

# Amtrak Office of Inspector General

EVALUATION REPORT E-09-05

## Amtrak's Infrastructure Maintenance Program

September 29, 2009



This report will become available to the public on October 29, 2009.

## **EXECUTIVE SUMMARY**

### **PURPOSE**

The purpose of this review was to evaluate the efficiency and effectiveness of Amtrak's Infrastructure Maintenance Program and to identify opportunities for improvement.

### **METHODOLOGY**

The efficiency and effectiveness of Amtrak's Infrastructure Maintenance Program was evaluated by utilizing a combination of qualitative and quantitative evaluation techniques. We conducted a comprehensive set of interviews of Amtrak Engineering staff members to determine what, why and how Amtrak completes its infrastructure maintenance work. To measure the relative efficiency and effectiveness of Amtrak's Infrastructure Maintenance program, we benchmarked Amtrak's performance metrics to those of comparable European railroads. To identify the "best practices" in infrastructure maintenance, we visited six European countries/infrastructure operators that were included in the benchmarking study and had unique expertise in specific areas of infrastructure maintenance and renewal.

### **OVERALL CONCLUSIONS**

Amtrak maintains over \$17 billion worth of infrastructure assets throughout its national rail passenger system, with the majority of these assets being located in the northeast region of the United States. Although a significant portion of its infrastructure assets are over aged, over the last several years Amtrak's Engineering Department has done a commendable job of improving infrastructure reliability and reducing infrastructure operating expenses.

In addition to these recent improvements, our benchmarking shows that Amtrak has an opportunity to further reduce its long-term infrastructure capital and operating maintenance costs by \$50 million to \$150 million per year by improving the overall efficiency and effectiveness of its infrastructure maintenance program to the level of comparable European railroads. It is recognized that many of the major cost drivers (e.g. age of infrastructure, weight of trains, multi-year funding commitments, regulatory rules and policies) impacting infrastructure maintenance are outside of Amtrak and/or the Amtrak Engineering Department's direct control. To capitalize on the opportunity to further reduce Amtrak's long-term infrastructure maintenance costs, the OIG has made 16 recommendations on the actions that Amtrak management should take to either influence the cost drivers that are outside their direct control or implement positive changes in the cost drivers that are within their direct control.

## **TABLE OF CONTENTS**

### **INTRODUCTION**

|                    |   |
|--------------------|---|
| PURPOSE            | 1 |
| SCOPE/ METHODOLOGY | 1 |
| SUMMARY            | 2 |

### **AMTRAK INFRASTRUCTURE**

|   |    |
|---|----|
| BACKGROUND                                      | 4  |
| CURRENT INVENTORY                               | 4  |
| CAPITAL REINVESTMENT LEVELS                     | 14 |
| STATE OF GOOD REPAIR                            | 15 |
| INFRASTRUCTURE EXPENSES & OPERATING RELIABILITY | 16 |
| SUMMARY   | 18 |

### **INTERNATIONAL BENCHMARKING**

|                               |    |
|-------------------------------|----|
| COMPARATORS                   | 19 |
| PHYSICAL PLANT AND OPERATIONS | 21 |
| ASSET AGE COMPARISON          | 23 |
| METHODOLOGY                   | 26 |
| NORMALIZATION PROCESS         | 27 |
| RESULTS                       | 29 |
| SUMMARY                       | 33 |

### **FINDINGS AND RECOMMENDATIONS**

|   |    |
|---|----|
| CAUSAL FACTORS IMPACTING EFFICIENCY & EFFECTIVENESS | 34 |
| PROCESS   | 36 |
| LABOR   | 57 |
| TECHNOLOGY  | 63 |
| SUMMARY – RECOMMENDATIONS                           | 76 |

### **LIST OF APPENDICES**

|  |    |
|--|----|
| I      SUMMARY OF EUROPEAN BEST TECHNOLOGY PRACTICES | 78 |
| II     CONTRIBUTORS                                  | 79 |

# **INTRODUCTION**

## **PURPOSE**

The purpose of this review was to evaluate the efficiency and effectiveness of Amtrak's Infrastructure Maintenance Program and to identify opportunities for improvement.

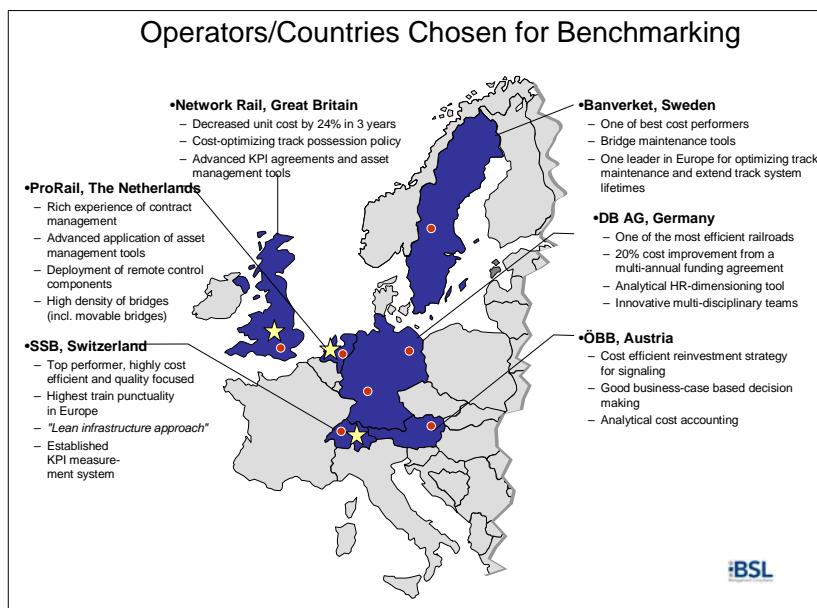
## **SCOPE/METHODOLOGY**

This review evaluated the efficiency and effectiveness of the maintenance of Amtrak's infrastructure assets, which can be categorized into their technical disciplines of Track, Structures, Electric Traction and Signal and Communications. Although Amtrak owns and maintains infrastructure assets throughout the continental United States, the majority of Amtrak's infrastructure assets are located in the Northeast Corridor between Washington, DC and Boston, Massachusetts.

The efficiency and effectiveness of Amtrak's Infrastructure Maintenance Program was evaluated by utilizing a combination of qualitative and quantitative evaluation techniques. We conducted a comprehensive set of interviews of Amtrak Engineering staff members to determine what, why, and how Amtrak completes its infrastructure maintenance work. We interviewed the Engineering staff members who had a direct influence on the decision making and the implementation of the Infrastructure Programs; including the Chief Engineer, the Deputy Chief Engineers, the Division Engineers, the Senior Director of Clearances & Inspections, the Senior Director of Planning & Budgeting, and others. The information obtained from the Engineering Staff interviews was subsequently used to develop a Systems Dynamic Model that identifies the causal factors impacting both the efficiency and effectiveness of Amtrak's Infrastructure Maintenance Program.

The relative efficiency and effectiveness of Amtrak's Program was determined by benchmarking Amtrak's infrastructure maintenance performance metrics to those of comparable European railroads. To obtain the required information for the European Infrastructure Programs, Amtrak enlisted the help of BSL Management Consultants, which had been benchmarking the performance of European Infrastructure Programs for the past 12 years. During these 12 years, BSL developed, with the cooperation and approval of the International Union of Railroads (UIC), a normalization process that produced meaningful comparisons of railroad maintenance costs by taking into consideration the differences in the major cost drivers (e.g. labor cost levels, purchasing power, turnout density, etc.) of each railroad. The data provided by this benchmarking analysis was used to help identify the specific railroads that had the best infrastructure maintenance practices in Europe.

Based upon the quantitative results of the benchmarking analysis and also the knowledge of BSL Management Consultants regarding European infrastructure maintenance procedures and technology, we decided to visit the following six countries/infrastructure operators to identify their “best practices” related to infrastructure maintenance. The team



that visited the European infrastructure operators included Amtrak’s Chief Engineer, the Deputy Chief Engineer of each engineering discipline, the BSL infrastructure consultant, and two OIG evaluators. The results of the benchmarking analysis and the review of “best practices” are incorporated into the findings and recommendations of this evaluation.

## EVALUATION SUMMARY

Amtrak maintains over \$17 billion worth of infrastructure assets throughout its national rail passenger system, with the majority of these assets being located in the northeast region of the United States. Although a significant portion of its infrastructure assets are over aged, Amtrak’s Engineering Department has done a commendable job of improving infrastructure reliability and reducing infrastructure operating expenses. During the FY ’02 to FY ’07 time period, the Engineering Department reduced its infrastructure operating expenses by 15% and its actions contributed towards a 60% reduction in infrastructure-related train delays.

Despite these recent reductions in infrastructure operating expenses, it is estimated that Amtrak spends about \$50 million more per year than the average European Railroad and \$150 million more per year than the “best”<sup>1</sup> European Railroads to maintain and renew infrastructure assets comparable to Amtrak’s Northeast Corridor<sup>2</sup>. There are numerous factors that determine why Amtrak spends more on its infrastructure maintenance and these can be categorized as either outside Amtrak’s control or within Amtrak’s control.

<sup>1</sup> The expenditure level of the “best” European Railroads is calculated based on the average of the railroads with expenditure levels in the lower half of the sample.

<sup>2</sup> The estimated \$50 million to \$150 million performance gap is based upon Amtrak’s total operating and capital expenditures related to the maintenance and renewal of NEC infrastructure assets.

Some of the major factors that impact infrastructure maintenance and are outside Amtrak Engineering's direct control are:

- Age Of Infrastructure – it is estimated that 30% of Amtrak's infrastructure assets are beyond their design service life, which is much worse than European Railroads, and, therefore, require higher frequencies of inspections and maintenance intervention.
- Weight of trains – the average passenger train on the NEC is more than twice that of the average European passenger train and there is even a larger variance in the weight of freight trains operated over these infrastructures. The weight of rolling stock has a significant impact on infrastructure maintenance expenses since the heavier trains require heavier, more expensive infrastructure components to support them; the heavier components are more expensive to maintain; and the heavier trains cause more damage to the infrastructure.
- Multi-Year Funding – Amtrak has not had the advantage of receiving multi-year capital funding commitments, which is a significant impediment to the planning and execution of an efficient and effective capital maintenance program.
- FRA and Civil Regulations – Amtrak must operate within FRA and Civil regulations that, at times, negatively impact its ability to optimize the efficiency of its maintenance programs.

Some of the major factors that impact infrastructure maintenance and are within Amtrak's control are:

- Advanced Technology/Equipment – Amtrak could improve the efficiency and effectiveness of its infrastructure maintenance program by using the advanced technologies and equipment that are being used by the European Railroads. In some cases, the financial benefits that could be derived from the advanced technology depend upon the modification of FRA and/or Civil Regulations.
- Asset Management Process – Amtrak could improve the efficiency and effectiveness of its maintenance programs by expanding the scope of its asset management process to provide the data and analytic capabilities required to optimize Amtrak's investment of capital and operating funds in the infrastructure assets in support of Amtrak's strategic operating goals.
- Maintenance processes – Amtrak could improve the efficiency of its maintenance programs by expanding the use of Industrial Engineering techniques to optimize the use of labor, machinery, and available "track time."

We recommend that Amtrak pursue the actions summarized on pages 76 and 77 of this evaluation, recognizing that the Engineering Department has already initiated some of the recommended actions, that they are not totally in control of all factors, and that they must enlist the support of outside agencies to accomplish several of these tasks. The rest of this report describes Amtrak's infrastructure in more detail, explains the results of our benchmarking with European railroads, and discusses our findings and recommendations intended to improve the efficiency and effectiveness of Amtrak's infrastructure maintenance.

## **AMTRAK INFRASTRUCTURE**

### **BACKGROUND**

When Amtrak began operations on May 1, 1971, it owned no track or right-of-way and relied upon the host railroads to provide all of the infrastructure and most of the manpower required to operate its trains. Over time, Amtrak began to acquire the infrastructure that it required (i.e. maintenance facilities, stations, some right-of-way, etc.) to operate the national rail passenger system. The vast majority of the right-of-way was acquired in 1976 when the Railroad Revitalization and Regulatory Reform Act transferred ownership of the Northeast Corridor (NEC) to Amtrak. In subsequent years, three additional short segments of non-Northeast Corridor route segments were acquired by Amtrak. It should be noted that:

- 1) the NEC uses existing rail lines that were built by four separate railroads as early as the 1830's and that significant portions of the infrastructure assets date back to the late 1800s and early 1900's,
- 2) similar to other assets acquired from the original passenger train operators, the right-of-ways had significant amounts of deferred maintenance.

### **CURRENT INVENTORY**

Amtrak's infrastructure assets are located throughout the continental United States, but the majority of them are located in the Northeast between Washington, DC and Boston, Massachusetts. Amtrak owns and maintains infrastructure assets (i.e. track systems, communication and signal systems, electric traction systems, stations, bridges & tunnels, maintenance yards, maintenance of way bases, and mechanical facilities) along the following rail lines.

- Northeast Corridor:
  - Washington to New York
  - New Haven to Boston
- Northeast Corridor Feeder Lines
  - Philadelphia – Harrisburg
  - New Haven – Springfield
  - New York - Albany
- Michigan Line

Additionally, Amtrak owns and maintains station, yard, and mechanical facilities at the following locations.

- Chicago
- New Orleans

- Florida Station
- Los Angeles
- Oakland Station
- Seattle Station

During FY '06, Amtrak's Engineering Department produced a State of Good Repair (SOGR) Document that grouped the company's infrastructure assets into four major categories (i.e. Track, Communication and Signaling, Electric Traction, Structures) and six geographical locations (i.e. NEC Mainline, Springfield Line, Harrisburg Line, Albany, Central, and West). This document provided a very comprehensive accounting of the infrastructure assets that Amtrak owns and an assessment of their state of good repair. An asset is considered to be in a State of Good Repair when that asset is being maintained and replaced within the design life of that component.

## **Track**

The State of Good Repair document provides insight into the wide range in types of infrastructure assets, their condition, and their distribution throughout the country. As shown in the following summary table, track assets are distributed throughout the United States, with the majority of them located within the NEC mainline.

### **Summary - Track Assets by Location**

| <b>Asset Description</b> | <b>Unit</b> | <b>NEC</b> | <b>Sp'fld</b> | <b>Albany</b> | <b>Harris.</b> | <b>Central</b> | <b>West</b> |
|--------------------------|-------------|------------|---------------|---------------|----------------|----------------|-------------|
| <b>Tracks</b>            | miles       | 1,196      | 86            | 99            | 274            | 160            | 17          |
| <b>Turnouts</b>          | each        | 1,807      | 19            | 29            | 222            | 228            | 0           |
| <b>Track Fasteners</b>   | sets        | 5,838,180  | 390,720       | 6,727         | 322,080        | 528,000        | 42,740      |
| <b>Wood Ties</b>         | each        | 575,000    | 284,590       | 296,850       | 745,110        | 527,000        | 76,290      |
| <b>Concrete Ties</b>     | each        | 2,919,090  | 195,369       | 0             | 161,040        | 264,000        | 21,370      |
| <b>Insulated Joints</b>  | each        | 12,204     | 446           | 551           | 1,822          | 1,176          | 362         |

In addition to geographical dispersion, there is also a wide range in the condition of the assets at each of these locations that require the appropriate maintenance and renewal programs. The rail, tie, and ballast conditions vary from that of the recently re-laid tracks

with concrete ties, new rail, and renewed ballast (picture on the left) to track that has worn rail, poor ties, and contaminated ballast (picture on the right).



In addition, the degraded rail and tie condition that exists at various locations throughout Amtrak's system creates poor track geometry, as illustrated in the following picture of a turn out in Washington Union Station, that causes poor ride quality and increased maintenance expenses for both the track system and rolling stock.



Note: This picture illustrates the poor alignment, gauge, cross level, and curvature of the station and crossover track.

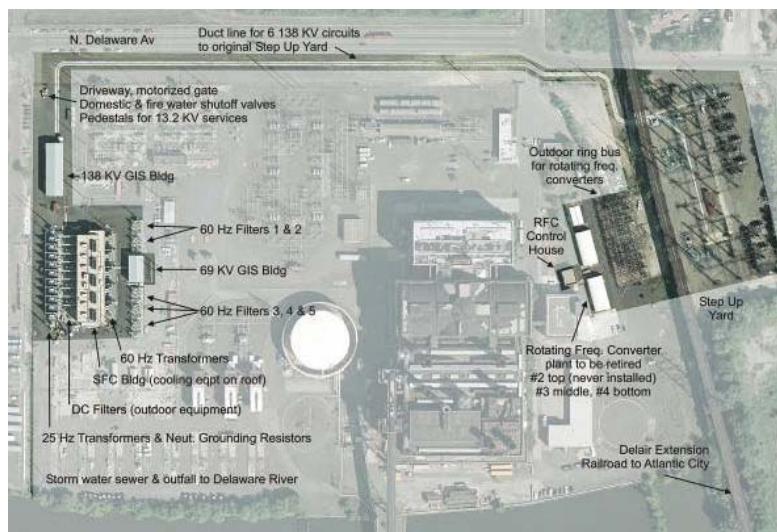
## **Electric Traction**

A review of Amtrak's Electric Traction assets reveals that, although Amtrak has electric traction assets on only two lines, there is a wide range in the condition of these assets and the size and complexity of the electric traction systems. The following table is a summary of the types and locations of the major electric traction systems/components.

## Summary - Electric Traction Assets by Location

| <b>Asset Description</b> | <b>Unit</b> | <b>NEC</b> | <b>Sp'fld</b> | <b>Albany</b> | <b>Harris.</b> | <b>Central</b> | <b>West</b> |
|--------------------------|-------------|------------|---------------|---------------|----------------|----------------|-------------|
| <b>Catenary System</b>   | Miles       | 1,285      | 0             | 0             | 278            | 0              | 0           |
| <b>Freq. Converters</b>  | Systems     | 18         | 0             | 0             | 3              | 0              | 0           |
| <b>Catenary Poles</b>    | Each        | 25,543     | 0             | 0             | 6,046          | 0              | 0           |
| <b>ET Transformers</b>   | Each        | 123        | 0             | 0             | 23             | 0              | 0           |
| <b>ET Breakers</b>       | Each        | 895        | 0             | 0             | 132            | 0              | 0           |
| <b>ET Switches</b>       | Each        | 2,141      | 0             | 0             | 180            | 0              | 0           |
| <b>3rd Rail</b>          | Feet        | 153,120    | 0             | 0             | 0              | 0              | 0           |

By far, the majority of the electric traction assets lie along the NEC mainline between Washington and New York and between New Haven and Boston. The complexity of the listed assets ranges from the relatively simple catenary pole, shown in the following picture on the left supporting a signal transformer, to a frequency converter station that includes multiple electric systems as in the aerial picture on the right.



