which is frequently the least efficient. For example, rail traffic in which small numbers of cars have to be delivered at very low speeds on industrial sidings in the downtown areas of major cities is handled in a costly manner and one which is sometimes complained about by people who live in these areas.

Proposal

Explore and test ways to improve productivity in terminal areas. For example, initiate the study by surveying the literature, selected shippers, and community spokesmen to learn of improved ways to handle rail traffic in downtown areas.

Effects of Transportation Systems Management on Urban Freight

Problem

In the short term, a major contribution towards lessening the environmental and economic costs of urban freight is possible through the use of transport systems management techniques such as one way streets and synchronized traffic signals. However, promoting these techniques for urban freight seems questionable until the system effects of such techniques are known. On the other hand, transport systems management techniques for passenger movement (bus lanes, bus priority, auto free zones, etc.) are being progressively introduced, and there is a real possibility that some of these may be having serious and costly impact on urban freight.

Proposal

1. Examine existing passenger-oriented transportation systems management schemes to determine their impact (if any) on freight.
2. Investigate the feasibility of developing and introducing transportation systems management schemes specifically oriented towards freight.
3. Develop an evaluation scheme to assess the merits and demerits of particular freight-oriented transportation systems management proposals, with a view to establishing their value to the community.

Workshop Papers

INDUSTRY AND GOVERNMENT RESEARCH NEEDS A CANADIAN PERSPECTIVE

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Chairman, Railway Advisory Committee (Canada)
Special Consultant, Canadian Pacific Limited

I am delighted to have this opporunity to talk to you. When one has two titles, there is the advantage that no one is quite sure on whose behalf one is speaking, which is particularly useful if they do not happen to like what one says. I shall dispense with this rhetorical schizophrenia and make it plain that my views are my own and are not necessarily those of Transport Canada, the Canadian railways, or Canadian Pacific Limited.

Exchanges of views regarding government transport policy between our two countries are generally useful and sometimes amusing. I was tempted to say "generally amusing and sometimes useful," but I shall opt for the former.

The basis for the exchange is that Canada alters its transport policy about once a decade, whereas the United States government adjusts its policies more conservatively and less frequently. Thus, Canadian after-dinner speakers can report enthusiastically on developments in Canada up to the point when the Canadian government is about to reverse its position---which may be the point where the U. S. government is beginning to wonder if there isn't something in it after all.

More seriously, I generally believe in letting competitive forces under free market conditions determine which mode of transport should be used, but I hasten to add that I recognize that there are a number of situations in which market forces are prevented from working effectively. By the same token, I believe that research should be left to corporations wherever there are adequate incentives, but as before, I recognize that there are a number of situations in which this simply won't or can't result in adequate and effective research being carried out.

I shall begin, therefore, by considering the nature of these situations,and I shall then consider the remedies that appear to me to be most appropriate. Although I started life as an aircraft engineer, I shall generally draw my examples from the railroad industry because this is what I am involved in as chairman of the Railway Advisory Committee in Canada. It will impose a form of self-discipline and keep my feet on the ground in more senses than one.

Should governments be involved in transport research? I expect you would answer "yes." I would answer "yes" also, but with some important qualifications and with a feeling that the answer is perhaps less obviously affirmative than one would suppose.

Nearly two-thirds of the Canadian civilian labor force is employed in manufacturing industry and in a variety of occupations which are collectively known as "trade," including the service industries but excluding transportation. How much is spent by the government of Canada on research to assist these industries? I do not know of any published statistics, but I would guess that it is around $200 million a year.

But, as two-thirds of Canada's GNP is around $120 billion, and as one would guess that research effort must be at least 2 percent of gross revenue, it seems probable that the public funding of research may well be no greater than 10 percent of the total. What these numbers seem to be saying is that there is no earthly reason why companies should not carry out their own research where it is in their advantage to do so, provided that there are sufficient funds available. But, of course,

there are some industries in which there are not the funds available, and the transportation industry is amongst the most important of these in both of our countries.

There are three kinds of situations in which governments may consider it appropriate that they should become involved in transportation research. These are:

1. Where community problems result from some particular mode of transportation (e.g., the automobile) having a major influence on lifestyle and social structures, but research would be beyond the scope or the responsibility of the manufacturer of the vehicle. In short---the economist's "externalities."
2. Where there is insufficient cash available for an industry to tackle its own research problems.
3. Where some special characteristic of the industry makes it desirable that research should be pooled, or where benefit to any one operator may be insufficient, but the collective benefit to all operators and users may be sufficient to justify the expense. (This is not necessarily a reason for government involvement although they tend to be drawn in where the effort is communal.)

