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,