Similar to the situation with track, there is a large variance in the condition of the individual assets making up Amtrak's electric traction system. Overall, the electric traction system that exists between New Haven and Boston is in excellent condition since it was recently installed as part of the electrification project of Amtrak's mainline between New Haven and Boston. The following picture on the left illustrates the essentially pristine condition of the constant tension catenary system that has been installed to support the high-speed rail service enabling the Acela to attain a maximum speed of 150 mph between New Haven and Boston.



The picture on the right illustrates the much older system on the south end of the mainline that is a non-constant tension system with components that are beyond their design service lives and that have major levels of deterioration. Examples of this include the contact wires that are far beyond their 30 year design service life and the severe deterioration that many of the catenary poles have experienced (see following pictures) on the south end of the railroad.

**Tubular Catenary Deterioration**



**Pole Foundation Erosion**



The extremes in individual asset conditions can also be seen in the electric traction substations where new single pole vacuum breakers sit beside 70 year old breakers (following picture on left) and 70 year old power transformers (following picture on right).



## Communication & Signaling

As detailed in the following chart, Amtrak has Communication & Signaling (C&S) assets located throughout its national system, with the majority of those assets located in the northeast portion of the country.

### Summary - Communication & Signaling Assets by Location

| Asset Description             | Unit  | NEC   | Sp'fld | Albany | Harris. | Central | West  |
|-------------------------------|-------|-------|--------|--------|---------|---------|-------|
| <b>ABS</b>                    | Miles | 1,085 | 83     | 19     | 261     | 104     | 0     |
| <b>Positive Train Control</b> | Miles | 428   | 0      | 0      | 0       | 66      | 0     |
| <b>Interlockings</b>          | Each  | 119   | 11     | 3      | 18      | 31      | 0     |
| <b>Radios</b>                 | Units | 6,650 | 115    | 117    | 613     | 2,255   | 2,262 |
| <b>Switch Heaters</b>         | Each  | 1,149 | 22     | 2      | 173     | 40      | 0     |
| <b>CETC System</b>            | Each  | 3     | 0      | 0      | 0       | 1       | 0     |
| <b>Crossing System</b>        | Each  | 11    | 36     | 0      | 3       | 97      | 0     |

As described in the following sections of this report, the state of good repair of the C&S assets are relatively good and the capital renewal costs low compared to that of the other infrastructure asset categories. However, there are C&S assets that are either nearing or beyond their useful service life. For example, the maintenance intensive, air operated switch machines shown in the following picture (left) should be replaced by modern electric switch machines that are more reliable and require less maintenance.

Air Operated Switch Machine



Electric Switch Machine



Other C&S assets that are not in a state of good repair are illustrated by the following pictures of a deteriorated signal case cable and an obsolete interlocking machine.

### Signal Case



### Interlocking Machine



Amtrak also has three centralized electrification and traffic control (CETC) centers that have obsolete computer software systems that need to be replaced with modern server based systems that are more economical to operate and that are easily backed up with a redundant system at a remote location.

### Structures

The following table summarizes the major types of structures that Amtrak owns and where they are located. As it will be shown in the following sections of this evaluation, the existing condition of facilities is a major issue for Amtrak because a major portion of these assets are not in a "State of Good Repair" and the cost to either rehabilitate or replace them will run into the billions of dollars.

### Summary – Structures and Locations

| Asset Description        | Unit    | NEC       | Sp'fld | Albany  | Harris. | Central   | West    |
|--------------------------|---------|-----------|--------|---------|---------|-----------|---------|
| <b>Moveable Bridge</b>   | Each    | 10        | 0      | 1       | 0       | 2         | 0       |
| <b>Signal Bridge</b>     | Each    | 99        | 6      | 2       | 76      | 4         | 0       |
| <b>Bridge Ties</b>       | Each    | 16,417    | 2,500  | 1,700   | 500     | 883       | 0       |
| <b>Undergrade Bridge</b> | Each    | 929       | 77     | 69      | 195     | 57        | 0       |
| <b>Culvert</b>           | Each    | 480       | 120    | 92      | 141     | 67        | 0       |
| <b>Fence</b>             | Feet    | 778,000   | 35,000 | 45,000  | 62,000  | 40,000    | 0       |
| <b>M/E Facility</b>      | Sq. Ft. | 1,258,000 | 0      | 124,000 | 0       | 1,244,000 | 414,000 |
| <b>M/W Base</b>          | Sq. Ft. | 582,000   | 33,000 | 13,000  | 100,000 | 24,000    | 21,000  |
| <b>Station</b>           | Each    | 18        | 7      | 3       | 8       | 269       | 139     |
| <b>Transp. Facility</b>  | Sq. Ft. | 297,000   | 0      | 2,000   | 3,000   | 92,000    | 70,000  |
| <b>Tunnel</b>            | Feet    | 95,973    | 0      | 1,584   | 750     | 0         | 0       |
| <b>Retaining Wall</b>    | Feet    | 74,000    | 2,700  | 0       | 4,000   | 0         | 0       |

Moveable bridges is one of the asset categories that is a major challenge for the Engineering Department because they are critical to the operation of the railroad, the bridges are very old with significant deferred maintenance, and any rehabilitation or replacement program will disrupt the normal operation of the railroad. The bridges are critical to the operation of the railroad since they must open and close reliably up to 3,000 times per year to permit water traffic to pass and avoid delays or disruptions in service to both rail passenger traffic and water traffic. Eleven of the thirteen moveable bridges that Amtrak owns were built between 1901 and 1919 and none of them are in a state of good repair.



As illustrated in the picture on the left of the Thames River Bridge in Groton, Connecticut, moveable bridges are very large, complicated structures with many critical structural, electrical, and mechanical systems.

Since many of these structures are either next to or relatively close to salt water, they are exposed to conditions that accelerate the normal deterioration of steel structures. The picture to the right illustrates the extent of the corrosion that occurs to the stringers of bridges after they have been exposed to these conditions. When these conditions occur, a decision needs to be made whether it is more economical to repair the components of the structure (e.g. bridge stringers) or to replace the entire structure. In some cases, the replacement of the entire structure is warranted when there is extensive deterioration in the other major components of the structure.



Another asset category that is a major challenge to the Engineering Department is tunnels. Amtrak currently has eleven tunnels with a total length of almost 100,000 feet. These tunnels were built in the 1871 to 1934 time period and have experienced problems

with waterproofing, drainage, structural integrity, and lighting. In addition, poor alignment of some tunnels prevents Amtrak's high-speed trains from operating anywhere near their design speed and consequently prevents the company from operating its premium service at its optimal train schedule. The following picture on the left illustrates the extensive deterioration to the concrete lining of tunnels and the picture on the right the fouling of tracks caused by seepage of water into the tunnels. It should be noted that these conditions



create mud spots, defects in track alignment and profile, and accelerates corrosion of critical track components.

Amtrak owns a substantial amount of fixed facilities, such as passenger rail stations, maintenance of equipment (M/E) facilities, and maintenance of way (M/W) facilities (see square footage statistics in table on page 10). Amtrak's major passenger rail stations include Penn Station New York, 30<sup>th</sup> Street Station Philadelphia, Baltimore Penn Station, Washington Union Station, Boston Back Bay Station, Chicago Union Station, Los Angeles Union Station, Seattle King Street Station, and New Orleans Station. The capital reinvestment in these stations has not kept pace with the deterioration of many of the facilities' sub systems. The following picture illustrates the type of deterioration that takes place to sub systems that are critical to the support of the facility super-structure.

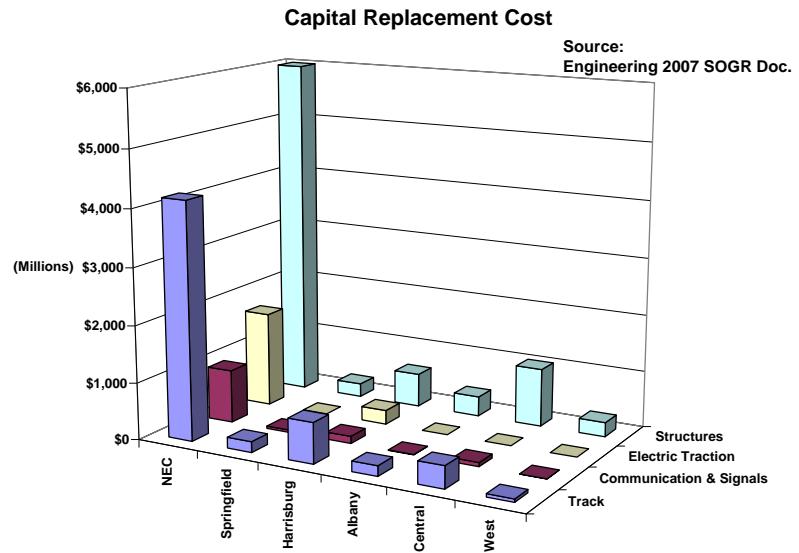
#### Corroded Girder



Amtrak also owns almost 182 miles of fencing and over 15 miles of retaining walls that are included in the inventory of structural assets. Although these are not high-profile assets, the fences are essential to insure the safety of rail passenger operations and the retaining walls are required to support the railroad fill sections. The following picture on the left illustrates a section of right of way fencing that is currently a potential hazard since, in its current condition; it will not adequately deter trespassers from entering the right-of-way. The following picture on the right illustrates the deterioration of a retaining wall that compromises its ability to adequately support the adjacent right-of-way.

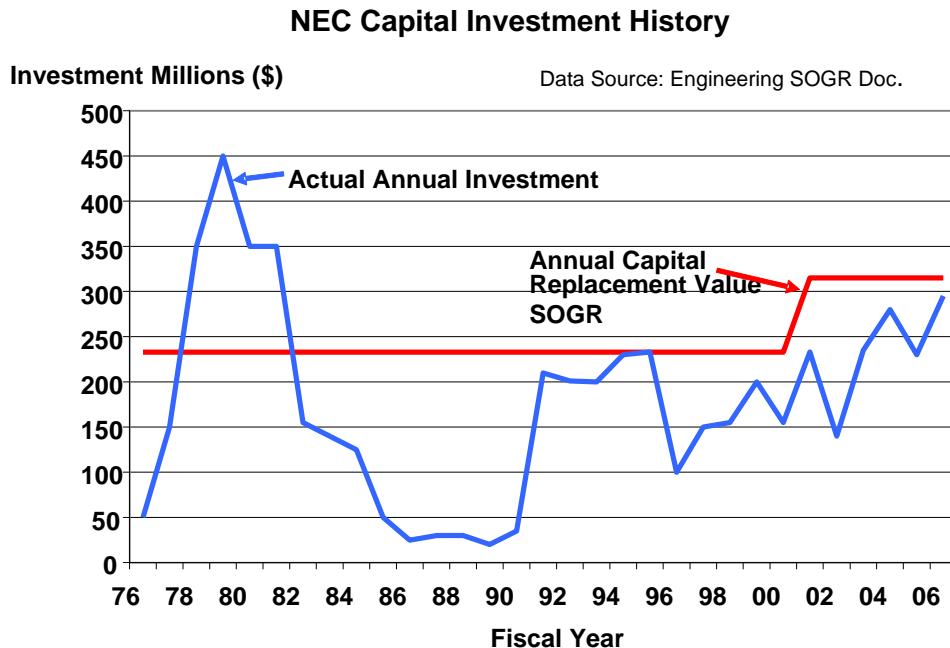


Amtrak's Engineering Department, which issued a report in FY 2007 on the State of Good Repair (SOGR) of the company's infrastructure assets, estimated that it would cost over \$17 billion to replace Amtrak's current infrastructure assets. As illustrated in the following bar graph, the NEC main line has the highest asset replacement cost and its structures account for almost 50% of that value. Structures include all bridges, tunnels, fencing, retaining walls, stations, rolling stock and right-of-way maintenance facilities, offices, and ancillary buildings. Structures account for such a large percentage of the total replacement cost because of the high unit cost to replace the major infrastructure assets of moveable bridges, major stations, and the Baltimore Tunnel. For example, the replacement of the movable bascule of the Thames River Bridge in Connecticut, which is a major but partial rehabilitation of this asset, cost \$76 million to complete. Amtrak owns and maintains 12 other moveable bridges that have similar capital upgrading requirements.



## CAPITAL REINVESTMENT LEVELS

There have been wide variances in the amount of capital reinvested each year to maintain Amtrak's infrastructure assets. These variances have been the product of a combination of when Amtrak acquired the infrastructure assets and the amount of capital funding that was appropriated to Amtrak by the Federal Government. As previously described, the majority of Amtrak's assets are located in the Northeast Corridor (i.e. NEC mainline between Washington and Boston, Springfield Line, Harrisburg Line, and Albany Corridor). In 1976, Amtrak acquired the NEC in a run-down condition due to years of deferred maintenance that occurred while the railroad was under the stewardship of the Penn Central and, for a brief time, Conrail. Subsequent to Amtrak's acquisition of the Northeast Corridor (NEC), the US Congress authorized a \$1.7 billion, five year capital program to reduce deferred maintenance, improve system reliability, and reduce end-point running times in the Northeast Corridor. This investment of capital funds did produce many of the anticipated operating benefits, but this initial infusion of capital funds was not followed up with sufficient levels of capital funding to properly maintain and replace the infrastructure assets as they reached the end of their useful service life. This phenomenon is illustrated in the following graph that compares the actual amount of capital funds that was invested in the NEC infrastructure each year to the amount of capital that would have been required to maintain these assets in a "State of Good Repair."



The blue line illustrates the wide variances in the amount of capital funds that were invested in the NEC each year, which is directly related to the amount of capital funds that Congress had appropriated to Amtrak. The red line is Amtrak's Engineering Department's estimate of the amount of capital that was required in each fiscal year to maintain the railroad infrastructure in a state of good repair. This amount increases in FY 2000 to reflect the

increase in capital assets that occurred from the electrification of the NEC between New Haven and Boston.

It should be noted that the red line estimates the amount of capital that is required each year to maintain the assets at a constant level of "State of Good Repair," but it does not include capital that is required to eliminate any pre-existing levels of deferred maintenance (i.e. infrastructure that are beyond their design service life.) As previously described, the NEC did have a significant amount of deferred maintenance when Amtrak acquired it, and consequently, the red line understates the amount of capital that would have been required to both eliminate the deferred maintenance and continuously maintain the infrastructure assets at a "State of Good Repair."

## STATE OF GOOD REPAIR

Amtrak Engineering has defined that a "State of Good Repair" exists when the infrastructure assets are being maintained/replaced before the assets reach the end of their design life, which means that there is no deferred maintenance of infrastructure assets. Although the design life of an asset may vary because of its specific use (e.g. the design life of rail on straight track vs curved track), it is reasonable to use an average design life when assessing the overall "State of Good Repair" of infrastructure assets and preparing high-level capital funding estimates. This approach was taken by Amtrak's Engineering Department to estimate the relative "state of good repair" of the NEC and the results are summarized in the following table. This table provides both a numeric and color coded identification of the percentage of assets, measured in terms of their replacement cost, that were considered to be in a "State of Good Repair" during FY 2007. That is, 70% of Amtrak's infrastructure

**Infrastructure Condition  
% at State of Good Repair**

Data Source: Eng. SOGR Doc.

|                                     | <b>NEC</b> | <b>Springfield</b> | <b>Albany</b> | <b>Harrisburg</b> | <b>Central</b> | <b>West</b> | <b>Total</b> |
|-------------------------------------|------------|--------------------|---------------|-------------------|----------------|-------------|--------------|
| <b>Track</b>                        | <b>81%</b> | <b>86%</b>         | <b>93%</b>    | <b>88%</b>        | <b>92%</b>     | <b>97%</b>  | <b>83%</b>   |
| <b>Communications &amp; Signals</b> | <b>82%</b> | <b>96%</b>         | <b>95%</b>    | <b>32%</b>        | <b>86%</b>     | <b>5%</b>   | <b>78%</b>   |
| <b>Electric Traction</b>            | <b>54%</b> | <b>NA</b>          | <b>NA</b>     | <b>8%</b>         | <b>NA</b>      | <b>NA</b>   | <b>48%</b>   |
| <b>Structures</b>                   | <b>63%</b> | <b>84%</b>         | <b>88%</b>    | <b>79%</b>        | <b>53%</b>     | <b>63%</b>  | <b>64%</b>   |
| <b>Total</b>                        | <b>69%</b> | <b>86%</b>         | <b>90%</b>    | <b>69%</b>        | <b>65%</b>     | <b>68%</b>  | <b>70%</b>   |

Color Convention:      85% - 100%      60% - 84%      0% - 59%

assets are in a "State of Good Repair" or conversely 30% of Amtrak's assets are beyond their design service life, which is a measure of deferred capital reinvestment (i.e. \$5.2 billion.) This chart illustrates that every infrastructure discipline and every geographical area has deferred maintenance. It also illustrates that, although electric traction has the highest

overall percentage of deferred maintenance, the other infrastructure disciplines had critical levels of deferred maintenance at certain geographical areas (e.g. Communication and Signaling on the Harrisburg Line).

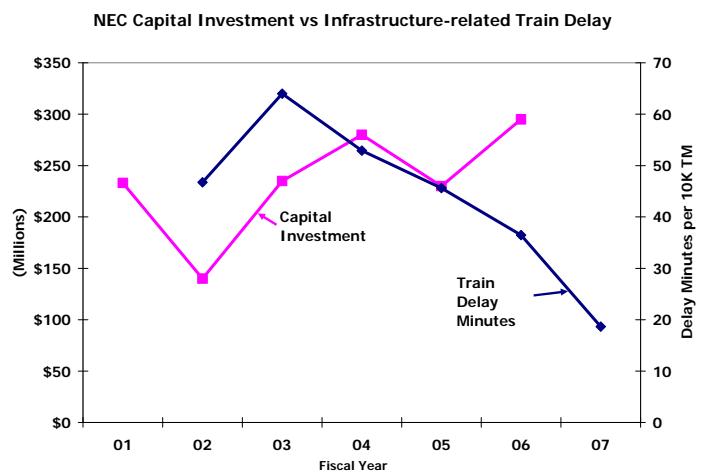
## **INFRASTRUCTURE EXPENSES AND OPERATING RELIABILITY**

There is a close relationship between the condition of a railroad's infrastructure and the railroad's operating and financial performance. The following sequence of relationships describes how the condition of the infrastructure impacts the factors that determine operating and financial performance:

- deteriorated infrastructure conditions will increase the frequency and severity of asset operating failures (i.e. defects),
- the increase in asset defects will increase unscheduled maintenance and the operating expenses required to complete repairs,
- asset defects will also increases the frequency and length of en-route train delays and possibly decrease train operating speeds,
- increases in train delays will negatively impact train on-time-performance (OTP),
- decreases in train operating speeds will lengthen train schedules,
- the combination of poor OTP and longer train schedules will negatively impact train ridership and revenue.

