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CO-OPERATIVE RESEARCH IN RAIL TRANSPORTATION
Some Probable Developments

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I am very pleased to have the opportunity to discuss co-operative railway research with you. It is a timely and important topic. As the theme of this session is to review the relative functions of universities, government, and railways in carrying out research, I shall begin by considering the role of each in turn.

The role of the university

The function of the university has been in dispute since the days of Ancient Greece. Aristotle believed that knowledge was "capable of being its own end*" -- but the Sophists believed that research was only useful if directly benefitting the community. During the last two centuries, this academic squabble has been renewed. Those who believe that the primary function of the university should be to extend man's knowledge are still at issue with those who perceive the university as an integrated part of the community and closely concerned with immediate problems. It is worth tracing how this difference of view developed.

By the end of the Middle Ages, such universities as Salerno, Bologna, and Paris were well established, specializing in the fields of law, medicine, and philosophy, respectively. Both Oxford and Cambridge are said to have taken their initial character from that of the University of Paris.

* RHETORIC by Aristotle.

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But, by mid-17th Century, universities had become "ivory towers" of introspection. Cromwell saw little use in them and applied his universal remedy for institutions he disliked. Charles II, whose enthusiasm for the physical aspects of life extended to science, founded the Royal Society to encourage the revival of scientific study.

Following the humiliation of Prussia at the hands of Napoleon at the Battle of Jena, Wilhelm Von Humboldt founded in 1809 the University of Berlin which, with Gottingen, were the prototypes for many American universities*, inasmuch that they were directly concerned with research on philosophical and scientific problems affecting the communities they served. The development of the modern American university was based more on the German model than any other -- in 1825 George Ticknor remodelled Harvard on this pattern.

In this century, Abraham Flexner, American educational reformer, considered the university to be:

> "Not outside but inside the general social fabric of a given era...an expression of the age as well as an influence operating upon both present and future...an institution consciously devoted to the pursuit of problems,..."**

But even he balked at the involvement of universities in applying themselves in the day-to-day problems of the business community and attempted to persuade Harvard University to disown the Harvard School of Business. They declined.

* In the opinion of Clark Kerr in his book THE USES OF THE UNIVERSITY, Harvard, 1972.
** UNIVERSITIES: AMERICAN, ENGLISH, GERMAN, by Abraham Flexner, Oxford University Press, 1930.

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Our own era has seen the rise of the huge university -- the "ideopolis" -- running every kind of specialized technical institute, business and law schools, hospitals and even quasi-commercial consultancies, and ringed by large numbers of high technology businesses. Closely allied to it are more specialized research institutions such as our own National Research Council.

The role of the state

The involvement of government in research is of more recent origin. During the 19th Century, the Germanic States, amongst other emerging industrial powers, made increasing use of universities for military and industrial research and, of course, the World Wars compelled the governments of the warring powers to do so. The Great Depression forced governments and universities into close association on economic problems. Today, even the most ardent supporter of the market system (me included!) accepts the political infeasibility of any government turning its back on social, economic and scientific problems.

The argument between Aristotle and the Sophists is as yet unresolved. The proportion of national research effort which should be applied to the gathering of new forms of knowledge is, of course, a national issue not specifically related to transportation (and therefore beyond the scope of this paper). The extent to which universities should be involved in the study

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of railway problems is of more direct concern. But the roles that government and railways should play in choosing which problems should be tackled or which approaches should be adopted is an even more vital issue.

The role of railways

Where railways are concerned, the problem of responsibility for research is more readily defined. A railway is a business and, as such, if it were not for some unusual characteristics, the Canadian railways could be expected to carry out their own research just like any other business, on a private and competitive basis.

Life is, however, not quite that simple. Firstly, all North American railways have to meet common specifications because their cars move from one system to another. Secondly, the individual Canadian railways have limited influence over the design of the products of major U.S. railway equipment manufacturers whose designs predominate in many areas. Thirdly, the scale of Canadian railway operations, large as it is in relation to the population is too small for the railways even as a whole to insist on the production of equipment fully suited to Canadian conditions. For individual railways, it is often quite impossible to persuade the larger manufacturers to make major changes in their specifications.

Thus, co-operative railway research is inevitable in Canada -- I am pleased to have been involved in organizing it.

Only with some government support can major technological advance be funded. It is, of course, highly desirable that the railways should also carry out and fund their own private research in areas where competition makes co-operation undesirable.

Greater research effort and closer liaison with management

The enormous scale of railway investment that will be desirable in the 1980s will require new attitudes to research and investment planning. A recent speech* by Mr. R.J. Hansen of CN Rail stated their investment budget for the 1980s would be $10.7 billion. Another speech** by Mr. J.D. Bromley estimated CP Rail's 1980s capital expenditure (in dollars at current value) at $7.65 billion, $5.65 billion of it in western Canada.

