his in-basket from virtually any office on the system.

The Chief Engineer's office is in the process of implementing full office automation. Files are being kept electronically and many of these will be shared among all engineering offices. For example, a file on the rehabilitation of a bridge could be accessed on the screen and memoranda posted from any office. The elimination of paper is seen as a way to free more time for planning.

LONG-RANGE PLANS

CP Rail has made a long-term commitment to implement Manufacturing Resource Planning (MRP) at the corporate level. MRP is a management philosophy that emphasizes planning and is run on integrated computer software that guides all aspects of the planning of work, through the ordering of materials and the monitoring of gang progress relative to plan. In effect, it makes 80 percent of CP Rail's current systems obsolete and replaces them with an integrated approach to planning and controlling resources used by all operating departments.

According to the plan, these strategies for improving track structure to eliminate weak links, and development of information systems to assess maintenance priorities, will enable CP Rail to make full use of a long-range integrated planning approach that will reduce firefighting to an absolute minimum.

# Principles of Maintenance-of-Way Planning

E. R. TRASK

ABSTRACT

Doing track maintenance in a planned manner reduces the overall cost of a series of related activities. To obtain optimum results, the planning staff should be experienced and technically knowledgeable. Some of the more important principles to consider when making any plan are establishing the size of the permanent work force, implementing directives from regulatory bodies, establishing standards, measuring rate of plant deterioration, educating staff, communicating effectively, mechanizing gangs, using forecasting material, forecasting future travel levels, creating a plant inventory, establishing a planning period, establishing a logical sequence for replacement of components, coordinating field activities with train schedules, using theoretical degradation models, and reporting progress of work and comparing it with the plan.

After the maintenance requirements for track, roadbed, and right-of-way have been identified, and after priorities have been assigned, the maintenance-of-way activities need to be planned. Almost any good, ambitious individual could fix up a deteriorating piece of track if he was told what to fix and if he had unlimited supplies of money, labor, material, and time. Because there are limitations, planning is required; this is based on the assumption that planning is a method of obtaining maximum benefit for minimum overall cost.

To obtain this benefit, the planning must be done by people who have a feel for how all of the different parts of a track structure relate to each other and what effect a weakness in one component has on other components. Therefore, the first obvious principle of maintenance-of-way planning is as follows: have the planning group staffed with people who have had practical field experience and a basic civil engineering education, and have an ability to do basic economic analyses.

Other principles that will be explained in more detail are

- Establishing the size of the permanent work force
- Implementing directives from regulatory bodies
- Establishing standards
- Measuring plant deterioration
- Educating staff
- Communicating effectively
- Mechanizing gangs
- Using forecasting material
- Forecasting future traffic levels
- Creating a plant inventory
- Establishing a planning period
- Establishing a logical sequence for replacement of components
- Coordinating field activities with train schedules
- Using degradation models
- Reporting progress of work

## ESTABLISHING THE SIZE OF THE PERMANENT WORK FORCE

In the railway industry in Canada, the general trend in track maintenance is to keep track as close as possible to the original construction standards to guarantee an uninterrupted train flow at published timetable speeds. Coupled with this is the need to discover deficiencies and sudden failures, and to protect trains against the hazards they may thereby encounter. Therefore, inspection, decision making, and slow order placing are required.

Because a rail line cuts across large blocks of land and by its very nature separates communities and groups of people, there is a continual call to cross it with items such as roads, wires, and pipelines. Consequently, a permanent, knowledgeable staff must be around to ensure that such crossings are done in away that is safe to both utility personnel and trains and with the least possible interference to railway traffic.

When the time comes to do major rehabilitation, construction, and relocation, it is necessary to have experienced foremen and supervisors to lead these groups. These leaders have to come from an everyday, permanent work force. A few examples of the work done by this permanent force are

- Changing a broken rail
- Regauging
- Lifting joints
- Adjusting rail anchors
- Tightening bolts
- Checking the throw pressure at switch stands
- Shimming
- Removing debris around culverts

The amount of work involved with some of these items is dependent on traffic, while with others it is more dependent on the size of the territory. To ensure a fair distribution of the work among the different groups of maintainers, some system of measuring the traffic, also taking into account the size of the territory, should be implemented.

Canadian National Railways has a mathematical model to help calculate maintenance units for any chosen piece of track. This model is basically dependent on lengths of track but does allow for adjustments based on curvature, traffic density, axle loading, and speed. Therefore, when the total company labor work force has been established by policy, economics, or otherwise, the relative distribution may be done on a fair, impartial basis.

As a typical example, this model might calculate that a crew of 1 foreman, 1 assistant, and 2 track maintainers is sufficient to maintain 18 miles of main track where the level of traffic is 20 million gross tons (MGT) per year, with 15 percent in cars with axle loading of 33 tons and speed of 40 mph and 5 percent of the territory curved to an average of 2 degrees. However, 1 foreman, 1 assistant, and 3 track maintainers would be required for the same kind of territory where the traffic level is 35 MGT per year with 20 percent on heavy axles.