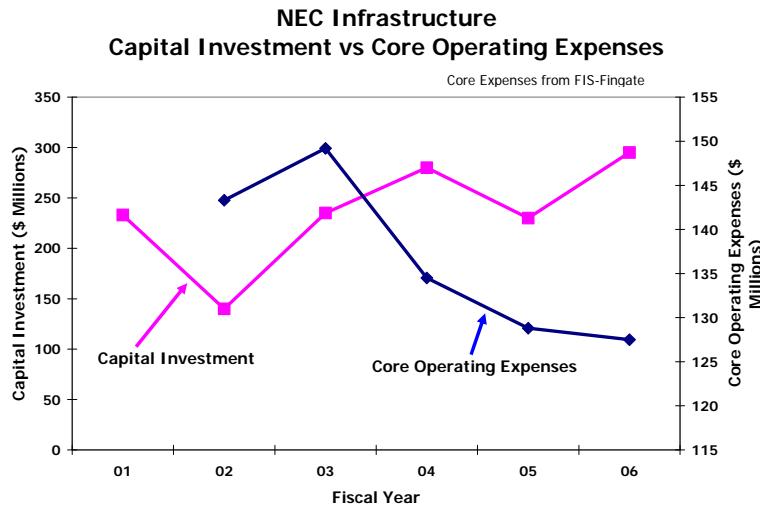
The latter part of this chain of relationships (i.e. relationship between train delays, OTP, train schedule, and train revenue) has been explored in greater detail in Amtrak's OIG Evaluation Report E-09-02 Financial Impact of Equipment Delays.

If it is agreed that infrastructure condition can affect the operating and financial performance of the company, then it should logically follow that increased capital investment in the infrastructure should also have a positive impact on both operating and financial performance of the company. To test this, we first compared infrastructure capital investment levels to infrastructure performance, as measured by infrastructure-related train delays. As shown in the graph to the right, for the time period FY '01 to FY '07, there appears to be a strong correlation between the level of capital funding and infrastructure-related train delays. Upon closer examination, there appears to be a one year time lag between changes in capital investment and changes in infrastructure performance. For example, the decrease in capital funding that occurred from



FY '01 to FY '02 was followed the next year by an increase in infrastructure related train delays (i.e. reduced level of infrastructure performance).

We then compared infrastructure investment levels to core operating expense levels for the FY '01 to FY '06 time period. As illustrated in the following graph, we noted a similar strong correlation between infrastructure capital investment levels and its core operating expenses. Also similar to the previous comparison, there was a one year time lag between changes in capital investment and the corresponding change in core operating expenses.



Although our analysis shows a fairly strong historical correlation between increased capital investment and reductions in both infrastructure-related train delays and infrastructure core operating expenses, capital investment levels should not be considered the only factor in these positive developments. At the same time that the capital investment level was increasing, the Engineering Department was implementing actions to both reduce infrastructure-related train delays and the core operating expense levels. For example, to help improve train OTP, the Engineering Department had established goals for each of its divisions to reduce the defect related delays by infrastructure discipline (i.e. track, ET, C&S, Structures) and these goals are related to the overall OTP goals of Amtrak's Acela train service. Actual performance was measured against these goals on a weekly basis and reviewed at the assistant division engineer level. To improve financial performance, the Engineering Department implemented management actions that helped it to reduce its operating expenses by approximately 11% during this five year time period when the US economy experienced a 14% inflation rate as measured by the Consumer Price Index.

To summarize, our analysis revealed that, historically, increases in capital investment coupled with strong management actions has resulted in significant improvements in infrastructure reliability and financial performance. This appears to be a recipe for future success.

## **SUMMARY – AMTRAK INFRASTRUCTURE**

The review of Amtrak's infrastructure and the history of its capital re-investment provided the following information:

- Amtrak owns and maintains over \$17 Billion (FY '07) of infrastructure assets that are located throughout the United States.
- The majority of Amtrak's infrastructure assets are located in Amtrak's Northeast Corridor.
- Due to past under-funding of capital programs, it is estimated that up to 30% of Amtrak's infrastructure assets are not being maintained in a SOGR and that over \$5.2 Billion of capital funding is required to eliminate the related deferred maintenance.
- Even though there had been a history of under-funding capital program requirements, the recent increases in capital funding for infrastructure programs and the Engineering Department's management actions have contributed towards:
  - an overall reduction in infrastructure related train delays, and
  - an overall reduction in infrastructure operating maintenance expenses.

## INTERNATIONAL BENCHMARKING

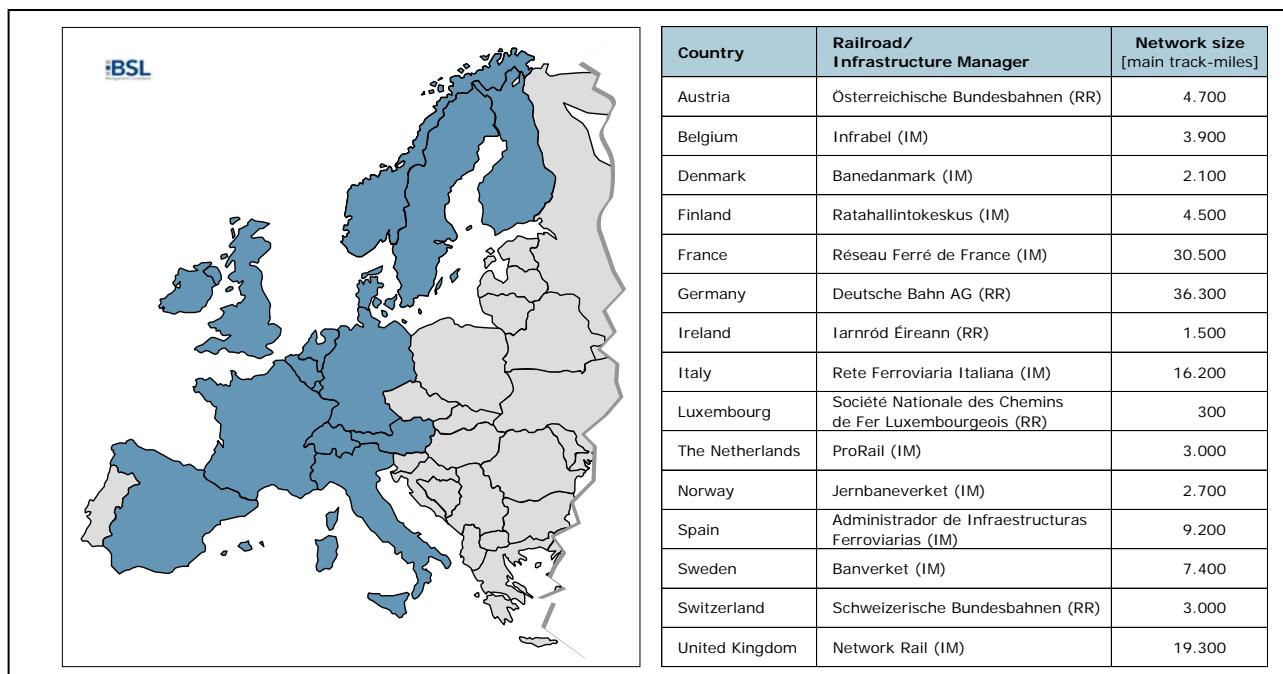
Amtrak's NEC infrastructure maintenance program was benchmarked to the infrastructure maintenance programs of European railroads to identify any significant gaps in the efficiency and effectiveness of Amtrak's program and to reveal any potential areas for improvement. Although there were significant challenges to insure that the appropriate measures were being used to compare infrastructure maintenance programs for railroads of different sizes, operating conditions, and national economic factors, the international benchmarking produced credible results because:

1. Amtrak's asset and operational characteristics match remarkably well with its peer European railroads, and
2. There is an established benchmarking methodology that takes into consideration factors outside the control of the infrastructure maintainer (e.g. currency, purchasing power, labor cost levels, etc.).

## COMPARATORS

The review compared Amtrak's NEC-infrastructure maintenance program to that of fifteen (15) European railroads (see the following illustration and table) that cumulatively account for 144,600 track miles of railroad. This table identifies the infrastructure system managers since, contrary to Amtrak, many of the European countries have separate managers for their rail operations and for their infrastructure operations. All benchmark results have been made anonymous for confidentiality reasons.

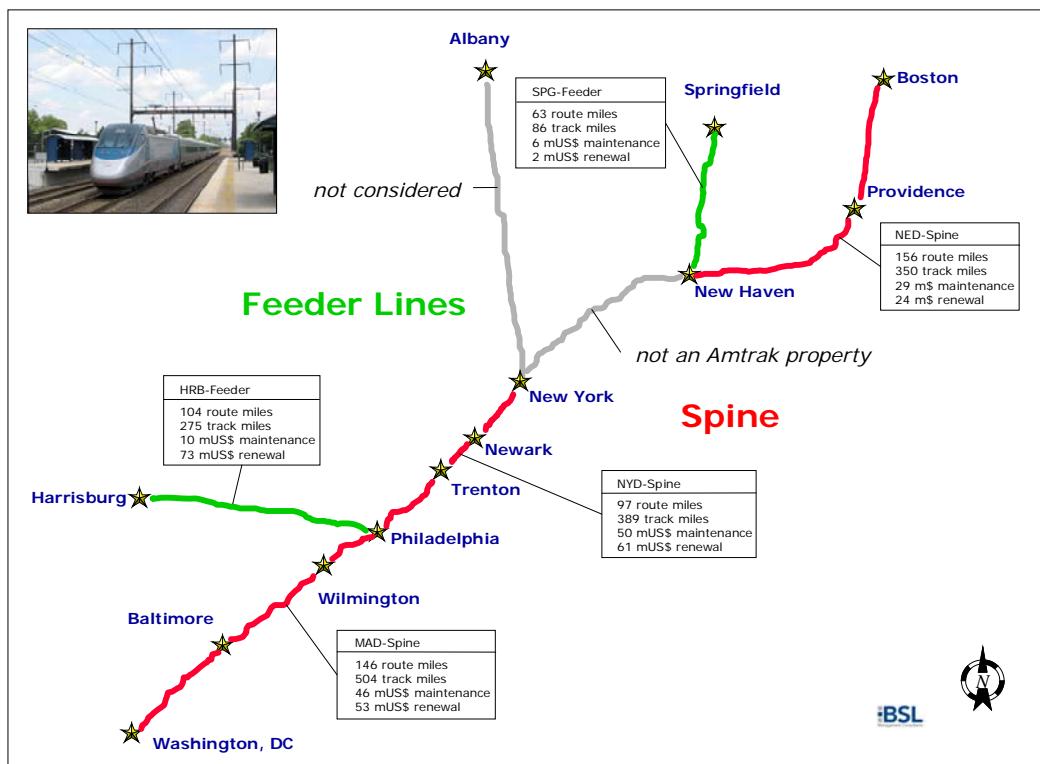
**Amtrak's Peer Railroads in Europe**



Amtrak's OIG contracted with BSL Management Consultants to participate in the benchmarking study since BSL is a European based company with over 12 years of experience benchmarking the infrastructure maintenance programs of European Railroads. BSL has worked with the UIC (Union Internationale de Chemis de Fers – International Union of Railroads) and the European Railroads to develop a comprehensive data base of the European infrastructure maintenance programs. BSL has also developed an agreed upon methodology<sup>3</sup> that normalizes the cost drivers of infrastructure maintenance so that valid comparisons can be made of the maintenance expenditure levels of the various railroads.

The NEC was chosen for the comparison since both its infrastructure and operations are very similar to those of the European railroads. For this comparison the NEC was subdivided into two sections, one designated as "Spine" that includes 1,243 electrified main track miles between Washington, DC and Boston, Massachusetts, the other designated as "NEC" that also includes the 361 main track miles from the two feeder lines to Harrisburg and Springfield for a total of 1,604 main track miles. The map below shows Amtrak's routes as they were considered for the Benchmarking.

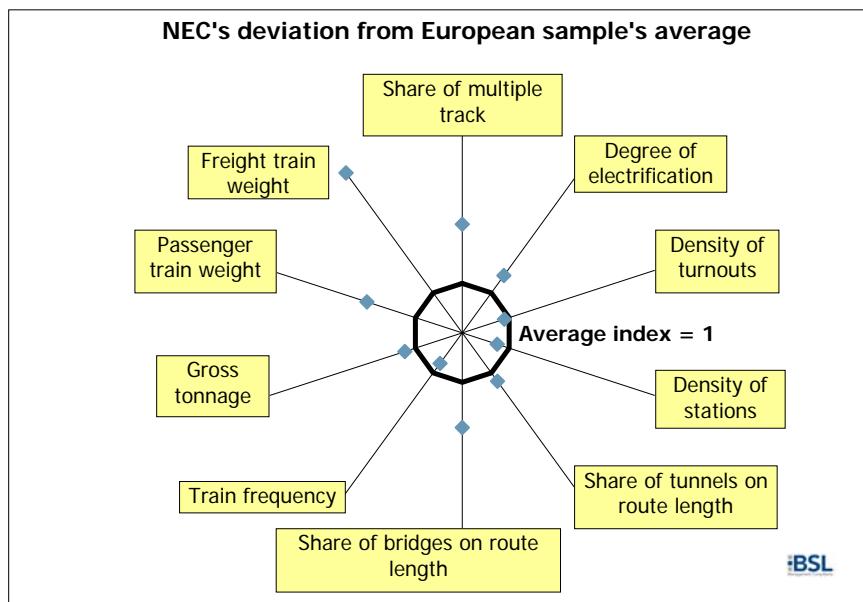
#### Amtrak NEC's Infrastructure as benchmark reference



<sup>3</sup> This methodology is described on page 27 of this document.

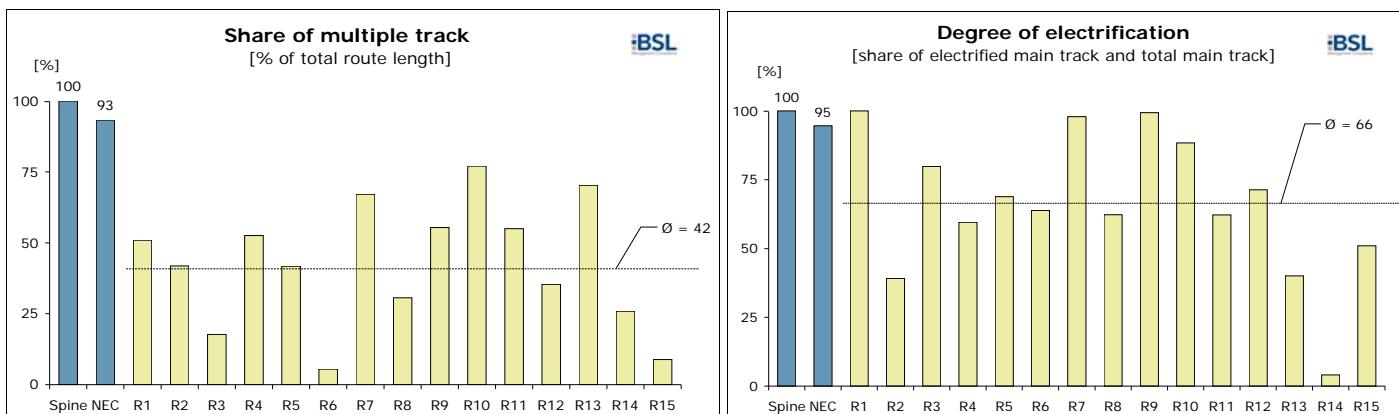
## PHYSICAL PLANT AND OPERATIONS

It is reasonable to compare Amtrak's infrastructure maintenance program to that of its European Peer passenger rail systems since the critical features of Amtrak's NEC physical rail system and its operation are very similar to those of its European Peers and a normalization process can be used to account for any significant variances that do occur in these factors. The following chart illustrates how Amtrak's infrastructure assets and operational characteristics compare to those of the European average for each characteristic. For this comparison, the European averages have been indexed to 1, and Amtrak's value for each characteristic has been plotted relative to the European index. With the exception of Freight Train Weight, most of Amtrak's parameters are very close to that of the European average.

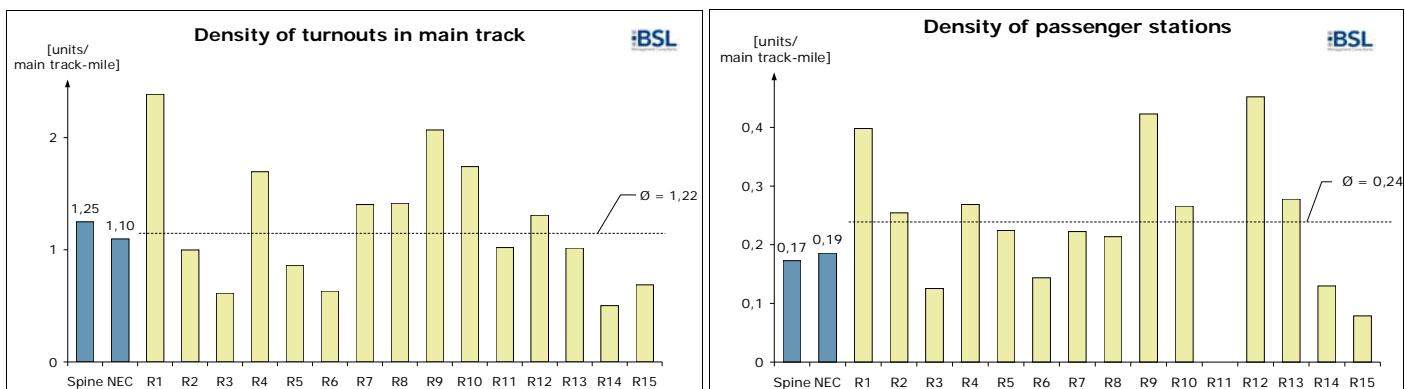


*Note: European values for the asset characteristics and operational parameters have been indexed to 1 and Amtrak's comparable value has been plotted as the blue diamond.*

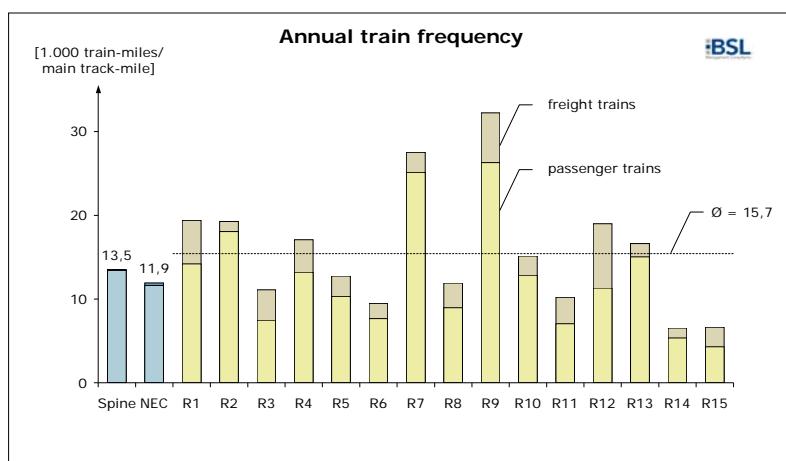
The following series of charts illustrate how the characteristics of Amtrak's infrastructure assets and operations in the NEC compare to that of each European railroad.



