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Adequacy of Research Funding for Transportation Management and Administration Research

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FOREWORD

In recent years, the Transportation Systems Planning Group Council (Group 1) of the Technical Activities Division has become concerned with the lack of research dealing with transportation management and policy development. When chief administrative officers from state and local highway, transit, rail and aviation agencies have been invited to address the Council regarding their primary topics of concern, they have invariably focused on management, finance and policy issues.

Substantial achievements have been made in funding research directed at reducing the costs of construction and maintenance of transportation facilities. To this end,the Strategic Highway Research Program has been established. The Group 1 Council believes that based upon the responses of the transportation CAO's, a similar program is desirable for management and policy research. The Council has been instrumental in initiating the National Cooperative Research Program project #20 -24, "Research Program Design - Administration of Highways and Transportation Agencies." (The project is discussed in this Circular.)

The Group 1 Council invited speakers to their meeting in January 1988 to discuss the problems of funding for transportation research. The following is a report on the meeting.

SUMMARY

Ronald F. Kirby
Group 1 Council

Over the past several years, the Group 1 Council has devoted considerable effort to investigating the adequacy of research funding for transportation, with particular emphasis on systems planning and administration. The Council was instrumental in the development of the NCHRP 20-24 research project on research needs of Chief Administrative Officers (CAO's) of state transportation agencies. In September of 1987, the Council held a workshop aimed at identifying significant gaps in research funding, the reasons for those gaps, and possible remedies. At the TRB annual meeting in January of 1988, the Council sponsored a session on research needs which included a progress report on the NCHRP 20-24 project, a review of trends in research funding in the public and private sectors, and a summary of the proceedings of the September 1987 workshop.

This document presents an edited transcript of the January 1988 session sponsored by the Group 1 Council, along with selected charts used at that session, updated information on the NCHRP 20-24 project taken from the final report of October 1988, and the Executive Summary of a Task Force Report on the status of the NCHRP program completed in February 1988. The following sections of the summary attempt to draw together the key points of the presentations and reports contained in this document, and to suggest some next steps in addressing the issue of research funding.

Adequacy of Research Funding

The review by Nan Humphrey of research funding in different public and private sectors of the economy showed that while total R&D spending in the U.S. has increased steadily as a percentage of GNP during the 1980s, civilian R&D has not grown as fast as defense and space R&D, and the growth that has occurred in civilian R&D has come entirely from the private sector. Federal civilian R&D has stayed level in current dollars, and declined in constant dollars. R&D spending in the transportation sector has also declined slightly in real terms during the 1980s.

For the four major transportation modes -- air, highway, rail, and public transit -- Nan Humphrey's

review showed that air transportation accounted for 85 percent of the total research funding followed by highways with eight percent. Over the 1980s R&D spending for air transportation increased, R&D spending for highways increased with the 1982 increase in federal fuel taxes, and rail and transit spending declined.

Comparing R&D spending as a percentage of sales for various industries and as a percentage of revenues for different transportation modes reveals wide variations. The average for all private industries with R&D budgets over one million dollars is 3.5 percent of sales, with a range from 7 percent for high technology industries like computers down to 1.2 percent for many manufacturing industries like steel and textiles. For the transportation modes, air R&D tops the list at 2 percent of revenues in 1986, a drop from 2.6 percent in the mid-seventies despite increases in constant dollar terms. For highways, the increase in federal motor fuel taxes in 1982 raised R&D as a percentage of revenues from only 0.1 percent in 1982 to 0.15 percent in 1987. Rail R&D spending has fallen from 0.28 percent of revenues in the mid-seventies to 0.14 in 1986, and transit R&D spending has fallen sharply from 1.5 percent of revenues in the mid-seventies to between 0.2 and 0.25 percent in 1986.

Nan Humphrey's review concluded that in comparison to private industry, transportation R&D spending as a percentage of revenues is "woefully low", all but the air mode falling well below the one percent level of the lowest spending private sector industries. For highways, this conclusion is supported in the NCHRP Task Force report:

> "In a national highway program that spends more than $60 billion each year, the 0.17 percent allocated to research is not adequate and is far less than even the most stable private industries are devoting to developing new technology."

At the September 1987 Group 1 Council workshop, attendees noted that the Corps of Engineers has been able to commit about one percent of its total revenues to research, and that the gas industry routinely devotes a portion of its revenues to a central institute which does research for the industry. The concept of earmarking a portion of all transportation revenues -- say one percent -- for research had considerable appeal.

There was a concern expressed at the Council workshop, however, about the danger in earmarking only certain sources of transportation revenue such as the federal programs, which may be declining in real terms. In this context, the NCHRP Task Force decided to recommend an increase in the percentage of state HP&R allocations allocated voluntarily to the NCHRP by the states from 4.5 percent to 5.5 percent, to combat the effects of "gradual erosion from inflation, coupled with the reduction in HP&R apportionments under 1987 legislation," which would otherwise "result in a 1988 program that represents only 59 percent in equivalent dollars of the program of 20 years ago." Concerns were expressed that the transit STRS proposal, which proposes to earmark one-half percent of the federal Section 9 and Section 18 funds, might suffer from uncertain federal funding levels.

Subject Area Gaps

In addition to inadequacies of overall funding levels for research, a number of concerns have arisen concerning subject area gaps. The distinction between "soft-side" and "hard-side" research was of considerable interest to the Group 1 Council, but numbers on the allocation of dollars between these categories were hard to obtain. Nan Humphrey's review noted that there was a decline in soft-side projects funded by NCHRP in the early 1980s, but some increase in 1987 and 1988. The new Strategic Highway Research Program (SHRP) has provided an increase in hard-side projects for highways. For transit, much of the funding decline was in "hard-side" projects, so that the proportion of funding for "soft-side" projects has actually increased as overall funding levels for transit R&D have fallen.

Project NCHRP 20-24 noted serious inadequacies in research oriented to the needs of the CAOs, and identified seven major research areas in order of priority:

- long term policy development;
- finance and resource development;
- organizational forms for implementation;
- financial management;
- decision support;
- understanding of the transportation industry; and
- public and political interactions.

The project panel concluded that subsequent phases of the project should concentrate on three of these topics:

- resource development;

- decision support; and
- financial management.

Continuing research is being recommended in these areas.

Gaps were also noted in long-term basic research, in multi-modal research and in funding for innovative research ideas stimulated by the researchers themselves. It was noted that NCHRP tends to be oriented to implementation issues, applied research, and the interests of the state transportation agencies. There seemed to be little or no prospect of an explicit program of transportation research at the National Science Foundation (NSF). The federal highway and transit agencies seem to have been directing most of their research funding to short-term policy oriented research. The new University Centers program promises to provide $20 million per year of research in the highway and transit areas, although all projects under this program must be approved by the Secretary of Transportation. There was some questioning of the extent to which this latter program will be able to close the gaps in basic long-term research areas given the approval process for projects.

Reasons for Inadequacies

This discussion at the Group 1 Council workshop in September of 1987 identified in order of priority seven major factors that were considered primarily responsible for the current inadequacies in transportation research:

- Agencies administering research funds currently are not oriented to long-term, basic research issues;
- Federal research funding has been reoriented to immediate policy priorities over the past six or seven years;
- The interests of the research community and government agencies do not match very well, and have been diverging over recent years;
- There is a lack of top management support for basic research in federal, state, and local transportation agencies;
- Overall funding levels for research have been declining for most transportation modes, as part of the overall decline in real terms of federal funding for civilian research;
- Research funding is very compartmentalized by mode, with little funding available for multi-modal research;
- There has been no politically potent constituency advocating research funds for "soft-side" projects.

Potential Remedies. The Council workshop identified the following potential remedies for these problems:

- Researchers need to devote more effort to educating or reeducating funding agencies on the value of research, particularly long-term research;
- Efforts should be made to extend the concept of earmarking a portion of sales or revenues perhaps one percent to a broader range of transportation revenue sources, including state and local funds, and perhaps tolls and fare revenues;
- Communications between researchers and funding agencies need to be improved through internships and staff exchanges between research agencies and the transportation industry;
- Resources should be provided for innovative research stimulated by the researcher, through funding of unsolicited proposals and student fellowships at universities;
- Funds need to be earmarked for multi-modal research, either as a small portion of the total for the modes or through some formal pooling of modal funds; and
- The paucity of soft-side research funded by NCHRP seems to be due to a lack of good research proposals. Researchers need to devote more effort to developing and advocating soft-side projects for NCHRP.

Overall, the Group 1 Council's inquiry into the adequacy of transportation research has concluded that there are serious shortfalls in funding levels and significant gaps in coverage of the spectrum of needed research. Now that funding levels are down, a major effort will be required to get research funding to levels approaching the one percent of revenues that are at the low end of the range found in the private sector. Funding levels for the highway, rail, and transit modes are particularly low at present -- in the 0.14 to 0.25 range as a percent of revenues.

Establishing adequate funding levels and

coverage of transportation research topics is likely to require new mechanisms to earmark research funds from a broader range of transportation revenue sources, and the design of a comprehensive array of research programs that includes all of the different types of research that are needed. The current efforts to formulate post-interstate federal transportation programs provide an immediate opportunity for researchers to advance some new proposals for funding and managing transportation research in the highway and transit areas. This and other avenues for increasing research funding and topic coverage would appear to be worthy of continued attention.

INTRODUCTORY REMARKS

Richard P. Braun
University of Minnesota

I think most of you here today would expect that a Department of Transportation (DOT) head, which I was for eight years, or someone who is on a top administrative level within the DOT, would have a different perspective on research than some of his or her staff might have. A key issue for some DOT heads is timing. You might look at that almost as impatience. But what it really involves is the fact that the person on top, the administrator of a specific unit, feels that something has to occur fairly rapidly.

In the case of the chief administrative officer of a DOT, just think about the longevity issue right now. Very few heads of DOT's last more than four years. I think there has been a turnover of more than thirty state DOT heads in the last 15 or 16 months.

Those in these top positions feel that they need fast answers; they need answers to respond to some political questions, some constituency questions or something a legislator might ask them. It is difficult to say "you're going to run that sort of request through a whole long process," such as the NCHRP process. That was one of the reasons why the synthesis projects were developed. This is a process in NCHRP where you could get a fairly exact answer in a relatively short period of time on a specific issue.

Actually, if you go back to, let's say, the late seventies, that was one of the reasons why the Commissioners of State DOT's (COSDOT) was created. COSDOT was a group of impatient young DOT heads who felt that AASHTO wasn't moving fast enough, and they started to organize entirely on their own. Over a period of years, for a variety of reasons, COSDOT went out of existence. Perhaps most of you don't even recall that there was such a group just a few years back.

The subject of research needs in administration next arose at a meeting that was held in 1986 to take a look at what the research needs are of administrators in general and more specifically the chief administrative officers. This meeting resulted in the research project NCHRP 20-24, which will be reported on by the first speaker.

The second speaker will discuss the trends in research funding in the public and private sectors. This is a critical topic for all of us, particularly in the current period of cutbacks in federal funding resulting from a large federal deficit and uncertainty as to the future of federal funding. Our third speaker will discuss gaps in research funding, the reasons for those gaps, and the possible remedies. This is a summary of the Group One Council meeting that occurred last summer.

I don't think there is much need for me to talk about the minute percentages of funds that are actually allocated to transportation research. I recall that Bill Agnew who is the technical director for environmental and human sciences at General Motors, did a really super job presenting this subject a year ago in an article in Transportation Quarterly. It was in that same issue that Tom Deen, the Executive Director of TRB, pointed out that less than three percent of the non-defense research goes to transportation. If you added in the defense research, less than one percent of the total money allocated to research nationally went into transportation.

TRENDS IN RESEARCH FUNDING IN THE PUBLIC AND PRIVATE SECTORS

Nancy Humphrey
Transportation Research Board

I was asked to provide some background information on research spending trends in both the public and private sectors to provide a context for your more specific concern about the adequacy of research funding in the area of transportation planning and administration. Basically I've organized my talk around four central topics:

1. an examination of overall R&D spending trends;

2. a comparison of how funding for transportation R&D has fared over the last several decades;

3. an analysis of how transportation R&D levels compare with private industry; and

4. an explanation of the reasons for positive R&D spending trends in certain transportation sectors.

I have drawn quite heavily on annual data that is collected by the National Science Foundation in an annual publication entitled "National Patterns of Science and Technology Resources". I have also used the NSF's definition of "research", which encompasses both basic and applied research and development, so the figures apply to a very broad definition of research. I'd like to start by giving you a brief overview of general R&D spending trends.

I had heard so much about research being in great decline, and found that if you look at total U.S. spending on R&D over a 20 year period, there's been quite an upswing in R&D spending since 1980; this trend is evident even after adjustment for inflation.

In the 1970's R & D spending hovered around $60 billion. Since that time, R&D spending has increased by about 70 percent and reached the $100 billion dollar mark in 1986. This increase in R&D spending is also evident if you look at spending as a percent of GNP over this same period. In 1986, R&D spending as a percent of GNP was back up to three percent, close to its high point in the late nineteen sixties.

However, when you analyze the increase in the R&D spending by type of spending, you find that not all of the recent increase is available for civilian purposes, such as transportation. If you separate out federal spending for defense and space from both federal and industry R&D funded for civilian purposes, you see that the former has increased more rapidly during the 1980s.

These differences are even more evident when you look at spending as a percent of GNP. Spending on civilian R&D has been rather flat over this period. Even though R&D spending for defense and space accounted for the recent rapid increase in R&D spending, however, in absolute terms the bulk of the spending in recent years has been for civilian R&D.

Now let us look at who finances R&D spending. In the mid-nineteen seventies, the private sector, mainly private industry, began to catch up with the federal government as a major sponsor of research. In fact, private industry spending for research increased and out-stripped federal government spending in the 1980s, and hence, the tilt toward more spending for civilian purposes.

