# International Heavy Haul Association

1994 Mini-Conference

"Rolling Asset Management"

*Maintaining the Flow -- Productivity on a Roll*

Omaha, Nebraska, U.S.A.

June 5 – 10, 1994

## Disclaimer

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## Preface

This workshop was co-sponsored by the International Heavy Haul Association (IHHA), the Association of American Railroads (AAR), the Railway Progress Institute (RPI), and the American Society of Mechanical Engineers (ASME). As the United States member of the International Heavy Haul Association, the Association of American Railroads acted as host organization.

A major goal of the International Heavy Haul Association is to promote an international exchange of knowledge leading to the greater safety, efficiency, and service capability of the world's heavy haul railways. This is done through the holding of major conferences covering a wide range of subjects every third or fourth year, as well as smaller workshops or mini-conferences focusing on specific topics during each of the intervening years.

A great many people contributed to the success of this workshop including members of the above-named organizations, the Burlington Northern Railroad, the Union Pacific Railroad and MK Rail Corporation. While too many to name, the sponsors and organizers wish to thank all of these people for their tireless and effective contributions.

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| John G. German | Roy A. Allen |
| Executive Director | Vice-President |
| International Heavy Haul Association | Research and Test Department |
| | Association of American Railroads |

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# Welcome Address

by Dr. Zhou Hongye

Chairman: International Heavy Haul Association

June 6, 1994 at Omaha, Nebraska

The Mini-conference on Rolling Asset Management is another important specialist technical session for railroad professionals that has been endorsed by the International Heavy Haul Association. The host country sponsors are the Association of American Railroads (AAR), the American Society of Mechanical Engineers- Rail Transport Division (ASME), and the Railway Progress Institute, (RPI).

Please allow me to congratulate, on behalf of the Board of Directors, the successful opening of the conference and to express our warmest welcome to all the delegates, railroad specialists and scholars from various countries all over the world.

Heavy haul has proven itself to be a very effective means of freight transport. In the process of attaining continuing perfection, the heavy haul technology has become more mature than ever before and has demonstrated that it is very successful and most cost effective as compared with other transport modes. It has contributed a lot to the advancement of the railway industry and has played an equally important role like the high speed railway passenger operations.

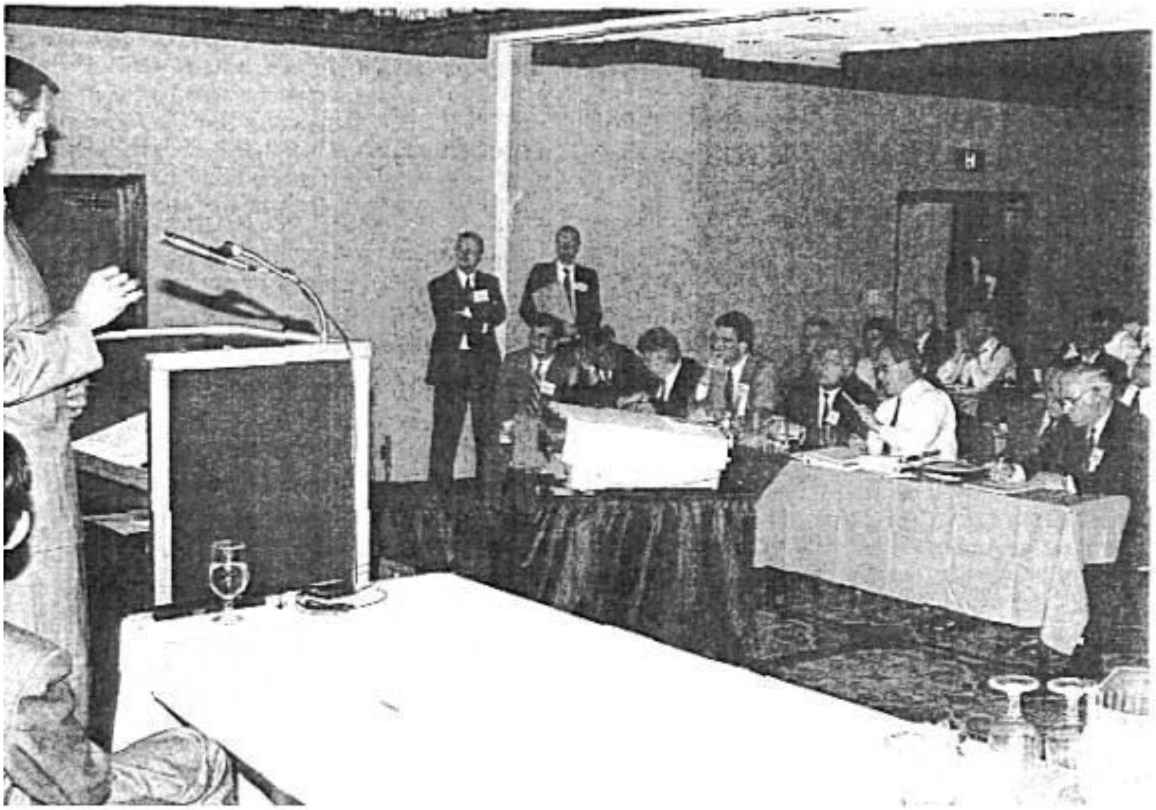
All the papers presented or included in the proceedings of the previous conferences and specialist technical session including this mini-conference actually have aroused extensive interests of railway colleagues. If one reads in depth all the papers, he may find that he can gain tremendous value out of them because they are just to his needs.

The mini-conference being held here today looks at heavy haul from yet another angle, that is, from the point of view of management of the rolling asset. It is a very important aspect, addressing such key issues like how best a railroad achieves its goals in the most efficient ways.

I believe and I am sure this miniconference will offer an excellent opportunity for discussions and exchange of ideas for the benefit of all the participants. Once again I wish every success of the mini-conference.

I would like to thank the host country for the good organization and also a specialthanks for the good cooperation of the Burlington Northern and Union Pacific Railroads. Thank you.

# Keynote Address



Mr. Art Shoener, Executive Vice President - Operations, Union Pacific- Railroad,

delivers keynote addresss to delegates, June 6, 1994

Art Shoener

International Heavy Haul Association

1994 Mini-Conference

June 6, 1994

Omaha, NE.

Good morning. I've never been introduced by a video before. I guess that's one of the signs that we're living in an age of expanding technology.

Anyway, welcome to Omaha and, to many of you, welcome to the United States. I'd like to thank you for inviting me to be your key note speaker this morning. It's certainly my pleasure to address an association that plays such an important role in advancing the technology of rail transportation throughout the world. The safe and efficient transportation of raw materials and finished goods is a critical link in the world's economic chain. And, what you are doing here this week – sharing information on heavy haul technology - exemplifies the type of interaction which will elevate the rail industry's role in our global marketplace. (pause)

I hope you enjoyed the brief, 'Two-Minute-Video' tour of Union Pacific. As you can see, we're a company that has a great deal of diversity in the communities we serve, in the freight we move and in the people that make up our railroad. I understand that you'll be viewing an expanded version of this video later this morning. I'm hopeful that between the videos and my comments, you'll become a little better acquainted with my company, Union Pacific railroad.

In reviewing the conference progrwn, it looks like you have a packed agenda this week. But I hope that during your stay, you'll be able to find time to visit some of Omaha's many attractions. We are a city in the heartland of America and take great pride in our heritage of hospitality, our diversity of people and enterprises, our pioneering spirit and, of course, our place in American railroad history.

An important milestone in the history of Omaha, and certainly, in the history of American railroading, occurred here in 1865. That was the year Union Pacific laid its first rail toward the completion of the first transcontinental railroad in the United States. In fact, just this year we are celebrating the 125th anniversary of the historical connection between the central Pacific and the Union Pacific Railroads; a connection that linked the east to the west by a ribbon of steel.

In 1869, a little more than four years after laying that first rail, Union Pacific railroad stretched for 1,805 miles from Omaha to Promontory Point, Utah. Since that time, Union Pacific has grown into a transportation company that spans 19 states with more than 17,500 miles of track. This makes us the second largest rail network in the United States. As you can see from our system map, we cover the western two-thirds of the united states, with strategic connections to Mexico along the Texas border and to Canada through northern Idaho. We have access to every major west coast and Gulf Coast port and we serve four major gateways to the east at: Chicago, St. Louis, Memphis and New Orleans. Also on this map you can see our principal switching yards and intermodal terminals.