The NEC is characterized by a higher percentage of multiple tracks and electrification than the average percentage for the European railroads. However, there are three European railroads that have the same degree of electrification as Amtrak's NEC.

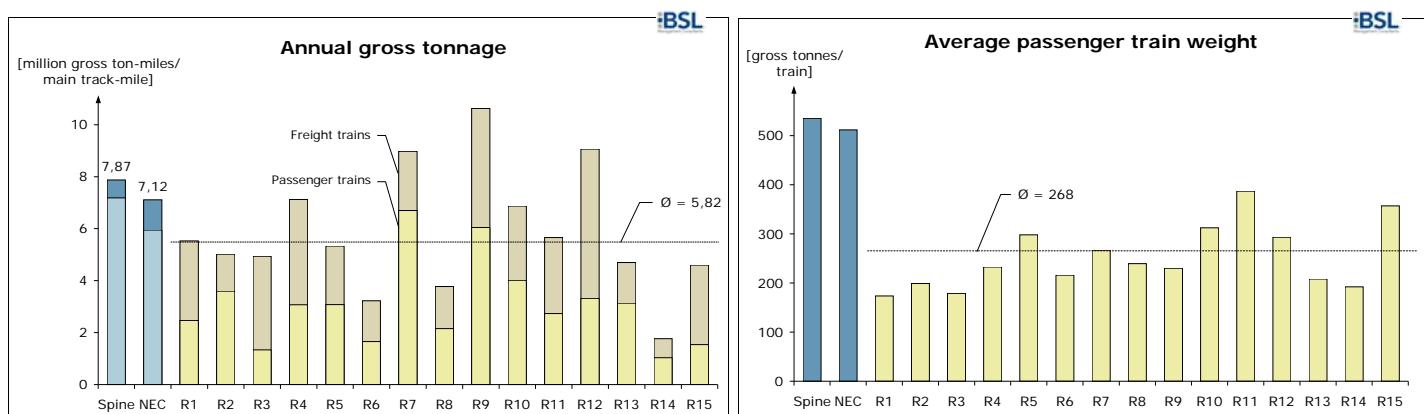


The turnout density describes the average number of turnouts per main track-mile. Here, Amtrak's NEC is very close to the European average. However, the density of stations on the NEC is less than the European average, with some European railroads having more than twice the Amtrak station density.



Similar to the density of passenger stations, the NEC's train frequency, which includes traffic by other operators, is slightly less than the European average, with two European railroads having train frequencies more than twice that of Amtrak. Freight train frequency on the NEC is noticeably lower than that on European RRs.

One of the major cost drivers of infrastructure maintenance is the amount of tonnage operated over the railroad. The following graph (left) shows that the NEC carries above average gross tonnage per track mile compared to European networks. This is primarily due to higher weight of US passenger cars and locomotives, which are roughly double the weight of the European average.

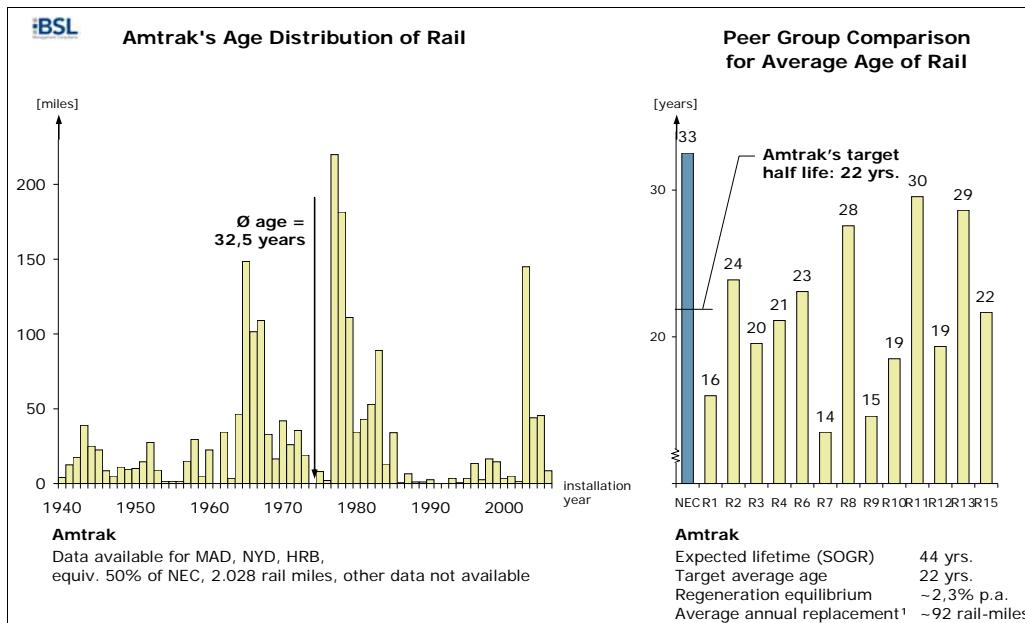


Although there were a few instances where there were significant differences in network and operational parameters, it can be seen that on the average the NEC and European railroad networks match well and build a solid foundation for a cost and performance benchmarking.

## Asset Age Comparison

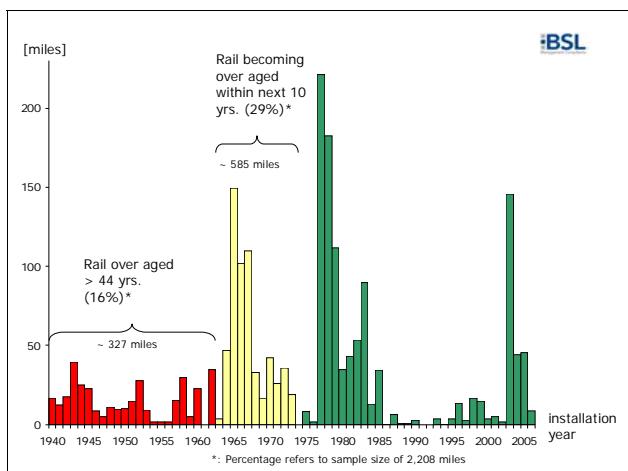
The comparison of infrastructure asset ages is an important element in the benchmarking process since the age of an asset has a significant impact on its maintenance costs<sup>4</sup>, especially when the asset is obsolescent and not in a State of Good Repair. Consequently, the age distributions and average age of Amtrak's major asset groups were compared to that of the European railroads. The following charts and narrative provide an age comparison (as of 2006) of Amtrak rail, turnouts, and under-grade bridges to that of the European railroads.

<sup>4</sup> A description of the relationship between infrastructure asset age and its maintenance costs is included in the discussion on Life Cycle Costs on page 50 of this evaluation.

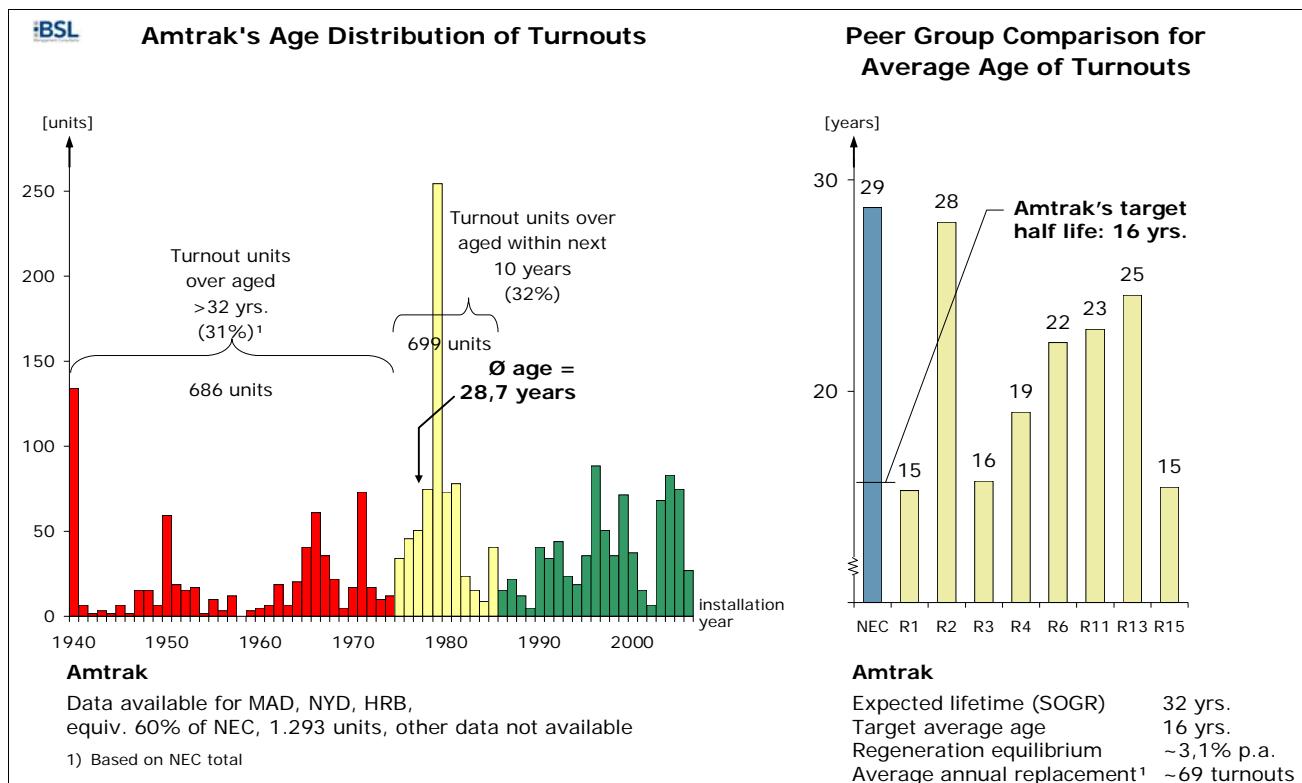


The above graphs illustrate how the age distribution and the average age of rail on Amtrak's NEC compares to that of the rail on the European railroads. It is obvious to see that investments in new rail were not done on a continuous basis, but on an irregular basis when capital funding was available. The investment in new rail funded by the Northeast Corridor Improvement Project (NECIP) in the late 1970's and by the Rail Revitalization and Renewal Act in the 2000's clearly shows up on this graph. The average age of the NEC's rail is 33 years compared to a significantly lower average of 21 years in Europe. Age distributions also reflect how much of the rail is already beyond its service life and how much will have to be renewed within the upcoming years. It should be noted that this assessment of State of Good Repair uses age as the only criteria. In reality, other factors are considered by Amtrak before any rail is renewed. For example, rail in curves do not achieve 44 years of average

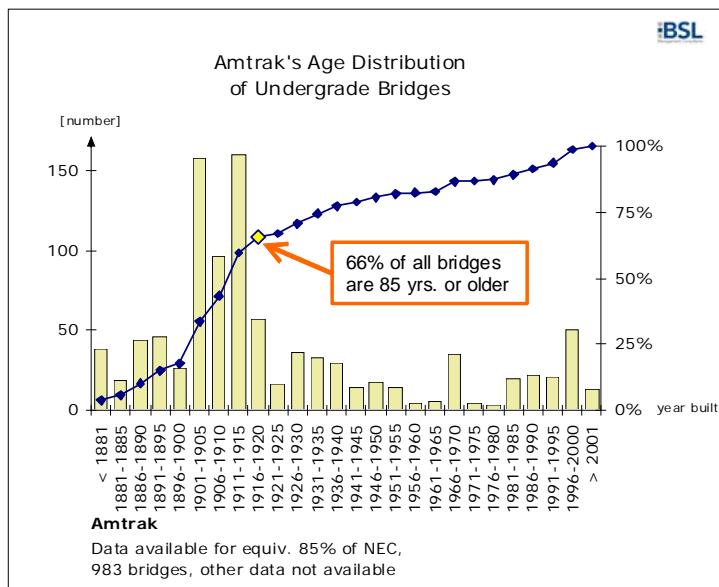
life expectancy due to higher wear while straight rail might have a longer service life. The chart to the left shows the same age distribution, but now highlights (in red) the rail that already exceeds the typical average lifetime of 44 years and how many miles of rail that will have to be renewed within the following ten years (in yellow). The chart above also illustrates the annual rate that rail needs to be renewed on the NEC (92 rail-miles per year) to insure this asset is in a SOGR and not operated beyond its service life.



Similar to track, turnouts in the NEC are a major type of track asset that are on average older than turnouts in Europe. As illustrated in the following charts, the NEC's turnouts are on average 29 years old while the European average is just over 20 years. The age distribution chart shows that the investment in new turnouts peaked during the NECIP when capital funding was available for infrastructure investments. The following Age Distribution Chart also illustrates the 686 turnouts that were beyond their useful service life and should be renewed. Based upon the estimated 32 year service life of turnouts and the roughly 2,200 turnouts that are in the NEC, Amtrak would have to replace, on the average, 69 turnouts per year to maintain these assets in a State of Good Repair. Any replacement rate that is less than this will, in the long term, increase the average age of the turnouts and build up an investment back log.



The age distribution of the approximately 1,000 NEC under-grade bridges is illustrated in the following chart. Although the under-grade bridges have a life expectation of 100 to 150 years, their renewals typically require a long planning horizon and multi-million dollars of capital funding. This chart also illustrates that 2/3 of the NEC bridges are 85 years or older.



In summary, the average age of major Amtrak infrastructure assets are significantly higher than the average age of comparable assets on European railroads, a substantial portion of Amtrak's assets remain in service beyond their expected service life, and up to another 1/3 of these major assets will be reaching the end of their expected service life over the next 10 years.

## BENCHMARKING METHODOLOGY

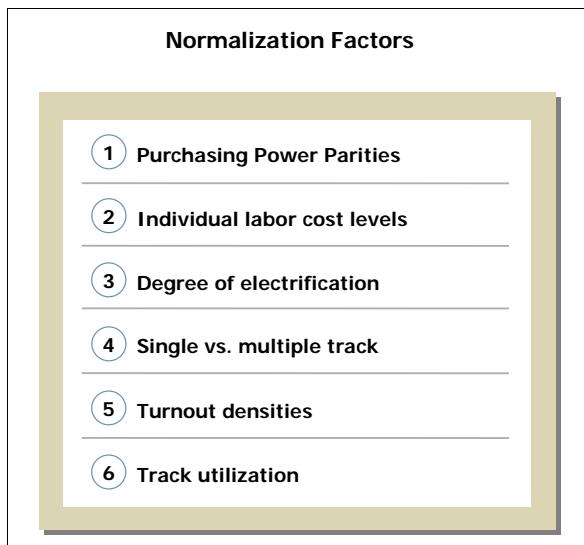
The objective of the benchmarking process is to compare Amtrak's infrastructure maintenance costs to the infrastructure maintenance costs of comparable railroads. The infrastructure maintenance costs include all operating and capital expenditures required to maintain the base rail line (i.e. excludes new construction for expansion or increased capacity). The infrastructure assets include track, communication and signaling, electric traction, and bridges & tunnels. The benchmarking excludes the infrastructure maintenance related to fixed structures, such as stations and office buildings, since the data base of European infrastructure maintenance did not include these expenses.

The benchmarking approach quantifies the infrastructure maintenance cost as the sum of all annual expenditures and a multi-annual average of capital investment expenditures for the defined infrastructure assets. A multi-year average is used for the annual capital investment to take into consideration the often wide variances in annual capital investments that have historically occurred due to irregular levels of capital budgets. The amount used for the capitalized renewal expenses is based on the average of five years of actual capital

expenditures. This is an acceptable approach to estimate the average annual capital expenditure since the size of the network includes a statistically significant number of assets and the regeneration cycle for the asset renewals is very long. This is the same approach that has been used in many successful UIC benchmarking projects.

## NORMALIZATION PROCESS

Although Amtrak's infrastructure characteristics and operations are very similar to that of the average characteristics of European railroads, any differences in network configuration or system operation could cause maintenance costs to vary and, therefore, could possibly skew any benchmark results. For example, if railroad A has double the number of turnouts per main track-mile than railroad B, railroad A would have higher maintenance costs. A cost normalization process will adjust a railroad's maintenance cost level by taking into consideration the different network configurations and system operations. Normalized costs reflect what a railroad's specific cost level would be if it operated under the circumstances of the reference railroad. For this comparison Amtrak is the reference case, so all benchmark partners' costs were normalized to Amtrak's specific characteristics for the parameters shown in the following chart.



Consequently, after the normalization process the infrastructure maintenance cost per main track-mile for the European railroads will be reported as if:

- the railroads had a common purchasing power parity with the US
- the company's labor costs matches Amtrak's labor costs
- their degree of electrification was 95% as on the NEC
- their network had 93% multiple track as on the NEC
- their turnout density was 1.1 turnouts per main track-mile
- their train frequency was 11,900 trains miles per track mile, and
- their annual gross tonnage was 7.12 million gross ton miles per main track-mile.

Each normalization step is a conversion with individual formulas based on experience or regression analyses developed in the UIC benchmarking approach. It is important to point out that the normalization procedure only harmonizes external factors that cannot be directly impacted by the Engineering Department's maintenance programs.

## RESULTS

The benchmarking results have been subdivided into two sections.

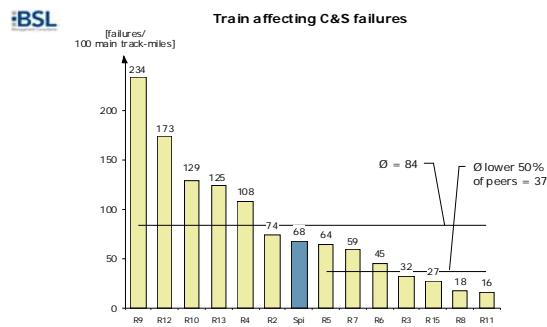
1. The first section compares the performance of Amtrak's infrastructure to that of its European peer railroads.
2. The second section compares Amtrak's infrastructure maintenance cost levels to that of its European peer railroads.