If you look at spending only for civilian R&D by funding source, you see that the share funded by private industry has increased, but that the share sponsored by the federal government has declined as a percent of the total and this has very definite implications for areas, such as transportation, where the federal government has been the chief sponsor of research.

To sum up this overview, I think first, that it is clear that there has been a resurgence in total R&D spending, particularly during the 1980s. Second, although civilian R&D spending has not grown as fast as R&D for defense and space purposes, it currently accounts for nearly two-thirds of total R&D spending. Finally, the increasingly important role of industry in funding research, and the lessening of federal support for civilian-related R&D, will affect the type of R&D expenditures for civilian purposes in the future.

Now I would like to turn to the topic of R&D spending in the transportation sector. Let me start by defining some terms. When I talk about transportation I am looking at transportation in the broadest sense of the word. I am including highways, air, water, rail, public transit, and even pipelines. I am also looking primarily at federally-funded R&D, since privately-sponsored R&D funding for transportation is highly fragmented. The federal government is the major funder of research in transportation.

In comparison to overall R&D spending, R&D spending in the transportation sector declined slightly in the 1980s when adjusted for inflation. This decline is more clearly shown by comparing compound average annual growth rates during the 1970s and 1980s for total R&D spending and for transportation R&D spending. Transportation R&D spending is lower in both cases, but it also declined in the 1980s relative to growth rates in the 1970s. Total R&D spending exhibited just the reverse pattern.

I also looked at how transportation R&D dollars

are allocated among the modes. Here I did exclude water and pipeline transport from my analysis, but they would only account for a very small share of the total. I looked at R&D spending averaged over the last five years for the four major transportation modes–air, highways, rail, and public transit. Air transportation clearly accounts for a majority (85 percent) of the total. The next highest spending area is highways, with eight percent of the transportation R&D dollar.

Despite aggregate spending trends, I found considerable differences in spending patterns between the individual modes. Highway R&D spending increased in the last several years, particularly since 1982 with the increase in federal motor fuel taxes. R&D spending for air transport also increased over this period. In contrast, R&D spending for rail and public transit declined.

In summary, it is clear that transportation R&D has not shared in the recent increases in total R&D spending. Aggregate figures, however, hide individual differences among the modes. Finally, at least in absolute terms, air transportation accounts for the majority of R&D spending in the transportation sector.

Next I would like to briefly review each of the four transportation modes – air, highways, transit, and rail – to summarize R&D spending trends over time in current and constant dollars; to identify the major funding sources; to analyze spending as a percent of operating revenues; and finally, where possible, to examine the allocation of R&D funds for "soft-side" versus "hard-side" research. The latter item was quite difficult, but I have a couple of examples that may be illustrative.

Starting with air transportation, there has been an increase in both current and inflation-adjusted dollars in R&D spending. The primary funders – and remember we are talking about federally-sponsored R&D – are NASA (the Aeronautical Research and Technology program spends considerable dollars on civil aviation) and, to a much lesser extent, the FAA. If you look at R&D spending as a percent of airline operating revenues, the picture is not quite as bright. Spending has dropped to approximately two percent of operating revenues in 1986 from about 2.6 percent of operating revenues in the mid-nineteen seventies.

Turning to the highway area, again, there has been an increase in R&D spending. The Surface Transportation Assistance Act of 1982 affected research programs which had a fixed set-aside, like the Highway Planning and Research (HP&R) Program and to a lesser extent, the National Cooperative Highway Research Program (NCHRP). Both of these programs substantially increased after 1982. There was also the beginnings of the Strategic Highway Research Program (SHRP) which will grow over time.

Despite these favorable funding arrangements, when you look at R&D as a percent of total highway disbursements from all levels of governments, the increase in funding from 1982 Act raised R&D funding levels from 0.10 percent in 1982 to only 0.15 percent in 1987.

I was able to get some detail on the NCHRP program, on the share of those program dollars that have been allocated to "soft-side" versus "hard-side" projects. In the early nineteen eighties, there was decline in funding for "soft-side" projects. Although more "soft-side" research projects have been slated for 1987 and proposed for 1988, SHRP, with its emphasis on "hard-side" research, will dwarf most of these increases.

Turning to transit, we can really see a dramatic decline in R&D spending in this transportation mode. Transit was vulnerable to the budget cuts of the Reagan administration, which is quite evident from the decline in spending from a high of $91 million in 1981 to a low of $22 million in 1986 (both figures are in current dollars). The plunge in spending is even more evident if you look at transit R&D as a percent of transit revenue from all sources; R&D funding has declined from a level of 1.5 percent of transit revenues in the mid-nineteen seventies to 0.20 to 0.25 percent of transit revenues in 1986.

This decline in funding was one of the reasons why TRB's Strategic Transportation Research Study (STRS) for transit recommended an annual one half percent set-aside of Section 9 and Section 18 funds for research. Even with that increase, which would translate into about $10 million dollars of additional funding for research each year, the level of transit R&D funding would increase to only about three tenths of one percent of transit revenues.

Again, I was able to get some information on spending for "soft-side" versus "hard-side" research. In transit, the trend is quite different than what you saw previously for the NCHRP program. There was a turning away from the high-technology orientation of the transit program in the early

nineteen seventies, with a resulting gradual increase in funding for "soft-side" projects.

The last area is that of rail. Again, there was a sharp decline in R&D spending in the nineteen seventies from $70 to $80 million to about $30 million today. The budget of the Federal Railroad Administration, the primary funder of rail research, experienced sharp cutbacks during the Reagan administration. Private sources of funding increased over this period, but not enough to offset the decline in federal support. (Rail was the one mode for which I was able to obtain estimates of private funding for research, in this case compiled by the Association of American Railroads.) When you look at rail R&D as a percent of operating revenues, spending has dropped to about half the level of that it was in the mid-nineteen seventies. R&D spending now accounts for about 0.14 percent of rail operating revenues.

In the final minutes, I would like to compare R&D spending levels in the transportation sector with private industry and finally, venture some explanation for positive R&D performance in certain transportation sectors.

When we compare public and private R&D spending levels as a percent of operating revenues for each of the four transportation modes, the highest is air R&D at nearly two percent of airline operating revenues. Highway, transit, and rail are all well under one percent of their respective operating revenues.

The average R&D spending for all private industries with R&D budgets of over one million dollars is 3.5 percent of sales. There is quite a range. For high-technology industries (i.e., computers, instruments, etc.), spending is about seven percent of sales. Many manufacturing industries (i.e. steel, food and beverages, textiles, etc.) are low spenders -- here R&D spending averages about 1.1 percent of sales. In conclusion, I think it is evident that, at least in comparison to private industry, transportation R&D spending levels are woefully low; they compare with some of the lowest spenders in the private sector. Moreover, share of revenues that has been expended on transportation R&D as a percent of operating revenues has declined over the last decade, with the exception of R&D for highways, the only sector which has maintained R&D spending levels as a share of operating revenues. This good performance can be attributed to the percentage set-aside of highway funds for research, under which research budgets benefit from an increase total allocations for the highway sector.

NEW DIRECTIONS FOR TRANSPORTATION ADMINISTRATION RESEARCH, A REPORT ON NCHRP 20-24

Richard R.Mudge, Apogee Research, Inc.

In response to concerns raised by the chief administrative officers (CAOs) of numerous state departments of transportation (DOTs), NCHRP Panel 20-24 was formed in late 1986 to explore the feasibility of a "top down" research program to help meet the management, administrative, and financial problems faced by CAOs. This effort was divided into two phases: an exploratory review and a more detailed research plan. The team of Apogee Research and John Clements was selected to conduct this research.

Our approach in the first stage of the NCHRP 20-24 project was to contact as many people and CAOs as possible. We had formal interviews with some 30-35 experts including 13 current chief administrative officers. (During the second stage, interviews were conducted with perhaps another half a dozen CAOs).

One problem we found is the tremendous turnover (particularly in recent years) among CAOs. Many of these people have been in the job a year or two or less -- they're brand new. There are fewer and fewer of the old hands around. But regardless of who we talked to, we found genuine interest in the project. Another clear finding was the importance of the form of communication; for example, only a limited number of CAOs come to TRB meetings. The form of communication by researchers is very important: it has to be in a form that CAOs can understand and be able to convert to direct use.

CAOs feel a clear need for targeted research; they have very specific problems to solve; they have to solve them in a very short time frame; and they have to be able to get research projects done quite quickly, and communicate the results effectively.

Not surprisingly we found that research needs vary quite widely among CAOs. Their backgrounds vary tremendously; for example, a number of CAOs were highway engineers and know the highway program very well (though they may have more limited knowledge of other modal areas), but they may be less involved in politics. On the other hand,

other CAOs come from a political background, may not know the program as well, and may or may not be good managers. Then there's another smaller group who typically come from business and consider themselves good managers, but who may be somewhat naive about politics or may have virtually no knowledge of the federal-aid highway program or the funding process for other transportation modes.

In the first phase of the research, we identified seven major research areas. There are no tremendous surprises; they are the types of problems that people talk about a lot. Our mandate was to put labels on them along with definitions so that we could focus our efforts on those that seemed to be most important.

While most of our effort was non-quantitative, we did use a questionnaire asking CAOs to rank problems in order of importance to them and their job, and then to note ones which they believed State DOTs were performing the best. One approach would be to focus research attention on those areas with the largest gap -- those areas which seem to be very important, but where performance is not as strong as it should be.

The area where there would seem to be the largest gap is one we called long-term policy development. This topic concerns long-term trends in society and the economy, their possible meaning for future transportation development, and how to design future transportation programs that will be in place to solve problems before they arise.

The second area was finance and resource development. In addition to identifying sources of funding, this area covers personnel resource development, in large part because there is currently a tremendous turnover problem with many highway engineers reaching retirement age. There was a real concern among many CAOs about their source of new middle and top managers. There was also a concern that they don't always know how to measure when an engineering department is doing a good job.

The third major area was implementation -- how do you ensure that a good job is done; what kind of organizational form works best; for example, what are the pros and cons of geographically dispersed decision making versus geographically concentrated? It includes very practical types of concerns.

The fourth major area was financial management. Given whatever resources you have, what is the most efficient way of allocating those resources among projects? What types of investment criteria make sense?

The fifth area was decision support -- what types of information systems or risk assessment systems are there in place to help you make both your day to day decisions as well as your long-term decisions?

The sixth area was general understanding of the industry -- what is the context of the world in which CAOs must make decisions, what is the trucking industry like, what are commuting patterns going to be like?

The final area was public and political interactions how do you explain to the public what your program is about, so they can understand what it is you're trying to do, and provide meaningful feedback?

After we prepared the first phase report, the panel met, commented on it, and concluded that the next phase of work should concentrate on three of the topics: resource development, decision support, and financial management. Those three areas were felt to offer the highest potential payoff.

Although we had found long-term policy development to be the biggest problem, the panel felt that finding answers to those three would also generate solutions to many long-term policy development problems. Further, given the limited resources available for the second phase of this work as well as the effort required to actually complete the research, it probably does make sense to focus on those three areas.

Based on personal interviews with CAOs and other transportation professionals, the first report found there was a clear need for an ongoing program of applied research that could meet the special problems faced by many CAOs. Rather than focusing on original research, however, most efforts under such a program would probably consist of syntheses of existing research, adaptation of work from other fields, case studies, and surveys of state practices. The interviews with CAOs found that effective communication of research results was vital and that different methods were required beyond the traditional formal written report.

At the panel's direction, the research program

developed in this report focuses on research topics within three broad problem areas:

- Resource Development;
- Decision Support; and
- Financial Management.

Within these three broad problem areas, seventeen separate research topics have been identified. Two generalities can be stated about these research topics.

First, although each could be completed individually, there clearly is a synergy among them, with implementation of one research topic often supporting one or more of the other proposed topics. Second, in contrast to the effort underway as part of SHRP, these topics do not appear to represent a backlog; rather they cover a set of ongoing problems that will continue to evolve over time. Both these findings appear to argue for establishing an ongoing applied research effort dedicated to helping solve the special problems faced by CAOs.

The seventeen research topics, in turn, have been broken into between three and ten separate projects each, for a total of some ninety projects. While differences exist depending on the individual topics, many of the research projects follow a five-step progression:

- Review or synthesis of current efforts and related research;
- Develop a general analytic framework;
- Demonstrate methods by analyzing a problem faced by a particular state or by developing case studies;
- Develop handbook or set of standards for applying the methods; and
- An update service to track and report on new advances.

SUMMARY OF PROPOSED RESEARCH TOPICS

Full details on each research topic are provided in the Appendix to the full report. A brief summary of these topics are described below.

RESOURCE DEVELOPMENT

The most basic resource of any DOT is its staff; in turn, this is supported by other resources such as computer hardware, computer software, and research of all kinds. Research topics proposed in the area of resource development are designed to help CAOs evaluate the effectiveness of departmental resources, pinpoint barriers to greater effectiveness, and maximize the support contributed by all resources. Topics are grouped into two areas: Personnel Development and Performance.

Personnel Development

The transportation industry faces a continuing crisis in the availability of appropriately trained professionals.

At the entry level, fewer qualified professionals are entering the state DOT work force. Within middle management, increased rates of attrition and retirement are being felt.

Four research topics have been proposed that deal with the several dimensions of these problems:

- Recruitment and Training addresses the need to increase the flow of professionals into the transportation field in general and attract these entry-level professionals to state departments of transportation in particular.
- Middle Manager Training and Retention focuses on achieving better retention of those managers that might otherwise leave state departments of transportation and explores the potential for transfer and training of middle managers from other professional fields.
- Incentive Systems explores the role of different types of incentives in attracting high-quality personnel and encouraging high levels of performance. Information gained from this research can make a significant contribution to the preceding two topics as well.
- Civil Service describes the various systems in effect at the state level and analyzes positive and negative impacts of such systems on departmental flexibility, efficiency, horizontal equity, and personnel promotion. The focus would be on how to maximize productivity within the existing civil service rules and on how changes could be made.

