

CO-ORDINATED AUSTRALIAN RAILWAY
TECHNICAL DEVELOPMENT AND ITS BENEFITS

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ABSTRACT:

Railways of Australia co-ordinates a technical development program which, although it mainly involves civil and mechanical engineering disciplines, is becoming increasingly involved in new techniques such as those included in the North American Advanced Train Control Systems.

The paper provides an overview of the research and development projects currently being conducted or recently completed. Benefits achieved to date and anticipated are identified and compared with project costs. Benefit/cost ratios are an important part of the project selection process.

ROA's research program encompasses, additionally, a strong emphasis on assisting in, and then monitoring, implementation of technical developments. The project management structure which has been developed to provide this emphasis is described.

INTRODUCTION

The Railways of Australia organisation co-ordinates matters of common interest to Australian government railways. An important part of this activity involves technology development.

Until recently exchange of technical development information within Australia's five rail systems had been handled in an ad-hoc fashion. One response to the increasing rate of technical evolution in railways was a decision in 1978 to undertake a vehicle/track research program (Nibloe et al. (1987)), overseen by the ROA Vehicle/Track Studies Co-ordinating Committee.

This group of senior engineers from all rail Systems has been strengthened, and renamed the Technology Development and Application Committee (TDAC), a name reflecting its significantly broader role and set of responsibilities.

Its defined objectives are:-

- (i) To minimise the operating costs of Railways Systems of Australia by arranging:
 - (a) relevant technical research, development and investigations related to vehicles and track.
 - (b) development of techniques for the application of technical development outcomes (whether derived in Australia or overseas) into the Australian railway environment.
 - (c) monitoring of such application.
- (ii) To have responsibility for other technical research and development activities funded by ROA which are referred to it by senior railway management.

This paper firstly provides an overview of the range of TDAC activities, following which a description of technical project activities together with the project management structure adopted, is given.

The final part of the paper reviews the benefits obtained to date, and comments on the key elements of what has been a successful technical development program despite its relatively small scale.

It should be recognised that work conducted under the auspices of TDAC covers only a part of the total technical research and development of the various railway authorities. Each rail System also undertakes significant investigations pertinent to their individual requirements. Recognising this, TDAC also plays an important role in facilitating the interchange of research findings from one System to another, with the aim being to maximise the benefits obtained while preventing unnecessary duplication of research.

2. SUMMARY OF TDAC ACTIVITIES

While the management of technical development projects has continued as the main TDAC activity, its role in recent years has broadened with greater involvement in standardisation activities and special projects.

The current activities of TDAC are briefly described in the following subsections.

Technical Development and Application Projects

This is the major activity of the Committee and more details are given in Section 3. A wide range of technical developments are being pursued. The concentration is on improving vehicle and track performance although there is now more emphasis on obtaining fuel savings. In future it is anticipated that a segment of the project activity will be directed specifically to assisting in the achievement of specific business goals. Projects must be subjected to a cost-benefit analysis prior to approval, and a minimum ratio of benefits to research costs of 8:1 has been established for review purposes.

Standardisation Activities

This is a newer role for the Committee, although a number of smaller matters, e.g., thermit welding, have been under continuing technical examination.

Currently, major activities are being undertaken by the Working Parties examining:-

- (a) National Vehicle Acceptance Standards
- (b) Advanced Train Control Systems (ATCS)

A number of potential standardisation activities including:-

- (a) Electronic Data Interchange (EDI)
- (b) Bridge Design
- (c) Vehicle Components

are currently being investigated.