### Performance

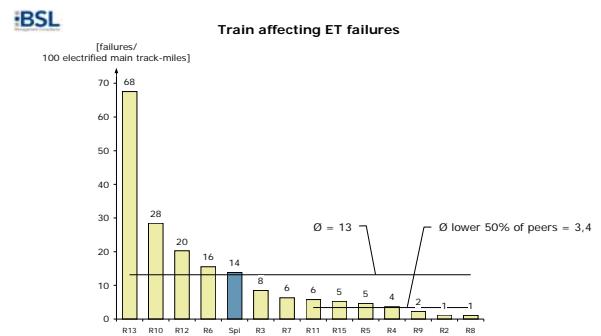
Although there was not a significant amount of data available regarding the performance of European infrastructure, the data that was available indicated that Amtrak's infrastructure performed as reliably as, if not more reliably than, the infrastructure of its European peers. The relative performance of the countries' railroad infrastructure was compared based upon the reliability of these assets and its ability to support the on-time-performance of passenger trains. The performance of the Communication & Signaling and the Electric Traction systems are measured as the number of annual failures that impact train on-time performance per 100 main track miles. The performance of the track system is measured as the percentage of the network that has been impacted by temporary speed restrictions due to poor track quality.

As illustrated in the following chart on the left, the NEC's Communication & Signaling failure rate is slightly below the European average and the chart on the right illustrates that the NEC's ET failure rate matches the European average failure rate.

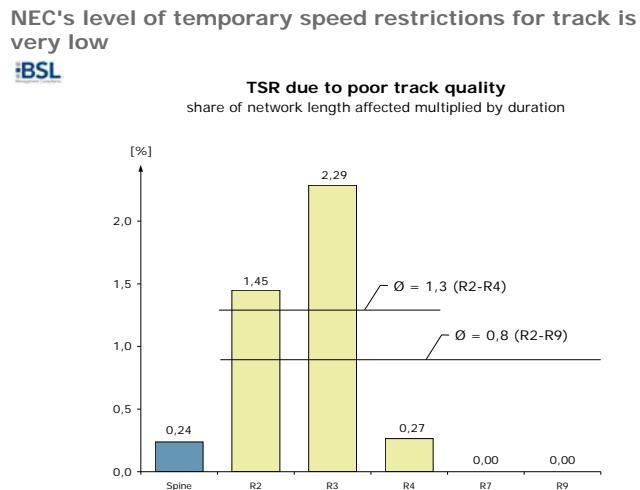
The NEC's C&S failure rate is slightly below European average, good practice is still significantly lower



For NEC's ET the failure rate matches European average, some peers have very low failure levels



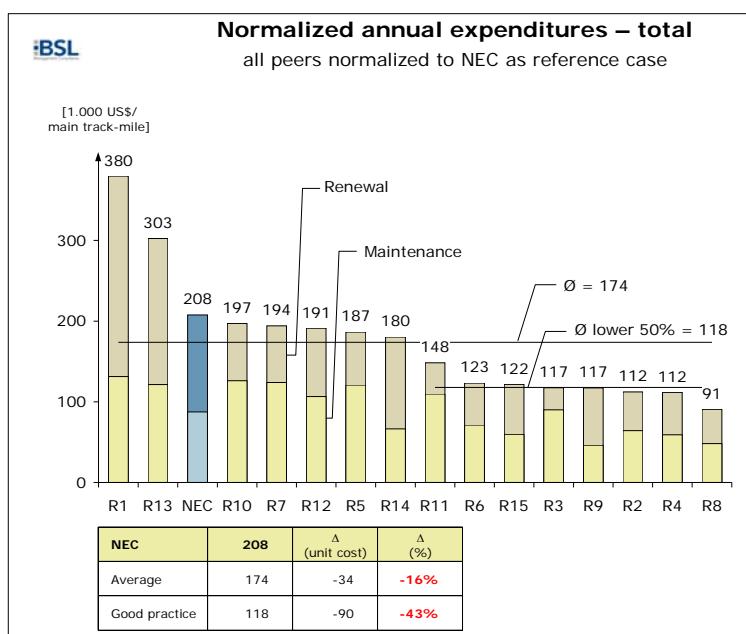
There was less data available from the European railroads on track reliability. However, as illustrated in the following chart, the NEC's level of temporary speed restrictions for track is very low compared to some of the European railroads that reported the related statistics.



As previously stated, the data that was available from the European railroads indicated that Amtrak's infrastructure performed as reliably, if not more reliably, than the average of its European peers.

### Maintenance Cost Level

At the summary benchmarking level, Amtrak's overall expenditures for NEC infrastructure maintenance are 20% higher than the average normalized level of the 15 peer European Railroads. As illustrated in the following BSL graph, Amtrak's annual renewal and maintenance expenditures amount to



\$208 thousand per main track mile while the European railroads amount to an average of \$174 thousand per main track mile, with individual RR costs ranging from \$91 thousand to \$380 thousand per main track mile. This comparison includes both operating and capital expenditures on infrastructure maintenance to insure that all expenses are included in this comparison and avoids any issues related to different accounting rules for capitalizing expenses. It should be noted that this comparison cannot be

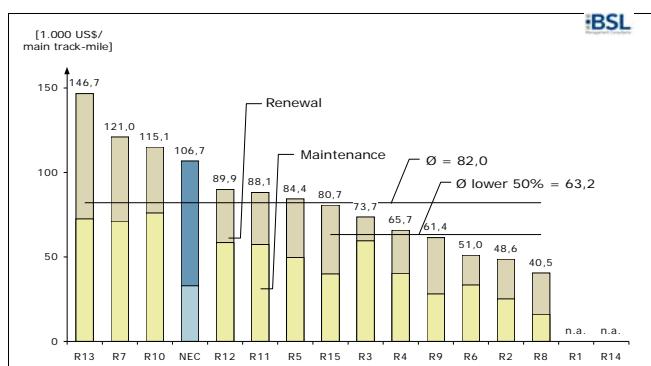
used to make any conclusions about the relative efficiency of the maintenance programs since factors, such as the relative levels of deferred maintenance, plays such a significant role in determining both the levels of renewal and maintenance expenditures.

The cost performance of the railroads can be grouped in basically three cost level clusters. The "lower 50%", representing half of the sample with the lowest annual expenditures, vary between \$91 thousand and \$148 thousand with an average of \$118 thousand per main track mile. This level of expenditures, which can be defined as the "best practice" maintenance level, is over 40% lower than Amtrak's expenditures for the NEC. The second cluster, which includes Amtrak, has expenditure ranges from \$180 thousand to \$208 thousand per main track mile. All these railroads have a relatively equal cost performance. Then finally, two railroads stand out with high expenditure levels above \$300 thousand per main track mile.

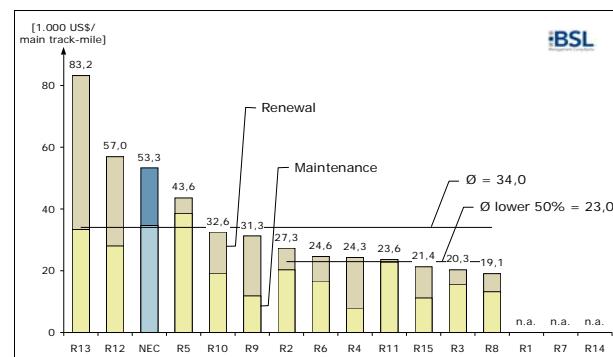
If Amtrak performed infrastructure maintenance on the NEC at the average expenditure levels of the European peer railroads, it would be able to reduce its average annual expenditure levels by over \$50 million and if it could perform at the average level of the lower 50% of the European peer railroads, it would be able to reduce its annual expenditure level by almost \$150 million.

The following four charts, which utilize the same graphical conventions as the previous chart, illustrate how Amtrak's four disciplines of infrastructure maintenance (i.e. Track, Communications & Signals, Electric Traction, and Structures) compare on a 1,000 \$ US/main-track mile basis to that of European railroads.

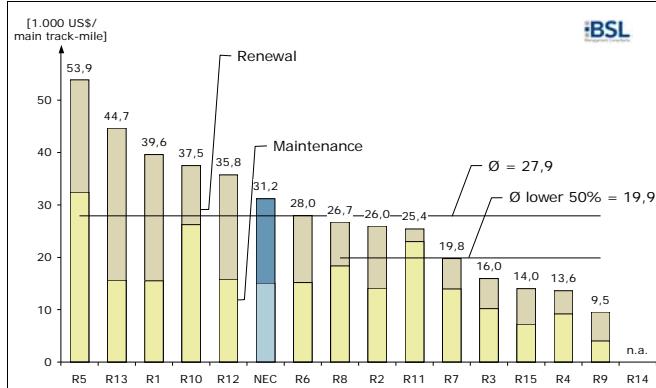
Track



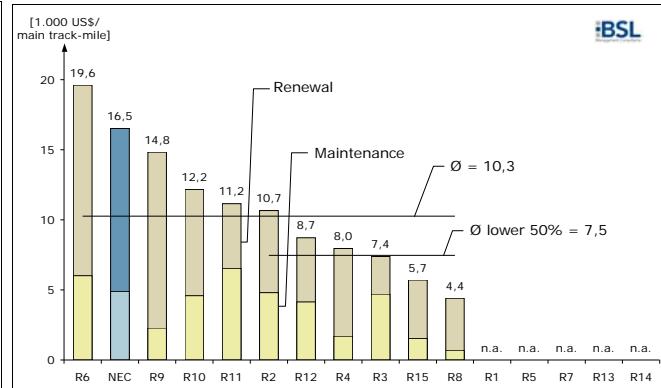
C&S



## Electric Traction

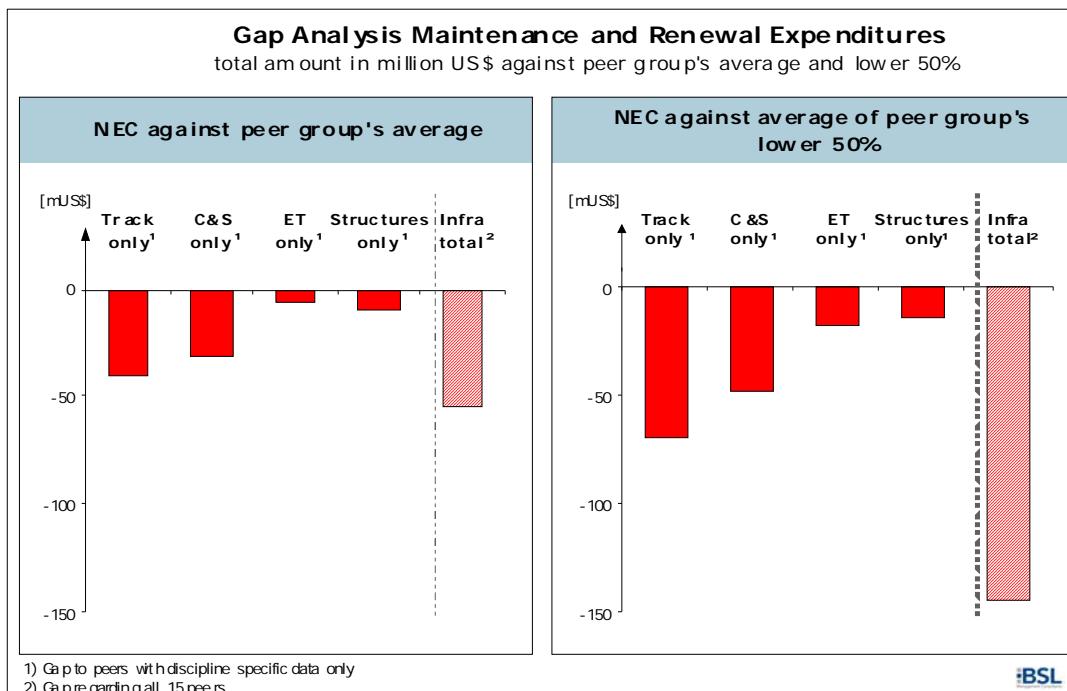


## Structures



That is, for each of the infrastructure disciplines, there is a gap between Amtrak's level of operating maintenance and capital expenditures and that of the European peer group. As previously stated, these comparisons of summary cost metrics do not determine which maintenance programs are being managed effectively, but they do indicate the level of savings in infrastructure maintenance expenses that Amtrak could attain by performing at the level of its European peer group.

The previous four charts are summarized in the following BSL gap analysis chart that identifies the variance between Amtrak's maintenance cost level and that of the European average maintenance cost level (on the left) and that of the "best practice" maintenance cost level for each infrastructure discipline (on the right). The annual cost per track mile of Amtrak's Track and C&S maintenance programs have the largest gap to the European peer group, which highlights them as priority disciplines for necessary improvement activity.



## **SUMMARY – INTERNATIONAL BENCHMARKING**

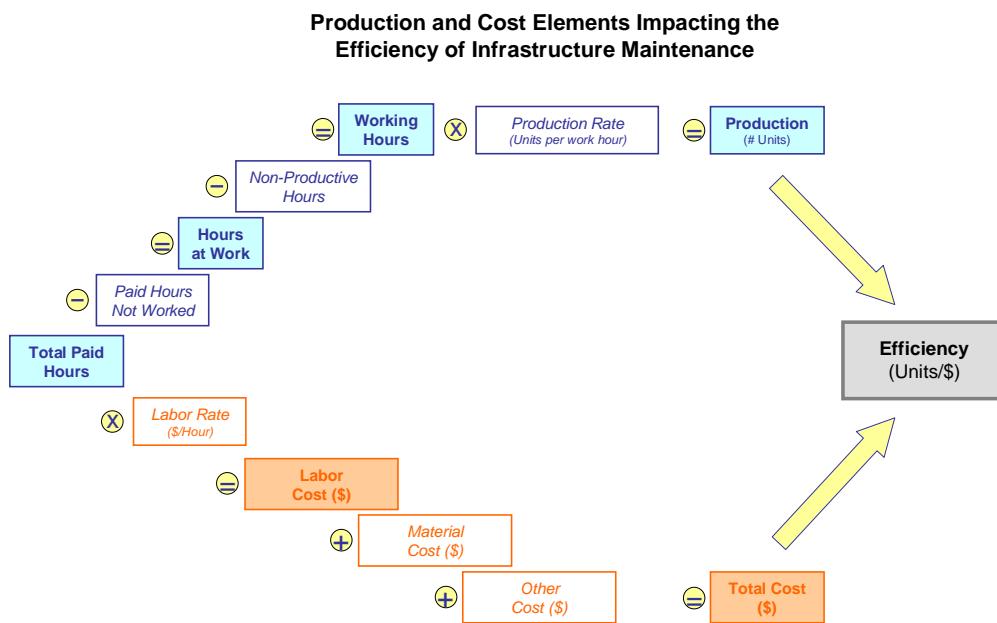
The benchmarking of Amtrak's infrastructure maintenance program to that of the European RRs revealed the following summary findings:

- The physical and operational characteristics of Amtrak's NEC are remarkable similar to those of the European RRs, although there were a few instances where there were significant differences (e.g. freight and passenger train weight.)
- The average age of major NEC asset groups is significantly higher than the average age of comparable European RR infrastructure assets.
- Amtrak's major infrastructure asset groups performed as reliably as the average European infrastructure performance.
- Amtrak spent approximately 20% more than the average European RR and 40% more than the "lower 50%" of the European RRs to maintain its NEC infrastructure assets.
- If Amtrak performed infrastructure maintenance and renewal on the NEC at the average expenditure levels of the European RRs, it would be able to reduce its average annual expenditure levels by over \$50 million, and if it could perform at the average level of the lower 50% of the European RRs, it would be able to reduce its annual expenditure level by almost \$150 million. The estimated \$50 million to \$150 million performance gap is based upon Amtrak's total operating and capital expenditures related to the maintenance and renewal of NEC infrastructure assets.

## FINDINGS AND RECOMMENDATIONS

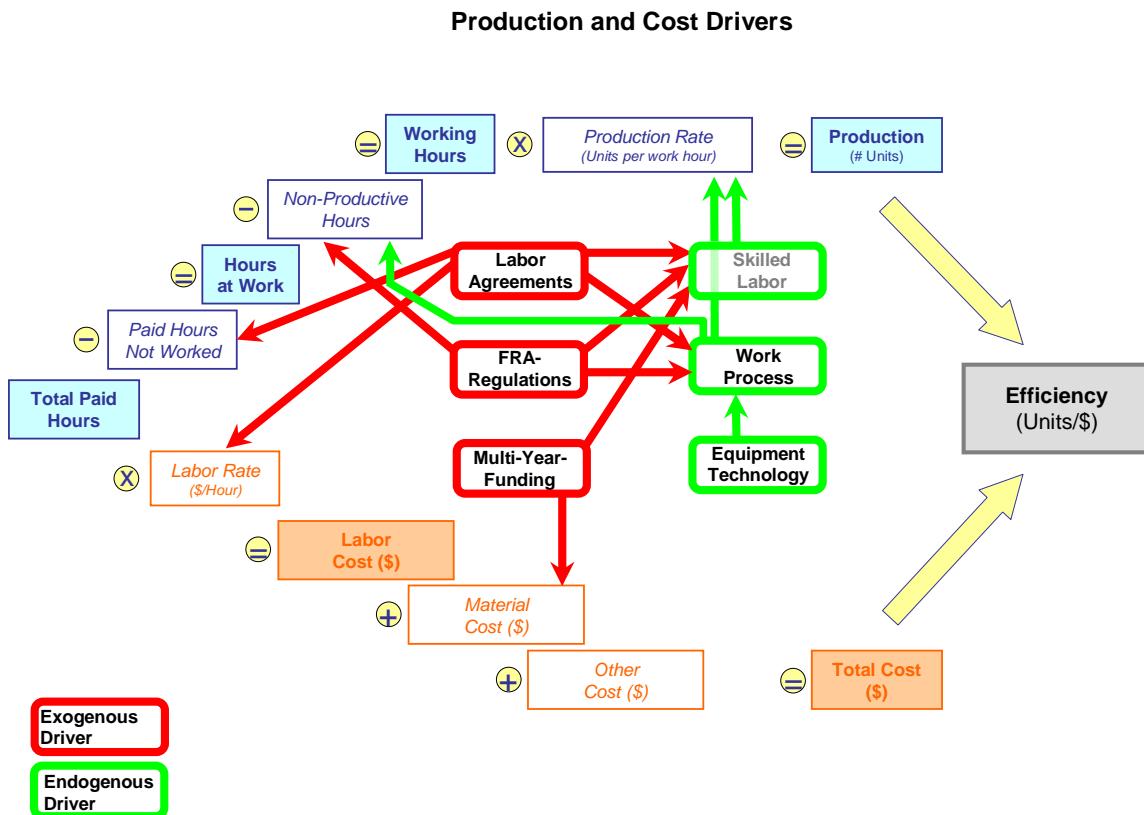
### CAUSAL FACTORS IMPACTING EFFICIENCY AND EFFECTIVENESS

Although there are numerous ways to define and measure efficiency, they all include measures of output (i.e. a desired product or outcome) and input (i.e. the amount of effort, expense, energy, etc.) that are required to produce the output. For the purposes of measuring the efficiency of Amtrak's Infrastructure Maintenance Program, it is reasonable to measure efficiency in terms of the units and the cost of production. The following flow chart is a Dimensional Analysis that illustrates how the basic production and cost elements interrelate to generate an efficiency metric.