Union Pacific provides service to 10,000 customers, transporting approximately 100,000 commodities for both domestic and international delivery. Our extensive rail franchise has enabled us to develop a very diversified commodity mix. We group these commodities into seven major categories. As this slide illustrates, revenues from our seven basic commodity groups are fairly evenly balanced. Chemicals and energy are the largest contributors by revenue share and intennodal is unquestionably the fastest growing commodity by carload share. No single commodity group, however, contributes more than 21% to the company's total revenue base. This diversity shields U.P. From overdependence on any one revenue sourre. In transporting this commodity mix, we average more than 1000 train starts per day, with 2000 plus trains moving on our system on any given day. Our average length of haul exceeds 725 miles and the average gross weight per train comes in at about 5700 tons.

In 1993, we had a business volume of 4.6 million cars, generating a revenue of 4.9 billion dollars. Compared with our performance in 1985, we've increased our carloadings by 48% and our revenue has grown by nearly 30%. 1 might add that this growth occurred at the same time that we reduced our work force by one third, from 41,000 to 28,000 employees.

The 4.6 million cars loaded last year equated to about 417 billion gross ton miles, making Union Pacific the heaviest haul railroad in the United States. Since 1985 total gross ton miles have increased by more than 50 percent. And for the first quarter of this year, our average gross tonnage is about 9.5% higher than that of the same period last year. This is another view of our system map, this time showing our highest tonnage corridors. As you can see, most of our system is high tonnage, class one track.

Our heaviest haul line is between North Platte and Gibbon, NE., where the majority of our East-west traffic, and coal from the Powder River Basin in eastern Wyoming, is routed.  This is the heaviest line in the world with more than 100 trains a day and gross tonnage exceeding 210 million tons, annually.

With anticipated Volume increases for just about every commodity, especially coal traffic, we're expecting continued high tonnage across this corridor.  Powder River coal is in high demand due to its low sulfur content, making it more environmentally safe than eastern coal.  During the first quarter of this year we averaged about 22 trains a day out of the powder river basin which is a 25% increase over last years train movement -during the swne period.  To put this growth in even better perspective, our daily average just two years ago, was 13.6 trains per day.  So, we've seen remarkable growth in the energy market and expect continued growth through the rest of the year.

Because of increased traffic, not only in Nebraska, but across the entire system, we're stretched for capacity in several areas.  This year we'll spend $120 million for capacity improvements designed to alleviate bottlenecks and improve service.  These include double and triple-tiracking existing mainlines, construction of new and lengthened sidings, installation of additional ctc, yard expansions and new and expanded interinodal facilities.

As these projects are being completed, we're increasing our traffic flow over alternative routes to improve our operating efficiency.  We're finding that the combination of capital projects and the optimization of our existing transportation network is our best strategy for dealing with the capacity constraint we've experienced over the past few years.  By balancing asset utilization and capital improvements, we've been able to meet customer commitments and plan for future capacity expansion, at the same time.

As I'm sure you're all very aware, the logistics involved in coordinating a high level of train activity require state-of-the-art technology.  The Harriman Transportation Center, just a few blocks away, is the world's largest and most sophisticated railroad control system.  From this center we control all train movement, distribute locomotives, and schedule track work.  In addition, we call crews and pay over $100 million a month in employee wages from the center.  We spent about $50 million dollars to construct the center - almost the swne price paid by E.H. Harriman to buy the entire railroad back in 1897.  By the way, the building that you see in this slide... It's the same one that was used as the auction site where Harriman placed his winning bid.

Here is a photograph as it looked back then. The same technology that drives the Harriman Center also links every major business system within our organization. As an example, the Harriman transportation center is directly linked to our national customer service center in St.Louis. Orders coming in from our customers are communicated to the Harriman Dispatch Center by way of our car and train scheduling information systems. At the swne time, our crews are notified, and work orders are sent out to computer terminals onboard our locomotives. Our crews use these work orders to schedule their pick up's and deliveries and report their status back to our customer service center.

The heartbeat of this integrated process is our transportation control system. We've been through the learning curve with this information system and it is now fully deployed throughout our network. Weve also made improvements to the system and have added, and are continuing to add, support systems that significantly extend its functionality; systems, for example, that:

optimize scheduling and distribution of freight cars, as well as build trains and manage transit schedules; systems that:

distribute locomotive for servicing while maximizing their utilization, and systems to plan and monitor track maintenance to maximize track time and minimize service disruptions.

We'll also be introducing some new technology currently in the final stages of development and testing. This will include rail yard management and intermodal load-planning systems.

The impact that information technology has on our ability to maximize asset utilization is enormous and we're taking full advantage of the tools available to us. As far as we've come, though, we know that it's only the tip of the iceberg. The potential for information technology within our industry will offer quantum leaps for future advancement in asset management.

Turning to our rolling stock, we currently have a fleet of 3000 locomotives with an average age of approximately 12 years; by our estimate the youngest fleet in the industry. We'll be augmenting our locomotive stock during the next four years with 240 new A.C. Traction locomotives. These 6000 horse power units will enable us to reliably replace the older 3000 horsepower locomotives on a two-for-one basis. Our move into this area fully supports our locomotive design direction for enhanced performance, fuel economy, maintainability and reliability.

Another project we're currently involved with is the testing of six liquefied natural gas (Ing) locomotives. We expect to begin field tests at the end of this year and continue them into 1996. Two of these units will be switch engines and will operate in the Los Angeles area. The other four will run between Los Angeles and North Platte, Nebraska.

Our freight car fleet consists of approximately 75,000 cars. With the addition of 2000 more cars this year and our all-out push to reduce cycle time, we believe that we're fairly well balanced for our current level of business.

As we replace existing cars, our intent is to increase hauling capacity from 263 thousand pounds to 286 thousand. We're looking at lighter weight materials and more optimal chwnber designs to haul the swne volume with fewer cars. Other design enhancements that we're currently implementing or testing include aluminum hatch covers, self locking gate systems, composite material for load dividers, plug doors and bridge plates and enhanced load cushioning devices and premium trucks for our autoracks. This year we will also rebuild more than 1 100 cars and update another 7200 cars as part of our quality improvement program. Our goal is to improve and upgrade 5% of our fleet this year and a similar number next year.

We service our locomotives and cars at six major repair shops and 75 light order repair and service facilities across our system. Major locomotive shops are located in North Little Rock, Arkansas; North Platte, Nebraska; and Salt Lake City, Utah. Heavy bad-order repairs and quality improvement programs for our car fleet are completed at Pocatello, Idaho; Desoto Missouri; and Palestine, Texas.

I mentioned earlier that we presently have a core of 17,500 miles of mainline track. Since 1987 we have sold, leased or abandoned 5700 miles of lightly used track which has allowed us to more efficiently deploy our resources to inspect, maintain, and improve our core network. We spend about $400 million annually to replace rail and ties, surface and line track, renew bridges, decks and crossings, purchase roadway equipment, and upgrade our signal systems.

As an example, during the last three years, we've replaced almost 1700 track miles of rail, nearly 9500 track miles of ballast and 1.8 million cross ties. And we're using the best materials available. We're expanding our use of head hardened rail and concrete ties and we're testing and purchasing premium turnouts. We're also continuing to tighten the technical specifications for the material we purchase to improve the overall quality of our track infrastructure.

On the equipment side, we're working closely with our suppliers to mechanize labor intensive jobs where ever possible. In addition to increasing our efficiency, mechanization is helping our people do their jobs more safely. We're having far fewer injuries, not only among our engineering forces, but across all crafts.

It's important to us that we maintain the safest and most efficient facilities and equipment that we can. We're convinced that growing our business requires prudent and appropriate investments back into the railroad. And we've done just that. For the past several years our total capital expenditures have exceeded our net income. We're proud of our franchise and we'll continue to deploy whatever resources are necessary to keep it in the best shape possible.

By now, I hope I've given you a little more insight into some of the key physical characteristics of Union Pacific. If you would like additional details, there will be several individuals from U.P. Here this week. I'm sure they would be happy to answer any questions you might have. Right now, though, i'd like to move on to the conference theme, <u>'Rolling Asset</u> <u>Management'.</u>

From my perspective, the underpinning for improving any business process, be it asset management, service delivery or customer satisfaction, can be summed up in one word – <u>integration.</u> Integration in this context means bringing together elements of a business environment that, together, contribute more than the sum of the individual parts. It's one of those marvels in life that defies mathematical principles - at least mine, anyway- where 1 + 1 can add up to three or more.