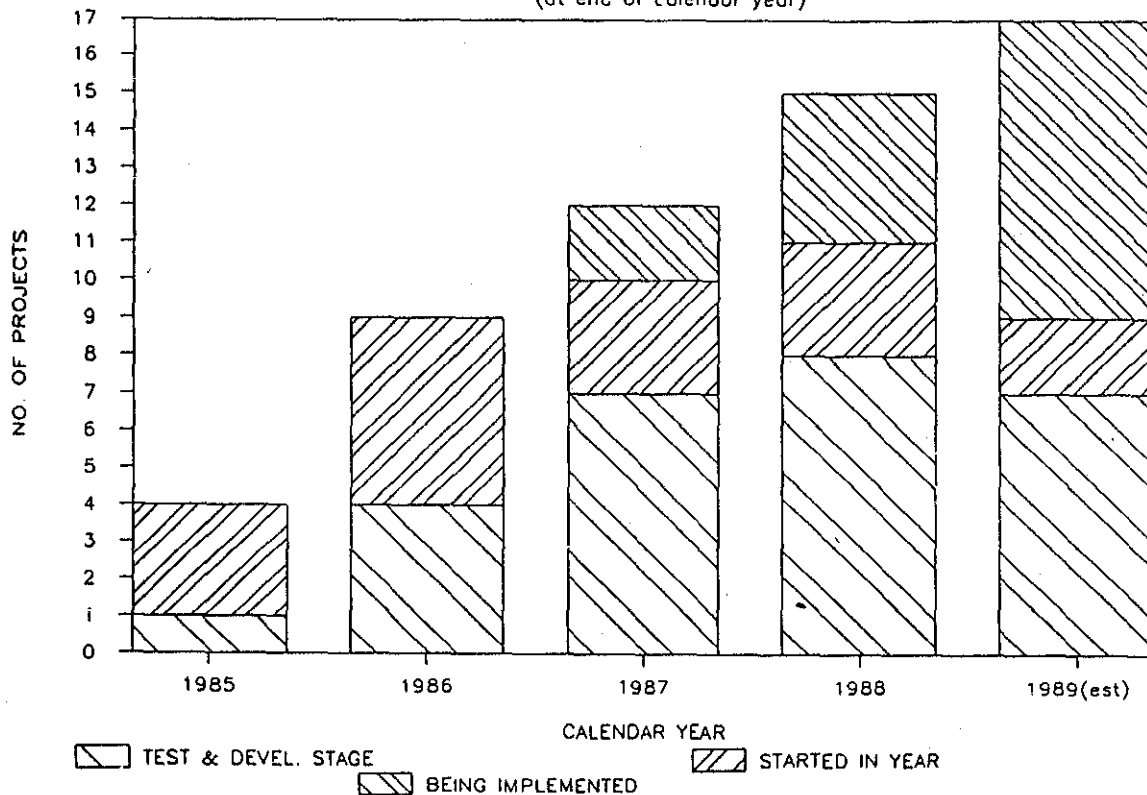
The work on ATCS is of particular interest. The ATCS project is a major technical development of the North American railroads which is intended to provide the precise and continuous control of all resources involved in train movement. Extensive use is being made of electronic/computer technology. Because of the ability of these Systems to directly feed information in other computer databases, train operation and management systems may potentially be radically improved.

Special Projects

From time to time, as requested by the Chief Executives of Railways, special projects are managed through the Committee. These activities are not continuous in nature although at times they may have significant scope.

FIG. 1- TDAC PROJECT NUMBERS AND STATUS

(at end of calendar year)



International Liaison

The objective of this activity is to maintain an awareness and, if appropriate, arrange for the transfer of overseas technology. International Union of Railways (U.I.C.) and Association of American Railroads (AAR) contact is maintained. Membership of the International Heavy Haul Railways Association provides another focal point. A technical exchange agreement is operative with Amtrak.

Co-ordination of Technical Trials Conducted by Individual Railway

The objective is to facilitate the introduction of new techniques through providing an awareness of trials being undertaken.

This is normally achieved through the transfer of brief reports on such matters as steel sleepers, bogie trials (e.g., UTDC frame bracing, etc.).

In some limited cases, the co-ordination may be managed on a project basis, e.g., current testing of microalloy wheels.

A regular report is issued on technical developments (civil and mechanical).

Technical Support Activities

These activities are limited but include the management of ROA instrumentation equipment; maintenance of some computer programs and reports; preparing technical publications, e.g., Track Design Review (Martinovich et al. (1987)) (O'Rourke et al. (1988)), and membership of the Australian Welding Research Association.

TECHNOLOGY DEVELOPMENT PROJECTS AND IMPLEMENTATION

Fig. 1 illustrates the growth in technical development projects since 1985. Because of the limited technical resources available within railways to examine and implement new developments, of which the TDAC work is only one part, no further growth is now planned.

While the number of active technical projects has increased in recent years the number of projects in the test and development stage has been relatively stable. The recent increase in active projects has been solely due to the emphasis on implementation in overall research project management. Projects are not considered complete at the end of the development stage. Implementation is managed and monitored on a project basis.

The original focus of technical projects was directed towards obtaining basic empirical data or the development of a theoretical model, e.g., the Simcar vehicle model described by Shelley (1987). More recently, however, increasing emphasis has been given to application oriented development, which can provide benefits in the shorter term, using the latest technical advances in order to improve railway productivity. An example of this is the work on wheel/rail profiles (2) (4).

A listing of current active projects is given in Appendix I.

RESEARCH MANAGEMENT

The ROA development program operated through TDAC differs in management structure and resource location from the conventional form adopted by many research oriented organisations in Australia.

Most importantly the technical development resources are highly decentralised with use being made of the skills contained within individual railways and consultants - in particular BHP Melbourne Research Laboratories - and, where appropriate, tertiary institutions.