These production and cost elements were identified by Amtrak's Engineering staff as the critical elements that determine overall maintenance efficiency. It should be noted that these same elements were identified by the European Infrastructure Maintainers during our review of their "best practices." For example, all infrastructure maintainers want to maximize the number of working hours of each infrastructure maintainer. There are various methods and technologies available to accomplish this objective, which will be described in the following sections of this evaluation's findings.

In addition to identifying the production and cost elements, we also identified the endogenous (i.e. controlled by Amtrak Engineering) and exogenous (i.e. outside the control of Amtrak Engineering) factors that impact the production and cost elements that determine maintenance efficiency. These production and cost drivers have been added to the following Efficiency Dimensional Chart to illustrate how the endogenous drivers (green) and the exogenous drivers (red) impact each element of the Dimensional Chart. It can be seen that some of the drivers impact more than one of the dimensional elements and consequently have a greater impact on infrastructure maintenance efficiency. For example, the availability of multi-year funding impacts Amtrak's ability to attract and retain a skilled labor force and it also impacts Amtrak's ability to negotiate the optimal contract terms for long lead material items.



Our findings and recommendations are organized around the major endogenous cost drivers of skilled labor, work processes, and equipment technology and the exogenous factors will be discussed as they relate to each of these cost drivers.

## **WORK PROCESSES**

Our evaluation of Amtrak's infrastructure maintenance program revealed that significant opportunities exist to improve Amtrak's production rate (i.e. units per work hour) by improving its infrastructure maintenance work processes. As illustrated in the flow chart on page 35, the level of production from Amtrak work forces is a function of how many hours that are actually worked and the work force productivity, as measured by the number of units produced per labor hour. Production per work hour is driven by a combination of the skill level of the workforce, the type of maintenance technology, and the processes used to perform the maintenance work. Listed below are six findings and recommendations related to Amtrak's opportunities to improve maintenance processes.

**Finding No. 1 – Amtrak could benefit from having a comprehensive Infrastructure Asset Management process in place that would enable the company to plan for and implement optimal maintenance and renewal programs.**

### **Discussion**

The Asset Management Primer<sup>5</sup> issued by the US Department of Transportation states that asset management "*is a systematic process of maintaining, upgrading, and operating physical assets cost-effectively. It combines engineering principles with sound business practices and economic theory, and it provides tools to facilitate a more organized, logical approach to decision-making. Thus, asset management provides a framework for handling both short- and long-range planning.*" The two key objectives of asset management are to:

- 1) provide the type, quantity, and quality of assets that are required to support the corporation's strategic operating plans, and
- 2) provide these assets in the most cost-effective way.

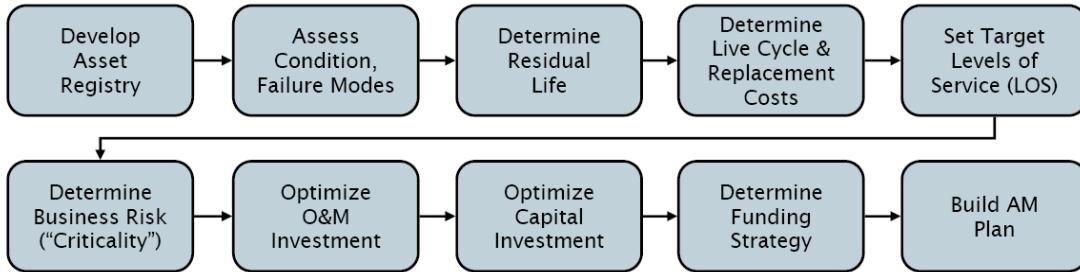
### **Asset Management Process**

Our review of the literature on asset management revealed that, although there are various methods of describing the asset management process, they all included the basic functions illustrated in the following process flow chart.

---

<sup>5</sup> Asset Management Primer, US Department of Transportation, December 1999

## Asset Management Process Model



This process produces an asset management plan (AM) that takes into consideration:

- the Level of Service required to support the strategic operating plan
- the current state of infrastructure assets
- the critical assets required for sustained performance (i.e. risk factors), and
- the optimal capital investment and maintenance strategies based on "life-cycle costs".

It should be pointed out that asset management is a data intensive process that is dependent upon having both an up-to-date asset registry and the ability to analyze the available data to optimize the financial and operating benefits of the asset management programs. The asset register typically includes the following information:

- description (e.g. asset no., purchase date, drawings, contracts, pictures, etc.)
- location (e.g. GPS mapping, address)
- purchase costs
- annual depreciation
- accumulated depreciation
- maintenance costs
- condition
- performance
- use (e.g. gross ton miles per year)
- estimated service life
- actual, condition adjusted service life

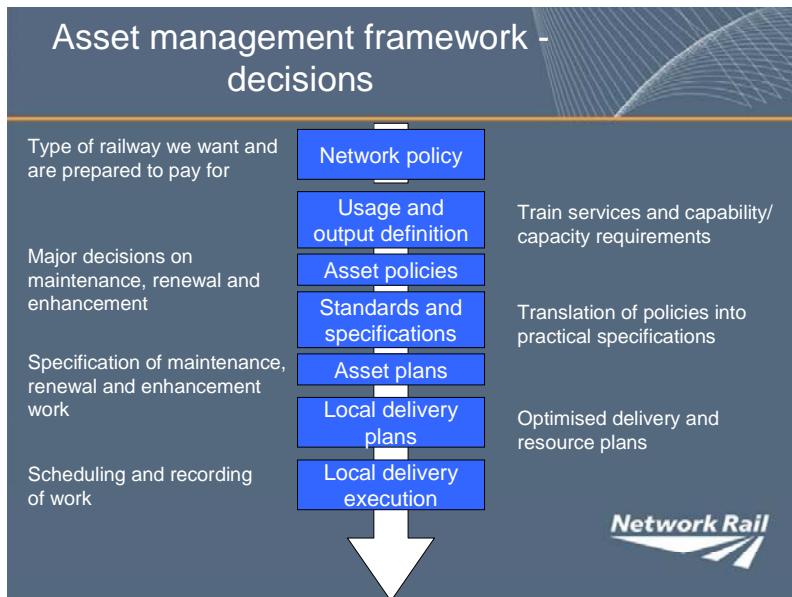
The analytic capabilities required by this process include:

- the estimation of the expected and actual residual life time infrastructure assets. This is usually done by means of decay curves that are devised from condition ratings and usage over many years of observations
- life-cycle-cost models
- asset performance models
- failure and risk assessments
- evaluation tools for modeling different scenarios for maintenance, refurbish, and replacements alternatives.

## Observations in Europe

The majority of the European infrastructure maintainers we visited used sophisticated infrastructure asset management processes to help them optimize the maintenance and renewal programs of the infrastructure assets that are required to support the corporation's strategic operating plans.

A prime example of how a European infrastructure maintainer coordinates its decision making process is illustrated in the following asset management decision process used by



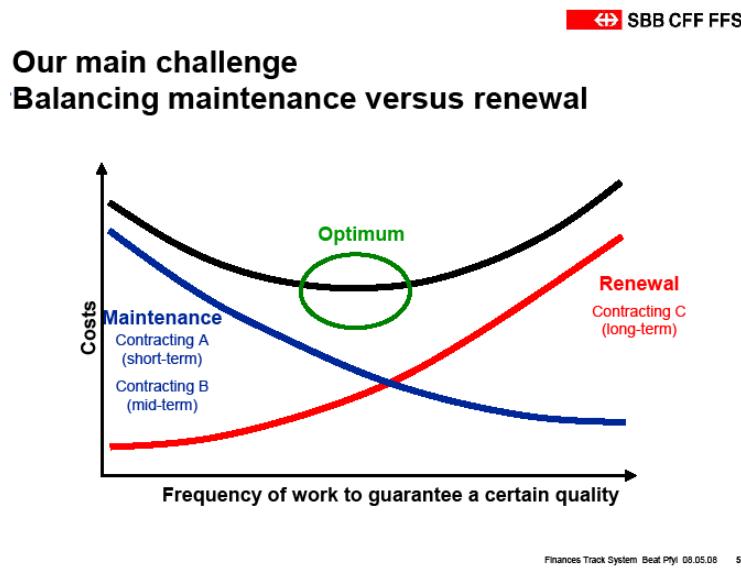
NetWork Rail. It shows how the decision process begins on a strategic policy level and leads down to the operational execution level. It can be seen that this process coordinates all asset management decisions to optimize the programs that will provide the infrastructure assets required for the company's planned rail operations.

NetWork Rail's Engineering Data Center (EDC) plays a critical role helping the company to attain its goal of transforming the company from a find and fix philosophy to a predict and prevent philosophy. NetWork Rail has concluded that switching to the new maintenance philosophy has enabled them to improve the reliability of their infrastructure assets and to optimize the efficiency of their maintenance programs. As an example of their improved infrastructure reliability, NetWork Rail provided the following chart that illustrates how the quality of their track structure, which is measured as level 2 deviations from standard per mile, improved since they have implemented this process. The EDC ensures that the investment of capital and operating funds are optimized by scheduling asset replacements and renewals, labor, machinery, and track outages to minimize the life cycle costs of the infrastructure assets. It should be noted that, to be able to perform the planning and scheduling of infrastructure maintenance, an asset

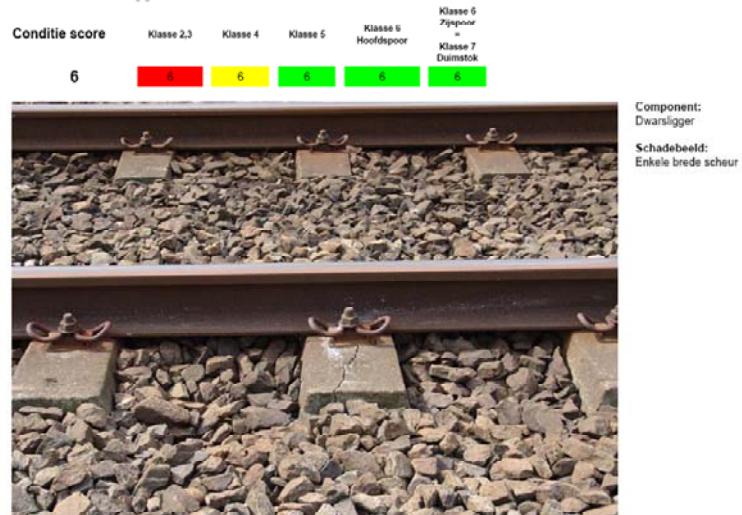


data base must be available that provides a readily available record of the condition, performance, use and maintenance expenses of all infrastructure assets.

SBB in Switzerland is another European railroad that makes a conscious effort to optimize its infrastructure maintenance and renewal expenditures. They have developed an optimization model to find the cost-optimal balance of maintenance, refurbishment, and renewal at predetermined performance levels. The chart to the right illustrates how SBB optimizes the life cycle costs of its infrastructure assets, although the actual modeling is far more complicated and detailed than that shown in this chart.

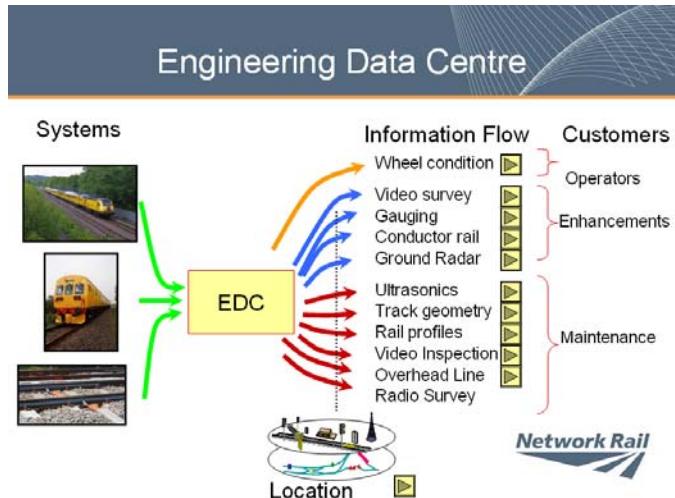


ProRail in the Netherlands also has an asset management system in place that helps to determine the optimal asset decisions to attain the company's corporate strategies. This was accomplished by defining the relationship between maintenance activities/costs and asset performance, the relationship between asset performance and operating performance, and the life cycle costs of those assets which is very similar to the process that SBB uses. For example, as shown in the picture on the left, ProRail's asset management system includes up-to-date pictures of its infrastructure assets and an assessment of its current condition. This information is cataloged geographically to support engineering decisions related to prioritizing projects and to phasing work to optimize the efficient use of labor, equipment, and track time.



As previously mentioned, to be able to optimize the infrastructure maintenance programs, the railroads need to have a data base that provides a readily available record of

the condition, performance, use and maintenance expenses of all infrastructure assets. Network Rail in England, as illustrated in the flow diagram to the right, uses state-of-the-art technology to measure the condition of its infrastructure assets and then efficiently transfers this data to its asset registers, which are managed by its Engineering Data Center, to provide up-to date reports on asset condition. This information is used, in combination with the other asset register data, to make informed decisions related to the maintenance, upgrading, or replacement of infrastructure assets and the scheduling of any related work.



Banverket of Sweden uses a web-based asset management system (BMS) developed by Vagverket (the Swedish National Road Administration) to manage its infrastructure assets, with modules for technical and administrative data, inspections, planning, maintenance records, and documents. A condition class rating for every asset defect is used as a first step in screening structures for repair, rehabilitation, and replacement. Currently, Banverket bridge managers use their experience to prioritize projects, but a BMS module is being prepared that will use present value calculations to determine optimal maintenance/renewal/replacement strategies.

During our visits to the European Railroads, we observed many examples of how they have developed and effectively use an extensive database on the condition of their bridges. For example, SBB and NetWork Rail have programs that provide up-to-date information of asset condition through their inspection program, grade the assets based upon their condition, develop the maintenance priorities based upon asset condition and use (e.g. type or rail line), determine optimal level of maintenance/renewal, and then schedule the maintenance/renewal work to minimize the impact on rail operations and to optimize the efficiency of the maintenance/renewal work. To obtain and record the condition of their bridges, SBB utilizes specially trained engineering employees (i.e. must pass qualification training and testing) to perform regular inspections of all bridges and their supporting structures and record their findings on computers while in the field. As illustrated in this picture, an SBB employee is recording the results of his inspection of the masonry support piers of a bridge while suspended under the bridge. This process improves the reliability and timeliness of the bridge inspections since the inspection conforms to the standard inspection process, the results are input on site, and it avoids transcription errors that might occur when manual reports are re-entered into an asset data base.



NetWork Rail utilizes the results of its inspection reports to rate the condition of its bridges and then these ratings are used along with data on route/service type, material type, deterioration rates, and required strength to decide on the proper maintenance intervention (i.e. replace, strengthen, repair, waterproof, etc.) As previously stated, NetWork Rail's philosophy is to predict and prevent infrastructure asset failures and this process provides them the basic information and disciplined process to accomplish it. Completing the appropriate type or inspection at the proper frequency (i.e. time interval) is a critical element of NetWork Rail's overall program. Amtrak will consider if any portion of NetWork Rail's, as well as other European infrastructure maintainer's, inspection program should be adopted by Amtrak.

In addition to the information we obtained from the European Railroads that we visited, we learned that the UIC (Union Internationale Des Chemins De Fer) has completed a 4-year project addressing the maintainability of bridges in Europe. This project has produced a wealth of information on the methods and processes available to optimize the maintenance, renewal, and replacement programs of railway bridges. The UIC study has incorporated the actual bridge inventory of 20 railroads and the technical expertise of 84 Institutes (e.g. University of Queensland, University of Maryland, etc.) and Companies (e.g. Portland Cement Association, Laboratoire Central des Ponts et Chaussees, etc.) to research the following subject areas.

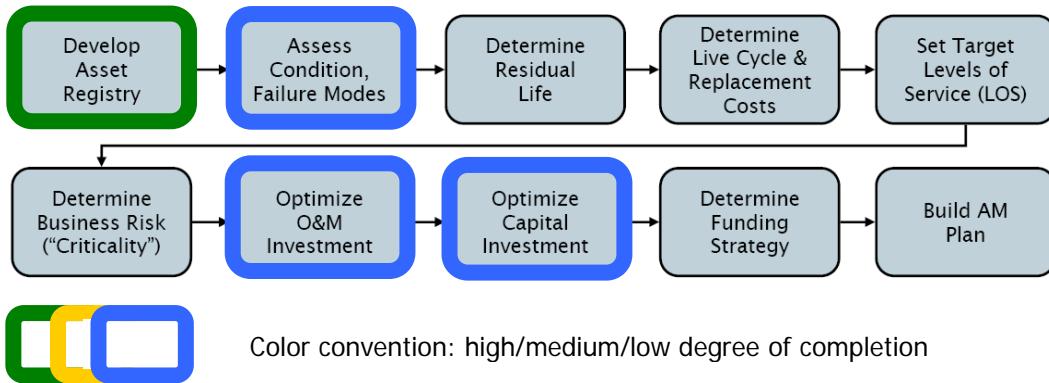
- Condition Assessment
- Structural behavior and monitoring
- Repair and strengthening
- Dynamic effects and vibration
- Life cycle analysis

The UIC Bridge Project may provide critical information that Amtrak could utilize to improve both the effectiveness and efficiency of its bridge maintenance and renewal programs.

### Amtrak Asset Management

Similar to the European Railroads, Amtrak Engineering is implementing an asset management system (Maximo from IBM) that is to coordinate "what to do" (e.g. Inspections and tests, root cause analysis) and "how to do it" (e.g. workforce allocation, maintenance planning, financial accountability) to determine the optimal point for maintenance intervention and capital investment. These goals are comparable to those of European infrastructure asset management systems and it is reasonable to expect that, once completed, Amtrak's asset management system will provide the same level of benefits being experienced by the European infrastructure maintainers.

Amtrak's Engineering Department is currently in the process of completing its infrastructure asset register by capturing the attribute data of its assets and it is also implementing the processes required to capture labor and material expenses related to asset inspection and maintenance. As illustrated in the following flow chart, Amtrak is still in the beginning stages in its efforts to implement a comprehensive asset management process.