Examples of the kind of integration I'm referring to include :

- people and machines
- functional specialties and business processes
- new technology and historical strengths
- interconnecting carriers

- railroads, customers and vendors
- and management and employees

We've learned during the past several years that these elements have to be properly aligned and integrated before consistent improvement in asset utilization can take place.  Let me explain how we came to that conclusion.  I'll begin with a brief look back to the days before the Staggers Act of 1980 and then bring you back to where we are today.

Before the Staggers Act and the deregulation that accompanied it, Union Pacific, like most other American railroads, had the luxury of a fairly predictable market base and a fixed pricing structure. Consequently, most of our service delivery processes focused on internal considerations, rather than customer satisfaction, as we know it today.

After deregulation, we had to learn a new languageone called customer service.  One of first things we learned was that we needed to make some changes to compete for the same business we'd always taken for granted:  changes in how we viewed our customers, changes in how we managed our busines processes and changes in how we evaluated our performance.

To coordinate and guide all of the changes we were undergoing, we needed a well laid out chart to navigate our way.  That chart proved to be the quality process we introduced in 1987.  Through it, we were able to make substantive changes that were systematically integrated throughout our entire organization.

Our quality process started with a clear mission statement: "to provide world-class transportation service which consistently meets or exceeds customer requirements at competitive costs."

The three basic components of the quality process include planning and control, business processes and employee involvement.  Through this approach, issues are identified and broken down into their basic elements.  Opportunities and problems with the highest return are tackled first; no problem is considered unsolvable and, everyone, throughout the company, is encouraged to participate.

The planning and control process establishes overall direction for the railroad. Goals are set and specific business objectives are developed. Through a cascading process, these goals and objectives become part of every work unit's action plans and part of every manager's job agreement.

Once objectives have been developed, specific business processes must be implemented to get the work done. Quantitative measures are established to allow progress to be monitored. The resulting improvements produce service consistency and enable us to take any necessary corrective action that's needed.

Employee involvement assures that business objectives are achieved at all levels of the organization through the active participation of those closest to the work. Since we started our quality process, we've had more than 700 quality improvement teams tackle problems of every description in every part of the company.

An essential part of the quality process is knowing where you are, where you want to be, and how you're going to get there. A tool that we use to make that assessment is our business objective matrix. Each of our seven business objectives defines a critical success factor and has it's own quantitative set of measures. These measures are stretch targets, designed to make us reach for excellence. Each year, we fine tune the matrix as customer requirements change and as measurement capabilities become more sophisticated. Goals are reviewed against perfon-nance and operational adjustments are made, as necessary, to enable maximum progress.

An important lesson that we have learned from our quality efforts is that the quality process is never over. I think we've made an excellent start, but in my mind it's only a "job well begun."

However, we are proud of the accomplishments that we've made so far, because they were made through hard work and real team effort. I'll highlight some of them for you.

First, the bottom line - net income. Since we started this process in 1987 our annual net income has increased by 50 percent. Our growth in net income would have been even more substantial, had it not been for the severe floods that hit the central United States last year. We had 1500 miles of main line track out of service costing us in the neighborhood of $34 million.

Our operating ratio has been below 80 for the past two years and has dropped nearly three points since 1987. Once again, had we not been fighting a '500 year' flood last year, we believe that our operating ratio for 1993 would have come in at a record level. Given the circumstances, though,lthink our people did a yeoman's job in keeping it below 80.

Asset utilization plays a major role in keeping the operating costs and consequently, the operating ratio down. Two measures of asset utilization that we follow very closely are locomotive utilization and car cycle time. We began using these indicators in 1989 and since then, have made significant progress in both areas. Our locomotive utilization rate, or the amount of time our locomotive fleet is actually employed pulling trains, has increased by 24%. One of the primary reasons for this improvement is our performance in servicing and maintaining our locomotives. Our current locomotive availability rate of 94 means that 94% of our fleet is available for train service. In the last three years alone, this measure has improved by three points. Car cycle time,, our second key measure of asset utilization, has dropped by more than 2 1/2 days since 1989, an improvement of 16% .

Savings. associated with these improvements is difficult to quantify, but by our approximation, each one percent improvement in locomotive utilization and each one-tenth of a day reduction in cycle time is equivalent to $30 million in avoided capital expenses. Clearly, efforts to maximize the use of these assets can have a considerable R.O.I.

Another indicator that we're very proud of is our employee productivity rate, measured in millions of gross ton miles per employee. As you can see here, we've made wonderful progress each year. Since 1987, we've increased our productivity by more than 45%. If we reach this year's goal, we'll be moving over 15.5 million gross ton miles per employee by year end.

There are several factors behind this remarkable improvement, but two that stand out are enhanced technology and employee communications. I talked about technology earlier. So let me just say that of all the efforts we've put into our quality process, none have been more fruitful than our communication effort. One of the key tools we use for communication is our business television network. We have 75 downlink sites now, and about 250 monitors that our employees can view. In addition to using this system for technical training, Dick Davidson, our Chairman, holds quarterly sessions to update our employees on business performance and company-wide issues.

Another measure I'd like to share with you was developed in the very early stages of our quality implementation schedule. Our <u>cost of quality</u> index measures the costs associated with operational failures along with our costs for failure prevention. When we introduced this measure in 1987, we learned that our total cost of quality exceeded 30% of sales. Because we had not fully identified all of these costs prior to the use of the index, we were surprised by the high costs of our mistakes.

At the end of last year, cost of quality was down to approximately 19% sales, so we've made a substantial reduction. But this is still entirely too high. We'll continue to whittle these costs down as we find better and more efficient ways to do our work. As I mentioned earlier, quality is a never ending process.

The final measure I'll review combines several different processes to give us a bottom line indicator of our service quality... <u>Customer commitment</u> is a measure of service reliability that tracks our performance against customer commitments and service performance requirements. It's the only measure in the industry that we're aware of that couples internal car and train scheduling information with individual customer service contracts. Our aggregate performance in meeting customer commitments has increased from just over 75% in 1989 to over 90% by the end of last year. So far this year, we've improved our performance to 93% and hope to make 95% by the end of the year.

Many different variables came into play in making these improvements. The one element that I believe has had the most impact on our progress to date, is the integration of people, processes and technology that was literally forced upon us by our quality process. Let me give you a couple of examples. When we started focusing on customer service, we also started to think like customers. This forced us to really analyze our business processes, which required a great deal of cross - functional cooperation. In turn, this led to innovations such as the Harriman transportation center and our customer service center.

What we found out was that customer focus not only served the customer, but also brought to light operational opportunities that had been buried under years of internal focus.  This was an example of integrating customer requirements, functional specialties and operational processes.

A more recent example of integrated thinking was the restructuring of our operating department to align more closely with our marketing and sales organization.  This restructuring subsequently led to the establishment of eight business teams, one for each commodity group and an eighth team focusing on our Mexico business.  Using a matrix management concept, each team is jointly managed by representatives from marketing, operations and finance.  This organization is a significant departure from the traditional business structure, in which marketing sold services and operations ran trains.  In this new environment, each team is responsible as a group for the satisfaction of customers, **the** efficiency of its operations and, ultimately, the profitability of its efforts. And since the teams were established, not only have we seen improved service to our customers, we've also improved equipment utilization and initiated new ways to optimize our transportation system.

As a final example, we have broadened the notion of customer focus to encompass our internal support departments such as information technology and human resources.  Departments such as these are evaluating their processes to better servo the end users of their services.  This is bringing both people and processes together to develop products designed to make real improvement in service reliability, asset utilization, employee satisfaction and, ultimately, heightened customer satisfaction.

Closing

Now, I don't want to leave you with the impression that we, at Union Pacific railroad, have all the answers.  If we've learned one thing from our quality efforts, ifs that we have a lot further to go than we've already come.  However, from our experience so far, it's clear that the key to maximizing asset utilization is the mutual planning, execution and improvement that comes with an integrated business system.  And, again, from our experience, that integration can only come about when there is a common alignment of every department and process within an organization.

I hope that by sharing our experience, I was able to provide you with some information that will serve you both in your work here, and when you return to your companies.