Performance

- System Performance is motivated by the need for a consistent set of measures for different

aspects of DOT management. Because performance is often difficult to quantify it is often ignored. In addition to developing a system of management and administrative performance measures, this effort would initiate a national system to collect performance data across all state DOTs.

- Computer Performance is a special problem since there are limited standards for evaluating how and when to adapt past hardware and software investments to a rapid technological change. For example, how can tradeoffs be made between past investments and future investments?

DECISION SUPPORT

The CAOs of state transportation agencies routinely face important management, administrative and planning challenges. Yet they have only limited time to find, evaluate, and initiate effective solutions. The difficulty of meeting these challenges is compounded by the rapid turnover of CAO's in recent years and the diversity of their backgrounds. The research topics are designed to aid CAO's by supplying them with analytical tools to help make these important decisions; they are grouped into the following three areas: Departmental Organization, Management Support, and External Relations.

Departmental Organization

With increasing fiscal scrutiny of operations, transportation CAOs are forced to search for the most cost-effective organizational structures for their departments. The research topics proposed in this area address the following:

- Contracting Out focuses on the delegation of responsibilities to the private sector. The research is designed to formalize the process of contracting out, including provision of a comprehensive analytical framework for the decision on when and what to contract out, thus providing a more rational basis for CAOs' decisions.

- Centralization Versus Decentralization would provide guidelines for decisions that affect the concentration of responsibility within state DOTs. The proposed research would review case studies of decentralization, focus on determination of optimal conditions for decentralization, and provide guidelines for a systematic economic evaluation of agency reorganization to aid CAOs in assessing these alternatives.

Management Support

Increasingly, CAO's of state departments of transportation serve for shorter terms and have come to office with limited prior experience in transportation. There is a pressing need for them to orient quickly to their new responsibilities. At the same time, the materials that they - as well as more experienced CAOs - must assimilate has become more extensive and sophisticated, adding greater urgency to the need for effective and timely support systems. Several research topics have been proposed to help provide this support:

- A Skills Inventory would offer a system to help CAO's evaluate their own unique strengths and relative weaknesses. This research would develop a task-based skills assessment and inventory for systematic self-evaluation. Part of this effort could also develop a guide to show CAOs how to use this information to remedy revealed shortcomings as, for example, through judicious personnel decisions and personal skill development. Further, types of technology transfer could be designed to strengthen CAOs personal command of subject areas identified as relatively weak. For example, curriculum design and establishment of a program of conferences, seminars, and mini-courses for new and incumbent CAOs; and creation of a compendium of available written and human resources that are particularly relevant to transportation CAOs.

- Senior Executive Service would design and establish a corps of experienced ex-CAOs to serve as mentors to new appointees to ease the transition and to provide informal support as needed thereafter. Research includes development of a classification and matching system to pair appointees with the Service members who can best serve them and creation of an organization to administer the Service.

- Communication for CAOs focuses on the delivery, rather than the content, of relevant information. This topic investigates the potential usefulness of less conventional communication modes in relaying information to CAO's already inundated with materials in traditional written form.

External Relations

The citizens of each state are the "customers" who use the transportation "product" or services generated by the DOT. Modern marketing techniques that create a two-way communication channel between customers and producers in the private sector can be used as well in the public sector to create and sustain transportation systems that are responsive to public wants and felt needs. Two aspects of external relations are proposed for research:

- Market Research focuses on the application to transportation of modern information gathering techniques to help CAOs assess public knowledge of and demand for different transportation components. The proposed research would review various market research techniques, evaluate their usefulness in transportation planning and consensus creation, develop information gathering instruments with a survey tied to the 2020 effort, and construct a guidebook for individual state application.

- Public Outreach focuses on market-directed dissemination of information related to transportation in general and individual projects in particular. This topic will investigate the role of outreach in building public consensus for transportation investment, resulting in a handbook to help state DOTs construct their own effective outreach programs.

FINANCIAL MANAGEMENT

Financial management encompasses "macro" level policy planning and "micro" level project selection and funding – both of which shape the structure of state transportation systems. The gap between funds available and funds needed for proposed projects must be addressed on two fronts: developing ways to increase available funds, and establishing more effective means of selecting among competing projects. CAOs must also make decisions that shape their states' transportation infrastructure far into the future – these macro-level decisions require analytical support based on a clear vision of long-term goals, bolstered by an evaluation of the likelihood of the various conditions. The following three research topics address these issues:

- Non-traditional Finance focuses on the recent rapid expansion of impact fees, exactions, tax increment financing districts, and other non-traditional financing. The proposed research would explore how these techniques and the funds they raise could be incorporated into DOT plans and operations. Efforts would be made to develop techniques to measure the extent of these approaches, and suggest means to project future revenues.

- Economic Analysis presents both "micro" level and "macro" level techniques to encourage systematic analysis of investment decisions. The approach is the public sector analog of profitability and rates of return in the private sector. The micro-economic techniques explored deal with evaluation and setting priorities for individual projects as one factor in helping CAOs to determine which ones to undertake in a world of limited financial resources. The socio-economic effort would focus on the value of transportation as an integrated system, in effect to help CAOs choose the long-term investment programs that most effectively support the state's socio-economic objectives.

- Strategic Planning describes and evaluates techniques for dealing with the uncertainties involved in projection and long-term decision-making. This research topic will provide CAOs with guidelines and techniques to incorporate alternative scenarios in their planning efforts, recognizing that some alternatives are more likely than others.

INSTITUTIONAL OPTIONS

The mission of NCHRP Project 20-24 is to design a targeted program of research to be implemented over the next several years. An integral part of this effort is determining the institutional framework that would be most conducive to successful implementation of the program.

There are several institutional options which could be used to implement this research program. The choice of institution depends on the priority given to the specific program characteristics, and the institutional organizational framework that each implies. The options discussed in this report include:

- Stand alone agency -- similar to the SHRP model;

- Merge/Attach to Existing Institution -- for example, merge with NCHRP, AASHTO or a University; and

- Combination.

Due to the scale of the program and the tie with research, housing the research within TRB seems to be the most promising option. However, selecting research topics and identifying appropriate contractors should be streamlined. This would reduce the response time from identification of the problem to initiation of the research -- a priority in this program. The ongoing reporting aspects of these projects might require a few changes as well.

PROJECT PRIORITIES

With an estimated cost in excess of $6 million, the scale of this program is clearly beyond the level of research funds that are readily available. While the selection of research priorities involves judgement, some research topics may address higher priority problems and may serve as building blocks for follow-on research. As mentioned above, the 20-24 Panel has decided to initiate the first half of the Market Research Program. In the personal opinions of the authors of this report, the following research topics appear to offer early promise: Senior Executive Service, System Performance, Middle Manager Training, and Contracting Out.

GAPS IN RESEARCH FUNDING: REASONS AND POSSIBLE REMEDIES

Ronald F. Kirby
Group 1 Council

As Chairman of Group One Council, I have been instrumental in pushing on with our deliberations on research needs, following my predecessor Bill Bulley, who initiated the Group One Council's interest in this area. It was under Bill Bulley that NCHRP Project 20-24 was generated. In my presentation I will try to give you a synthesis of a fairly lengthy discussion that we had at a meeting involving the Group One Council and a number of resource people in September of 1987. The meeting was prompted by a strong sense that research funding in transportation, particularly on the "soft" side, had been declining rather dramatically. We wanted to try to understand firstly whether that was true; secondly, what the reasons for it might be; and finally, what remedies there might be for this problem. At the time, we did not have the benefit of the excellent review prepared by Nan Humphrey -- we were deliberating in the absence of the kinds of numbers she assembled. Fortunately, I think our deliberations were based on assumptions that are consistent with her numbers.

In September we brought together a number of people on the buyer's side of transportation research, and some people on the seller's side, to give us their perspective on what was happening with transportation research spending. We then had a structured discussion with a facilitator to try to distill out of this information what really was happening and what might be done about it. The reason for Group One Council's interest in this subject is that the Council is designed to be an umbrella group over all of Group One -- and if you think about that, that means all modes. There are about 25 people on the Council, and they are carefully selected to represent all of the modes.
One of the first things you find when you come onto the Group Once Council as a new person, as I did a few years ago, is how fragmented modal activities really are. When people from highways, transit, rail, air, and waterways get together, often they find that they don't know each other very well, if at all. We don't talk to each other very much -- and we don't generally look at things in a multi-modal way. To try to turn the multi-modal composition of the Group One Council to advantage, we decided at our September 1987 meeting to get input on research funding from representatives of all the modal areas, and to make some comparisons between what was going on in those areas. We wanted to look at different ways in which research was being funded, in the hope that we'd find some that were doing well that we could use as models to improve others that were not doing so well.

The presentations that we had from the buyers of research were from the National Cooperative Highway Research Program (NCHRP), the U.S. Corps of Engineers, the National Science Foundation, the Federal Highway Administration, a representative of a state DOT who spoke about state sponsored research, the Association of American Railroads, the Chairman of the Transit STRS Committee, and a representative from the Urban Mass Transportation Administration. Representing the sellers or providers of research, we had speakers from the Council of University Transportation Centers (CUTC), a university professor interested in freight research, and representatives of some of the Group One Committees in TRB. We had one person who reported on a joint committee meeting that had been held a few weeks earlier, in which a number of transit and highway committees got together to talk about the emerging suburban congestion problem.

I am not going to try to summarize in any depth what these people told us, but I do want to give you

a few of the highlights as I saw them. With regard to the NCHRP, the notable points were earmarking of a fixed percentage of federal highway funds for the program, and also the orientation of the NCHRP research program to applications questions. The speaker, Bob Reilly, had a very nice chart that shows NCHRP on varying dimensions such as arrange between research and development and training and implementation, between applied and basic research, and between AASHTO priorities at one extreme and researchers interests at the other extreme. NCHRP also looks for projects with a high probability of success. As good as NCHRP is, and as great a contribution as it makes, it does not cover the waterfront of transportation research.

With regard to water research, it was notable that the Corps of Engineers spends about one percent of their total revenue on research and they try to keep their funding at about that level. Because they're a relatively unified operation, they are able to keep their research funding pegged at this fixed percentage. By comparison, for the other areas of transportation, which are very fragmented by mode, by level of government, and by public versus private, it's virtually impossible as Nan Humphrey demonstrated to even identify the overall percentage devoted to research. Since we don't have that number, we are in no position to know whether we're keeping to a certain level or not.

The comment from the National Science Foundation was that we shouldn't expect to see an explicit transportation program at NSF. NSF may happen to touch on transportation in the process of performing economic research or social service research or other research but that will be largely by chance. We shouldn't count on NSF for any explicit effort devoted just to transportation.

With regard to FHWA and UMTA, the important characteristic was the shift to short-term policy oriented research and away from basic longer term research. It is this shift that has accounted for much of the decline in the long term basic research funding over the last six or seven years. The representative from the Association of American Railroads pointed out essentially what Nan Humphrey's slides showed; that FRA has been cutting back, and private industry has been trying to increase research funding. AAR staff members have been administering a lot more research, but they feel like they're very much up against budgetary constraints, and are unable to do as much as they should be doing.

The Transit STRS representative reported on a plan to earmark a portion of the federal Section 9 money for a new research program that would generate about $10 million a year, to be oriented to practical day to day problems of the transit industry. Two concerns were raised about this program: firstly, $10 million is not a lot of money when you compare it to earlier levels of UMTA funding, which were close to $100 million at one point, and secondly, if federal Section 9 monies continue to go down as they have been doing, the research program, which hasn't yet even been created, will also go down. Shouldn't we try to earmark a percentage of state contributions to transit, as well as local contributions, and even fare box revenue? If you're interested in getting a certain percentage of your revenues devoted to R&D, you've got to look for your base to a much broader set of sources than just the federal government, because its share of revenues has been going down.

On the seller's side, there was a lot of discussion about the fact that the buyers don't want to fund basic research or long term research; they want short term, high payoff types of research, and there's a real dearth of funds available for long term research. The universities are particularly concerned about this phenomenon. We had quite a lengthy discussion about the new University Center program that was created in the 1987 Surface Transportation Act. The program provides $5 million a year from UMTA and an equivalent amount from FHWA, and it requires a 50 percent state and local match. If it all comes together, it will provide for $20 million a year of research in the highway and transit areas, which is a substantial amount of money -- $100 million over five years.

However, this University Centers program will be run by a national advisory council which will include several U.S. DOT people. The Secretary of Transportation makes the final decision about the research topics. A concern here is that the program may be geared to the same short-term policy oriented research that has been supported by the federal government over the last five years. There's considerable uncertainty as to how much of that money will be approved for projects that really are basic long term research. The common theme in these presentations is that we have some serious problems. Funding for research certainly has gone down significantly. Even if the best options we have in the pipeline like the transit STRS program, the University Centers program, and the NCHRP meet our expectations, there will still be gaps related to the total dollar levels that we've had in the past,

and more importantly, gaps in subject matter – long term basic research in particular.

We followed these presentations with a structured discussion which dealt with two questions; why this decline in funding has occurred, and what the possible remedies might be. Barbara Harder, a member of the Group One Council, brought a person from Pennsylvania DOT to serve as a facilitator for the discussion. In quite an impressive manner he got this group of people from different modal areas organized into developing a consensus on a number of points. I'm going to report to you the results of that exercise. We concluded that there were seven major factors that were responsible for our problems, and we ranked them in order. The first factor was that funding agencies are simply not oriented to long-term, basic research issues. It is very difficult to get people who administer research budgets interested in funding long term research.

The second factor was that federal research funding has been oriented much more to supporting immediate policy priorities over the last six or seven years than it has in the past. There has been a reluctance to fund long term basic research that might not have immediate policy relevance for the federal agencies.