Clearly there are many fields for transportation research in these three categories. The first category includes research into the protection of the environment, safety, societal effects of transportation, and a great many allied issues. It is a task for governmental research agencies and universities to tackle. It is an important part of the "raison d' etre" for your own organization.

Where the second---the cash shortage---reason for government support is concerned, I think one must distinguish between research in support of operations---such as rail passenger services---which are very unlikely to be financially self-sustaining, and other research in support of potentially profitable operations made necessary because of the impecunious condition of the operators.

Milton Friedman has pointed out that, in the long term, return on investment varies little in real terms. If the flow of investment funds falls, then industry becomes less profitable and contracts in size until it stabilizes at a level appropriate to its cash flows. Surely if the real terms return on industry has a tendency to stabilize, then there is no fundamental reason why an industry such as rail transportation should be less profitable than any other industry. If this is so, then measures to restore cash flows in the railroad industry may be viewed as an alternative in the longer term to continuing to subsidize research directly. There is no basic reason why railways should be impecunious, and one hopes that public funding of research and development for this reason is a temporary phenomenon.

I mentioned a little while back that the special characteristics of railroads may justify some communal effort in railway research and that these may make some degree of government involvement desirable. I had in mind that a railroad has some inherent characteristics which are quite unlike any other transport system.

There is no other form of transport that I know of in which so many manufactureres are involved in the initial construction of the road and in the supply of the vehicles. One or more manufacturers provide the locomotives, others the cars. Someone else provides the ties, the signalling equipment and so on. Although each manufacturer sells his own equipment under warranty, the manufacturers collectively do not take overall responsiblity that any combination of their products will operate satisfactorily together. Yet they are expected to do so on a track on which the numerous combinations of gradient and curvature provide an infinite variety of unique situations.

It is almost as if an airline bought some wings from Boeing, some fuselages from McDonnell-Douglas, some stabilizers from Lockheed, some motors from Pratt and Whitney, bolted them together in any random combination and taxied out fearlessly to the take-off point. If this analogy seems rather far fetched to you, do please explain to me why it is so different from what we do every day. It would be reassuring to know the reason.

The problems inherent in this randomized system have been exacerbated over the years by forces of economic circumstance. Increasingly severe competition from trucks, and escalating cost levels encouraged the railroads of North America over the last quarter century to increase both axle loading and train length by very substantial amounts. For Class 1 U. S. railroads, gross train load increased from an average of 2630 tons in 1950 to 4130 tons in 1975. The average weight of a loaded car increased from 77.8 tons in 1950 to 105.9 tons in 1976. However, as a great many 1950 cars were still in service in 1976, the increase in the loaded weight of new production cars probably increased even more drastically than this 36 percent increase in average loaded weight.

Although I have no doubt that the railways were most circumspect in the manner in which they tested new equipment such as the large new unit trains which have entered service during the last 10 years, at no stage until recently did we stand back from current problems and examine afresh the engineering and economic qualities of the railway system as a whole. At no stage---that is---until the Association of American Railroads began their highly important series of programs into the fundamental character of the relationship between the train and the track upon which it travels. (As I said earlier, this is a reason for cooperative effort but not necessarily for government involvement).

Summing up, I believe that some government involvement in railway research is both inevitable and necessary. This is partly to make sure that community needs are adequately represented, but it stems also from the inherent characteristics of railroad systems and their tendency to be something less than perpetual money spinners.

Canadian research priorities. This is a convenient point to switch from my cursory mention of the reasons for communal research effort and talk about ways in which the government of Canada and the Canadian railroad industry are cooperating. I personally believe and hope that this cooperation will be extended to closer ties with governmental research institutes and the railroad industry in the United States.

There is little physical difference between the railroads in Canada and those in the U. S. Although we have particularly severe winters with snowfall exceeding 250 inches in some areas, it is doubtful if conditions are substantially worse than those encountered by the principal roads in the northwestern states. We have a few unique problems such as permafrost, but the scale of our operations in these areas is comparatively small. Most of our railroad---and indeed many other---transportation research problems are common to both our countries.

The Canadian Railway Advisory Committee was formed three years ago with the object of bringing about a closer liaison in which the railway industry---

including equipment manufaeturers, trade unions, and research institutes---advise Transport Canada on the most favorable directions in which research programs should be initiated and funded. It was not a question of finding a new means to spend public money for the benefit of the industry---in fact, in many cases, the cost of the programs has been shared between government and nongovernment participants. It was rather that there was a growing realization that a major research effort would be needed to meet Canada's vast and growing needs for rail transportation, and that this could be provided most cost effectively by combining our forces.

Before discussing some aspects of the research programs we propose, I feel that I should say something about the philosophy on which they are based. I personally believe that the history of railroading indicates continuing need to increase productivity of labor and capital. To some extent this occurs because of technological progress in competing modes of transport, but the rising level of wages (in real terms) also makes it necessary to increase progressively the proportion of capital to labor.