I'd like to leave you with one last thought thatlbelieve is appropriate to the purpose of this conference and the integration of ideas and infon-nation that will be taking place: someone once said, "there is a reason why all the astronomers of the world cooperate - they have to, because there's no one place in the world from which the entire sky can be seen." It's really the same in our industry. No one has the whole picture or all the answers. The more we share our expertise, the stronger we'll be as individual companies, as an interconnected network of service providers, and as an industry.

Thank you.

IHHA delegates at the Opening Session, June 6, 1994

General Session 1

# Heavy Haul

# Systems

*"An Asset Intensive Approach"*

## EXPERIENCE GAINED ON THE RUSSIAN RAILROADS

## IN HANDING FREIGHT TRAFFIC

## INCLUDING HEAVY HAUL

**G. M. FADEYEV**

Minister of Railway Transport

of the Russian Federation

at the HIRA Mini-Conference

"Rolling Asset Management"

Omaha, NE, USA

June 6, 1994

Introduction

Mr. Chairman, Ladies and Gentlemen:

On behalf of the railroaders of Russia I would like to convey our best regards and express my sincere thanks for the opportunity to participate in this esteemed conference.

The Russian economy is presently passing over to market relations, which is a fundamentally new situation for the operation of our railroads. The railroads, being the basis of the transport system of Russia, play an important roll in the materializmg the Program of Reforms. The railroads account for 77% of freight and 49% of passenger traffic. In terms of figures that is 1.6 trillion tonne-kilometers and 272 billion passenger-kilometers (I. I trillion ton-miles and 169 billion passenger miles respectively) (as can be seen in Fig. 1.).

Speaking of the scope of operations of railroads in Russia I also could refer to some other figures. The route length of Russian railroads is 7% of the total of the world's railroads yet they handle 35% of the world rail freight and 18% of the world rail passenger traffic! Our rail system fully meets the demand of the country for moving goods and passengers; it is one of the few branches of the Russian economy which functions reliably and economically efficient. These results have been attained because we succeeded in setting up an efficient railroad management structure combining the economic independence of the railroads with a centralized management of system wide operation which suits best the present Russian conditions. The experience gained over the last two years proves that this was a correct decision.

The Railways of Russia will retain their leading role in the transport system of the country for years to come. This is due to their historically bw'lt up significance in relation to other modes of transport, to their high carrying capacity, their operational reliability under severe climate, low actual cost, energy savings and environmental preserving feature --- especially with regard to the electrified railroads.

I would like to make it a special point, taking account the interest shown in the world and specifically 'M the USA in the technical and econorm'cal aspects of converting diesel traction to electric traction, the strategy pursued in our country with regard to large scale rail electrification has proved to be a success (as can be seen in Fig.2). As a matter of fact all mainlines running from the western border to the Far East are electrified. Electrified lines, which make up 44% of the total route length of system, handle 77% of the total traffic (as can be seen in Fig. 3)!

The experience gained in operating electrified lines wider severe climate and on complicated track profiles especially ;.n the eastern part of the Transiberlaii line and on the Baikal-Amur line is unique.

The experience gained in operating high tonnage electrified lines under severe conditions could be of interest to other countries as well. We are willing to cooperate on a mutually beneficial basis in this as well as any other field. The possibilities for a fruitful cooperation are available.

With a vast technical and scientific potential at our disposal capable to solve complex problems while maintaining close cooperation with Russian industry, which is supplying rail equipment, our rail system relies indeed on using advanced technologies.

At the moment the Ministry of Railways controls 19 railroads, a number of locomotives and rolling stock repair factories, which also manufacture spare parts, factories manufacturing signaling and remote control equipment as well as research and development centers, training 'institutions and medical services.

With regard to the technical standards and freight handling practices the Russian Railways operate under conditions sinidlar to the railroads of the USA, Canada and Australia. As for passenger traffic we are closer to Western Europe and the Japanese railroads.

**Heavy Haul Experience**

Coming to Heavy Haul, which is the subject of this esteemed conference, I would like to tell you that we started operating heavy haul trains back in the early eighties. At that time, due to a substantial increase of the volume of freight traffic, we had to raise traffic density on all major lines, especially on lines linking the Far East and Siberia with the Urals and the European part of the country.

Based on theoretical and experimental investigations and applying experience gained on our railroads as well as on the railways of other countries we have developed efficient practices of making up heavy and long trains and of placing motive power in the consist so as to get the best results of train handling techniques.

Test runs covered a wide range of weights of trains from 6,000 to 30,000 tonnes (6,615 to 33,075 tons). The top limit of the equipment has been evaluated during a test run undertaken with a 43,500 tonne (47,900 ton) train using four groups of locomotives with a total power of 45,000 KW (I 3,41 0 hp) placed in a train 6 kilometers (3.7 miles) long and nm on a line with a complicated profile.

Based on the test results an optimum tonnage was fixed ranging from 6,000 to 18,000 tonnes (6,615 to 19,845 tons) and the length of the train was set ranging from 1,400 to 2,700 meters (4,590 to 8,860 feet) (as shown in Fig.4).

One of the specific features of implementing the program of 'increasing the weights of trains on the Russian railroads is that Heavy Haul is limited by the number of stations which can accommodate long trains.

The experience gained on the Moscow Railroad over the last 10 years in making up and operating 10,000 tonne (I 1,025 ton) trains while placing locomotives at the front and rear of the train and joining the braking system is of interest. Such trains are running on lines with extensive mixed freight and passenger traffic and with a limited number of station tracks corresponding to the length of such a train.

I might refer to another example as well.  On the eastern part of the Transiberian line from Irkutsk down to the ports on the Pacific block trains made up of 8-axle tank cars are nm.  These tank cars have a higher per meter load compared to 4-axle cars which makes it possible to operate 7,000 tonde (7,718 ton) trains on a 4,000 km (2,486 mile) line with station track have a  standard length of 850 meters (2,790 feet).

On the whole, the weights of trains operated on the Russian Railways depend on the traffic situation, on the track profile, the motive power used and on the length of the station tracks.  Anyway, 5,000 tonne (5,513 ton) trains are regularly operated on lines of a total length of 30,000 kilometers (18,642 miles).

Apart from this, during track maintenance operations (which means half of the year), double and triple trains are running on a large scale.

**Locomotives**

Heavy Haul is a complex problem involving motive power arrangement and utilization.  The basis of electric motive power used on the Russian Railways for Heavy Haul are 8-axle locomotives. To ensure reliable Heavy Haul electric locomotives can be used as a multiple unit consisting of two, three or four units, that is, making up a motive power unit of 8, 12 or 24 axles.

The efficiency of locomotive utilization is enhanced by increasing the power of traction motors, by improving the bogies, applying smooth thyristor control and by improving slippage control systems.  Also, the traction power is boosted by developing manufacture of 12-axle electric locomotives rated at 10,000 KW (13,410 hp) (as shown in Fig. 5).

The new generation of electric locomotives to be developed over the period of 1996-2005 which will incorporate the latest technical and scientific achievements will result in reducing metal consumption by 15 to 29% per unit of power.  The consumption of copper will be reduced substantially.     By improving the locomotive design operational and maintenance expenditures will be reduced by 20 to 25%.

The State Program of Developing National Locomotive Manufacturing provides also for updating the industry manufacturing advanced diesel-electric locomotives. It calls for the

development of 8-axle and 12-axle diesel-electric locomotives with 3,000 or 4,000 hp per section incorporating the latest developments in dieselelectric locomotive production including the field of traction motor and microprocessor techniques.

I would like to seize the opportunity to inform you that an 8-axle single unit diesel-electric locmotive of the TEP-80 type rated at 8,000 hp built at the Kolomna plant near Moscow was tested at a speed of 271 km/h (168 mph). At the moment this is the highest record for diesel-electric locomotives as far as I know.

It should be mentioned that the development of a locomotive using alternative fuel is making progress. The Ministry of Railways of Russia has been cooperating with the industry for a number of years now. A prototype of natural gas fueled locomotive will be tested this year. We note with satisfaction positive results of the cooperation of the Burlington Northern on this issue.

One of the directions for future locomotive development is the joint effort by General Motors together with the Russian Diesel Electric Manufacturing Works of Lyudinovo and the scientists and experts of the Ministry of Railways of Russia to develop a 4,000 hp freight locomotive incorporating the latest achievements of locomotive construction of the parties involved.

The Russian Railways are open for a mutually beneficial partnership. We are ready to use the experience gained by advance countries and companies, and the other hand, we are willing to share results we attained in enhancing the efficiency of operation of railroads.