The third point which came out of the concerns of the university professors was that research interests of the research community and government research funding priorities do not match very well – they have begun to diverge. The fourth point was that there appears to be a lack of top management support in federal, state, and local agencies for basic research. It would appear that even project NCHRP 20-24 reported on by Richard Mudge will focus on some very specific areas of immediate payoff to CAO's as opposed to building our long term knowledge base.

The fifth point was that federal funds available for research have been decreasing over the last six or seven years, as indicated in Nan Humphrey's presentation. The sixth point was that research funding is very compartmentalized by mode. And that makes it very hard to do long term multi-modal studies: topics that involve relationships between modes, comparisons between modes, and comprehensive multi-modal analyses. The final point was that there is no politically potent constituency advocating research funds for planning and management; there is nobody to make loud complaints as the soft research funds were being cut.

In our discussion,we identified what we felt would be constructive responses to each of these problems. First, we concluded that we need to make a major effort to educate or reeducate potential funding agencies on the value of research, particularly long term research. We need to explain, in a much more convincing way, the relationships between short-term policy needs and long term research: in particular, that if you don't keep up your long term research base, there won't be anything to synthesize when a new CAO comes in. We've been living off our past research base to a large degree, it's declining, and we're not replacing it with new basic research for all of the quick answer type work that's so necessary. On the second point regarding the availability of funds for long-term research, the one strategy that seems to work consistently is to establish earmarked funding. The success stories here are SHRP and the NCHRP program, and the transit STRS proposal is heading in that direction. In this context, there was mention of private industries which routinely commit certain portions of their revenues to research. The gas industry, for example, devotes a portion of its sales or revenue to a central institute which does research for the industry. The understanding is that when you take in a dollar, you send a portion such as one percent into the central research pool -- that's accepted as the thing that you must do in order to keep your industry vital and competitive for the future.

The third point is to improve communications between researchers and funding agencies through techniques such as internships for researchers in administrative agencies, staff exchanges between universities and the transportation industry -- transit operators, highway departments, airlines and so forth. The establishment of joint research committees that would have both academics and other researchers and industry would also help. Other possibilities would be to set aside funds for individual unsolicited research proposals, and to fund student fellowships in transportation for university graduate students, with no restriction on research topics.

A missing ingredient that we were searching for here was a source of funding for innovative research stimulated by the researcher. Suppose a researcher comes up with a good idea, -- how does he go about seeking funding? In all of the current programs it's a tough battle to get consideration of an idea that falls outside the established priorities. Even for the NCHRP program, the lead time for the funding process can be on the order of two years --

if you think of an idea now, it's going to be two years before you can get funding, even if everything goes well for you. This is not to say that we couldn't do more in obtaining funding under the NCHRP program for soft research topics. The committees on NCHRP are willing to fund soft research projects and there have been occasions where Group One committees have really gone after that money, and gotten it. Those of us interested in the soft research area need to devote more effort to developing projects for NCHRP funding.

The fourth point was to educate top managers on the value of research – essentially an extension of the third point. The fifth point is a very important one. We should seek sources other than federal funds for research so that we're not vulnerable to major shifts between federal, state and local funding of various transportation modes. That means trying to earmark a percentage of state and local funds and direct user revenues for a research pool. If we're going to get one percent of total sales for research for example, we're going to have to seek one percent of all revenues. In the past we've gotten a few percent of the federal funding and little or nothing from other revenue sources. Now that the federal funding has gone down, the total percentage of sales devoted to research has gone down because we don't get anything from the other revenue sources. What this would suggest is that every time there's a gasoline tax increase in a state, you should try to earmark a portion of that for research, and every time there's a sales tax increase for transportation, you should try to earmark a portion for research. It may not be easy to do, but it's the kind of thing that we'll have to do if we're going to have reliable sources of research funding. The sixth point was to earmark funds for multi-modal research. There was a feeling that multi-modal research would not get done unless there was a certain portion of funding set aside for it, either as a portion of the total or through some formal pooling of modal research funds. The final point dealt with getting some political support behind research funding. The major notion here was to make the case every time there's a proposal for a new transportation funding program – a new tax increase or a new source of revenue for transportation expenditures – that one percent or so should be taken right off the top for research. In the past, this has been the successful way of getting research funded.

If we could create as an accepted practice the concept, as the Corps of Engineers and the gas industry appear to have done successfully, that you really ought to put one percent into research, we would be able to get research funds allocated at the same time that increased expenditures are committed for things like highways, transit, commuter rail, airports, and other facilities.

In conclusion, our collective view was that the problem of inadequate research funding is very real, and even the best proposals on the table now will not meet the needs adequately. Once research budgets are down, as they are now, it's very hard to get them back up because research is not an easy product to sell. It's very hard to go to funding agencies and say, "Well, we want to triple last year's research budget", which is probably what we need. It will take a major commitment from everyone interested in this soft research area to get these funding levels turned around. The SHRP example might be a good model, in that there, a very concentrated effort was made, with a lot of justification of the need for substantial new funding earmarked as a portion of the highway trust fund. The NCHRP 20-24 appears to be producing some useful results focused on the needs of the CAO's. However, the research needs in the soft area are broader than that, and we're still very fragmented across transportation modes and in our particular interests. We're going to keep working at this in the Group One Council. We'll try to press on with this effort by increasing awareness of the problem and suggesting remedies for it. Hopefully we'll make some significant progress over the next year or two.

APPENDIX

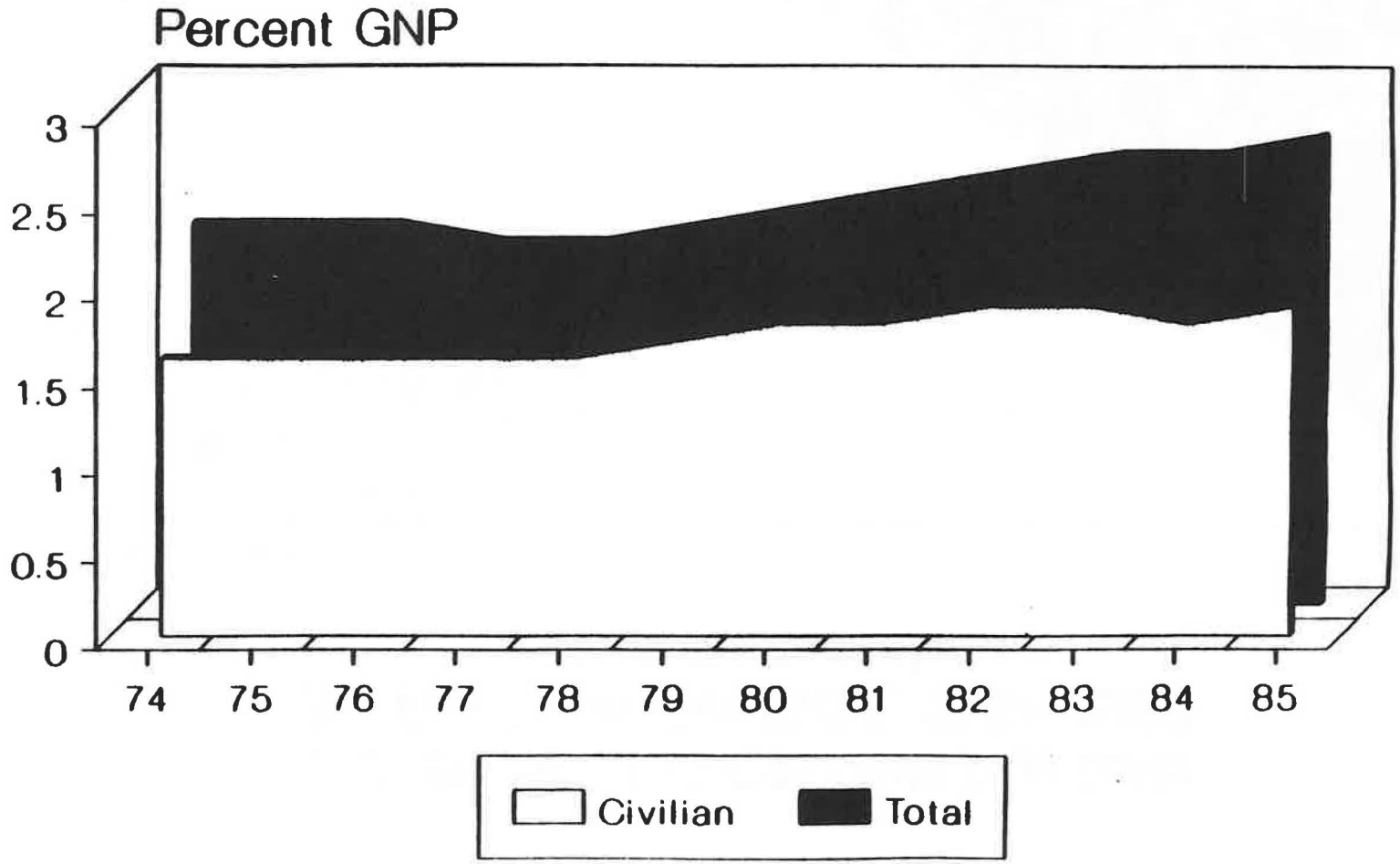
GRAPHICS FOR THE PAPER

TRENDS IN RESEARCH FUNDING IN THE PUBLIC AND PRIVATE SECTORS

by

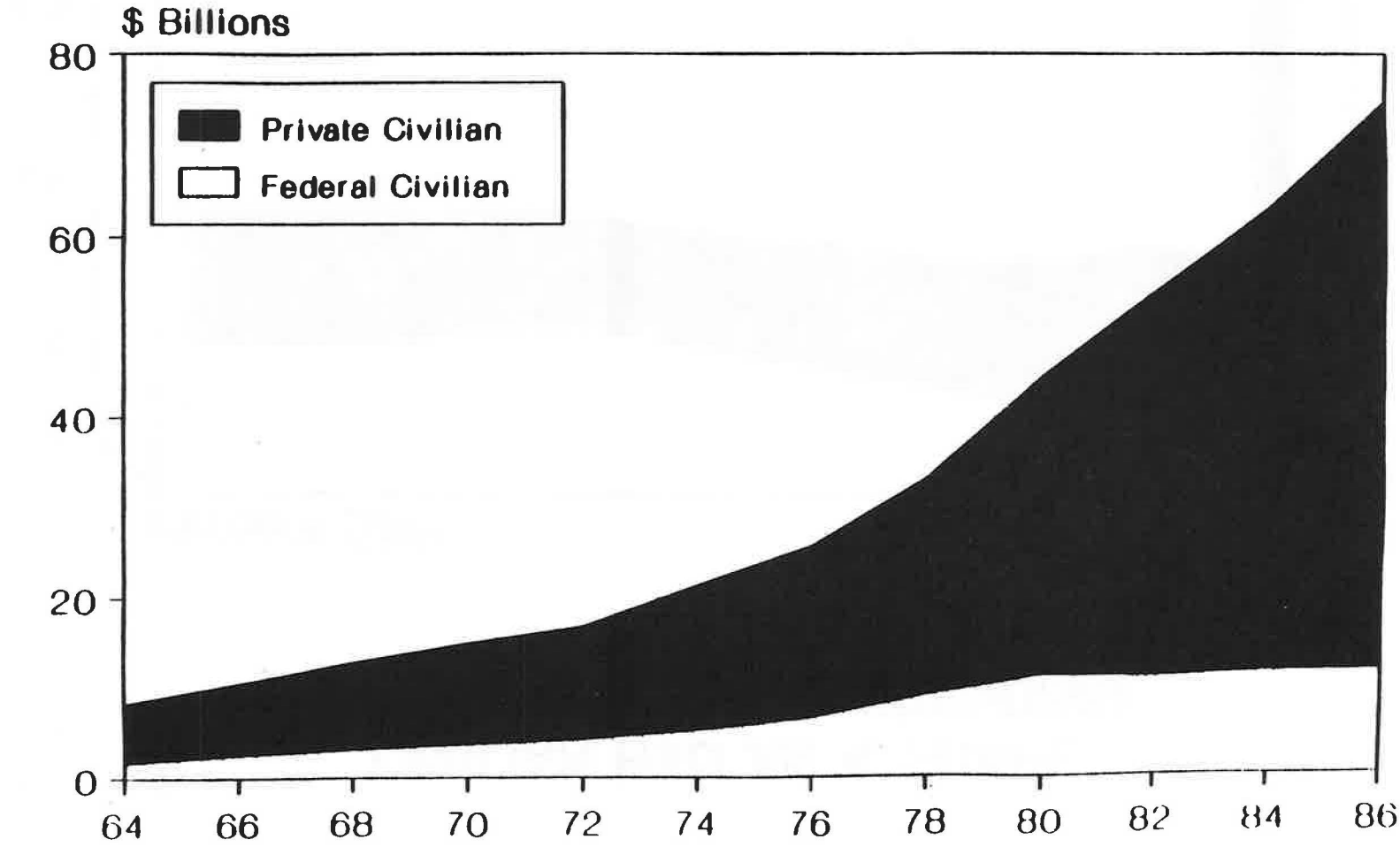
NANCY HUMPHREY
TRANSPORTATION RESEARCH BOARD