The Canadian railways fully appreciate that after a century in which there has been extensive spare capacity, save for the occasional bottleneck, they will now have to provide increased capacity on a very substantial scale. CP Rail have, of course, already done so with three major grade revisions in western Canada. But the proportion of cash flow that will be required if the progressive enlargement of plant is to keep pace with the growth of resource industries is already entering a progressively increasing trend which will endure to the end of the century and beyond.

* Address by Mr. R.J. Hansen, Vice President, CN Rail, Prairie Region, to Marketing & Transportation meeting, Miami, Manitoba, December 3, 1981.

** Address "Rail Capital Shortfalls in the 80s" by Mr. J.D. Bromley, Vice President, Pacific Region, CP Rail, to Coal Association of of Canada, Vancouver, August 6, 1981.

Secondly, it is within the bounds of possibility that before the end of this decade, major electrification projects on Canadian main lines may have reached the planning stage and, during the 1990s, this work may well increase the demand for railway capital.

Thirdly, we appear to be reaching the end of the era when the principal use of computers was to provide management with information and to automate such clerical functions as invoicing. We are entering an era when computers will also aid decision takers by indicating the financial and technical consequences of each of the options available on the system viewed as a whole.

Fourthly, there is the prospect of the application of robotics in railway workshops. In recent years, there has been a substantial advance in the rate of track renewal using recently developed machines, and no doubt this trend towards greater automation will continue also. (The use of concrete ties facilitates the use of this machinery and, by cutting down the time that track is out-of-service, contributes to improved track capacity.)

There are two reasons why the huge scale of these cash requirements will necessitate a closer integration between railway research and central railway policy making. The first reason is -- very simply -- that it may no longer be possible to finance projects

just because their rate of return may happen to be particularly favourable; the limit of the railways' ability to raise external finance is likely to compel the compounding of major investment projects into integrated programs designed to minimize the external borrowing requirement. Projects that generate large cash flows in early years will be put in place wherever possible ahead of slower cash generators (even with higher internal rates of return) in order that the former may help to finance the latter.

The second reason for change in research strategy is that the return on massive projects such as grade revisions and electrification are likely to be mutually interdependent. For example, the return on a grade revision will influence the rate of return on electrification because less new locomotives would be required.

My purpose here is not to estimate the effect of electrification on the return on grade revisions or vice versa. It is rather to emphasize that decisions on projects of this magnitude will have to be determined in one overall package, if costly mistakes in the timing of projects are to be avoided and if the most favourable use is to be made of the limited sources of cash that will be available.

If these conclusions are acceptable, then it must follow that the current practice in which research projects are undertaken either because someone has had a "bright idea" or because an operating department of a railway requests aid in solving some specific problem, will need to be supplemented by research planning of a more comprehensive kind. In all probability, managements and technical departments will have to sit down together and determine what levels of technological attainment should be targetted for, say, five, ten and fifteen years ahead in order to provide the necessary capacity and to achieve whatever advance in the productive use of labour and capital is consistent with financial solvency. Let me offer an example to illustrate why this setting of "technological plateaux" may be necessary.

Suppose that a railway decides to revise its grades in the loaded direction whilst at the same time electrifying the route. The electric locomotives will probably have better adhesion -- that is to say, less locomotive weight for the tractive effort exerted -- and will certainly generate more power per unit weight than the diesels they replace. Suppose that the descending grades in the loaded direction remain unchanged. Trains would then be descending severe grades with far less weight of locomotive per unit weight of train than previously. It would be desirable to carry out whatever research might be needed to ensure that train stability and braking would be satisfactory in this new situation. It would be financially disastrous for

any railway to make huge investments in electrification and grade revisions only to find that the full return on them cannot be obtained until some unforeseen problem is remedied. It seems to me to be inevitable that future research projects will be "targetted" in terms of the time -- the technological plateau -- by which a solution must not only be found, but implemented.

If there is serious doubt as to whether it is possible to complete all the research needed by the planned date, then clearly the large cash outlays must be delayed, or their sequence adjusted until there is assurance that the full return on major expenditures will be immediately available. Put in another way, we need to think in terms not only of the return on investment on individual projects, but also of the overall rate of return (at various traffic levels) to be achieved with the improved productivity resulting from the best available "package" of new technologies.