**Freight Cars**

Freight cars are most important in Heavy Haul as well. On the Russian Railways freight cars are most intensively used, exceeding substantially the practices of other countries. The strategy of improving cars is geared at handling 'increased volumes of traffic. In order to ensure reliable heavy haul the requirements to be met by freight cars with regard to strength have been drastically increased.

Severe climatic conditions under which Russian Railways operate call for increasing the quality of metal and other material to withstand ambient temperatures of nu'nus 60 degrees C. For this reason investigations and development have been undertaken with objective to increase equipment reliability under low temperatures. We started making cast steel components of the bogle and of the automatic coupler using low alloy steel with an increased yield limit.

We devote special attention to raising the carrying capacity of cars. At the beginning of the 80's our railroads were operated under extremely high traffic density which was due to a drwnatic increase of volumes of traffic. The Ministry of Railway had to raise the standards with regard to loading the cars in excess of the calculated values: that is in 1981 we raised the axle load to 23/25 tonnes (25.4/27.6 tons) from 22 tonnes (24.3 tons), in 1982 we went to 23.5 tonnes (25.9 tons) and in 1985 we reached 25.75 tonnes (28.4 tons). The increased values of these standards were first checked by calculations and tests.

Of special value were the results we get by accelerated tests carried out at the Test Cnter located at the Scherbink-a station near Moscow. A 10,000 to 12,000 tonne (11,025 to 13,320 ton) test train covers 800 to 1,000 kilometers (497 to 620 miles) per night, the axle loads of the cars exceed by 3 to 4 tonnes (3.3 to 4.4 tons) those fixed for regular operation. The rate of accumulating fatigue failures in the carrying components of the cars exceed 8 to 10 times normal practices of system wide operations which made it possible to forecast the technical condition of the car fleet with a sufficient degree of accuracy.

At the moment due to the decline of the volume of traffic we consider it reasonable reduce the axle loads of the car fleet down to 23.5 tonnes (25.9 tons). Nevertheless we go on working on altemative ways to raise the carrying capacities of cars; tests are going on at the Test Center with axle loads of 27 tonnes (29.8 tons).

Russian Railroads together with the car building industry are working on more reliable cars, which we call "repair -free" cars. The concept of this development provides for cutting planned overhauls so repairs are due by the time major components and parts have to be replaced due to fatigue wear. On this issue Russian Railroads cooperate with American companies.

**Conclusion**

Mr. Chairman, Ladies and Gentlemen:

In accordance with the subject of this Conference I presented to you some of the basics with regard of the present situation and future development of the equipment of Russian railroads related to increasing the efficiency of freight traffic. We are closely following Heavy Haul developments in other countries with a view to make use of the positive experience gained in the world practices, including on the America Railroads. I am sure that the discussions ahead and the exchange of views on such important issues will make it possible to develop a comprehensive strategy with regard to strengthening the position of railroads in all countries.

Thank you for your attention.

Parallel Session A-1

# Locomotive Issues:

## *"Design & Selection"*

**AN EFFECTIVE PARTICIPATIVE APPROACH**

**FOR ROLLING STOCK PROCUREMENT**

**Brian G. B. Duncan**

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**ABSTRACT**

This paper describes the rolling stock procurement process currently used by Spoomet, the national railway company of South Africa.

The process focuses on satisfying the operational objectives of the users of rolling stock. Various engineering management techniques including project management, systems engineering, and user centered design are used. A participatory project environment is established and maintained by the procurement project manager to ensure that the user requirements are correctly interpreted by the system designers.

Areas that are covered include the process used to generate procurement specifications, design management, technical support documentation, and training of maintenance and operating personnel. The benefits derived from the process are discussed.

# AC TRACTION FOR HEAVY HAUL

# INITIAL EXPERIENCE IN REVENUE SERVICE

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## ABSTRACT

In mid 1992, the first North American heavy haul locomotives with AC traction were put into revenue service on the Burlington Northern Railroad. These four SD60MAC pre-production locomotives were developed and built by Electro-Motive Division of General Motors in partnership with Siemens AG. These 6-axle diesel-electric locomotives ushered in a "new age" in locomotive adhesion by demonstrating record levels of tractive effort: 175,000 lbs. (780 kN) or 45% adhesion for starting trains and 137,000 lbs. (610 kN) or 35% adhesion for continuous operation. By early 1993, it had been demonstrated that these adhesion levels could be utilized effectively in heavy haul railroading and that

AC traction would provide superior reliability in the severe winter climate of North America. In addition, it became apparent that the configuration of radial steering trucks, AC traction motors, and one AC inverter per truck could produce not only the highest adhesion seen to date but low wheel wear at the same time. The Burlington Northern ordered 350 SD70MAC production locomotives. By the end of 1993, SD70MAC locomotives were being delivered, and after an initial period of time dedicated to training employees in the operation and maintenance of this new technology, the SD70MACs were put into heavy haul coal service. Testing has demonstrated that the SD70MAC exhibits higher all-weather adhesion levels as a result of a more powerful computer and further improvement of the control system based on a five-month demonstration tour of the SD60MACs on North American railroads. Initial experience with the SD70MACs has confirmed performance and reliability expectations.

# EXPERIENCE WITH HEAVY HAUL LOCOMOTIVES

# IN WESTERN COAL SERVICE

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## ABSTRACT

Low-sulphur coal is moved from the Southern Powder River Basin in Wyoming by dedicated unit trains (110-to-117 cars). Current operating volumes are approximately 24 loaded trains per

day (100 million net tons per year). The most severe operating conditions are in the initial 123 miles of a 210 mile railroad, requiring lifting loaded trains over 43 cumulative miles of 1.00 percent grades. Heavy trains and grades require large amounts of tractive effort, typically 365,000-to-395,000 pounds. In 10 years of operation, 6 different types of locomotives have been assigned; locomotive consist size has been reduced to increase efficiency. Maximum adhesion demand for 3-unit locomotive consists is 30+ percent. Continuing growth of train weights increases service demands on all components, especially couplers, requiring special operating practices to accommodate limitations of materials, men and machines.

# LIFE CYCLE COSTING OF TRACTION UNITS:

# THE CASE OF THE GREEK RAILWAYS

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**ABSTRACT**

A methodology is presented that determines the extension of the life cycle period of a diesel locomotive, if the actual time needed for maintenance is longer than the scheduled. The proposed period is defined as the shortest of three periods: one based on the conversion of the real productive years during the life cycle period to calendar years and other two based on economic profitability criteria determining the calendar years period needed to recuperate any loss in revenue due to unavailability of diesel locomotives, caused by increased maintenance times. The recuperation is done either by extending the life cycle of the existing diesel locomotives or by purchasing new. An application is done for six different types of diesel locomotive s of the Greek Railways Organization using the life cycle

costing period established by the UIC Fiche 374R.

# Parallel Session A-2

## Locomotive Issues:

### *"Assignment Strategies"*

# DISPO – LOCOMOTIVE DISPOSITION IN LARGE NETWORKS

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**ABSTRACT**

The computer system package DISPO, developed at the Institute for Transportation, Railway Construction and Operation, is suitable for the disposition of locomotives in large networks. By the use of a graph model, an exact depiction of the data basis, marginal conditions and influence parameters can be acghieved. The complex relations are, thereby taken into consideration.

Calculations to demonstarte the efficiency DISPO have been made using the locomotives BR 110 and BR 111 of the German Railway. The examination area included the complete net of the German railway, as well as several foreign routes. All in all, 265 reversing stations had to be considered, where at least one train route started or ended.

Timetable data included passenger and freight trains, as well as shunting movements and trains of empty stock. The marginal conditions (compulsary connections, reversing times for a change of a tractive unbit from one train to another and train services) have mostly been individually considered. For the fulfilment of all train services, a demand of between 342 and 450 of locomotives

was calculated, depending on the model parameters. The number of calculated locomotives represents the minimum number of locomotives necessary according to the marginal conditions.

## IMPROVEMENT IN MOTIVE POWER UTILIZATION

## THROUGH MANAGEMENT DECISION SUPPORT SYSTEMS

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**ABSTRACT**

Motive power is a significant part of a railway's asset base. During the 1980s and early 1990s, two North American railways achieved significant gains in motive power productivity. These gains were achieved not only by purchasing advanced technology locomotives and improving maintenance procedures, but also by implementing decision support systems that increased motive power utilization. These systems improved the ability of the railroad to manage the assignment and distribution of locomotives, the primary source of motive power in freight railroading. This improved ability translated directly into measurable gains in utilization productivity.