CIVILIAN R&D AS A SHARE OF TOTAL U.S. R&D SPENDING 1974-1985



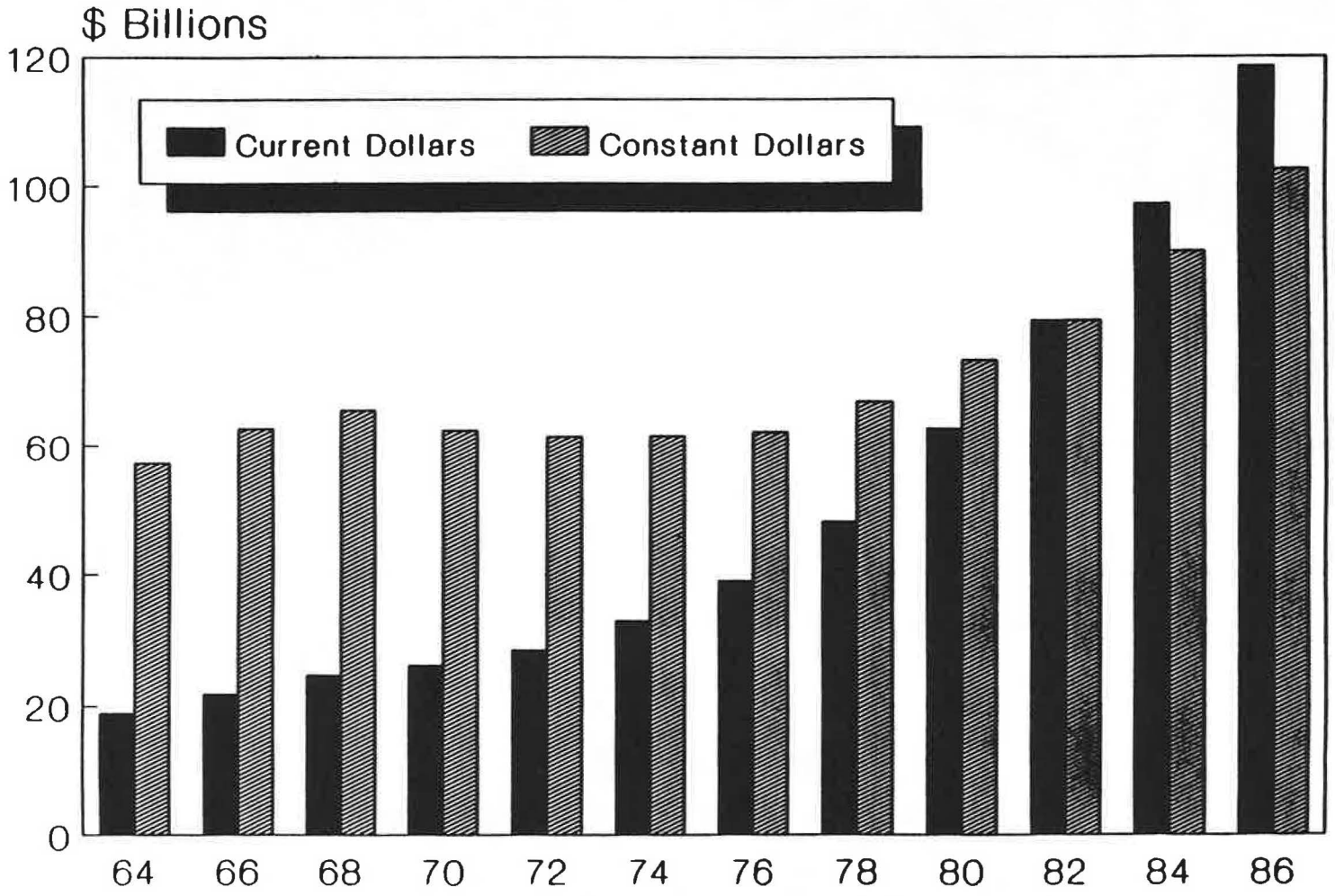
Source - NSF

U.S. SPENDING ON CIVILIAN R&D BY FUNDING SOURCE: 1964-1986
(Current Dollars)