At this point you might be justified in suspecting that I have some recondite addiction to centralized planning. Please be assured that nothing could be further from the truth! I fully accept that, with the severe fluctuations in traffic levels to be expected in a Canadian economy heavily involved in world commerce, detailed traffic planning even a few months ahead is a sufficiently difficult task. Yet the fact remains that major technical changes such as electrification will take upwards of ten years to implement. It is highly desirable, therefore, that

the return on this and other elements of the research "package" should be computed over a wide range of longer term traffic projections in order that the financial risk should be evaluated and its extent understood. This is why it is so essential that research should become more closely related to the major decision taking required of railway managements.

In making these suggestions, I fully appreciate the realism implicit in a remark by Dr. R.A. Bandeen that:

> "A manager would rather live with a problem he cannot tolerate than with a solution he cannot understand*."

In the era we are entering, there is thus no alternative but to develop methods of computing optimal combinations of decisions that *can be* comprehended by managers. The numbers are too large to make do with anything less.

Some tentative conclusions

In the few remaining minutes, I shall endeavour to summarize my conclusions concerning the research responsibilities of government, railways and universities, concentrating in particular on what is likely to change.

Firstly, and as aforesaid, the responsibility of the university for advancing knowledge in ways unrelated to specific problems

* In a speech, "A Management Look at Corporate Problems & Operations Research", made to the Canadian Operational Research Society, Toronto, June 1972.

is likely to remain unchanged. But the proportion of national income that should be devoted to "pure" research of this kind, I regard as a central national issue which, however, great its importance, is beyond the scope of this paper.

Secondly, as long as we have a competitive transport system in Canada, there will continue to be kinds of research that individual railways will wish -- very properly -- to conduct privately and to fund from their own sources. In particular, the formulation of the "technology packages" that I discussed earlier, the central investment strategies and the sequencing of the use of funds are all matters which railways will wish to consider in private. And this is how it should be.

But, thirdly, I believe that co-operative research of which government, transport operators and equipment manufacturers share the costs will continue and on a much increasing scale, extending possibly to intermodal services; the high cost and large volume of research that will be needed will make it essential to carry it out in this most economical manner. If, for example, electrification and the development of new more productive track replacement machinery were part of the private investment strategy for two or more railways, there would be no reason why the research itself should not be carried out in co-operation even though each would regard its individual plans as private. Furthermore, the development of the equipment to carry out these plans may be important to industrial development.

Fourthly, so far as government is concerned, the extent of financial participation in co-operative research will determine the rate of railway technological advance -- apart from any attendent benefits to the economy resulting from the development of new products. Without such research funding, railway capability to move traffic will be limited by the upper level of internal and external sources of finance that will be available. If that is enough, then well and good; if it is not, then the extent to which the rail system's capacity and capability should be extended by the use of public funds for research and technological development is a matter for government to decide.

Fifthly, co-operative research may be expected to become increasingly hardheaded in a commercial sense because the efficient operation and financial viability of railways, under the load of increasing traffic, will be strongly dependent on its success. Even though research can never be free of risk, funds will be committed most readily when there is an assurance from whatever research institute is involved concerning the results that may be expected and *when* they may be expected. Our universities and other research institutions will, of course, remain free to carry out any other research they choose -- and I very much hope that they will use this initiative to the full. What I am pointing out is that problem solving under contract, in which the objectives of the work and the approaches to be adopted are predetermined, may well be carried out separately from other work

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in which the initiative available to the researcher is unrestricted. Universities in Canada may find it desirable to spawn quasi-commercial institutes if wishing to participate in research of the former kind, because contractual requirements may be hard to reconcile with the traditional "academic freedom" of the university. Researchers will have to choose which field they wish to work in -- and which set of rules they are willing to observe.

Sixthly, the playing of hunches by individuals involved in the sponsoring of research is likely to be supplanted by debate in which senior railway managers and researchers are closely involved. A recent organizational change has brought the Vice Presidents, Operations & Maintenance, of six Canadian railways to a closer interface with the research-interested people in both government and industry, who form the Railway Advisory Committee -- which recommends what co-operative research should be undertaken. This is a significant development, a meeting of minds between researcher and user.

A final word. Although research may become more highly commercialized, the system must not become over-rigid. All through history, many of the most brilliant ideas have come from the most unlikely sources. A series of gliders, the first to have the basic configuration of the modern aeroplane, was built between 1809 and 1850 by Sir George Cayley, a Yorkshire landowner

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with no scientific training. Radar was invented, not by some defence researcher, but by Sir Robert Watson-Watt, whose primary concern was to further the science of meteorology. The jet engine was invented, not by the research department of some aircraft engine manufacturer, but by Sir Frank Whittle, a flying instructor at the Royal Air Force College.

So, although we shall need to develop new structures for research and investment planning and for their more efficient integration into general railway management, we must never become so over-organized that we cease to be responsive to new ideas even if beyond immediate railway plans.

Inventors of the world, we shall always welcome your ideas!