This paper outlines opportunities to improve motive power productivity, focusing on improved management systems. It discusses the merits of various utilization measures, and statistically compares utilization rates for the railroads with improved decision support systems to a control group.

# TECHNICAL PERFORMANCE OF $ND_5$ GE-MADE DIESEL LOCOMOTIVE AND ITS OPERATION EFFECTS, FAULTS, AND MAINTENANCE ON CHINESE RAILWAY

**Qian Lixin**

Research Fellow, Deputy Director

China Academy of Railway Sciences

**ABSTRACT**

The 421 units of $ND_5$ deisel locomotives made by GE started their service on Chinese Railway in 1984, most of the'm having run over one million km and requiring 8-year overhaul. This paper introduces the measurements of the tests of the locomotive technical performance, analyzes the operation efficiency and economic effects on CR and the problems of various kinds in their 8-year service, briefs on the effects on the fault-shooting measures and their effects. It also makes the suggestion of a rational unit traction power rating for $ND_5$ locomotives running on the main line of the Chinese Railway.

# Parallel Sessmion A-3

## Locomotive Issues:

*"Driver Information and*

*Control Systems"* Y

**LOCOMOTIVE CAB ELECTRONICS**

**Stephen R. Montgomery**

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**ABSTRACT**

Rockwell's Locomotive Cab Electronics (LCE) system is an advanced method of locomotive data collection and display. Through the use of twin full color liquid crystal flat panel displays, a ruggedized and highly reliable Cab Consolidation Computer and strategically placed sensors, Locomotive Cab Electronics enhances safe, efficient crew operations and improves the engineers management of locomotive performance. Status information, critical data, and warning messages are centrally displayed. This improves cab ergonomics and leaves the crew more time to monitor the track ahead.

The integration of cab electronics improves locomotive availability by consolidating standalone equipment used on traditional locomotives. Locomotive Cab Electronics reduces locomotive maintenance costs by allowing maintainers to quickly diagnose faulty locomotive systems using the on-board computer and displays.

The Locomotive Cab Electronics equipment has demonstrated high reliability and is in daily operations on several U. S. railroads. The architecture allows the flexibility as either completely integrating ftincfions (event recorder, crew alertness, overspee,d) or providing a sefial link to separate equipment (electronic air brakes, End of Train equipment, cab signaling devices).

Future growth at minimal cost is a feature of Locomotive Cab Electronics. Locomotive Cab Electronics provides an efficient, cost-effecfive growth path to advanced features such as Advanced Train Control System, distributed consist control, locomotive health monitoring and other customer desired enhancementsthrough the ufilizafion of the existing displays and on-board computer.

Locomotive Cab Electronics can be installed on new locomotives or added to existing locomotives to upgrade their capabilities for fleet commonality. All system components are designed to be interchangeable between locomotives, reducing railroad requirements for maintaining extra spares inventory.

## LSI - LOCOMOTIVE SYSTEM INTEGRATION

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**ABSTRACT**

This paper outlines the development and implementation of an AAR Standard for cab electronics known as Locomotive Systems Integration, or LSL As electronics have become cheaper and more powerful, they have begun to replace electromechanical and mechanical systems on locomotives. The LSI system architecture is designed to rationalize the proliferation of new electronic components and to provide a standard display screen to the locomotive operator.

## BELTPACK® COMPUTER CONTROLLED

## LOCOMOTIVE CONTROL SYSTEM

**J.C. Johnstone**

CN North America

Montr6al, Qu6bec, Canada

**W.N. Caldwell**

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**ABSTRACT**

In 1987, the development of the BELTPACKO system was started by the CN Rail Technical Research Centre with application geared to improved productivity in Hump Yard Operations. This technology was introduced in revenue humping operations successfully in December 1990 at CN's Symington Hump Yard in Winnipeg, Manitoba. After a corporate restructuring, the developmental work has continued at CANAC International Railroad Technologies for a similar concept in flat-yard switching.

This product encompasses,the necessary attributes of enhanced safety of operations, increased labor productivity, and significant return on capital investment to justify its commercialization.

# Parallel Session A-4

## Locomotive Issues:

*"Reliability."*

## EFFECTS OF OEM MAINTENANCE PROCEDURES ON LOCOMOTIVE TRIP RELIABILITY AND LIFE CYCLE

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Manager, Fleet Maintenance

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**ABSTRACT**

Contract Maintenance of locomotives refers to an arrangement in which a Railroad contracts with Electro-Motive Division of General Motors to maintain, repair and overhaul its locomotives. It is a relatively new business, having begun in 1986. ne approach, which is outlined in this paper, provides a wide range of benefits to both the Railroad and Electro-Motive. In addition to reduced maintenance costs, the major advantage to the Railroad is **in**creased locomotive system reliability. System reliability is the probability of the locomotive system operating without failure for a specified period of time. With the introduction of AC locomotives to the railroad industry, the new AC locomotive systems provide additional potential in improving trip reliability. With new technology, new maintenance procedures need to be integrated into the railroad maintenance practices. Use of Contract Maintenance can reduce the transition cost of utilizing this new technology, and increase the benefits to a Railroad. This paper outlines the use of Contract Maintenance to facilitate the new technology introduction.

# RELIABILITY, COST, AND PERFORMANCE

# OF LOCOMOTIVES FOR HEAVY HAUL SERVICE:

## Defining the Parameters for Success


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**ABSTRACT**


The "horsepower race" between US locomotive manufacturers ended in the late 1960s with the withdrawal of the American Locomotive Company (ALCO) from the market. Within a short time, the experimental 4,000 HP units of General Electric and GM's Electro-Motive Division were withdrawn from service, and a 3,000 HP unit became essentially standard on North American railroads. The high reliability and relatively low cost of these units has made them the choice of heavy haul operators in the US, Australia, and Asia. However, these 3,000 HP units must be used in blocks of three, four, five, or more units to move the very heavy trains typical of heavy haul practice.

Since 1980, EMD and GE have been slowly increasing the horsepower of their units. EMD now offers the 4,000 HP SD70, and GE the 4,400 HP Dash 9. MK Rail has just produced the first of its 5,000 HP units, and

has announced plans for 5,500 HP and 6,000 HP models. In an apparent answer to MK's announced plans, EMD has a 5,000 HP SD80, and 6,000 HP SD90 under design, and GE has plans for a 6,000 HP unit.

The re-ignition of the horsepower race is also a response to a North American rail industry which is attempting to minimize costs. Several railroads have recently rebuilt locomotives without cabs, or designated certain units "non-lead qualified," in an attempt to reduce the costs of owning and maintaining motive power. The unit reductions permitted by very high horsepower locomotives are another path to cost reduction.

This paper will examine the factors determining the economic viability of very high horsepower units. Locomotives will be compared in an example service, using various combinations of cost, horsepower, maintenance cost per unit mile, fuel economy, reliability, and adhesion. A best combination of factors will be defined for typical heavy haul service.

# Parallel Session A-5

## Locomotive Issues:

### *"Adhesion and Braking"*

# AN ANALYSIS: TO INCREASE UTILIZATION FACTOR OF ADHESIVE WEIGHT FOR ELECTRIC LOCOMOTIVES

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**ABSTRACT**

This paper analyses major reasons that electric locomotives are liable to wheel slip. The conclusion is that electric locomotives have higher requirements on utilization factor of adhesive weight than diesel locomotives. The measures o f improving Iocornot ive structural design and electric compensation may be taken to raise utilization factor of adhesive weight of electric locomotives above 94-95% . It is especially necessary for heavy haul electric locomotives, In this way, the starting tractive force of locomotives **can** be given full play, and wheel- rail attrition fault resulted from wheel skidding while in braking can be avoided.

KEYWORDS utilization factor of adhesive weight, wheel slip, wheel skidding

# UPGRADING THE ELECTRIC BRAKE CAPACITY OF A FLEET OF 50 LOCOMOTIVES TO ENSURE SUITABILITY FOR OPERATING 20 800 METRIC TON COAL TRAINS


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**Willie Coetzee**

Rolling Stock

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## ABSTRACT


This paper gives a brief overview of the historic development of the Ermelo - Richards Bay coal line together with the considerations which lead to the decision to upgrade the rheostatic brake of 50 class 7E1 locomotives. The salient features of the upgrade are described together with the

acceptance test programme, the problems resulting from the upgrade and their resolution. Finally, conclusions are made from the lessons learnt.