Source NSF

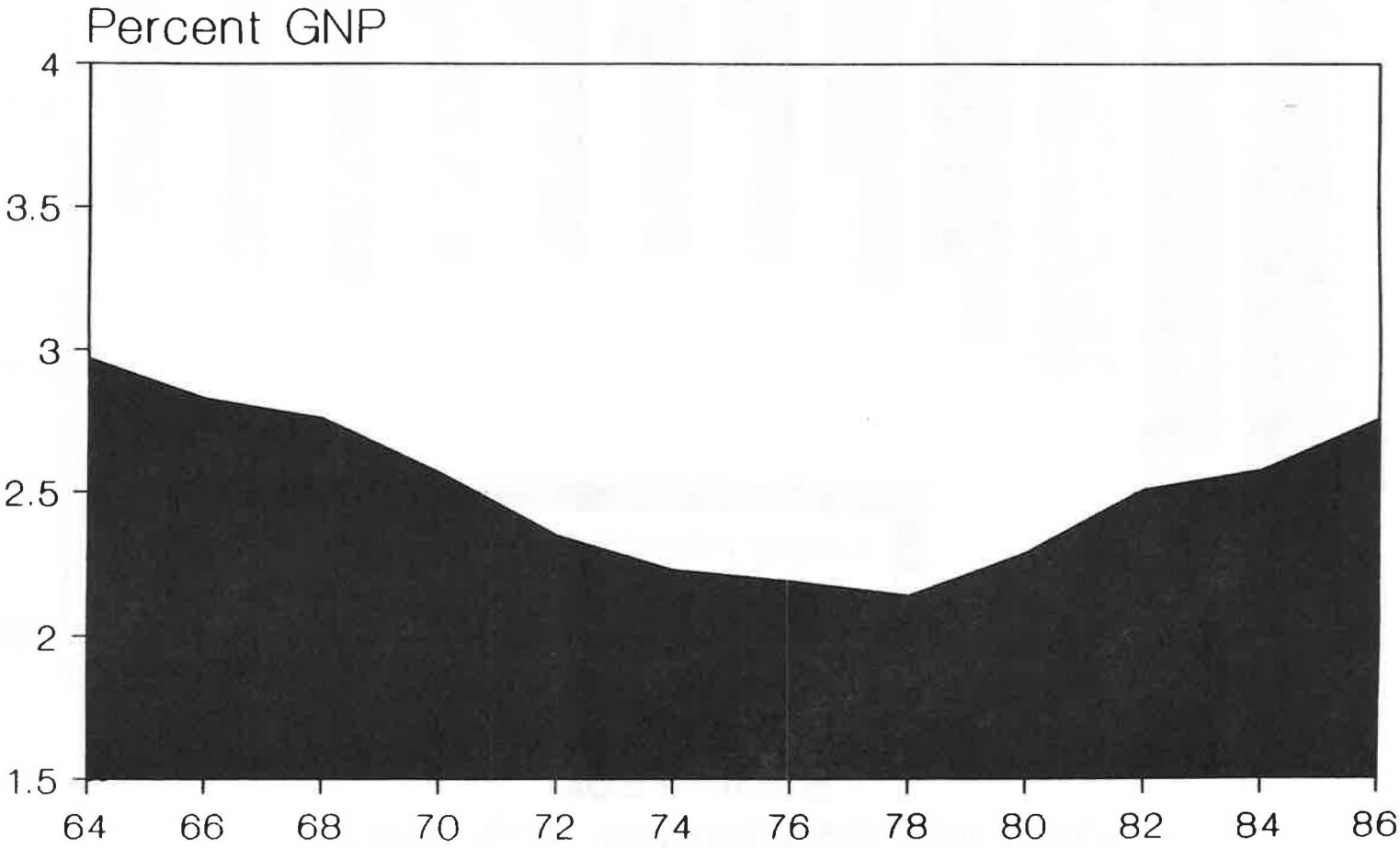
TOTAL U.S. SPENDING ON R&D
1964-1986



Based on 1982 Dollars

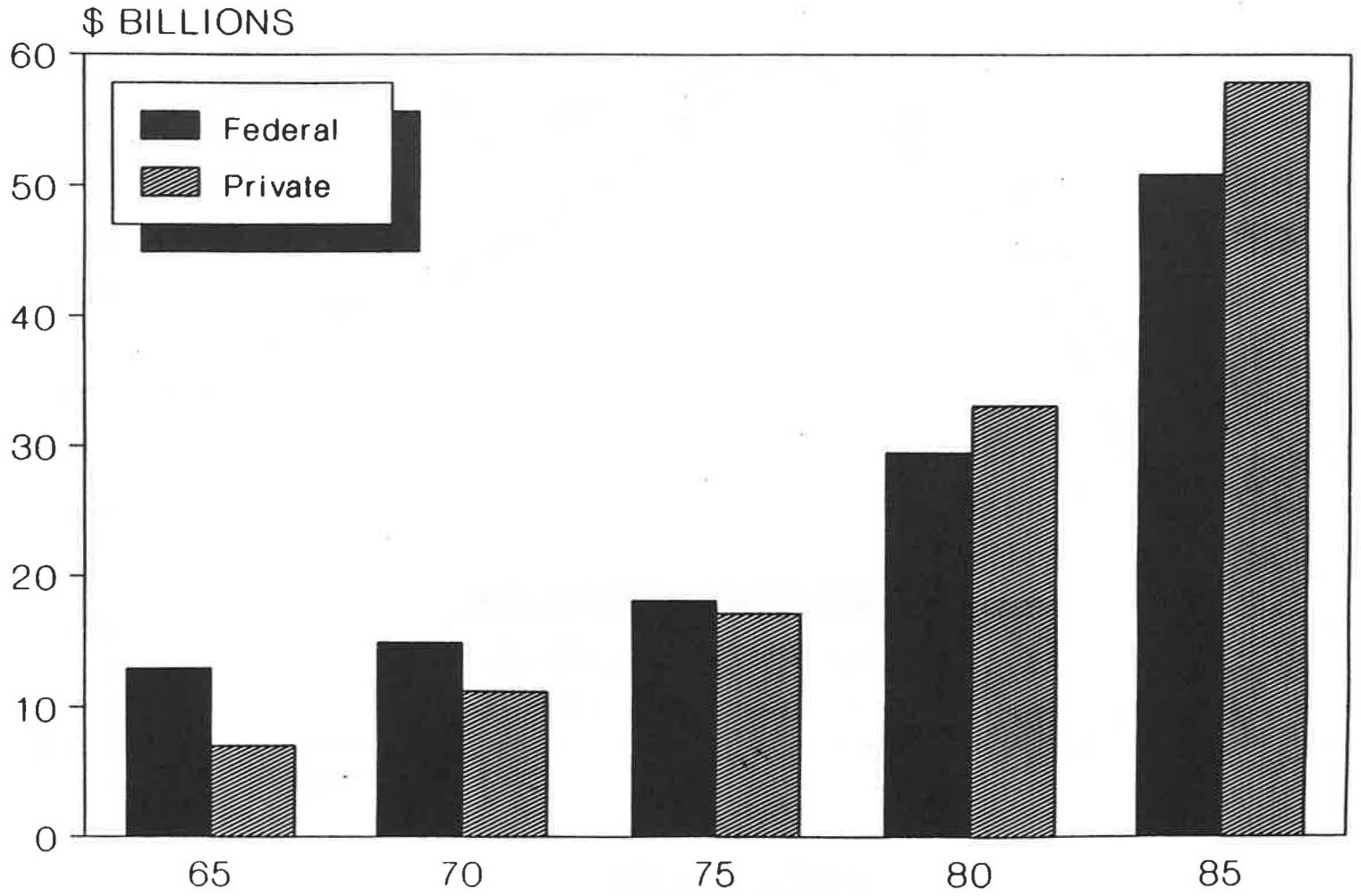
Source - NSF

TOTAL U.S. R&D SPENDING AS A PERCENT OF GNP 1964-1986



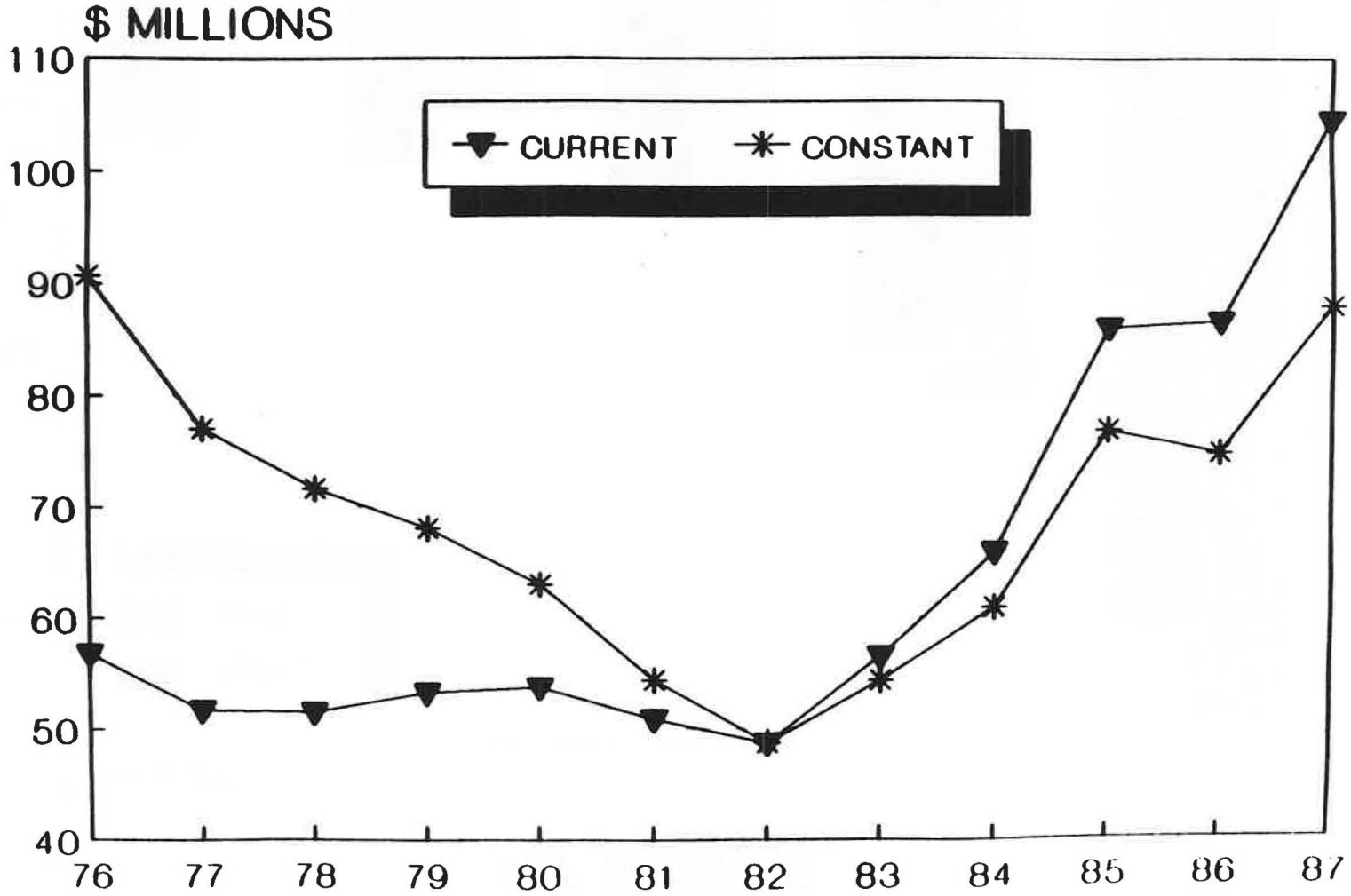
Source - NSF

TOTAL U.S. SPENDING ON R&D BY SOURCE



Source - NSF

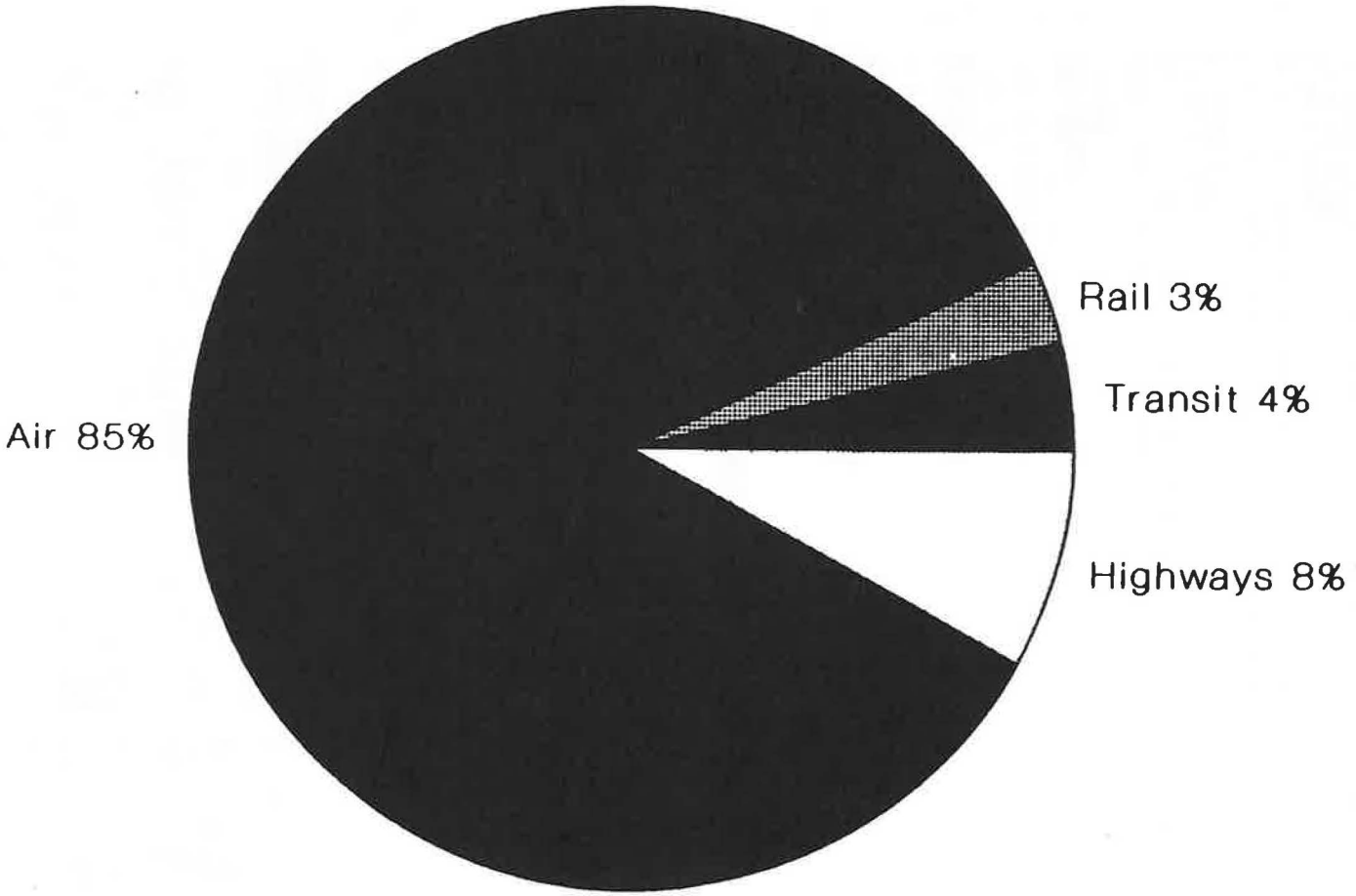
TOTAL SPENDING ON HIGHWAY R&D
1976-1987



Based on 1982 Dollars

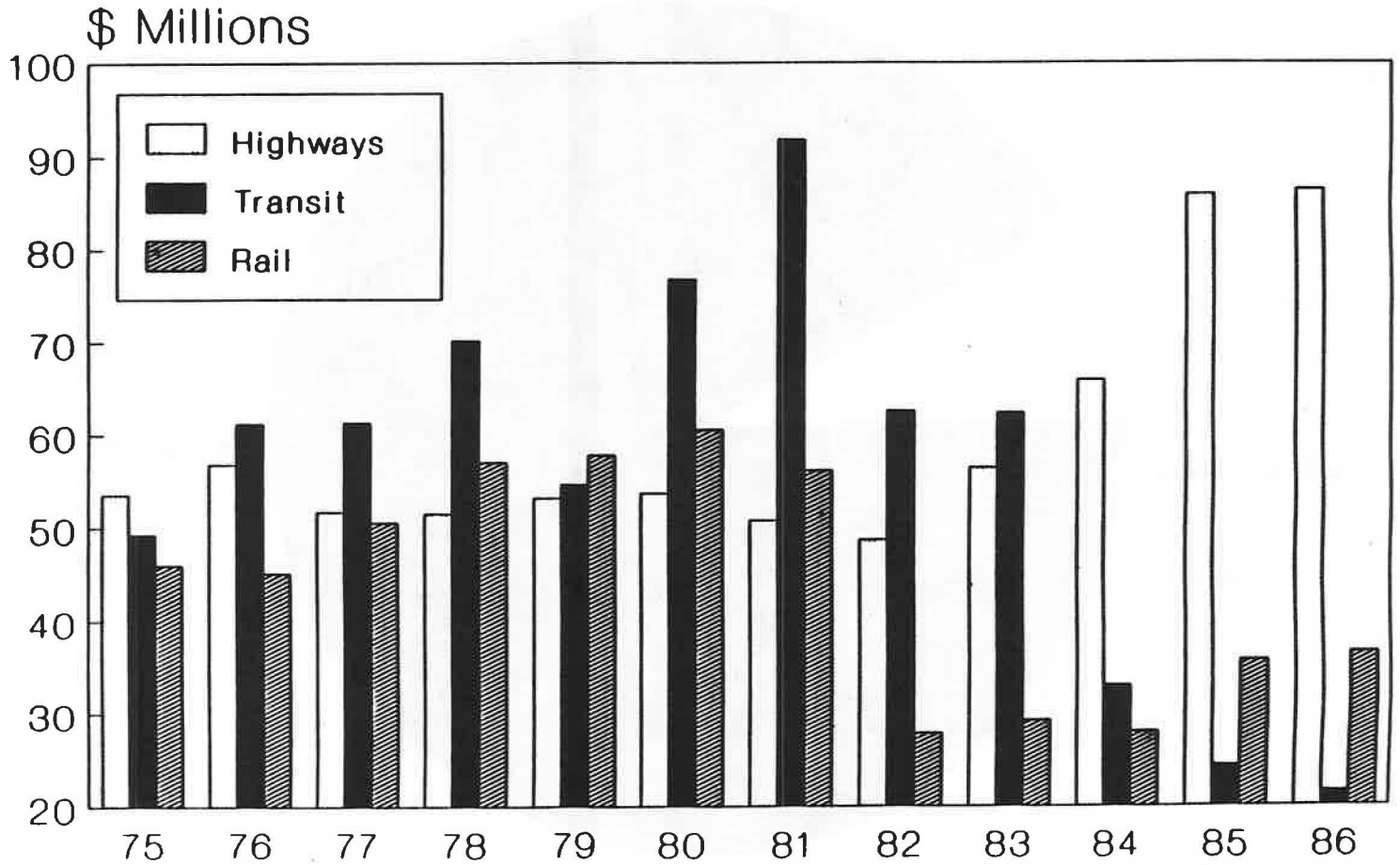
Sources - FHWA Report of the Federally
Coordinated Program of Highway Research
Strategic Highway Research Program

R&D SPENDING BY MODE
5 YEAR AVERAGE: 1982-1986



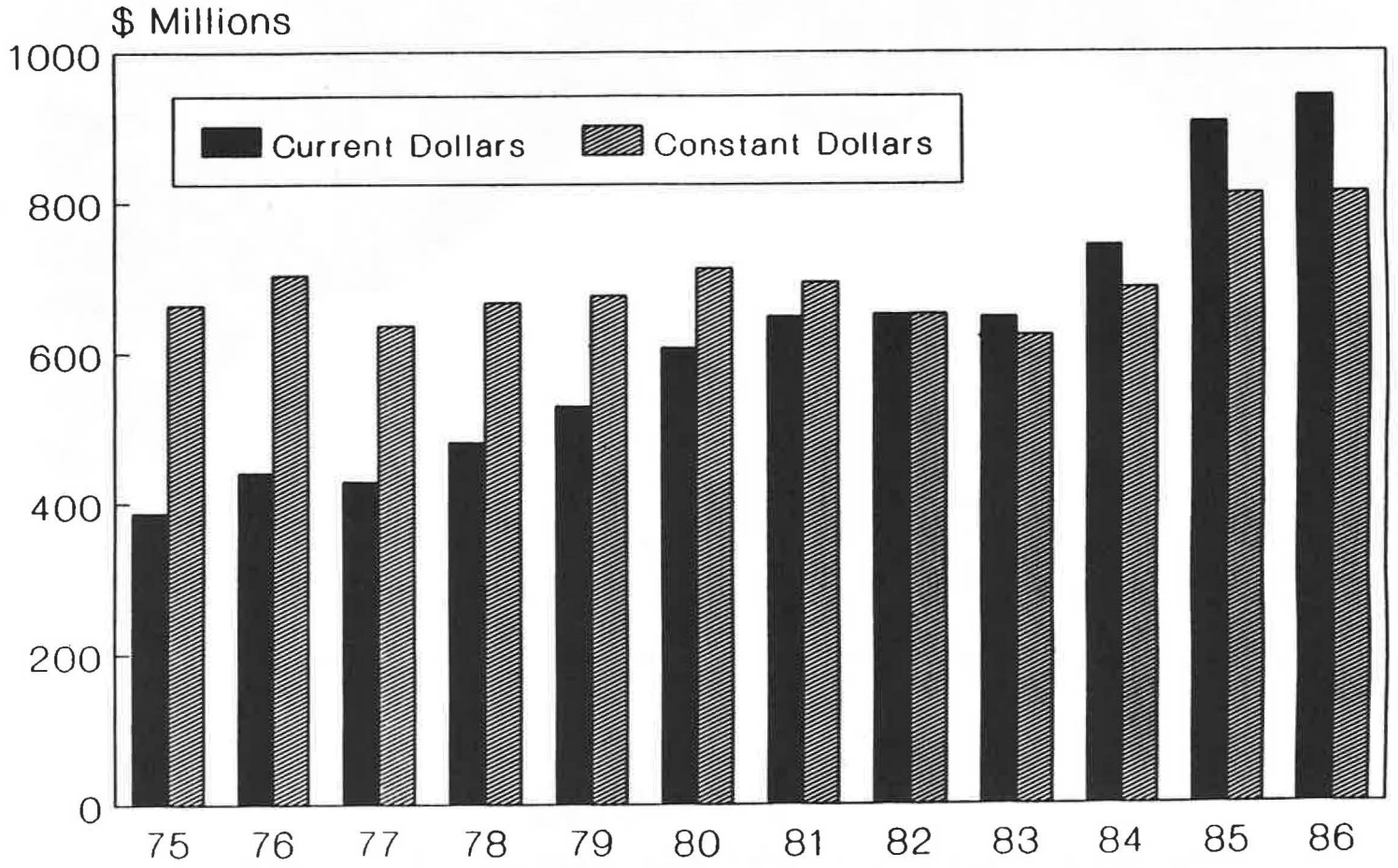
Sources - Budget of the United States
FHWA Report of the Federally
Coordinated Program of Hwy Research
Strategic Highway Research Program
UMTA Office of Technical Assistance
AAR Annual Report

R&D SPENDING BY MODE
HIGHWAYS, TRANSIT, RAIL
1975-1986



Sources - FHWA Report of the Federally
Coordinated Program of Hwy Research
Strategic Highway Research Program
UMTA Office of Technical Assistance
AAR Annual Report
NSF