Amtrak Engineering is commended for the significant progress that it has made towards completing Amtrak's infrastructure asset register and the collection of asset maintenance expenses. It should be noted that the German railroad Deutsche Bahn required over ten years to collect and input the data for its infrastructure asset register. Although Amtrak Engineering has made significant progress towards implementing an effective asset management system, there is still a long list of action items that must be completed before Amtrak will be able to benefit from the system's anticipated financial and operating benefits. When completed, Amtrak's infrastructure asset management system should:

- align the asset management plan with the corporate long range strategy
  - asset performance, availability, accepted risk level, regulatory compliance
- provide an up-to-date asset register
- assess impact of asset condition
  - predict asset failures, estimate residual asset life
- develop a life-cycle-cost and optimization model
- develop a business risk model
- develop methods to optimize maintenance work/procedures
- develop methods to optimize capital investment work

**Recommendation 1 – That the Chief Engineer continue to develop and implement an asset management process that will provide the appropriate data and business decision processes required to optimize Amtrak's infrastructure maintenance and renewal programs.**

**Finding No. 2 – Amtrak could benefit from the expanded use of Industrial Engineering techniques to optimize the use of resources on infrastructure maintenance projects.**

**Discussion**

The information we collected during our interviews and field trips revealed that the processes that Amtrak currently uses to complete infrastructure inspections and maintenance are primarily determined by:

- Historic methods for completing maintenance tasks,
- Federal Railway Administration (FRA) regulations, and
- Available maintenance technology.

Although these production drivers are not 100% independent of each other, they can be individually reviewed to identify better methods and procedures to perform infrastructure maintenance work.

It is reasonable that Amtrak's current work processes are in large part determined by the historic methods for completing similar tasks. However, this is not the most reliable method to insure that efficient processes are being used to complete the maintenance tasks. This fact was illustrated to us by Mr. Tom Denio, Superintendent, Engineering Production. Mr. Denio related how Amtrak's Tie Gang was laying 60-100 ties per day when he first arrived to work at Amtrak. Following his review of the maintenance process, he modified the sequencing of the work to emulate the process used on the Norfolk Southern RR (NS) and was able to increase the production to 700 ties per day with the same size labor force. He further stated that the NS can lay from 1,300 to 1,800 ties per day with the same level of man-power, but utilizing employees with a different skill set and processes that are not feasible on a passenger rail system.

Further discussions with our Engineering Staff members revealed that Amtrak does not routinely perform Industrial Engineering analyses to determine the optimal processes for completing the various maintenance tasks. For that matter, Amtrak's Engineering Department has only one individual at the staff level who is qualified as an Industrial Engineer. This is in contrast to the practices that were observed at the European railroads. For example, Network Rail, the infrastructure maintenance company in England, has an Engineering Data Center (EDC) that monitors the condition of the infrastructure assets and then plans and reports upon the maintenance of the infrastructure assets. Network Rail prepares detailed plans for the execution of its infrastructure work, including written procedures, activities, manpower assignments, equipment assignments and the logic that supports these plans.

In addition to Network Rail in England, DB in Germany also uses Industrial Engineering techniques to identify the optimal processes to complete infrastructure maintenance work. During our visit with DB, they described how their analytical work identified and quantified the benefits of performing the inspection and maintenance of switches using a team comprised of both track employees and communication & signaling employees. Switches are complex machines that include components that are inspected and



maintained by different engineering disciplines. The track structure (rails, ties, tie plates, spikes, ballast and sub-ballast) are the responsibility of the Track Department and the switch motors, switch heaters, electronic detection, control and signal equipment are the responsibility of the Communication & Signaling Department. The following picture illustrates the rails, ties, push rods, pneumatic switch motor, and an oil switch heater of a "vintage" switch that is close to the end of its useful service life.

The safe and reliable operation of switches is dependent upon the ability of each switch component to operate reliably and as designed. The most effective and efficient method to inspect the components of the switch is to have the Track and C&S Departments jointly inspect the switch. A joint inspection of the switch will minimize the amount of time the switch is out of service for inspection and it will insure, not only that the components of the switch will operate properly, but that all the components of the switch operate properly in tandem.

By expanding the use of Industrial Engineering techniques, Amtrak should be able to both increase the productivity of its labor and improve the quality of infrastructure maintenance.

**Recommendation 2 –That the Chief Engineer expand the Industrial Engineering expertise within Amtrak’s Engineering Department so that it can regularly develop infrastructure maintenance programs that optimize the use of manpower, materials, and technology.**

## Finding No. 3 – Amtrak could benefit from a comprehensive set of metrics to monitor infrastructure maintenance performance and to support effective decision-making.

Amtrak indirectly reports infrastructure maintenance efficiency at a high level by producing both production reports and budget reports. As shown in the following table, Amtrak Engineering reports on its actual weekly and year-to-date production against its goals for each maintenance function. This information is also presented in Amtrak's Monthly Performance Report along with Engineering Actual and Budgeted Expenses. The

| Major Production Summary for Week ending 3/30/06 |                      |       |                |        |        |             |        |                  |        |
|--|----------------------|-------|----------------|--------|--------|-------------|--------|------------------|--------|
| Operation  | Closest Interlocking | MP    | Work Direction | Weekly |        | FY 06 Units |        | Cal.Yr. 06 Units |        |
|  |                      |       |                | Goal*  | Actual | Goal*       | Actual | Goal*            | Actual |
| <b>Northeast Corridor</b>                        |                      |       |                |        |        |             |        |                  |        |
| Surfacing (pass miles)                           | Var                  | Var   | Var            | 6.2    | 5.4    | 310.6       | 287.9  | 87.7             | 74.7   |
| TLM-Ties (each)                                  | Baldwin              | 10.5  | South          | 0      | 0      | 0           | 0      | 0                | 31,375 |
| TLM -(track miles)                               | Baldwin              | 10.5  | South          | 0      | 0.0    | 0.0         | 0.0    | 0.0              | 11.9   |
| TLM-Rail (track miles)                           | Baldwin              | 14    | South          | 0      | 0      | 0.0         | 0.0    | 0.0              | 0.6    |
| Holland Welder-TLM (each)                        | Baldwin              | 9.8   | South          | 0      | 0      | 0           | 0      | 0                | 109    |
| Field Welding -Division (each)                   | Var                  | Var   | Var            | 36     | 33     | 859         | 816    | 435              | 425    |
| Undercutter-Y700 RM95 (miles)                    | Grove                | 117.8 | South          | 0.0    | 0.0    | 5.6         | 5.3    | 0.0              | 0.0    |
| Undercutter -Y701 RM76 (miles)                   | Lansdowne            | 131.1 | North          | 0.0    | 0.0    | 0.0         | 0.0    | 0.0              | 1.7    |
| Sys Spot Undercutter (miles)                     | Bacon                | 46.6  | South          | 0.2    | 0.1    | 0.2         | 0.1    | 0.2              | 0.1    |
| Concrete Ties Installed SES (each)               | var                  | var   | var            | 0      | 0      | 0           | 0      | 0                | 1748   |
| Turnouts - SES (each)                            | County               | 32.8  | West           | 0      | 0      | 0           | 0      | 0                | 23     |
| Turnouts - MAD (each)                            | n/a                  | n/a   | n/a            | 0      | 0      | 4           | 4      | 2                | 2      |
| Turnouts - NED (each)                            | n/a                  | n/a   | n/a            | 0      | 0      | 1           | 0      | 1                | 10     |
| Turnouts - NYD (each)                            | n/a                  | n/a   | n/a            | 0      | 0      | 1           | 1      | 1                | 25     |
| Turnouts - Sys Prod (each)                       | Pawtucket            | 187   | Var            | 0      | 0      | 5           | 5      | 5                | 0.0    |
| RAIL GANG NED (Track miles)                      | Hunter               | 11.9  | West           | 0      | 0      | 0           | 0      | 0                | 10.6   |
| Production Welding                               | Gate                 | 8.7   | n/a            | 0      | 0      | 30          | 30     | 30               | 5      |
| Holland Welder-RCCO (each)                       | Brook                | 11.9  | West           | 0      | 0      | 0           | 0      | 0                | 72     |
| Rail Train-Lock Up (track miles)                 | Brook                | 92.25 | West           | 0.0    | 0.0    | 1.1         | 0.6    | 0.0              | 0.0    |
| Rail Train-Unload (track miles)                  | Davisonville         | 176.8 | East           | 0.0    | 0.0    | 3.0         | 2.6    | 0.0              | 0.0    |
| NED & Machine Work                               | Otis                 | 145.2 | West           | 0.0    | 0.0    | 0.0         | 0.0    | 0.0              | 37.9   |
| Badger Ditcher (Pass Miles)                      | Var                  | Var   | Var            | 0.0    | 0.0    | 15.5        | 12.7   | 0.0              | 67.9   |
| NED Shoulder Cleaner (Track miles)               | 0                    | 0     | 0              | 0.0    | 0.0    | 0.0         | 0.0    | 0.0              | 0.0    |
| NYD Shoulder Cleaner (Track miles)               | Gate                 | 0     | East           | 0.0    | 0.0    | 0.0         | 0.0    | 0.0              | 0.0    |
| MAD Shoulder Cleaner (track miles)               | n/a                  | n/a   | n/a            | 0.0    | 0.0    | 2.3         | 1.4    | 0.0              | 0.0    |
| MAD Slot Machine (miles)                         | Bay                  | 92    | South          | 0.0    | 0.0    | 0.0         | 0.0    | 0.0              | 1.8    |
| Rail Grinding (pass miles)                       | Allied               | 3.5   | East           | 0.0    | 0.0    | 691.0       | 691.0  | 691.0            | 691.0  |
| Bridge Decks Retrimmed (Each)                    | Baldwin              | 15.02 | n/a            | 1      | 1      | 2           | 2      | 15               | 16     |
| Bridge Tie (Each)                                | Baldwin              | 15.02 | n/a            | 55     | 55     | 148         | 148    | 103              | 384    |
| Bridge Converted to Ballast Deck (Each)          | Baldwin              | 8.64  | South          | 0      | 0      | 0           | 0      | 0                | 1      |
| Bridge Converted to Ballast Deck (feet)          | Baldwin              | 9.64  | South          | 0      | 0      | 0           | 0      | 0                | 80     |
| Electric Catenary Hardware Renewed (miles)       | n/a                  | n/a   | n/a            | 1.4    | 0.6    | 38.0        | 20.8   | 19.3             | 10.4   |
| ET Transformers (each)                           | n/a                  | n/a   | n/a            | 0      | 0      | 10          | 5      | 2                | 1      |
| ET Breakers (each)                               | n/a                  | n/a   | n/a            | 0      | 0      | 16          | 18     | 11               | 10     |
| Signal Cable Replaced (miles)                    | n/a                  | n/a   | n/a            | 0.0    | 0.0    | 0.0         | 0.0    | 0.0              | 3.0    |
| Concrete Tie Gang NYD (each)                     | Union                | 21.9  | East           | 0      | 0      | 0           | 0      | 0                | 4248   |
| NYD Slot Train (each)                            | Union                | 21.9  | East           | 0      | 0      | 0           | 0      | 0                | 1937   |
| Concrete Tie Gang MAD (each)                     | Winans               | 102.5 | South          | 0      | 0      | 0           | 0      | 0                | 1063   |
| Wood System Tie Gang MAD (each)                  | Bell                 | 22    | South          | 0      | 0      | 6,363       | 2,608  | 50               | 4852   |
| Wood System Tie Gang NYD (each)                  | Elmora               | 18.8  | West           | 0      | 0      | 0           | 0      | 0                | 4024   |
| CWR Installed System Prod ( track miles)         | Gate                 | 9.1   | East           | 0.00   | 0.00   | 3.48        | 2.51   | 1.35             | 1.06   |
| Wood System Tie Gang Hellgate Trk 5 (each)       | Gate                 | 5.4   | East           | 0      | 0      | 12027       | 6917   | 0                | 0      |

R.Shiloh  
3/31/2006

1 of 4

0324 0330 Weekly production report.xls

combination of the production and cost metrics provides a high-level measure comparing Engineering Actual and Budgeted Efficiency. However, this does not provide a measure of the efficiency of specific maintenance activities (e.g. # ties per labor hour), which is needed to more effectively manage the resources of the engineering department. For example, this information is required to determine if labor efficiency is increasing or decreasing, if past capital investments have provided their anticipated benefits, and the magnitude of benefits that should be anticipated from future investments or changes in maintenance practices.

Our evaluation revealed that there are many benefits that can be derived from the way US Class I and European railroads use unit production rates to plan for and report upon their infrastructure maintenance gangs. Utilizing production unit rates for daily planning

enables the Class I railroads to better coordinate manpower assignments, material requirements, and track outage or curfew requirements. The reporting of daily production rates by production gang helps to ensure that there is an organization-wide focus on production levels and that actual production equals or exceeds planned production. The production reports, which are shared on an organization-wide basis, generate an in-house competition between the production gangs and by themselves help to increase the overall productivity of the infrastructure maintenance programs.

Our interview with the Chief Engineer of the Canadian National RR (CN) revealed that they have both high level and detailed level measures of maintenance efficiency. CN compares actual daily production to production goals by maintenance gang and the engineering staff has the experience to know if the specific gang is working efficiently given their actual production and the particular environment in which they are working. For example, the actual production rate of a tie replacement gang would be different on straight track than on an interlocking. CN also measures and reports upon the number of units produced per 100 labor hours and the direct labor cost per unit produced. We also learned that Deutsche Bahn (DB), Germany, uses standard production rates as part of its human resources dimensioning tool to identify the human resources (i.e. number and type of employee by craft) required to complete the company's planned infrastructure maintenance, renewal, and replacement programs.

Network Rail, as illustrated in the chart to the right, took a slightly different approach of measuring labor productivity by reporting upon the "Time on Tools" of their maintenance crews. The "Time on Tools" is the same metric as Working Hours that is shown in the Systems Dynamic Model that is shown on page 34 of this evaluation. Network Rail compares the "Time on Tools" to the total number of available hours as a measure of how efficiently available labor resources were employed. These measures are provided by maintenance territory (as shown above) and also by maintenance discipline (e.g. track, C&S, etc.)

| MBR : MAINTENANCE PRODUCTIVITY SUMMARY |               |                 |     |                    |        |                           |   |
|--|---------------|-----------------|-----|--------------------|--------|---------------------------|---|
| Territory                              | Maximum Hours | Available Hours |     | Planned Norm Hours |        | Total Norm Hours Produced | Productivity w/o Large hours<br>(% Planned from Actual)<br>Dedicated from Actual/<br>Bk. hours) |
|  |               | Actual          | %   | Actual             | %      |                           |   |
| LNE                                    | 114,108       | 88,949          | 79% | 32,098             | 45%    | 21,627                    | 35,832  |
| LIW                                    | 141,980       | 107,487         | 76% | 35,531             | 41%    | 14,837                    | 31,934  |
| South East                             | 146,552       | 118,521         | 81% | 40,486             | 45%    | 22,328                    | 51,266  |
| Scotland                               | 43,921        | 34,840          | 79% | 16,855             | 29,532 | 17,317                    | 29,415  |
| Western                                | 71,932        | 54,324          | 70% | 26,450             | 34,565 | 15,549                    | 36,653  |
| Maintenance Totals                     | 519,494       | 404,121         | 78% | 151,420            | 46%    | 91,657                    | 185,100   |
|  |               |                 |     |                    |        |                           | 36%   |

**Recommendation 3 – That the Chief Engineer develop and use a comprehensive set of metrics that monitor infrastructure maintenance performance to support effective decision-making.**

**Finding No. 4 - The combination of Railway Worker Protection rules and Civil Noise Abatement Regulations significantly reduces the overall productivity of production crews.**

**Discussion**

As previously discussed, Mr. Tom Denio, who was Amtrak's Superintendent of Engineering Production stated that work processes is a major factor that determines labor productivity. The impact of disruptions to the work process became very apparent during a site visit to the Harrisburg Line where Amtrak's track laying system was working. The Track Laying System (TLS) is a highly automated combination of men (approximately 100 both on site and support) and machinery that renews the track structure (i.e. ballast, ties, and rail) in a single pass over the renewed right of way. The TLS is designed to continuously (i.e. without stopping) pick up old ballast, ties, and rail and lay down new ballast, ties and rail. Although the TLS is designed to operate without stopping, the process was constantly stopped for safety reasons while regularly scheduled trains passed the work site. During the

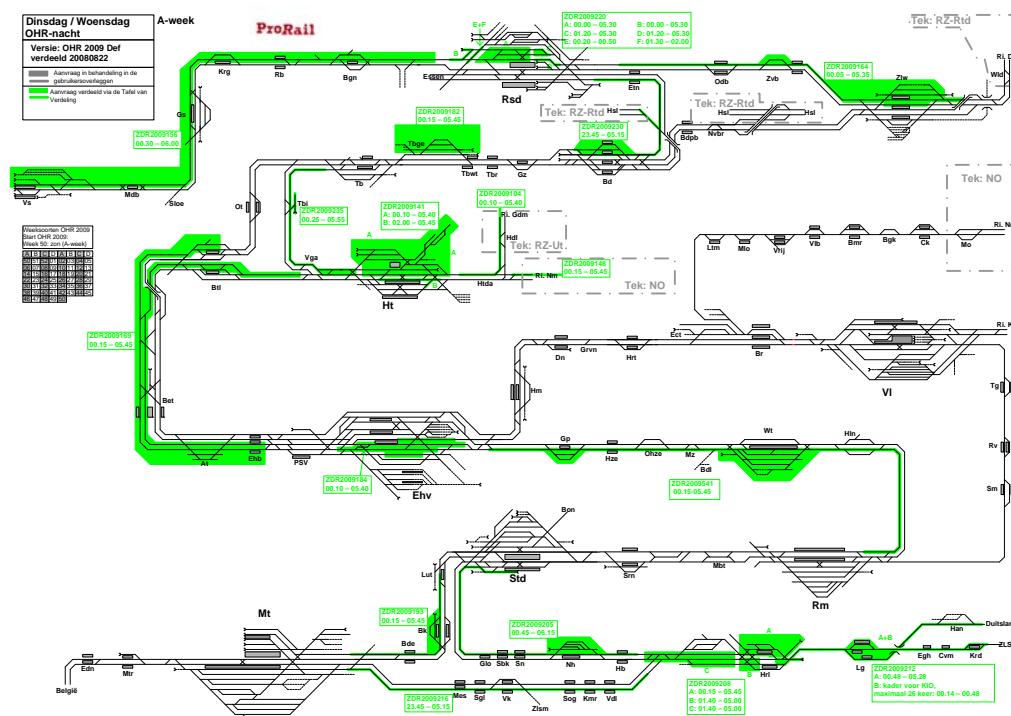


period of time that we watched its operation, the TLS was inactive for more than 50% of the time waiting for trains to approach and then pass the work site. Unlike the Freight Railroads, Amtrak's TLS is not as efficient as it could be because it cannot curfew regularly scheduled intercity and commuter trains on the right of way where the TLS operates. In addition, local city noise ordinances have prevented Amtrak from performing the work at night. Consequently, the unit cost of this infrastructure maintenance

process is significantly higher than theoretically possible because of the conditions under which it operates.