# Development of A New Electro-Magnetic Air Brake System For the Speed-Up and Formation of Long Trains


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Chief of Laboratory

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## ABSTRACT

The Electro-magnetic air brake system and the Automatic air brake system are used in Japanese freight trains and in many other trains in the world today. We have developed a 'New Electro-Magnetic Air Brake System" for the speed-up and formation of long trains. This new brake system has superior characteristics in performance, cost, control, security and compatibility when compared with current systems. The main differences between the new brake system and the current one are Quick-Action-Prevention and QuickService. This paper describes the configuration of this new brake system. Furthermore, the results of experiments are presented, and suggestions are made as to the possibility of speed-up and long formation for freight trains using the new brake system.

# DEVELOPMENT A NEW METHOD FOR ADHESION IMPROVEMENT

# REPLACING TRADITIONAL SANDING

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**Takumi Ban**

Tribo-materials Laboratory

**Takanori Obara**

**Kiyoshi Kawaguchi**

Brake Control Laboratory

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**ABSTRACT**

A new method to improve the adhesion between wheel and rail replacing the traditional sanding has been developed. In this method, a little amount of ceramics particles required is jetted with compressed air between wheels and rails with high speed, high efficiency and high response. The skid in time of braking and slip in time of powering during high speed running are almost stopped with an amount of 0.3 mm ceramics particles which is less than in the traditional sanding. This paper gives an outline of this new method with results of some laboratory and field tests.

# Parallel Session A-6

# Locomotive Issues:

## *"Health Monitoring"*

**Locomotive Availability Improvement Using Health Monitoring**

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**ABSTRACT**

In today's highly competitive market, railroads are constantly seeking techniques to improve their asset utilization, and reduce their maintenance costs. Installation of locomotive health monitoring is one method a railroad can use to improve locomotive utilization.

By idendfying locomotives with substandard performance, locomotive health monitoring can prevent the dispatch of faulty locomotives that could lead to road failures, and possible train delays. The system also detects particular faults, and assists in the isolation of intermittent failures. Repair can then be verified with the use of the health monitor. As such, the system can be used to also improve poorly performing locomotives, and to reduce the number of on-line locomotive failures.

Installation of Rockwell's Sentinel™ health monitoring system can help railroads gain all of these benefits. A Radio Frequency (RF) link can also be added to the Sentinel™ system to allow

remote monitoring of the locomotives' health data.

# A COMPUTER SELF-SERVICE SYSTEM FOR LOCOMOTIVE BY MEANS OF SATELLITE LOCATION

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**ABSTRACT**

There are three distinct tendencies in the update development of railway transportation. This are the high speed the heavy load and the safety. The location of the trains play an important part in this field. It is posible now to use the satellite communication for a location tool in the railway

transportation. From the analys of the accidents in the railway we can conclude that the satellite location of train must be a powerful measuer to the safety. So it is worth to develope this technology. I think China is an attractive market of this technology for any who like to join us. Consider of the safety and reliability, this system may consisted of the technology the computer, the control to the whole train, the fault tolerance and the radio digital transmition. This system should be sutible to different type of locomotives, different locations and cover all the ground of China.

# Parallel Session B-1

# Car Fleet Issues:

## *"Design and Selection"*

### MATHEMATICAL MODELING OF RAILCAR DYNAMICS

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**Nathan J. Reese**

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**ABSTRACT**

Advances in mathematical modeling of railcar dynamics enables design engineers to simulate vehicle behavior for a variety of real world conditions. These programs allow variations in design parameters to evaluate the sensitivity of these parameters to performance outcomes. Several programs have gained wide acceptance as a means for vehicle evaluation both to assist in the design/development phase as well as evaluate abnormal or undesired behavior in testing and/or in service. Several applications are documented for each program along with a description of the individual program, its features and any limitations. An appendix lists published reports using these programs with a commentary on the specific application. Recommendations are made for using these programs in specific design situations.

# NUCARS INVESTIGATION OF HEAVY HAUL CARS

# WITH VARIOUS SUSPENSION DAMPING ARRANGEMENTS

**James F. Wright, P.E.**

**A. D. McKisic, P.E.**

**B. Edward Henderson**

A. Stucki Company

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**ABSTRACT**

In the United States, as elsewhere, there is an impetus toward increasing the gross rail weight (GRW) of bulk commodity freight cars. Here the normal gross weight for bulk commodity cars is expected to increase from about 29,800 kg per axle to 32,400 (from 32.9 to 35.7 US tons). There has been a lively discussion about this change. Much of the technical argument has centered on implications of such a change on the strength and fatigue of the cars, truck components, wheels, and track.

This paper summarizes a study of the effect of various levels and types of suspension dainping on these larger cars. It reports the results from NUCARS dynamic simulations of the vertical response of a generic 129,700 kg (286,000 lb) GRW car passing a difficult grade crossing. It compares the effects of variably damped., constant damped and supplementally damped systems, as well as comparing it to a I 19,300 kg (263,000 lb) GRW car. The emphasis of this work is the avoidance of spring bottoming.

## ANALYSIS OF EQUIPMENT MAINTENANCE POLJCIES

## BASED ON REUABILITY, COST, AND INSPECTION CRITERIA

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**ABSTRACT**

The maintenance strategies followed by railroad car owners in North America have shifted from a "replace upon failure" policy to various types of preventive maintenance programs. In many cases, these preventive maintenance policies are not based on the reliability of the specific components of the car, the costs of in-service failures versus planned replacements, or the impacts of inspection policies and quality. The authors recently completed a study of a privately owned fleet in which these factors were determined and used in a simulation model to aid in the selection of a more cost-effective preventive maintenance program.

Based on the analysis, a more sophisticated maintenance policy was developed which distinguished between car types, car ages, and inspection and PM quality programs. The new policy is expected to maintain the current levels of reliability at a much lower cost, and with fewer cars removed from service for unneeded maintenance.

It is 'clear from the study that maintenance planners and managers, especially those working with heavy haul railroad operations, can benefit from this type'of analysis in developing maintenance programs.

# Parallel Session B-2

## Car Fleet Issues:

*“Bogies or Trucks”*

### DESIGN OF THREE-PIECE BOGIE FOR LOW TRACK FORCES

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**ABSTRACT**

The traffic capacity will increase 19.7% under the condition of station track length 1050m, as the axleload increasing from 21 tonnes to 25 tonnes. It is necessary to develop low track force freight bogie for decreasing the damage of track and substructures caused by the high axle load. The design outcome of it is the frame bracing, two stage bolster springs, flexible rubber bearing adapter, hollow axle and dip dish plate cast steel wheel etc. Prediction of calculation and analysis shows that the dynamic performance of 25 tonnes axleload bogie for low track force will be closed to the conventional 21 tonnes axleload bogie.

# A METHODOLOGY FOR THE EVALUATION OF

# THE ECONOMICS OF IMPROVED TRUCK DESIGNS

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**ABSTRACT**

The technical inadequacies of the standard three-piece freight car truck in the areas of dynamic stability, steady state curving, and high speed lateral stability have been emphasized by the demands placed on the freight car truck by the 286,000 and 315,000 pound gross weight cars currently being introduced into service. These technical inadequacies give rise to economic penalties: high wheel and rail wear rates, rail and car body fatigue, derailments and reduced equipment utilization. Design efforts by both railroads and suppliers in countries that operate "heavy-haul" freight railroads have led to a number of new truck designs intended to improve one or more of the inadequate performance characteristics of the standard three-piece truck.

Many of these designs will be tested and evaluated as part of the Facility for Accelerated Service Testing (FAST) Heavy Axle Load (HAL) program. The technical results of preliminary evaluations have been discussed at the HAL Steering Committee and the VTS Program Review. This paper examines each cost stream generated in service with conventional freight cars equipped with three-piece trucks, and to establish the potential economic benefit of changes in the performance characteristics of freight cars equipped with improved trucks. In addition to the performance dimensions of stability, curving, dynamic behavior and ride quality mentioned previously, the energy consumption related to the rolling resistance and weight of the freight car truck will be considered. A better understanding of the cost streams generated by service using current freight truck technology can focus our future design efforts toward those areas of maximum economic return. The methodology documented in this paper can be used to evaluate other premium truck/suspension designs.