I know that you would hasten to point out that there are other societal needs which may not be directly related to growing productivity, but which may be just as urgent in their demands for research funds, and indeed this may be true. But it is also true that for the railroad industry to meet new challenges such as modern, fast, intercity passenger services, it must begin the day in a sound financial state and with economic justification for its continued existence. One need only look at the problems of some European railroads to appreciate the magnitude of the economic burden on the community when it is necessary to retain a major passenger network that is allied to freight services which have long since ceased to meet the needs of the industrial community.

For many years, railways increased their productivity either by increasing the length of haul, by increasing the length of train, or by higher axle loadings. The average length of haul for Class I U.S. railroads increased from 416 miles in 1950 to 535 miles in 1976. I have already given you statistics for the other two parameters.

It is clear that we cannot make trains much longer than the present lengths—which sometimes exceed 3000 yards---without encountering severe train handling problems; in any case the economic advantage for doing so is questionable. We certainly cannot increase axle loadings above the 32.5 tons of today until we know a great deal more about the riding characteristics of trucks and their consequence upon the wheel/rail interface.

We could, I suppose, haul our loads further, but there is a limit to very long haul traffic and, as traffic is lost, there would be the need for still greater productivity improvements from remaining traffic. Before too long, "from sea to shining sea" would take on a new meaning---it would be the origin and destination for most rail traffic.

As it appears that there is little prospect for any major improvement in productivity of the large long-haul freight train, then it follows that there are only three principal areas in which substantial productivity improvements may be obtained. The first of these is in the productivity of road and equipment maintenance (including construction projects such as the elimination of severe curvature and gradients). The second is the efficiency with which we handle rail traffic at the beginning and end of the journey. The third is the greater throughput and reduced locomotive maintenance obtainable through electrification.

New equipment to improve the productivity of track maintenance surely deserves a high priority. The mechanization of track maintenance during the 1950s and early 1960s enabled the real terms cost of maintaining track per unit gross ton mile of traffic to be reduced by possibly as much as 30 percent on some major roads. I treat the figure cautiously because it is rather important to distinguish between legitimate cost saving through mechanization, and that obtained through deteriorating standards.

We need a new generation of automated rail layers, tie changers, tamper/liners, ballast cleaners, not only to reduce our costs so that we can remain competitive and contribute fully to the economic development of our two countries; we need them also if we are to continue to provide high quality track suited to the needs of high speed passenger trains, where these are socially desirable. The frequent attention that track needs in this latter circumstance and the growing volume of traffic on some main lines will make it essential that track gangs should be able to move at much higher working speeds than the 500 feet an hour that is typical today.

Higher productivity in terminal areas is necessary because this is the phase of rail freight operations which is frequently the least efficient. Some kinds of rail traffic such as unit trains carrying bulk commodities, piggyback,and container services are already handled efficiently at the end of the run. Other kinds of rail traffic in which small numbers of cars have to be delivered at very low speeds on industrial sidings in the downtown areas of major cities are handled in a costly manner and one which is often complained about by people who live in these areas.

The main point about domestic container systems is that the marine container is unsuited for domestic use because its 8' x 8' cross section does not make satisfactory use of the cubic capacity available on either rail or highway vehicles. I note that some experimental container cars aimed at remedying this deficiency are under construction in the U.S.

Regarding electrification, I shall say little as the subject was covered thoroughly at a recent conference in Washington, and you are no doubt aware of the excellent study by the Canadian Institute of Guided Ground Transport. May it suffice to say that I regard electrification as an inevitable development, but one which will come about progressively and probably without major government stimulus whenever it becomes truly economic in some specific application. I need hardly add that it will not come about unless and until the cash flows earned from railroading are brought into line with those in other industries.

I have reviewed the three most likely areas from which productivity improvements may result, but there are other areas of railroad research which merit at least as great priority. The first of these is simple. It is the need to improve the efficiency with which the railroads tackle their existing workload.

I have already referred to the track/train dynamics program of the AAR and in which the government of Canada and the Canadian railroads are involved. Perhaps I should have mentioned this ahead of the productivity improvements because in some ways we are making up for a backlog of research which we might advantageously have tackled 20 or more years ago. What could be more fundamental in research than to ensure that the trucks ride in a stable manner on the track and without causing undue wear to either wheel or rail?