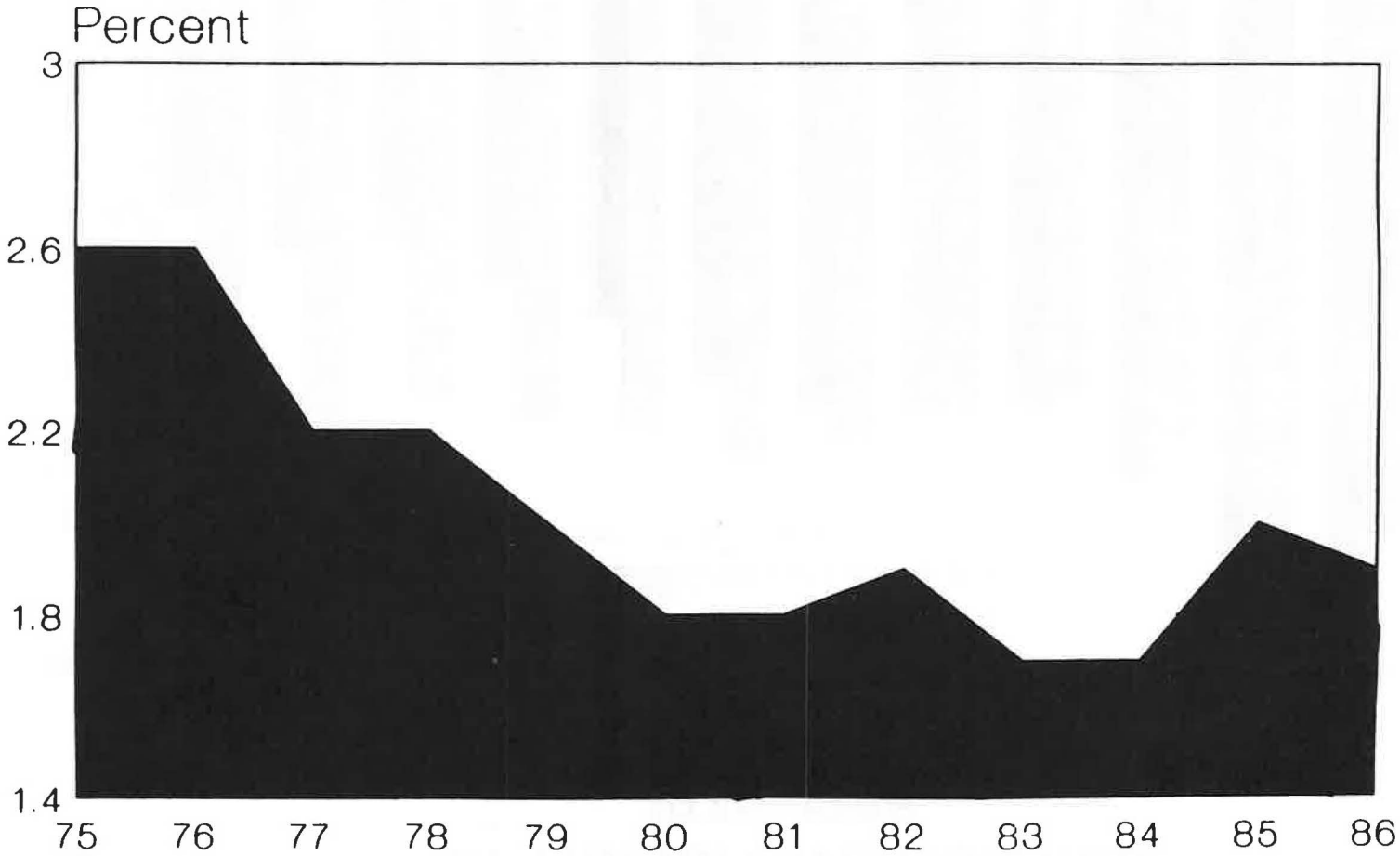
TOTAL SPENDING ON AIR TRANSPORTATION R&D 1975-1986



Based on 1982 Dollars

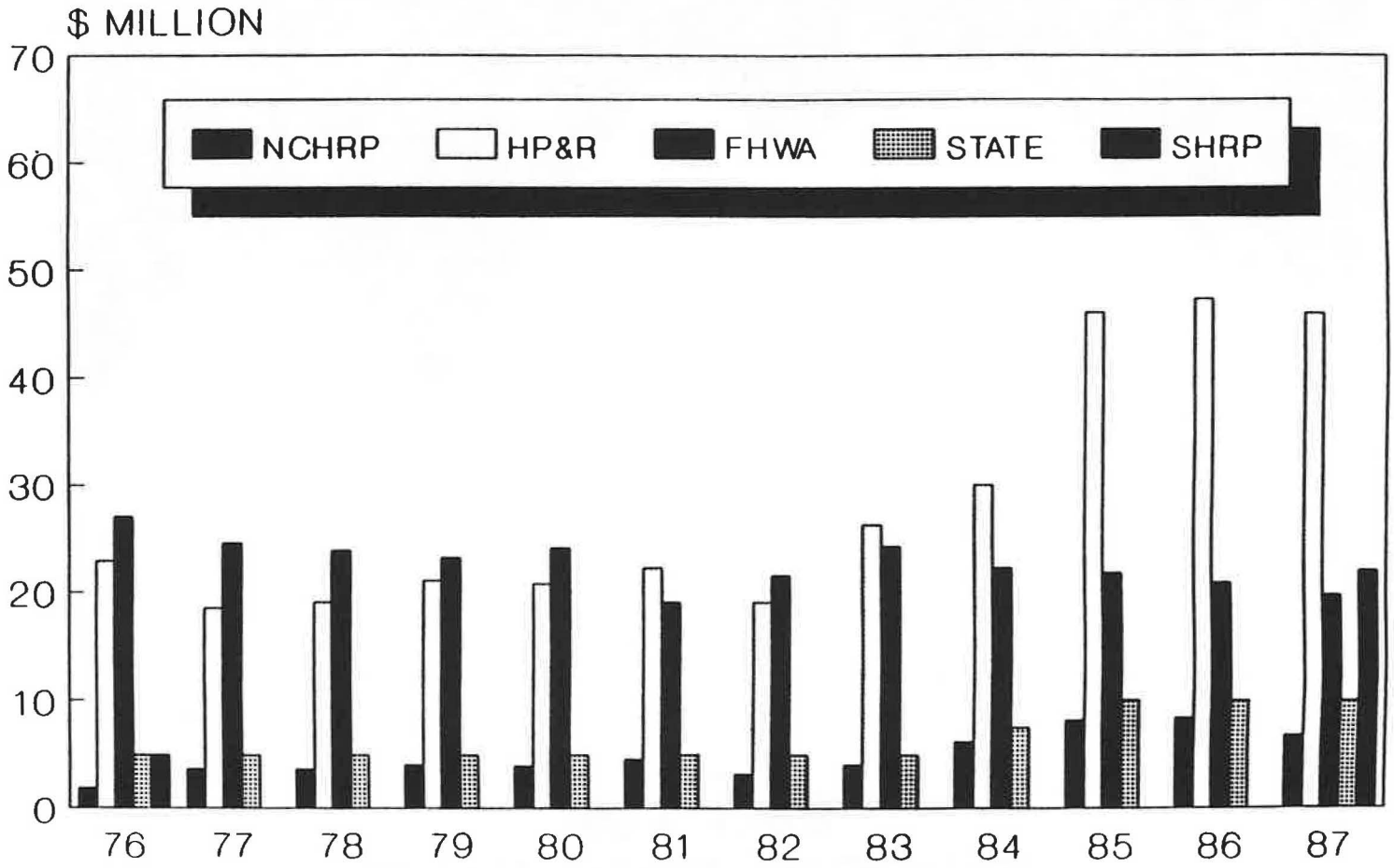
Source - Budget of the United States

AIR TRANSPORTATION R&D AS A PERCENT OF AIR OPERATING REVENUE 1975-1986



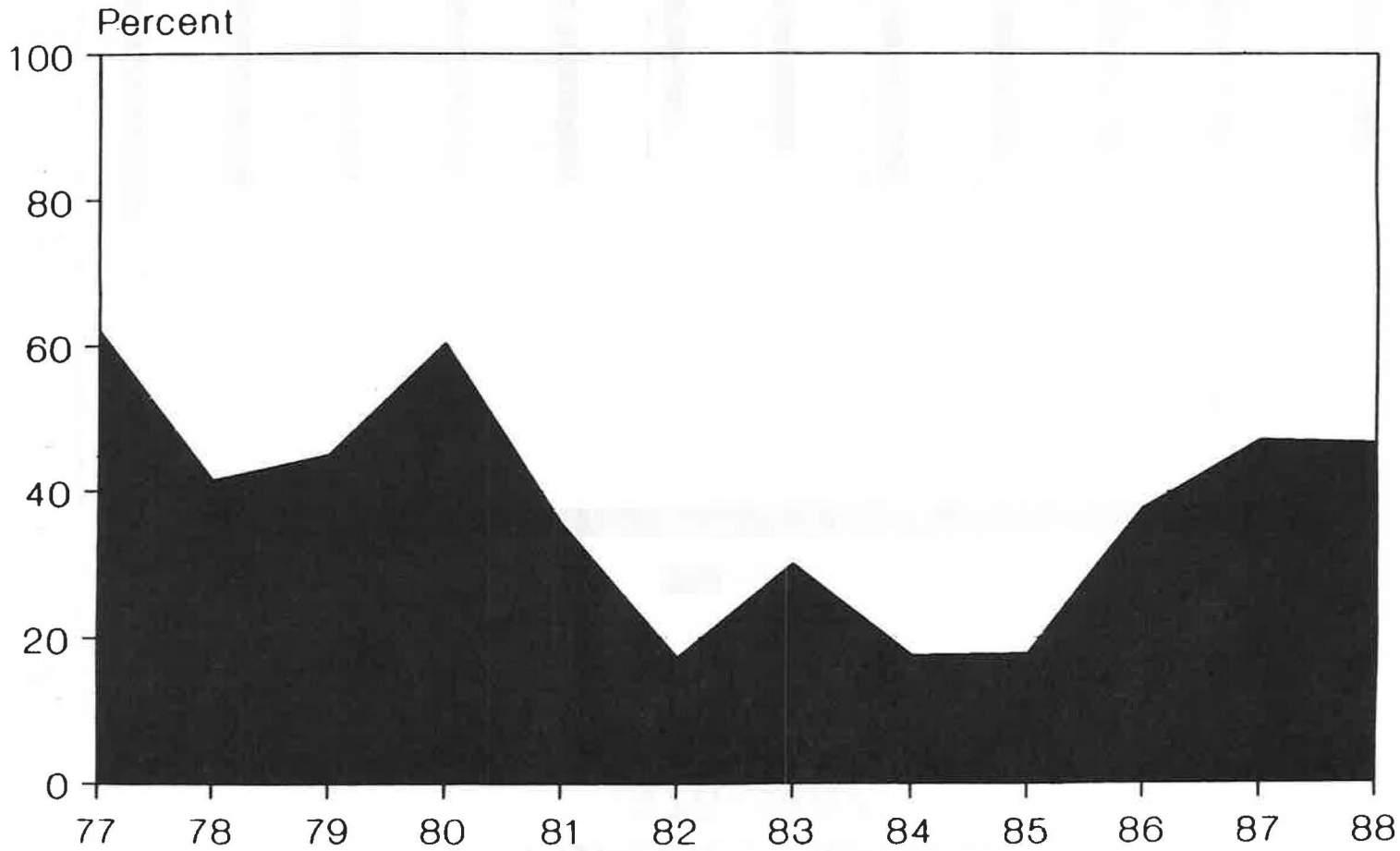
Sources - Budget of the United States
U.S. DOT Air Carrier Financial Statistics

SPENDING ON HIGHWAY R&D BY FUNDING SOURCES 1976-1987



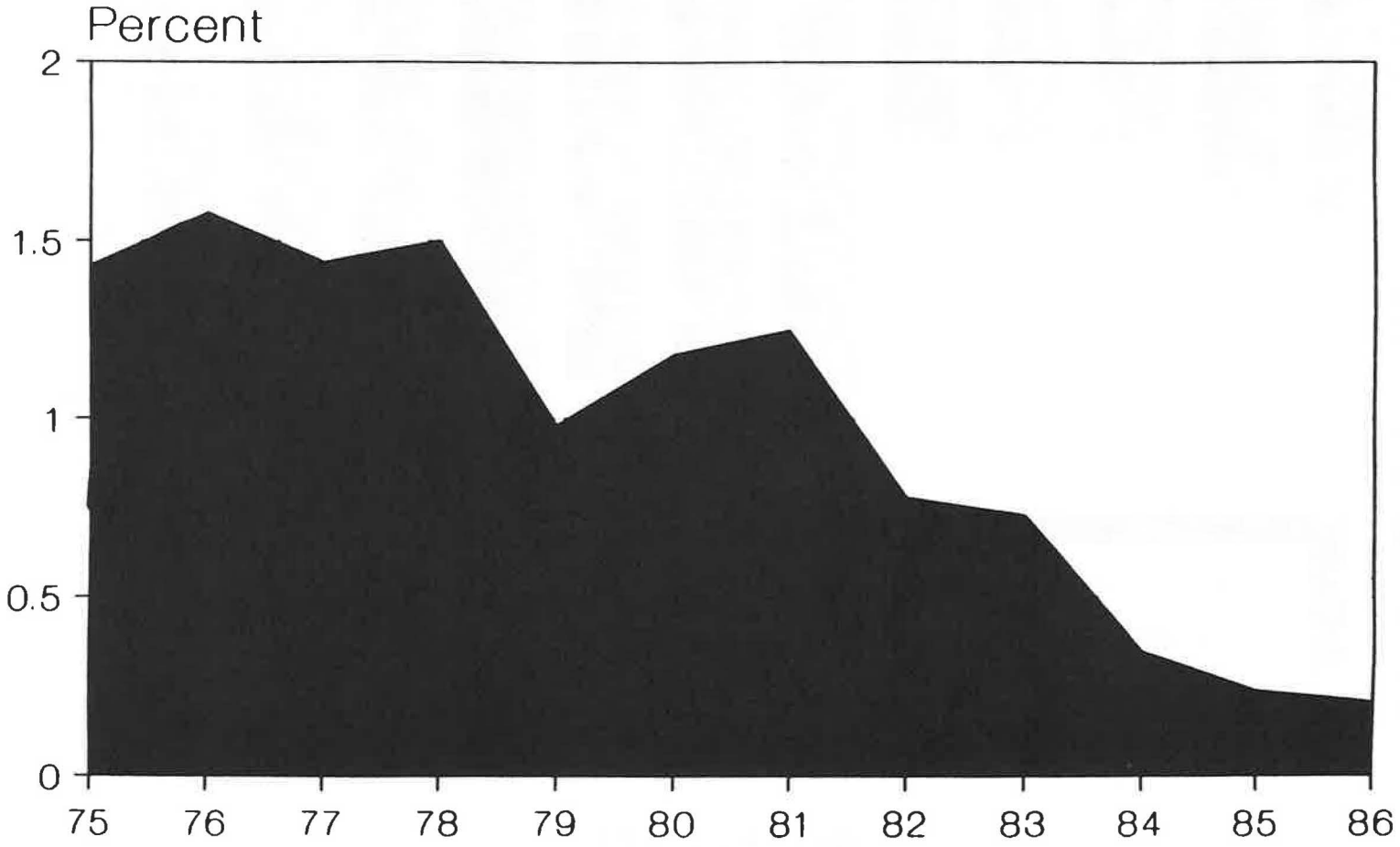
Sources - FHWA Report of the Federally Coordinated Program of Highway Research
Strategic Highway Research Program

