TRENDS in RAIL TECHNOLOGY

Harold M. Kohn
Director, Rail Division
Centre for Surface Transportation Technology (CSTT)
National Research Council, Ottawa [1]

Introduction – The Importance of Rail

The role of rail transport as a driver of the Canadian economy has been well understood for many years. Canada's first Prime Minister, Sir John A. MacDonald, recognized that a steel ribbon from east to west would help to bind Canada together and resist the natural tendency to trade with Canada's southern neighbor. More than a century later, that natural tendency dwarfs any concept of Canadian economic nationalism to such an extent that one of Canada's major railways, Canadian National, has for several years been one of the largest and most efficient railways in North America and arguably in the world, and as such is a dominant force in North America. Today, the two nations are essentially seamless in terms of rail transport and the interchange of railcars and commodities across the border.

Canada and the US remain significant trading partners, and rail transport forms an integral part of that trade. Over half the revenue freight carried in Canada is hauled by rail (the other half being truck) although the number of companies that operate their own trucks (for their own account) is proportionately the same as the revenue freight carried by truck. A significant volume of rail freight in Canada originates in the US, destined for export via Canadian ports. Nevertheless, with rising fuel prices, long haul trucking is, in some

[1] The opinions expressed in this paper are the views of the author and do not necessarily represent the views of the National Research Council.

areas, giving way to long haul rail transport as trucking companies use the railways for the long haul. Trucks are then being used for local delivery and distribution. Although fuel prices rise and fall, the longer term tendency to rising fuel prices may make rail transport even more important in the future. Rail transport will continue to be a vital part of the economic system in Canada, underlining the importance of an efficient North American rail transport system.

Much of the freight carried by Canadian railways is a driver of the Canadian economy in that a significant portion of materials carried by the railways are for export and the raw inputs to Canadian manufacturing. Although there are variations on a year by year basis, there are ten commodities that account for almost sixty percent of rail freight carried in Canada. These commodities are shown in Table 1.

It is interesting to note that, since the transportation of these commodities is the first stage in the economic cycle, any changes in the volume carried by rail indicate where the economy is headed. Statistics Canada uses monthly railway carloadings (which provides the number of rail cars and the tonnage by commodity) as an input to the leading economic indicators that Statistics Canada publishes. A paper published at CTRF[2] by this author showed that containers carried on flat cars[3] is directly related to GDP, and that these container loadings are an excellent indicator of future growth about three to six months into the future. It is clear that rail transport is an important indicator of how the Canadian economy is changing, in both an up and downwards direction and confirms the relationship between rail freight and the economic well being of the country.

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[2] "Timely Railway Data – A Leading Economic Indicator for GDP?" CTRF Proceedings, 1999.

[3] Containers carry mixed freight from raw materials to finished goods.

Table 1	Millions of Tonnes of Freight Carried	
	2007	2008
Coal	33	35
Mixed/unidentified	26	26
Iron ore and concentrates	18	20
Wheat	22	19
Potash	18	17
Lumber	13	10
Other basic chemicals	10	9
Wood pulp	9	9
Other cereal grains	8	8
Canola	6	7
All other commodities	118	113
Totals	281	270

Source: Statistics Canada, Rail in Canada, Catalogue 52-216

Thus there is no doubt that the economic future of Canada is dependent on many factors including a reliance on rail freight. The long term sustainability and increasing efficiency of rail freight in Canada are key to ensuring a strong economic future for Canada. Technology has and will continue to play an important role.

Technology – A Key to Long Term Economic Viability of the Railways and Canada

With Canada's economy highly dependent on transportation, the long term growth of its economy depends on the ability of carriers to handle increasing volumes of traffic in the future. Over the years, the railways have implemented the use of longer trains, more cars per train and heavier cars. The average number of rail cars per train increased, from 68 in 1999 to 82 in 2008.[4] Average speeds are still less than 40 mph, but in an attempt to increase productivity, the former president of CN set 90 mph as an objective. Winter issues are a major challenge, not only in Canada but around the world. Winter

[4] 2009 Railway Trends, The Railway Association of Canada

problems result in more delays than in other seasons because cold weather weakens steel and increases the number of broken wheels and damage to equipment and track. Delays and backups that may occur when trains cannot negotiate hills or slow down because of track conditions or when trains are cancelled cause productivity and financial losses. Winter weather remains a challenge.

Despite the increased traffic over the years, and the pressures to perform, the number of railway accidents has been steadily decreasing, from just over 1700 per year in 2003 to just over 1500 per year in 2008.[5] Reducing the number of accidents still remains a significant challenge.

The long term viability of Canadian railways depends on many factors such as continually improving productivity, controlling costs, meeting the needs of shippers, avoiding accidents and derailments, finding solutions to winter problems and a variety of other factors.

Heavy haul rail freight is not the only area of rail research in the world today. The other major area is passenger travel, especially high speed intercity as well as urban transit. Much of the focus on the passenger side of rail transport, as is the case in heavy haul freight, is focused on helping passenger system operators reduce costs and lengthen the serviceability of equipment and tracks, as well as reducing noise and vibration.