The disadvantage of this approach is that the technology skills to be utilised in particular projects are not always readily available at the skill level required in the short term, while the retention of skills in the longer term will be difficult. The advantages however are considerable as:-

- (i) there is greater flexibility available in choosing the appropriate resource, since it is not necessary to utilise manpower and equipment previously dedicated to different developments.
- (ii) the potential for implementation of research results is greatly enhanced as often railway personnel drawn into the research programs (e.g., in trials) will be involved in implementing results.
- (iii) management can concentrate on research project management as less emphasis needs to be given to managing personnel and resource requirements.
- (iv) a wider pool of available resources including manpower skills and equipment can be called upon.

The close involvement of railway system personnel in the research programs is a necessary ingredient for success since not only must the research be technically successful but new practices must also be implemented if 'potential' productivity improvements/costs benefits are to be actually achieved.

To assist in achieving this involvement, each active project is managed by a project team consisting of a nominated officer from each railway System. One officer acts as project manager. The project team and manager are not involved in the project development work. Rather their role is to provide oversight and input to the development resource. The project teams also have an ongoing role at the end of the development phase to monitor implementation.

A small central management provides oversight of particular programs, allocates the limited capital available for technology development, and reviews and assists in implementation of research results.

With centralised research, research reports often become the major means of conveying research results to the potential implementers. Unfortunately, these reports can become bookshelf occupiers in some organisations despite the quality and effectiveness of the research.

In contrast, experience with the decentralised structure is showing that implementation, at least on a trial basis, is often underway before final reports are issued. As such the role of the research report is as a complementary information resource, with the objective of end-of-project documentation being secondary.

In the same way the research program being conducted is complementary to the engineering concerns of each individual railway System.

RECENT BENEFITS OF TDAC DEVELOPMENTS

This section of the paper describes the results and benefits from a number of four projects completed in 1987 and 1988, viz:-

- (i) Wheel/Rail Profile Optimisation
- (ii) Rail Design Module
- (iii) Track Buckling
- (iv) Rail Thermit Welding Stress Device

Results from early work on vehicle/train dynamics and the benefits are given in Nibloe et al (1987).

Wheel Profiles

Traditionally a coned 1:20 wheel profile has been used by all railways in Australia.

The technical output from the project has been a range of modified wheel profile shapes such as those shown in Fig. 2. The actual modification consists of a slight change in geometry in the area between the start of the taper and the flange. Undertaking this modification in general requires little or no expense.

A number of trials were initially conducted to obtain comparative performance data. The first of these trials were conducted with Westrail woodchip traffic which travels over a route with gradients as steep as 1:40 and curve radii down to 160m. Forty-five percent of the track length is curved and of these curves over two-thirds have a radius of 300m or less.

The results obtained are shown in Table 1. Significant flange wear reductions, on average of over 50 percent, were obtained from the modified wheel profile, compared with the standard profile installed at a back-to-back dimension of 997mm.

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TABLE 1
Wear Reduction Achieved by Westrail

	Wear Expressed as a Percentage of the Standard Profile Wear Rate			
	Left Hand Side		Right Hand Side	
	Flange	Tread	Flange	Tread
Modified - 997 Back to Back	62%	94%	72%	90%
Modified - 990 Back to Back	64%	100%	33%	90%

Another major trial on Queensland coal traffic proved particularly effective. Results in this application are given in Fig. 3. After 80,000 km of travel wear rates were reduced by about 2/3 on leading wheelsets and were almost negligible on trailing wheelsets. The graph also illustrates that the greatest benefits from improved wheel profiles are obtained during the initial wearing in period where wear rates on the standard wheels are greatest.

Modified profiles are now being widely implemented throughout Australia. The costs of wheel purchases and wheel machining are about \$50 million p.a. and it is expected that benefits of \$15 million p.a. will be obtained in the longer-run as the fleet is changed over to the new profiles. This may be compared with a development cost of less than \$100,000.

As wheel and rail wear are proportionally related rail replacement costs will also reduce as will energy costs (energy is absorbed in wear) by approximately \$4 million p.a.

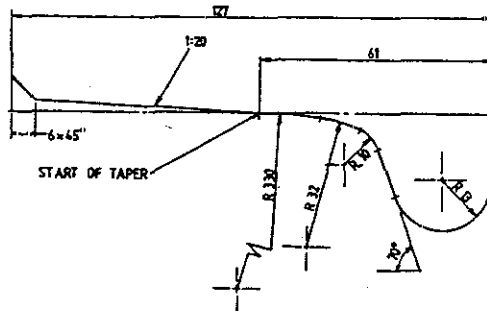


Fig. 2 : Modified Wheel Profile - Queensland, Victoria.