SHARE OF NCHRP PROJECTS EXPENDED ON SOFT-SIDE RESEARCH 1977-1988



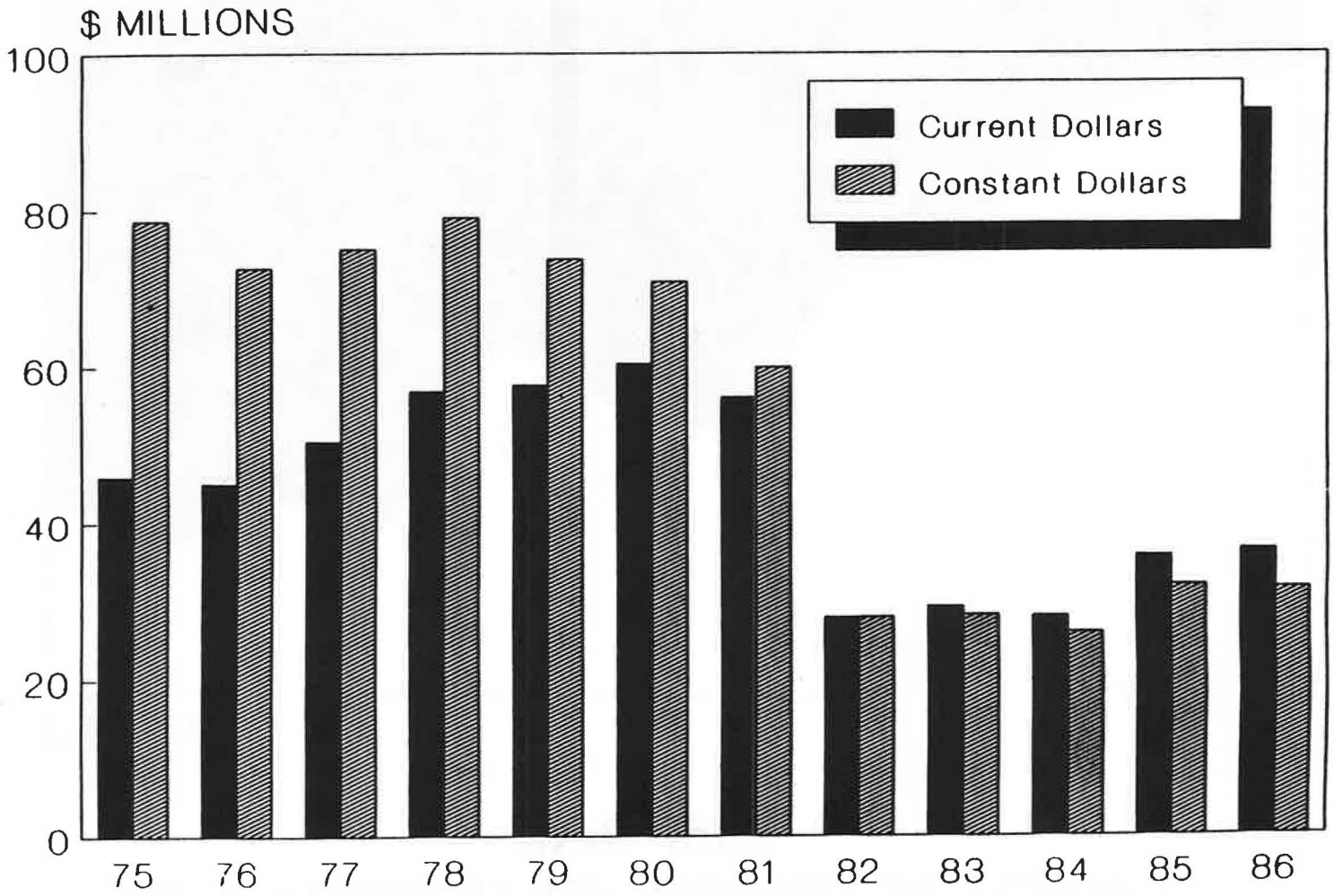
Source - TRB

SPENDING ON TRANSIT R&D AS A PERCENT OF TRANSIT REVENUES 1975-1986



Sources - UMTA Office of Technical Assistance
APTA Transit Fact Book

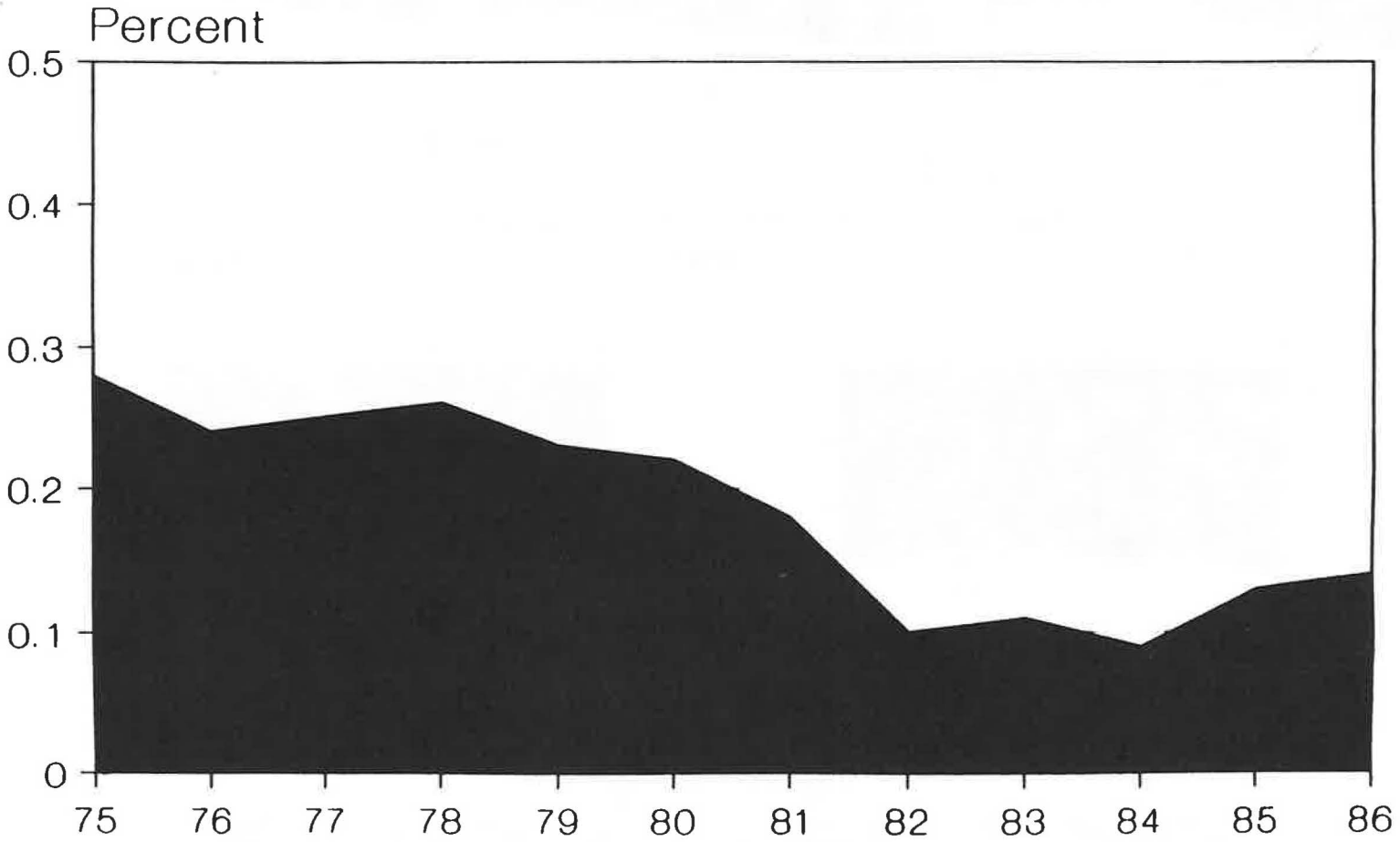
TOTAL SPENDING ON RAIL R&D
1975-1986



Based on 1982 Dollars

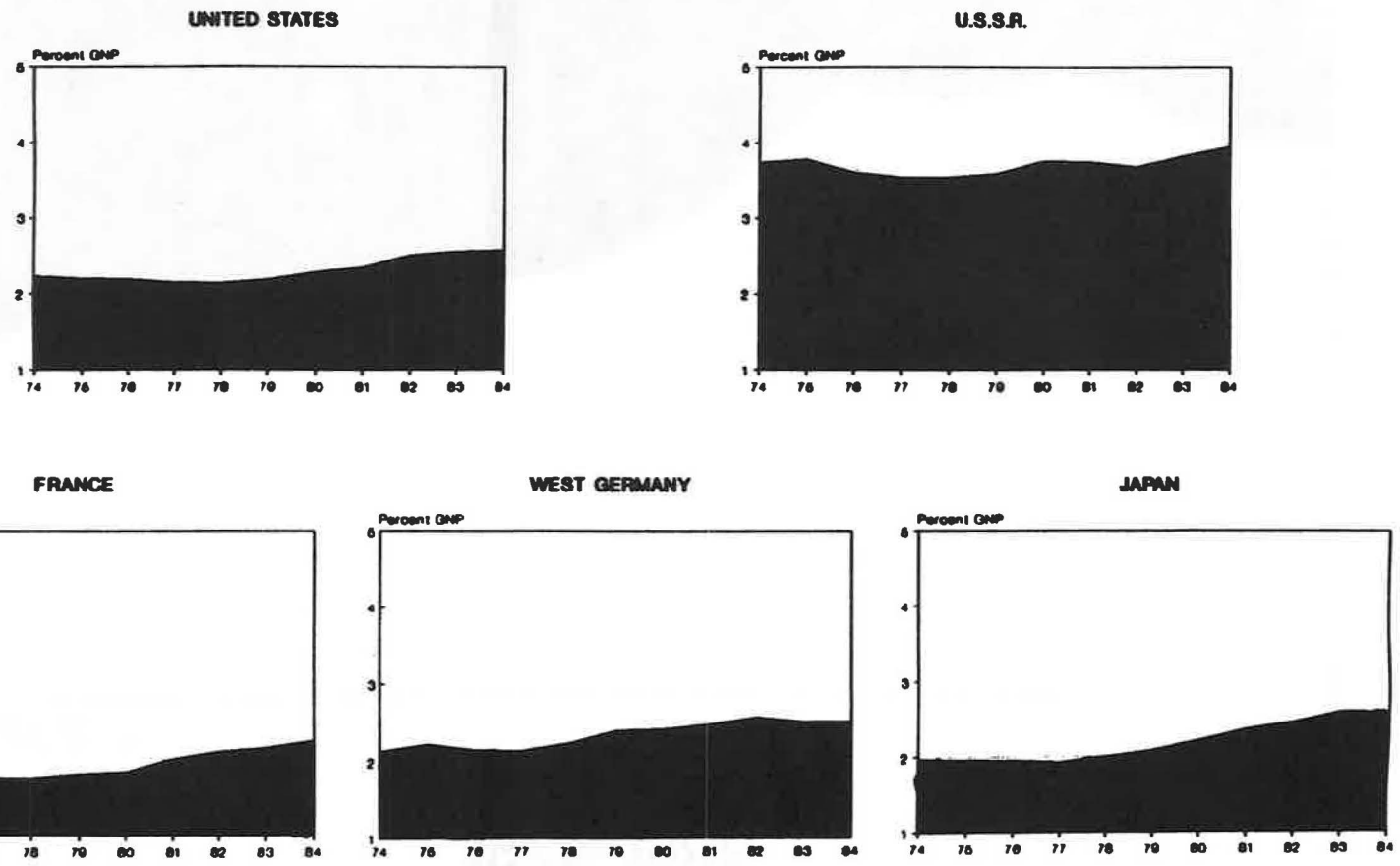
Sources - AAR Annual Report
NSF

SPENDING ON RAIL R&D AS A PERCENT OF RAIL OPERATING REVENUES 1975-1986



Sources - AAR Annual Report
Railroad Facts
NSF

NATIONAL SPENDING ON R&D AS A PERCENT OF GNP BY COUNTRY 1974-1984



Source - NSF