Before the committee was formed, the principal railways and the government had already seen the

need to support track/train dynamics amongst other programs. There is, in fact, a close liaison and several Canadians are members of the various committees and steering groups which supervise the AAR programs. Indeed, the chairman of their track/train dynamics steering committee is a prominent Canadian railroader. Track/train dynamics apart, there are a host of other improvements to the design of locomotives and equipment which could contribute to the reliability of railroads. Prevention of winter slush from entering the ventilation exhaust ports of traction motors, and prevention of leaks in braking systems are typical examples. There is nothing romantic about such projects. Researchers who work on them are unlikely to receive Nobel prizes. But if you knew how many traction motors Canadian railways change every winter, you would appreciate the virtue of such lackluster projects. You might also buy some shares in a company making copper wire.

Lastly, there is the need to give adequate priority to the development of railway equipment of kinds that are not able to be financially self-supporting. I refer, of course, principally to high speed passenger services. Here the railways of Europe and Japan appear to have left those of North America some way behind in the development of technology regarding the trains themselves and possibly concerning techniques to maintain track at reasonable cost to the quality needed for running at speeds of over 100 miles per hour.

Some organizational developments. During the early part of this talk I mentioned the reasons for cooperative effort between governments, railroads, railroad equipment manufacturers, and others in planning research programs of the greatest community benefit. During the middle part of the talk, I discussed some of the principal research needs and priorities. Now in the last few minutes, I should like to say something about the organizational means of directing the communal effort to achieve research objectives in Canada and also concerning the need for cooperation between our two countries.

Soon after I became chairman of the Railway Advisory Committee, I decided that the first need was to set up small task forces each consisting of seven or eight of the committee members most closely concerned with the specific problem. Each of these groups consists of hard headed practical railroaders including both operators and civil or mechanical engineers, senior public servants, trade unionists, and research specialists.

The task for each group is to recommend to the government of Canada the desirable content of research programs in their specialized field over each of the next several years. I hope that within the next six to eight months the first of these programs will have been formulated and discussed with the government. It does not, of course, follow that the government is under any obligation to accept the advice piecemeal---it may have its own priorities including some that are unknown to the members. But at least a mechanism has been set up which should be able to structure railroad research programs in a highly realistic manner and in a way which maximizes the benefit to both the community and the railroad industry.

To date, one of these groups is tackling the whole problem of railroad construction and maintenance; another is tackling all problems concerned with motive power and cars. A third is concentrating on problems concerned with track/train dynamics. I hope that by the end of the year, we shall have four or five such groups hard at work.

I personally believe that a closer liaison in railroad research in our two countries would be to the benefit of everyone and will be necessary for the economic resurgence of railroading, which is both profitable and desirable. High potential energy efficiency was the original reason why railroads were built; it is likely to provide the rationale for development in the future.

I suppose that some large part of the difficulty in railroad research results from the maturity of our industry. During the latter part of the steam era, the railroads of North America attained a plateau of technological stability in terms of the design of cars and track---somewhat less so concerning locomotives. Compared with the automobile, trucking, air transport, or shipping industries between, say, 1920 and 1960, technical change was comparatively minor. Furthermore, research effort has been somewhat fragmented for reasons I have explained. As an industry, we ceased to be research minded.

Now the Sleeping Beauty period is over. The railroads have been wakened by the unwelcome kiss from the uncharming prince of mounting costs. We need a major effort to augment the rate of technological progress. Only by collective effort are we likely to succeed.

SOCIAL, ECONOMIC, AND ENVIRONMENTAL NEEDS

William A. Bulley
Director, Washington State Department of Highways

It is a distinct pleasure for me to be here today and to participate on this panel to discuss with you perhaps an outsider's view of research needs and possibilities in the social, economic, and environmental area.

I say that because it appears that I am the only representative on the panel, with the possible exception of Mr. Smith, who comes from an organization that, in effect, is "on the firing line" with responsibility to the public for producing a product which involves planning, constructing, maintaining, and managing transportation facilities. Perhaps I can share with you from the standpoint of a state highway administrator some of the problems that we face which, in turn, may generate some ideas regarding research relating to transportation that will be worthy of consideration and helpful to those who are involved in implementation of a program.

The state of Washington recently concluded the longest legislative session in history, lasting 164 days. I understand that is typical of many states, but perhaps what is not so typical is that it was the most significant session in many years in terms of transportation-related legislation.

The legislature addressed an organizational structure for overall transportation programs for the state. The Department of Transportation will become effective September 21. It is organized similar to several other states in that it will contain Divisions of Highways, Aeronautics, Marine Transportation, Public Transportation, and Planning and Budget. There is established within the Department of Transportation responsiblity and authority at the state level for developing transportation policies and a transportation plan.

Legislation also was passed to fund highways. There was $135 million in bonds authorized for capital improvements of the Washington State Ferry System, which is an integral part of the state highway system and one of the largest public transportation systems in the United States. There also was legis-