STRUCTURAL STEEL

FINAL REPORT
FOR
MLR-91-3

AUGUST 1992

Highway Division

Iowa Department
of Transportation

FHWA EXPERIMENTAL PROJECTS REPORT FOR 1993

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HR-556	IA-93-01	Structural Contribution of Various Thickness of Asphalt Resurfacing and of Crumb Rubber Modified Asphalt Concrete on US 63, Howard County	S1
HR-558	IA-92-04	Raised Pavement Markers	T1

NATIONAL COOPERATIVE
HIGHWAY RESEARCH PROGRAM REPORT **306**

CORRELATION OF BRIDGE LOAD CAPACITY ESTIMATES WITH TEST DATA

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

T. J. Wipf
K. Jeyapalan
J. T. Neiderhiser

Long-Term Structural Movement

February 1986

Iowa Department of Transportation

Sponsored by the Iowa Department of Transportation, Highway Division, and the Iowa Highway Research Board

report

Iowa DOT Project HR-275
ERI Project 1795
ISU-ERI-Ames-86205

College of Engineering
Iowa State University

Evaluation of Rapid Determination of the Chloride Permeability of Portland Cement Concrete By AASHTO T277-83

Project No. MLR-86-11

Highway Division
September 1987

Iowa Department of Transportation

Attachment G

IOWA DEPARTMENT OF TRANSPORTATION

TO OFFICE: Transportation Research DATE: November 24, 1993

ATTENTION: John Whited REF. NO.: 436.2

FROM: Bernard C. Brown

OFFICE: Materials Engineer

SUBJECT: SHRP Product Implementation

The following are the procedures in place for reviewing SHRP products for possible implementation in the DOT:

1. I receive all SHRP products. The products consist mostly of reports, manuals, videos, and software. I usually receive 5 copies, but this can vary. Some of the products are unpublished reports which are so technical in nature that the distribution is limited.

2. Upon receiving the SHRP product I review it briefly and establish what I believe to be the office(s) that would have the most interest in the subject. The distribution would be based upon this review. At the same time I make a recommendation as to how the product can best be utilized. This recommendation is made to the New Products Evaluation Committee.

3. The New Products Evaluation Committee formally discusses the product at one of their scheduled meetings. The New Products Evaluation Committee answers to the Specification Committee; consequently their analysis and action is sent to the Specification Committee for concurrence or alternate decision.

Lee Smithson and I are co-SHRP Implementation Coordinators for the DOT.

By use of the above procedure and direct contact by Lee with the Highway Operations Section of SHRP, the loop is pretty well closed.

The Long Term Pavement Performance (LTPP) activities in Iowa are monitored by an in-house SHRP committee. Materials, Construction, Maintenance, Road Design, Traffic Inventory, and Transportation Research are represented on this committee.

BCB/esb
cc: L. D. Smithson

IOWA DEPT. OF TRANSPORTATION

SHRP IMPLEMENTATION PROCEDURE

1. SHRP Product delivered to the Iowa D.O.T. Implementation Coordinator (Lee Smithson & Bernie Brown). The products usually consist of reports, manuals, standards and videos. Usually 5 copies are delivered.

2. The product is reviewed and distributed where there would be the greatest interest. One copy is delivered to the New Products Evaluation Committee with a recommendation for implementation if appropriate.

3. The New Products Evaluation Committee reviews the product in detail and makes a final recommendation to the Specifications Committee regarding implementation.

4. The Specifications Committee makes the final judgement regarding implementation.

IV. Transportation Research Record (No. 738)
....Utilization of Research Results

A major problem is the breakdown in the process of transferring research results into practice. Much effort is devoted to the conduct of research however, in many cases, the process of implementation and research utilization are ignored.

Research almost invariably involves the same sequence of steps:

1. Recognition of the problem.
2. Problem definition.
3. Theory building and explanation.
4. Information gathering.
5. Informational analysis and interpretation.
6. Development of conclusions.
7. Formation of recommendations.
8. Implementation and action.

The potential usefulness of a research project can be affected by the way in which each of these steps is undertaken. If there is substantial deviation in how things are viewed by the researcher and the user, the likelihood of eventual implementation is decreased. Thus, if the research fails to recognize or properly define a problem in a way that is meaningful to the user, the probability of implementation is lessened.

This general process of research leads to the following axioms of research utilization (RU):

1. Probability of RU is inversely proportional to distance between the researcher and the user.

   Research utilization is enhanced through the involvement of the potential user of the research in the entire research process. If frequent and informal communication between the researcher and the user is established throughout the process they are more likely to identify points of deviation as they occur and to correct them before they become irreversible. In addition, there is an ease of information transfer and a greater degree of understanding of the other person's needs and intents.

2. Probability of RU is inversely proportional to degree of formality between researcher and user.

   Another factor that may cause a deviation between the researcher and the user is differences in organizational structure. For example, the research that takes place between a university and a user in a mission-oriented agency. The environment that the university researcher works, the decision making process he goes through and his objective (to publish) may be quite different to that of the corresponding agency user.

3. Probability of RU increases with the degree of understanding that a researcher and user have of each others problems and motivations.

   It is important that both the researcher and the user understand the environment in which the other works. If this is the case, both can recognize some of the barriers to research implementation that may develop.