## IMPLEMENTING DIRECTIVES FROM REGULATORY BODIES

Regulatory bodies refers to the Railway Transport Committee of the Canadian Transportation Commission, the Federal Railroad Administration, state legislatures, and agencies that are charged with protecting the public, railway employees, and shippers. One way that they influence the size of the permanent work force in Canada is by having established a frequency of inspection for different classifications of track. This, to some degree, establishes the maximum size of territory that a crew can handle. They also have established a maximum number of hours per day that may be worked and, therefore to some extent, the overall productivity of the large rehabilitation gangs. All of this must be taken into account when planning maintenance-of-way activities.

For example, part of the directive indicates that on busy main tracks, inspection must be carried out so that no more than 2 days fall between inspections. Thus, track inspected on Tuesday must be inspected again, at the latest, on Friday.

## ESTABLISHING STANDARDS

To estimate costs accurately and to ensure safety of operation at chosen speeds, it is necessary to assume a level of quality of a fixed plant; this chosen level of quality should be published as a set of standards. For a plant exposed to a dynamic operating environment, such as a railway, there will be wear. Therefore, it is necessary to have both construction standards and maintenance standards. Construction standards indicate the variation from ideal that is allowable at the completion of a new job. Maintenance standards indicate the amount of wear and the amount of deviation that is acceptable before speeds have to be reduced or rehabilitation has to be undertaken.

If standards are set by the railways, consideration has to be given to the ability to finance improvements as well as to the pure engineering aspects. Therefore, standards set at a chosen level should be estimated for cost purposes, and the ability to finance them should be checked with financial officers and corporate executives. This is of utmost importance because the planning of maintenance-of-way work, as far as the exact timing is concerned, is closely related to the funds available.

At Canadian National Railways, there is an Engineer of Standards who is responsible for checking with other railways, regulatory bodies, research agencies, technical societies, and engineering line officers in order to establish practical standards and modify them in light of changing loads, material developments, and operating conditions. There is also a System Maintenance Engineer who has the responsibility for field inspection to find out if the standards are being followed and for determination of what should be done to ensure that they are. Both engineers meet with senior line officers three or four times a year to decide on new standards and refinements to existing ones. A Chief Engineer negotiates with financial control officers on the level of standards that can be financed without jeopardizing the financial health of the company.

## MEASURING RATE OF PLANT DETERIORATION

Timing maintenance can be done on an analytical basis only if the rate of deterioration of various components is known. If the rate of deterioration is established, the point in time when the components reach their minimum assigned value may be calculated. Some examples of what Canadian National Railways uses to measure deterioration are as follows:

- A physical count of defective wood ties every third year
- Head loss of height and gauge face wear on rail on curves every year
- Quality of ride as measured by a track geometry car that measures surface, alignment, gauge, and cross-level irregularities twice a year

## EDUCATING STAFF

If a company establishes construction standards and maintenance wear limits and has a system of measuring wear and relating it to traffic and thus time, it is necessary to make the company employees aware of them. It is also necessary to teach field workers the best methods of inspecting track and the most effective maintenance techniques to obtain the maximum use out of the track components at the least cost.

For a large railway, it appears that this requires both a formal training program at a center away from the work site as well as on-the-job training. It is also necessary to update the professional technical staff periodically. A company should encourage their people to attend technical seminars and participate in organizations such as the American Railway Engineering Association and local professional engineering organizations.

Canadian National Railways now has a formal training program, which all new track maintainers must take and pass within a 2-year period after being hired. It consists of at least three weeks of classroom instruction from an experienced group of track supervisors. More classroom-type instruction is required if a person expects to be promoted to a higher position, such as Track Maintenance Foreman.

In addition, the training program has several audiovisual information packages aimed at both the field workers and the professional staff; these are meant to provide the latest information on specific techniques such as operating a track motor car safely, maintaining continuous welded rail, and distressing continuous welded rail. They are not meant to be shown only once and then forgotten, but to be repeated at least once a year and more often if there are many new staff or if problems are arising in specific areas.

## COMMUNICATING EFFECTIVELY

For planning to be efficient it must be understood and accepted by the various levels of management, from headquarters to the line supervision. Communication should start before the plans are put together, with discussions out on the track among the various levels. Headquarters staff responsible for final approval of plans should travel over selected portions of track in accompaniment of local engineering supervisors on inspection vehicles, as well as walk a certain percentage. Then there should be continuous discussion among the various levels as plans are prepared and changed.

Unfortunately, in large organizations there is a tendency to require much communication from the field level up to headquarters, but little from headquarters to the field level. This has an irritating effect on the various levels of supervision that participate in the preparation of plans. A determined and specific effort on behalf of senior management is required to overcome this inertia. Finalized plans are then more readily accepted and are generally implemented smoothly and more efficiently.

## MECHANIZING GANGS

Any plans made regarding maintenance-of-way revolve around the amount of machinery available. This not only determines the length of time required to do a job, but also determines the size of work gangs and the split between work to be done by permanent staff and extra or production-style gangs. For example, providing a substantial amount of tie-handling equipment to the permanent maintenance staff could eliminate the large mechanized tie gangs. This, in turn, would reduce the big work blocks that such mechanized gangs require.