Areas of Technological Research

Although the National Research Council's (NRC) rail research work does not encompass all types of rail research being conducted around the world, the work being done is representative of much of the work taking place around the world. Most of the work NRC does is for clients outside Canada, and is, therefore, representative of world demand. Rail research at the NRC is work that clients pay for. The Rail Division has operated under full cost recovery since 1995; thus

[5] ibid

the work that the Division does represents what industry really wants and is willing to pay for.

There are basically four types of research that NRC is conducting.

The first type is physical testing, where rail cars are put through various tests to measure performance or durability. These are done using buildings and facilities at the NRC rail lab in Ottawa, or in the field at a rail location. NRC capabilities include an impact hill (see Figure 1) and the Dynamics Bay (Figure 2), used for dynamic testing (vibration and repeatable tests), strength and durability testing and testing related to trucks, wheels and the car body.

Figure 1 and 2

The impact hill is a real hill where rail cars are winched to the top of the hill and then released and stopped hard at the bottom of the hill. The hill is used for a variety of rail car tests but mainly to test strength and durability or rail car or tie down components.

NRC's dynamic vibration facilities can, for example, bounce a fully loaded rail car up and down hundreds of thousands of times to measure the durability of various rail car and truck and wheel systems. Accelerated testing can also be done, where one month of dynamic testing can reproduce months of actual service. Computer programs are used to build in the kind of vibration that rail cars would incur on actual rail lines.

Recent field tests include measuring performance and forces on both the vehicle and track. One such test was conducted on fully loaded freight rail cars on actual operating revenue trains on the main CN and CP line in British Columbia. Other field tests have focused on resolving vibration and noise issues for major North American transit authorities.

Another illustration of physical testing is the work that NRC is doing for Transport Canada, to understand what happens when empty tank cars derail, in a domino fashion, one by one, when an empty tank car at the end of the train derails. Accidents like this have occurred several times. Figure 3 shows an example of this type of accident.

NRC engineers spent a year analyzing the reasons for the accident. It is not as straightforward as might first appear. In the image, it can be seen that every second truck is still on the track. For this type of rollover to occur, the tank car had to rise more than 8 inches to clear the pin on the truck, but this only happened at one end of the car. It was finally determined that the cause of the domino effect is the type of coupler that is used to couple tank cars. The coupler that is used holds fast in case of an accident, thereby preventing punctures in an adjoining car. Although this is by itself a desirable outcome, the domino effect is not.

Armed with that theory, NRC engineers first developed a computer simulation model to verify that the coupler is the cause, and how a modified coupler could remedy the situation.[6]

A physical test was conducted in February, 2011, to see if the domino effect could be duplicated in real life. The domino effect was confirmed. In March, 2011, the test was redone with the modified coupler, and as expected, the tank cars did not roll over. The simulation and real life test both confirmed the analysis of the engineers.

Figure 3

The second type of research being done by NRC is that related to the performance of the wheels and rail, at the interface, and relates to damage to tracks or wheels, rolling contact fatigue, ways to resolve

[6] Simulation work is another area of rail research work being done by NRC. It is discussed briefly later on in this paper.

that damage through grinding and the use of friction management strategies. Other types of work include that to identify and resolve noise and vibration issues and mitigate problems in winter. NRC also does studies that gather scientific evidence to help policy makers and railways to understand the impact of regulation and proposed regulatory changes.

A third area of research that NRC is engaged in is working with primarily Canadian companies to develop new technologies, both in freight and transit, with a view to developing new solutions to problems.

The fourth area, which has already been mentioned, is computer simulation. In the recent past, there has been a remarkable and noteworthy increase in the use of computer simulation modeling to represent and study real world phenomenon. Simulation work can be less expensive to conduct than physical testing, since there is no requirement to set up real rail cars in real world situations complete with data acquisition set ups and the engineering and technical labour that are required to set up and conduct these tests. In some cases, there are no alternatives to physical testing, but as computer modeling becomes increasingly more and more sophisticated, with the inclusion of a plethora of variables, simulation becomes more robust and reliable. Some clients still insist on having physical tests conducted to confirm the results of computer modeling, and in some cases it is necessary to achieve regulatory certification, but in the future it is possible that an increasing portion of rail research work will be done behind the computer monitor, rather than in the field.

A current example of simulation work is that which is being done for a major North American transit operator, which wants to develop a maintenance manual of best practices designed to improve the efficiency of the maintenance budget. The intent is to provide the transit commission with the tools and information to fix problems before they occur rather than replacing parts or track that may not be in danger of failing, but otherwise would have been repaired because that had been the practice in the past. The work began with a comparative analysis with other transit systems, but in the end, it was determined that differences between transit systems are so significant as to make any conclusions drawn and applied to a specific operator somewhat questionable. The answer was, in the end, to use computer modeling simulation, using a model of the specific transit system, with its specific use of wheels, track, speeds, etc. to develop such maintenance guidelines.

Lengthening the Life of Physical Assets

For business reasons, all operators want to reduce maintenance costs and lengthen the service life of equipment and track. Replacing broken wheels and track, and repairing damaged track and wheels is expensive, and puts trains out of commission, thereby reducing revenues and levels of service.