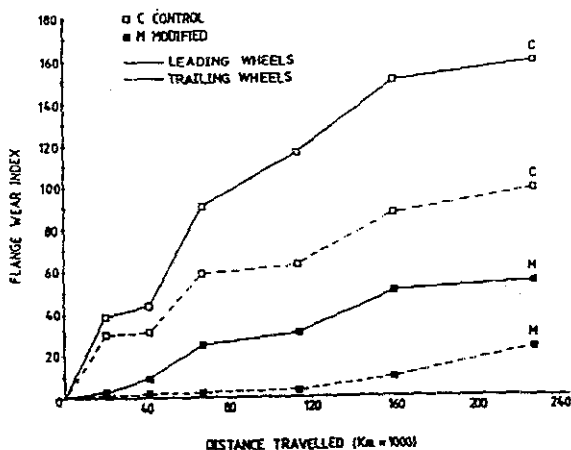


Fig. 3 : Results of Queensland Tests

Rail Design Module

This project was directed at the development of a computer program which incorporated the most up-to-date rail design procedures with an economic analysis. The aim was to assist railway engineers to more effectively determine rail replacement and operating requirements. More details on the module are given in Solieman et al (1988).

A listing of applications of the rail design module by Australian railway systems is given in Table 2. Some, such as the assessment of the effects of various vehicle types, are straightforward technical analyses. In other analyses, however, the use of the rail design module in examining rail performance forms only one part of the overall study, e.g., the investigation of increased axle loads on the Moura coal line in Queensland.

Because of its use as a design tool and the difficulty in allocating benefits in multi-faceted projects an exact estimate of project benefits is difficult. It should be noted, however, that ten per cent of the benefits in two cases given in Table 2 would amount to \$0.5 million p.a. The development cost was less than \$100,000.

As further evidence of benefits rail purchases by railway Systems fell to a seventy year low in 1988/89.

Track Buckling

Work on this project was completed in 1988 and the management procedures developed to prevent track buckling are now being implemented in a limited number of locations on a trial basis. Further details of the project are given by Hagaman and Kathage (1988).

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TABLE 2
Implementation of the Rail Design Module

System	Application
V/Line	- Melbourne - Albury: Standard Gauge Upgrading.
V/Line	- Rail Wear Criteria for 47kg/m rail.
V/Line	- Stresses and wear life of existing rail under possible changes in axle load and speed.
V/Line	- Justification of deferment of rail replacement in curves.
WA	- Effects on rail of new DA class locomotive.
WA	- Effect on rail of new AN '5 Pack' container wagons.
WA	- Effects of proposed NG-Class locomotive on rail.
WA	- Effects of 19 tonne axle load on 60lb WA rail.
SRA	- Hunter Valley rail operation options, e.g., increasing speeds for 100t vehicles from 60 to 80km/h and increasing axle loads from 25t to 27t between Ulan and Newcastle.
QR	- Investigations of wagon fleet options for the Mt Isa line.
QR	- Investigations of increased axle loads on Greenvale nickel railway and on the Newlands and Moura lines.
QR	- Tangent track rail wear limits.
AN	- Optimum rail section for 23t 110km/h operations.
AN	- Investigations for relaxed axle load/speed for particular vehicles, e.g., type AFIY wagon speed constraints at 20 and 23t; 800 or 930 Class locomotive operation on 60/63lb rail; 25t axle load wagons on 80lb rail in Tasmania.
AN	- A variety of other investigations, e.g., cant and cant deficiency in Adelaide Hills; track structure upgrading options for Leigh Creek.

Initial trials of the Buckling Prevention System (BPS) led to a reduction in the incidence of buckling with one single trial location in the Brisbane area giving benefits greater than the project cost.

The main area of concern is the time/organisation required in utilising the BPS. This concern should be addressed more fully during the next two years, when wider field experience is available. The project management team continues to actively monitor progress and address these issues.

Rail Thermit Weld Stress Device

During 1988 a prototype device to assess the stress-free temperature of rail by measurement before and after thermit welding was produced and delivered. A field trial in V/Line followed by more detailed examinations is now planned for 1989.

No benefits have been achieved to date.

SUMMARY

The past four years has seen an increase in the scope of engineering research and development being conducted by Australian railways.

The aim of the research is to improve the productivity of particular facets of railway operations and results from work which has been completed, e.g., on wheel profiles, rail design, etc. indicates that real benefits are being obtained as is evident by the high benefits/cost ratio being achieved with these completed projects.