# ECONOMICS OF WHEELSET MANAGEMENT

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**ABSTRACT**

This presentation analyzes the wheel-rail interaction and further identifies wheel profile wear and related disadvantages as far as progressive wear and increased traction power consumption is concerned.

The presentation further outlines a Fleet Management Concept utilizing wheel profile measurement techniques and modern underfloor wheel profiling equipment to enable Economic Wheelset Management for safe rail transport of locomotives and freight cars.

Parallel Session B-3

# Rail Systems Planning:

## *"Capacity Considerations"*

# IMPROVING HEAVY HAUL ASSET MANAGEMENT THROUGH

# LINE CAPACITY AND TRAIN PERFORMANCE MODELS

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**ABSTRACT (inserted)**

An essential element of railroad heavy haul asset management is the use of computer models for operations planning. This paper will present the development, validation, and application of a family of third-generation models for line capacity and train performance studies. First-generation models of this type were traditionally mainframe applications. The second generation were microprocessor based operating in **a** batch environment. The third generation is microprocessor based running in Windows™ with Graphical User Interface (GUI). This step has considerably improved the user friendliness of the models. The result is a more cost effective and timely means for asset management by heavy haul operators.

# AN EXPERT SYSTEM FOR TECHNICAL RECONSTRUCTION SCHEME DECISION OF SINGLE-TRACK RAILWAY

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**ABSTRACT**

This article describes how an Expert System for Technical Reconstruction Scheme Decision of Single-track Railway (ESORR) simulates the complex thinking process of railway experts in developing technical reconstruction schemes.  ESORR utilizes knowledge presentations of multi-knowledge base, rules with dynamic variables and metaknowledge, adopts the forward-backward inexact inference strategy and an interval-valued-based uncertain reasoning model to establish a feasible technical reconstruction scheme.  With similar priority ratio theory of fuzzy Logic and based on the fuzzy overall level concept, a recommended scheme is finalized, thus completing, the whole process of decision-making.

# SIGNALLING FOR SOUTH AFRICAN HEAVY HAUL LINES

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**ABSTRACT**

This paper will concentrate on the traffic control systems which are already in use by Spoornet for heavy haul purposes together with those being developed and those still in the concept stage. The principles of the signalling systems for heavy haul are discussed, with reference to the special requirements of these trains. Particular reference is made to the "Coal Line" and the "Sishen - Saldanha Line". Current developments referred to are radio based systems, hydraulic operation of mechanical signalling, fail-safe data transmission, automatic train protection and the maximum power demand system.

# Parallel Session B-4

## Rail System Planning:

*"Signals and Detection Systems"*

### DETECTION OF HEAVY HAUL TRAIN AND TRACK FAULTS IN SOUTH AFRICA

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**ABSTRACT**

This paper discusses the systems which have been implemented on the two main heavy haul lines in South Africa to detect train and track faults. The reasons for each system, together with the successes achieved by having such systems are given. Further developments on existing and new systems and the reasons for these developments are discussed.

# ECONOMIC ANALYSIS OF HIGH IMPACT WHEEL LOADS

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**ABSTRACT**

Recent research conducted by the AAR Research and Test Department concluded that the existing car interchange rules on dimensional criteria of wheel tread irregularities do not adequately identify high-impact-load wheels. A car interchange rule based on impact loads, related to the extent of damage done to the track and vehicle components, would be consistent with the industry move away from dimensional standards to performance standards. This report estimates the economic impact threshold for removing high impact load wheels and also analyzes the implication of such an economic threshold to the existing AAR Car Interchange Rule 41, Section A.

The economic threshold is the impact load level at which the net present value of the incremental cost is equal to the benefit. The incremental costs and benefits of replacing high impact load wheels are estimated using life-cycle costs. The costs and benefits computed in determining the economic impact load threshold are the incremental wheel removal, track and equipment damage, and fuel costs. Finally, some recommendations based on the sensitivity analyses of the estimated threshold are also included.

# Parallel Session B-5

## Rail Systems Planning:

### *"Physical Plant Impacts"*

# THE TECHNICAL MANAGEMENT OF ROLLING STOCK

# IN SPOORNET

(with specific reference to the maintenance environment)

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**ABSTRACT**

The effective technical management of rolling stock is an important building block for the success of a railroad. The Rolling Stock Department of Spoornet has developed a process whereby they apply a focused approach to the life cycle management of the rolling stock. Key concepts in this process are the functions of Business Management, Project Engineering, Technical Fleet Manager, and Technical Owner.

# RAIL FORCE MEASUREMENTS UNDER HIGH ADHESION

# AC TRACTION LOCOMOTIVES WITH RADIAL TRUCKS

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## ABSTRACT

The introduction of the SD60M-AC locomotive on the Burlington Northern Railroad (BNRR) in revenue service brought with it a concern about the long term effect of high adhesion locomotives on track longitudinal forces and displacements, and a desire to quantify the lateral rail force/curving performance of the truck under high adhesion conditions. This new locomotive also included a radial three-axle truck design.

The Association of American Railroads (AAR) participated in performance testing of the SD60M-AC locomotive at the Transportation Test Center (TTC) in 1992, including the measurement of lateral rail forces during operation of a SD60M-AC locomotive in the Heavy Axle Load (HAL) test train, which operates at the Facility for Accelerated Service Testing (FAST). Then, at the request of the BNRR, the AAR completed a series of revenue service track force tests in November 1992 in cooperation with the BNRR, Santa Fe Railroad, and Southern Pacific Railroad. The BNRR tests involved heavy tonnage unit coal trains.

The revenue service testing consisted of instrumenting two track cribs in curves on an ascending and descending grade to measure longitudinal, vertical, and lateral rail forces and displacements under high tractive and dynamic braking forces. Similar data was taken for DC motored locomotives with conventional three-axle truck designs. Results showed that the AC motored locomotives generated higher average tractive and dynamic brake forces than the DC motored locomotives. The increase in longitudinal forces was not suff icient to cause any restriction to be placed on the locomotives for service. The AC motored locomotives with radial trucks produced lower lateral rail force than their DC counterparts with conventional trucks. The force data was consistent with the displacements and angle-of-attack measurements. The data taken at the TTC during the HAL test showed consistently lower lateral rail forces and Lateral to Vertical force (L/V) ratios for the radial three-axle trucks as compared to conventional 2-axle trucks under the DC locomotives used in the same consist.

## ON THE PLANT INVESTMENT OPTIONS FOR HEAVY HAUL SERVICE


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**ABSTRACT**

In this paper the basic situation and features of heavy haul service in China are simply related at first. Secondly, the matching conditions between the rolling stock for heavy haul service and railway plant concerned are presented. The stress is on the plant investment options for verifying, calculating and optimizing thoroughly under maintaining the flow-productivity of the rolling stock at last.

**Key words:** heavy haul service, plant investment options, flow productivity, matching.

# Parallel Session B-6

## Rail Systems Planning:

### *"Track Infrastructure"*

## AN ANALYSIS OF THE SCHEDULING OF THE WORK WINDOWS FOR RAILROAD TRACK MAINTENANCE GANGS

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ABSTRACT

Each time a track maintenance gang will occupy the track, a determination must be made of the work window (or times) in which this will happen. Historically this has been a manual process but the technology now exists to automate and streamline the work window scheduling operation. This paper presents an analysis of that operation, including goals, constraints, and strategies. It also discusses the structure and functionality of a software system that schedules track maintenance, the Intelligent Maintenance Scheduler.

The goal of a track maintenance scheduler is to maximize work window size and to minimize train delays. This must be done within the constraints associated with labor agreements, train service contracts, physical limitations, maintenance project characteristics, etc. Outputs of the system should include the specific track occupancy times of the work gangs and the resultant train delays. This information should be made available on a day-by-day basis as well as at a project summary level. Interactive, graphical displays allow the user to easily and quickly review and modify the proposed schedules.

It is found that track maintenance work windows can be scheduled automatically and intelligently. Not only does this save a lot of the time and effort associated with the scheduling process, it results in a schedule where work window sizes are maximized and train delays are minimized. Furthermore, this process can be implemented in a user-friendly and cost-effective manner to run on a personal computer, as demonstrated by the Intelligent Maintenance Scheduler. Overall, benefits are found in terms of cost, effort, and time savings as well as an improvement in the quality and reliability of the developed schedules.