NRC engineers can often be found on freight and transit track, all over the world, investigating various kinds of track and wheel damage. They can identify various types of damage and identify the causes of that specific type of damage. NRC engineers then provide the operator with methods to reduce that damage. These methods include grinding the track to an optimum profile to reduce friction and wear and tear on both the wheel and the track. Another method, which should be used in conjunction with grinding, is the implementation of a track lubrication program. It is estimated that grinding, in addition to properly designed lubrication and friction management practices can reduce maintenance costs by at least twenty-five percent.

The Instrumented Wheel Set

One of the methods to measure real time track and vehicle forces is the use of the instrumented wheel set. These are actual wheels installed on rail cars. The wheels and axles are instrumented to measure various forces while the train is in operation.

Current technology requires the wheelset to be installed on real trains in actual service, unless special test trains are used. Both methods have an impact on the carrier's ability to earn revenue (which is obviously an obstacle since such tests interfere with the normal operations of railways). An adjoining rail car is required for engineers and technicians, to monitor the wheel set data in real time, using sophisticated data acquisition systems.

Such tests can be expensive but the payback in terms of improving safety, performance and reducing maintenance costs are significant. Such tests are mandated in Europe on high speed trains. AMTRAK routinely performs such tests on its high speed north eastern corridor. NRC clients include mining operators where the heavy cars, filled with ore or other mining materials, tend to wear track and wheels at an accelerated rate. The maintenance savings result from optimal grinding strategies coupled with a complete friction management program.

Figure 4 shows an instrumented wheel set.

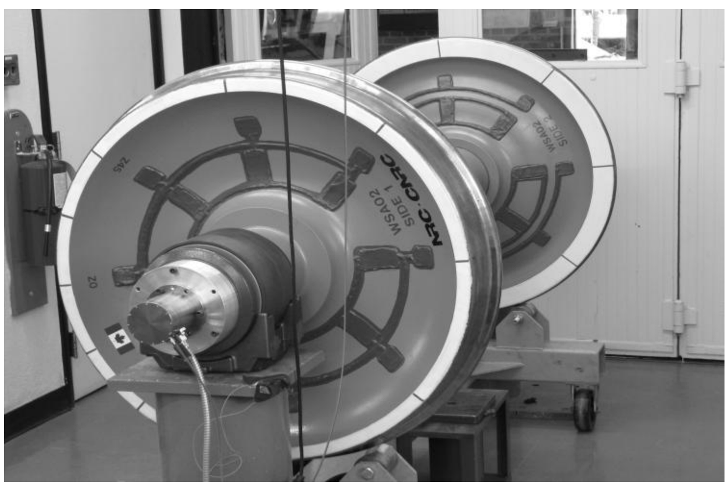

Figure 4

NRC is now working with the private sector and transit operators to develop a significantly less expensive wheelset with advanced electronics, coupled with transmission of the data via satellite back to the NRC lab in Ottawa. This new wheelset is autonomous and does not require a manned calibration car. The wheelset is robust enough to be left on the train full time, for lengthy periods, transmitting data continuously round the clock. The advantage of continuously monitoring the track provides a wealth of information that can be used to identify and predict where and when maintenance is required. One of the features of the system is that it can detect track defects as they begin to develop. Coupled with GPS data, the location of such problems can be identified and crews sent out to repair the defect.

The advantage of this next generation of technology is that the costs of performing the tests are significantly lower and more attractive to operators who want to know how the train and track are performing. Even more exciting is the ability to predict, using the data, where damage on the track will occur, so that maintenance efforts are focused on actual damage being created, rather than damage that might occur.

Systems Approach in Track and Car Design

The evidence of several years demonstrates that when a railway or transit system is being built, it is vitally important to ensure that that rail car, its truck, wheels and track all work in a thought out and properly designed system. There are several examples around the world where this type of systems approach was not used, with detrimental results. When Korea developed a high speed train system based on the French TGV, the track was built independently of the railcar. When the project was completed and the railway executives boarded the train for the initial run, the train had to be stopped once it neared maximum speed because the train became unstable. Researchers then redesigned the truck and the train became stable and usable.[7]

NRC researchers are sometimes called in by operators because the manufacturer of the track or railcar are unable to find the true cause of a specific problem, sometimes pointing to the other. Often, the

[7] Discovery Channel documentary

problem is that the rail car and truck have not been designed within a system, and that is what is causing the problem. Operators building systems now are more aware of the need to use a system approach to design a rail system.

Summary

Rail transport has and will continue to be a vitally important component of the Canadian and world economies. The movement of both raw materials and finished goods by train is a significant component in ensuring sustainable economic conditions, and the efficient movement of people between and within cities remains critical to that economic sustainability. As demand grows, technology is vitally important in assisting operators to meet that growing demand. In the short term, technology can assist operators by lowering costs and increasing productivity. In the longer term, the growing economic envelope requires technology to provide answers to new and emerging issues. Canada is playing a vital role in developing that technology.