To ensure benefits are obtained emphasis is being placed in the management of research on implementation. The involvement of railway personnel in a decentralised and flexible research framework assists in this as the research program in a very real way complements the engineering initiatives of the individual railways.

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CURRENT RAILWAYS OF AUSTRALIA TECHNICAL PROJECTS

NO.	TITLE	OBJECTIVE (TECHNICAL)	CURRENT STATUS	RECENT RESULTS
2	WESTRAIL TEST TRACK (WA)	To determine the lifetime costs of different standards of track structure.	Due for completion 1990/91. Force and track geometry data have been analysed. The assessment of concrete sleeper fastening performance is near complete.	Dynamic track loadings have been established for several traffic classes.
6	SIMCAR MODEL ENHANCEMENT & BOGIE COMPARISON (AN)	To incorporate different bogies curving and track geometry in Simcar. Compare alternative bogies using Simcar.	Tangent curving and modelling complete. Bogie appraisal commenced	Assessment of five-pack performance by AN. Three-piece bogie performance with side-bearers dependent on set up height and stiffness.
8	WHEEL/RAIL PROFILE OPTIMISATION	To develop wheel and rail profiles to reduce wheel wear.	Development complete. Implementation underway throughout Australia.	Significant wheel wear reductions of between 20 and 80% obtained.
9	WHEEL DETERIORATION & FAILURE (Systems/ROA)	To evaluate the performance of improved wheel metallurgies in service with view to reducing wheel wear and associated maintenance.	Microalloy wheels obtained and are being installed in various applications. Some trials are now underway.	
11	TRACK BUCKLING (QR)	To reduce the incidence of track buckling and associated derailments	Technical development complete Now being implemented.	Reduced buckling incidence evident in QR field trials.
12	FREIGHT BOGIE MAINTENANCE STANDARDS (V/Line/Systems)	By monitoring bogie performance establish appropriate maintenance standards.	Review of workshop practices and tolerance range complete. Assessment of tolerance effects complete.	Need for improved standards for higher speeds. Wheel diameter difference significant.
13	WHEEL STRESS MEASUREMENT DEVICE (UOT)	To develop a device which can differentiate wheels suffering a residual stress change due to high thermal loadings.	Prototype device and field trials complete. Comparative assessment of strain gauge measurements and device output underway.	SRA, V/Line, HI & MNM trials indicate new and service wheels clearly differentiated.
14	UNIT TRAIN AERODYNAMICS (RMIT)	To assess the technical effectiveness of various vehicle design modification and add-on devices in reducing aerodynamic drag and hence energy consumption.	Funded by NERDDC. Wind tunnel tests complete. Project team is examining implementation of several design features.	Partial covering of hoppers may provide a cost effective means of reducing drag and increasing carrying capacity.
15	RAIL GRINDING (MRL)	To develop a procedure which will enable the effectiveness of rail profile grinding practices and the appropriate grinding cycle to be assessed.	Profiles fully implemented in Queensland and designs finalised for Westrail, Inter-system use. Westrail are trialling.	Minimal wear in 300m and 500m trial curves after 9 months (30MGT). Some surface spalling (limited) to be investigated.
16	RAIL LUBRICATION (SRA/MRL)	To trial and determine the effectiveness of various lubrication techniques and greases in reducing energy consumption.	Hi-rail lubricator tests completed in SRA, WA & QR. New lithium base greases being introduced. New lubricators fitted to SRA locomotives are under trial. Computer program to assess energy savings on specific routes distributed	SRA trials indicate 10% fuel savings on specific track sections. Westrail results indicate 3 to 10% savings.
17	RAIL STRESS DEVICE (UOT)	To develop a prototype device to be used in checking rail stress free temperature after thermit welding	Device completed. V/Line is now to arrange testing.	
2/88	ALLOWABLE WHEEL GEOMETRICAL DEFECTS (SG/AN)	To examine geometrical wheel defects and their dynamic effects and consequences with a view to establishing limits.	Commenced October 1988. Field tests completed in AN. Theoretical work underway.	
3/88	SLACKLESS COUPLERS - LONGITUDINAL FORCE MODEL	To establish current coupler and draft gear characteristics and what may be desirable characteristics using modelling.	Requires final approval.	
5/88	TIMBER SLEEPER DEVELOPMENT (QR)	To establish more effective specification, management, and inspection methods with timber sleepers.	QR commenced project in 1989. Due for completion 1991.	
6/88	WHEEL MANAGEMENT (MRL)	To develop a program to assess management and selection procedures for wheel purchase and timing of wheel machining, and to provide preferred flange and rim thickness limits.	Commenced 1989. Data collection underway in rail Systems.	