## USING FORECASTING MATERIAL

Planning for maintenance-of-way involves the use of materials such as rail, ties, turnouts, tie plates, and anchors. These materials are unique to railways and generally unavailable from nonspecialized vendors. It is usually necessary to have them produced by special order through direct negotiation between a railway and a producer. Therefore, it is necessary to be accurate in predicting what is required and to make predictions 1 or even 2 years in advance.

Canadian National Railways has established a logistics center that has the responsibility of contacting the using functions and obtaining estimates of future material requirements. It then works closely with the Purchasing Department and the engineering supply yards in obtaining the material, coordinating the delivery to the work sites, and making improvements to the overall materials handling systems.

## FORECASTING FUTURE TRAFFIC LEVELS

Planning requires predicting when a component will reach the end of its useful life. When deterioration is dependent on train traffic, the prediction of future traffic levels is called for.

At Canadian National Railways, the Marketing Department has the responsibility of predicting traffic levels and advising the operating departments, such as transportation, equipment, and engineering. Their predictions, which are generally expressed in revenue tons, have to be converted to gross tons before they are used to calculate rail life and the life of other track components. This type of forecasting is essential to planning rail relays, and is very useful for ordinary maintenance, such as transposing rail on curves.

## CREATING A PLANT INVENTORY

To make an overall maintenance plan, it is necessary to know how much of what has to be maintained. This necessitates preparing records of how much track is operated and the location and size of curves, turnouts, culverts, rails, ties, ballast, and many other items.

This information is not a secret to railways. Many of them have kept meticulous records on paper for 100 years or more. What is happening now, however, is that they cannot afford the staff to keep these records or to analyze them in the detail that modern financial constraints impose. Many large companies have found it essential to place their plant inventory on mainframe-type computers, with the proviso that on-line staff have the capability to update as changes occur.

## ESTABLISHING A PLANNING PERIOD

To be cost-effective and to convince financial executives that maintenance-of-way knows where it is going, it is necessary to use planning periods of longer than 1 year. This has logic to it because the nature of track rehabilitation requires dovetailing ballast, tie, and rail renewals. For example, new rail could be seriously damaged if trains operate on it when the ties are in poor shape or if the roadbed is too soft. Also, it is generally impractical to take a busy track out of service long enough to conduct three large rehabilitation programs.

It is recommended that the longest planning period possible be used so that senior officers have the best overall view of upcoming major expenditures. However, there is no sense in choosing a period so far in the future that the marketing forecasts become untrustworthy. Practical experience indicates a 5-year planning period to be both useful and reliable.

## ESTABLISHING A LOGICAL SEQUENCE FOR REPLACEMENT OF COMPONENTS

After a planning period has been chosen, a practical manner in which the various work activities should follow each other can be determined. For example, if traffic predictions indicate that the rail will need to be relaid in 4 years, it would be wise to check the condition of ties, ballast, and embankments, and possibly plan improvements to them as well. If embankment widening is required, it should be done before ballast is added because dumping it later would foul the new ballast. To allow time for the embankment to consolidate, it should probably be constructed 2 years before rail relay and 1 year before ballast restoration.

## COORDINATING FIELD ACTIVITIES WITH TRAIN SCHEDULES

A useful principle of maintenance-of-way planning is coordinating engineering and transportation activities; this can be done when there is a long-term plan plus a detailed construction season plan. If joint meetings are held early enough, detour routes for trains can be planned and work blocks can be chosen so that a minimum number of conflicts arise. Marketing personnel should attend these meetings.

## USE OF DEGRADATION MODELS

Predicting when rehabilitation is to be done may be made more reliable if the rate at which traffic and the environment wears out components is known. This would be fairly easy to calculate if all traffic, wheels, rails, alignments, climate, and so forth were the same. Unfortunately, they are not and there is almost no such thing as a straight-line relationship between wear, tonnage, and time. It varies with axle load, shape of wheel profiles, metallurgy of rail, kind of tie, degree of curvature, and many other factors.

However, with good plant inventory records, traffic records, and much experimental research, it is possible to construct mathematical models that incorporate many of these variables. It is usually necessary to use a computer to do the manipulation because it would be tedious and time-consuming to do otherwise.

Presently, Canadian National Railways has a model for rail and tie degradation and is considering one for ballast.

## REPORTING PROGRESS

While work is progressing, the actual rate should be monitored. This is necessary to take immediate corrective action and to enable more accurate future planning.

Canadian National Railways' Logistics Center contacts each large rehabilitation gang daily and obtains quantities produced on the previous day. This information is then stored on a small computer, average rates are determined, and completion dates are estimated. Senior officers receive a daily report and are thus immediately aware of any serious deviation from accepted rates and can take appropriate action.

## SUMMARY

A brief introduction to some of the principles involved in planning maintenance-of-way activities has been given. There are more such principles, and undoubtedly what is important on one railway is less important on another. However, these principles hopefully will be of some assistance to those charged with the responsibility of planning maintenance-of-way activities.