   Once a research project has been successfully completed in that the stated objectives have been met and the research has some potential utility, we come to its utilization. The utilization process includes three basic phases:

   a. Dissemination: It can occur by both formal and informal means. Formal always involves written material and is likely to have the widest distribution. Informal can occur in a variety of ways, but generally involves person-to-person contact between the researcher and a potential user.
   b. Acceptance
   c. Implementation

Given that the research had been successfully disseminated, the potential user must accept the ideas presented and must be able to put them in practice. There can be many reasons why the user may fail to accept or implement. This often occurs when a problem is defined with limited input from the potential user. Research personnel tend to define problems along disciplinary lines and have a goal of advancing levels of knowledge; user personnel tend to define problems along policy lines and have a goal of making decisions. Obviously, extensive interaction is desirable to define mutually acceptable problem statements.

Certain basic principles applicable to applied research can serve as guides for increasing implementation:

1. Research results must be timely and available to the user for decision making.

   The conduct of research and the flow of research results should ideally parallel the decision-chain process (each decision in a given sequence is dependent on the previous decision) so that the accumulation of research results coincides with, and has important implications for, each stage of the decision process.

2. Research must distinguish between variable that are subject to manipulation by the user and variable that are not.

   Since implementation often involves a policy change, it is important for the researcher to emphasize the policy variables and possible ways in which they may be used to institute changes. Also, being aware of the legal, institutional, financial, political, or other constraints of the user by the researcher can have direct affect on the relevancy of the research being contemplated.

3. The user must be included in the relevant stages of the research process.

   In those situations where the user has had little or no input into the research process, he all to often finds it difficult relating the results to his particular situations since the problem definition may not be acceptable.

4. Research must translate the results into a language that is understandable to the targeted user.

   Though seemingly self-evident, violation of this principle is common, and users often complain about technical language used in research reports.

5. Research should subdue personal values and interests and not engage in advocacy.

   However, advocacy may be appropriate in making recommendations to the user, but should avoid, if possible, situations where advocacy leads to great conflict with the user. Research should be conducted in a responsible objective manner.

6. Research should recognize that implementation frequently requires some change in the user's methods of operations.

   Bureautic organizations are highly resistant to change, but the researcher may be able to foster and encourage implementation if good rapport has been developed with the user. Again, being aware of the user's environment can have a direct affect on the re-research being contemplated.

7. The common element underlying successful implementation is communication.

   Effective information transfer is crucial to the implementation process. It is important to recognize and deal with the problems that may hamper this transfer as early as possible in the process.

8. In situations where a research project has promising potential for implementation, it is important at the outset to plan implementation along with the research.

   The researcher should be conscious of the process of implementation and the role it plays in the conduct of research. They should be viewed together.

10 RULES OF EFFECTIVE RESEARCH

"Managing for the Future - 1990s and Beyond"
by Peter F. Drucker

First five rules are about what to do. The last five lay down how to do it.

1. Every new product, processor, or service begins to become obsolete on the day it first breaks even.

2. Thus, your being the one who makes your product, process, or service obsolete is the only way to prevent your competitor from doing so.

3. If research is to have results, the nineteenth-century distinction between "pure" and "applied" research better be forgotten. A minor change in machining a small part may require pure research into the structure of matter. Yet, creating a totally new product or process may involve only careful rereading of a standard handbook. Nor is pure research necessarily more difficult than redefining a problem so that well-known concepts can be applied to its solution.

4. In effective research, physics, chemistry, biology, mathematics, economics, and so on are not "disciplines." They are tools.

5. Research is not one effort--it is three: improvement, managed evolution, and innovation.

   - o Improvement aims at making the already successful better still. Improvement starts with feedback from the front line: people who make the product or deliver the service; sales people; and, the users. Then, the company's own product designers must convert the front line's suggestions and queries into changes in product, process, or service.

   - o Managed evolution is the use of a new product, process, or service to spawn an even newer product, process or service. Its motto is "each successful new product is the stepping stone to the next one."

   - o Innovation is the systematic use of opportunity of changes: in society and the economy, in demographics, and in technology.

6. Aim high! "If we succeed will it make a real difference in the customer's life or business?"

7. Effective research requires both long-range and short-range results. The efforts needed are too great to be satisfied with the short term alone. A short-term result must also be a step in a continuing long-term process.

8. Research is separate work, but it is not a separate function. Development--the translation of research results into products, processes, and services that can be manufactured, sold, delivered, and serviced--must go hand in hand with research. Land manufacturing, marketing, and service all affect research from the beginning, just as much as the results of research in turn affect them.

9. Effective research requires organized abandonment--not only of products, processes and services, but also of research projects. Every product, process, service, and research project needs to be put on trial for its life every few years--"would we now start this product, process, service, or research project, knowing what we know now?

   Three good clues when to abandon:

   1) when there are no more significant improvements
   2) when new products, processes, markets or applications no longer come out of managed evolution.
   3) when long years of research produce only "interesting" results

10. Research has to be measured like everything else.

   - For improvements, it is fairly easy to set specific goals and to measure them.
   - In managed evolution, goals can be set
   - Innovation requires appraisal. Every three years or so a company needs to review its innovative results.