Our visits to the European railroads revealed that they face many of the same challenges that Amtrak faces to safely and efficiently perform infrastructure maintenance while minimizing any interruptions to scheduled train operations. The following processes and technologies are being used by Amtrak's European peer railroads to overcome these challenges and improve the efficiency of their maintenance programs.

- Switzerland uses an automated system to warn infrastructure maintenance crews when a train was approaching their work site. The system provides reliable and sufficient warning so that the work crews can move to a safe location before the train arrives at the work site. Although the crews productivity is interrupted while the train approaches and passes the work site, the number of flagmen required at the work site is significantly reduced. The number of required flagmen can be quite large (e.g. nine at one time) for major programs such as the TLS when working on tracks with numerous curves.
  - For every mile of its main line tracks, ProRail has 5 ½ hours scheduled - twice a week during weekday nights - in the railroad's timetable for track maintenance. The following chart illustrates the tracks available (tracks highlighted in green) to ProRail for maintenance work on this portion of the railroad on Night 1. A different set of tracks are available for maintenance on Night 2 of the schedule. It should be noted that other tracks are still available for regular train movements on both night schedules. By providing dependable, uninterrupted track access time for maintenance work in the railroad timetable, ProRail is able to achieve 4.5 to 5 hours of productive working time on each shift.



- Volker Rail, which performs infrastructure maintenance for ProRail in the Netherlands, utilizes a system that allows its workers to safely work while trains pass on adjoining tracks. As shown in the following pictures, the workers perform their duties within an

enclosure that is basically a shell of a rail car. This system significantly improves the productivity of these crews since their work is no longer interrupted by passing trains.



**Recommendation 4 a – That the Chief Engineer investigate the feasibility of implementing the European practices used to optimize the productivity of its infrastructure maintenance crews.**

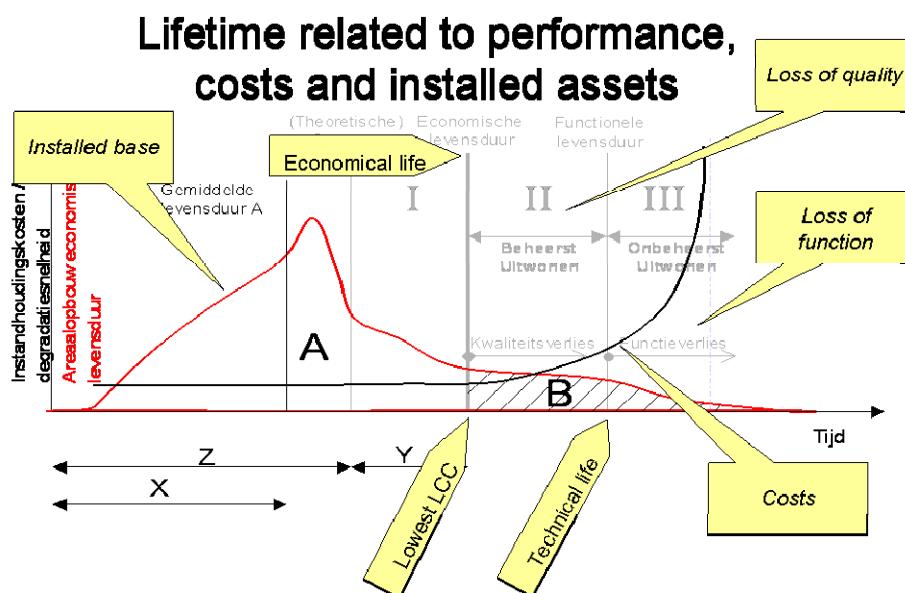
**Recommendation 4 b –That the Chief Engineer identify the civil noise and other restrictions that are the greatest impediment to efficiency and develop the operating and financial benefits that would justify their modification.**

**Recommendation 4 c – That the Vice President for Government Affairs & Corporate Communications work with local governmental jurisdictions in an attempt to modify the civil restrictions that the Chief Engineer identified as hindering the efficiency of infrastructure maintenance.**

## Finding No. 5 – Amtrak could benefit from the adoption of some of the long term planning processes that are being used in Europe.

Effective long term planning of infrastructure maintenance and renewal activities has a major impact on asset performance and life cycle costs. A newly built or renewed asset has an expected lifetime<sup>6</sup> in which it functions with a minimal effort of maintenance (economical lifetime). Beyond this point, functionality can only be achieved with intensified maintenance resulting in higher costs and usually loss of asset quality (technical lifetime) until even further deterioration leads to loss of function. Ideally, an identified equilibrium of maintenance and renewal costs leads to the lowest life cycle costs (LCC). Any variation leads to either higher maintenance costs or waste of asset value due to early replacement.

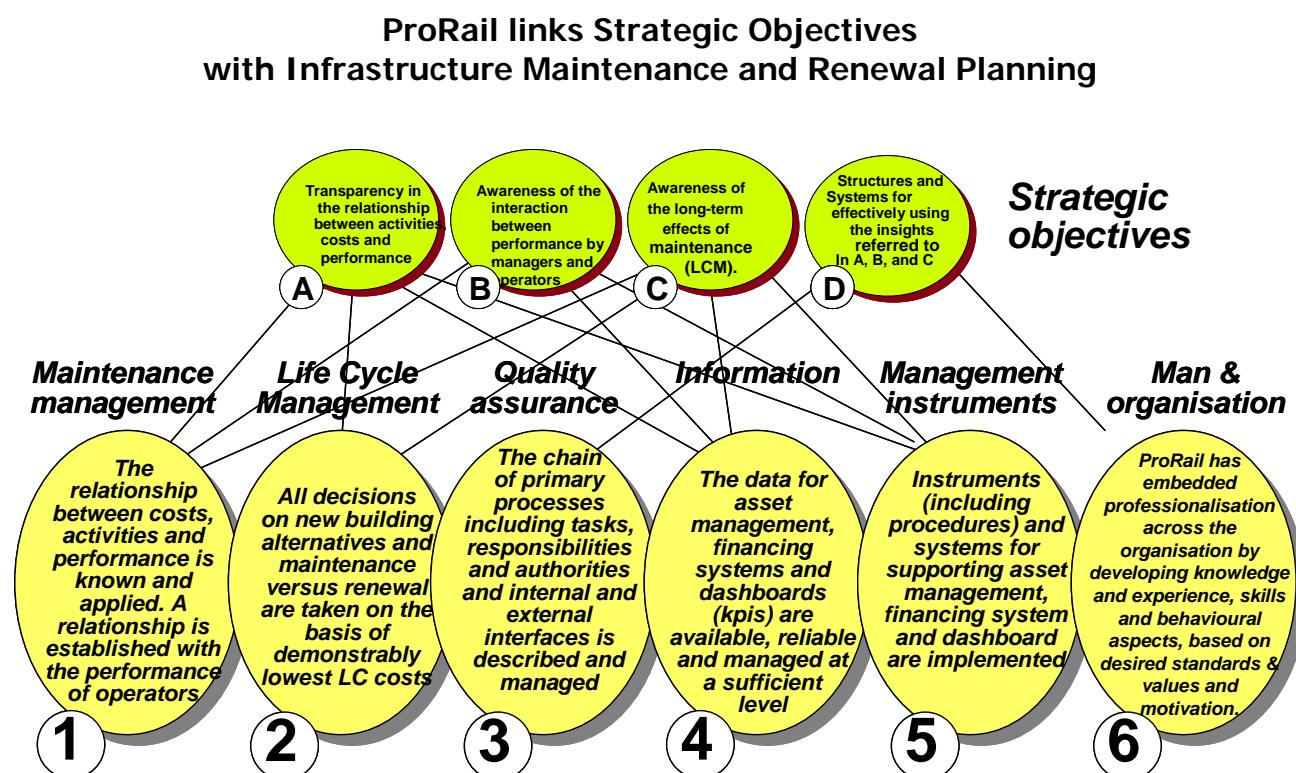
The relationship between the lifetime costs and performance of infrastructure assets is illustrated in the following diagram that was prepared by ProRail. It should be noted that the prerequisites to effectively managing the optimal replacement times for thousands of infrastructure assets is a thorough understanding of the asset condition, the factors causing asset degradation and the nature of this degradation. This can only be achieved by regular and objective asset condition monitoring, which can be effectively delivered by automated systems as previously mentioned, and by fact based analysis that has quantified the factors causing asset degradation.



<sup>6</sup> Lifetime can be determined by physical age, level of usage, or measured condition.

The majority of the European infrastructure managers that we visited use a long term planning process to determine their maintenance and renewal programs. It should be noted that the long term planning process is enabled by the multi-year funding commitments made by each country for the infrastructure maintenance and renewal programs. The multi-year funding programs, ranging from three to five years, enabled the European infrastructure companies to develop programs for the cost effective and timely replacement of infrastructure assets. Historically, Amtrak receives only a one year funding commitment for its maintenance and renewal programs and frequently does not know what this level of commitment is until well into the budget year. The impact of this funding situation on Amtrak's ability to optimize the efficiency of its capital programs is further described later in this section.

In addition to simply performing long term infrastructure planning as a stand alone process, some of the European infrastructure maintainers have successfully merged their long term planning process with the company's strategic objectives, asset maintenance and performance goals, information and reporting systems, and manpower and organization. As illustrated in the following chart, ProRail described how they coordinate these planning and management processes to attain their corporate objectives and optimize their infrastructure maintenance and renewal programs.



Our review of the European infrastructure maintainers also identified the following processes that were being used to help them plan for the optimal maintenance, refurbishment and replacement of the railroad's infrastructure assets. Some of these processes are enabled by the funding mechanisms utilized by the particular European central government and consequently Amtrak may not be able to adopt them without appropriate changes being made to its capital and operating subsidy legislation.

Planning Horizon The planning horizon for the European infrastructure maintainers tended to be longer than that for Amtrak. For example, ProRail used a 10 year planning horizon for its major projects, which were described and reviewed at a high-level summary level and then had shorter term plans that were described and reviewed at increasing levels of detail. These plans eventually cascaded down to weekly plans that were very detailed, describing work procedures, labor assignments, material and tool requirements, and track outages. This process helped to insure that the long term infrastructure requirements were properly planned for and that these plans were coordinated with mid-term and near term plans and programs.

Asset Designs In line with their longer planning horizon, the European infrastructure maintainers planned and designed their assets based upon their future transportation requirements and not just upon their need to replace or upgrade existing assets. A prime example of this is the new city line that is planned for Stockholm, Sweden. This new line will supplement the existing rail line that serves Stockholm's Central station and will include two tracks, six kilometers of railway tunnels, three new stations, and a one kilometer flyover. Another example of this approach is the new high-speed rail line being built between Vienna and St. Polten, Austria. This rail line, which is being built as part of a long term project to increase the rail passenger capacity between Western Europe and Eastern Europe, includes an intermediate station stop that has no near-by population centers. The station stop has been constructed with the concept that "build it and they will come."

Multi-Year Funding Commitment All of the European infrastructure maintainers have some form of multi-year funding commitment from their federal rail passenger agency. Both Deutsche Bahn and OBB have a 5 year rolling capital budget commitment, NetWork Rail has a 5 year capital commitment, and ProRail has a 4 year capital commitment. The multi-year funding commitments enable the European infrastructure maintainers to both prepare long-range infrastructure plans and to implement the actions (e.g. order long-lead materials, negotiate cost effective multi-year contracts, hire and train qualified staff) required to efficiently complete the related programs. It should be noted that some of the multi-year funding commitments are made concurrent with commitments by the infrastructure maintainer to make measurable improvements in the operating and/or financial performance of the rail line.

Capital Funding Justification To provide their Federal Government a yardstick to measure the benefits of capital investment in the railroads infrastructure, ProRail presents three funding scenarios:

1. Base case – current funding level that results in decreased asset condition, a back log of required capital investment, and decreased network quality/performance.
2. Current Performance Levels – funding level required to avoid further deterioration of asset condition.
3. Improved Performance – funding level required to return infrastructure to a SOGR and improve the network quality/performance.

ProRail stated that this approach has helped them to justify the capital funding required to improve the quality and performance of their network.

Life Cycle Costs Many of the European infrastructure maintainers took into consideration the life cycle costs to make decisions regarding when to replace assets and how to prioritize their capital projects. Even though the European infrastructure maintainers had consistent subsidy levels, these subsidy levels were not adequate to support their unconstrained funding requirements and they did have to allocate available funds to their highest priority projects.

Capital Funding Allocation Sweden utilizes the approach of allocating its capital funds taking into consideration the combination of projects that optimizes the railroads financial and operating performance. This approach goes beyond reviewing individual projects/programs as stand alone proposals and takes into consideration network utilization, project criticality and how each project impacts other projects and the bottom line performance of the railroad. This approach appears to enhance Sweden's ability to optimize the financial benefits of its capital investments.

Operating versus Capital Budget To insure that the operating budget is directly linked to capital investments, Deutsche Bahn of Germany first develops it capital budget utilizing the Life Cycle Cost approach to optimize financial benefits and then develops the operating budget that reflects the operating and financial benefits derived from the capital investments. For example, if a section of rail line is totally renewed, then the reduced maintenance requirement for this section of the rail line would be reflected in the operating budget and the improved train performance would be reflected in the revenue budget.

Maintenance Prioritization SBB, Switzerland, has a formal, quantifiable process to prioritize their infrastructure maintenance programs. SBB uses a risk assessment model that, utilizing up-to-date condition assessments of the infrastructure assets, quantifies the risk (i.e. cost) related to train derailments, train delays, and asset repairs. This risk assessment takes into consideration type of asset, type of rail line, consequences of asset failure, and probability of occurrence. If applicable at Amtrak, this process will help the company optimize the financial and operating benefits of the money invested in infrastructure maintenance.

Amtrak could realize the following benefits by adopting the "best practices" of the European Railroads related to long term planning:

- Insure that the appropriate infrastructure assets will be available to support the company's strategic goals.
- Insure that the highest priority projects will receive the available capital funding.
- Improve the method for justifying the investment of federal funds into Amtrak's infrastructure.
- Insure that the infrastructure maintenance program, which includes both the capital programs and operating programs, is optimized.

**Recommendation 5 - That the Chief Engineer establish a long-term planning process that optimizes the investment of capital and operating funds for infrastructure maintenance by taking into consideration the timing of asset renewals and related asset reliability and performance.**

**Finding No. 6 - The lack of a multi-year capital funding program has negatively impacted the efficiency of Amtrak's infrastructure maintenance program.**

**Discussion**

The most common theme revealed to us by Amtrak's Engineering staff is the negative impact Amtrak's current capital budgeting process has on labor productivity. Historically, Amtrak Engineering does not know with certainty what its capital budget level will be until after the fiscal year begins. Often, Engineering does not have a fixed capital budget until the second quarter of the fiscal year when it is too late to make any efficient adjustments in projects prioritizations or labor assignments. The absence of a predetermined capital budget, more importantly a multi-year capital budget, has negatively impacted the efficiency of the capital projects by:

- Inhibiting the Engineering Department from hiring and training the skilled labor force required to efficiently perform the capital projects since, otherwise, they would hire and train employees who would have to be laid off if the required capital funding is not obtained.
- Preventing the Engineering Department from ordering the long lead material items to have them on hand when required for the capital projects since, otherwise, they risk the likelihood of wasting any materials that had been ordered for projects that were subsequently canceled due to lack of capital funding.
- Depriving the Procurement Department the advantage of negotiating contracts for materials that have quantity discounts.
- Inhibiting the investment in the most productive technology and machinery to complete major capital projects. These types of major investments can not be justified unless it is known that there will be sufficient capital funds available to complete the projects that will utilize the new technology and equipment.
- Preventing labor from maintaining their skills when projects are prematurely terminated due to capital funding shortages. Mr. Denio pointed out that the maintenance gangs with the highest productivity on freight railroads stay together as a team from year to year because multi-year funding has been committed for the work.
- Preventing Engineering from obtaining the best contractor rates and skill sets. Better contracts can be negotiated when it is possible to offer longer-term agreements that have certain funding authority. Contractors are reluctant to invest in the hiring and training of employees if there is a lot of risk associated with the proposed agreement.

In contrast to the situation Amtrak faces regarding capital funding uncertainties, every European Railroad that we visited had some form of a multi-year capital funding source. The majority of the railroads had five year capital funding commitments, with some having a rolling five year commitment and others with five year commitment blocks. In either case, these railroads were able to optimize the scheduling of their projects, develop productive relationships with their contractors, and assemble the labor and materials for the timely and

efficient completion of their projects. The majority of these railroads provided their funding sources with some measures (i.e. On-Time Performance, average speed, average age of assets, etc.) of the benefits to be derived from the capital investments. For example, ProRail not only measures the relationship between their capital investments and their operating performance, but they also program their asset maintenance based upon their asset age and condition, which is related to asset investment.

**Recommendation 6 a – That the Chief Engineer develop the operating and financial benefits that would be derived from a consistent multi-year capital funding program.**

**Recommendation 6 b - That the Vice President for Government Affairs & Corporate Communications consult with the Congressional appropriation committees in an attempt to obtain multi-year commitments of capital funds from the Federal Government.**

## **LABOR**

Our evaluation of Amtrak's infrastructure maintenance program also revealed that opportunities exist to improve Amtrak's labor production rate.<sup>7</sup> Skilled labor is a major driver of productivity rates and consequently, the overall cost of performing infrastructure maintenance. For example, a well trained, highly motivated labor force will have a higher productivity rate than one that is not. Additionally, labor should be the primary focus for improving the overall cost efficiency of infrastructure maintenance since direct labor costs account for 80% of infrastructure core operating expenses and 50% of infrastructure capital expenses. The combination of our interviews with Engineering Department staff, field observations, and visits to the European railroads revealed numerous opportunities that exist for improvements in this area. Listed below are three labor related findings and recommendations on Amtrak's opportunities to improve the efficiency and effectiveness of its infrastructure maintenance program.

**Finding No. 7 – Some of Amtrak's labor compensation policies are not competitive with other employers in certain areas of the country and, therefore, they hamper the Engineering Department's ability to attract and retain a skilled work force.**

### **Discussion**

A theme that repeated itself during our interviews with the Engineering staff is Amtrak's difficulty in attracting and retaining employees in certain crafts and job markets. Although the recent signing of new labor agreements has ameliorated some of the related problems, it has not solved them all. The attraction and retention issue is a pressing one for Amtrak because a large portion of its labor force is approaching their retirement age and there will soon be a critical exodus of these individuals from the labor force. In addition to this factor, certain labor crafts are being hired away from Amtrak by Commuter Railroads or Commercial Industries that are able to offer better wage and/or benefit packages. Amtrak's Deputy Chief Engineer– Electric Traction, stated that he has had a very difficult time keeping a sufficient number of qualified electricians in his work force since, as soon as he hires and trains them, they leave to work for a Commuter Agency that pays better.

The issue of attracting and retaining qualified employees was a major topic that was addressed in the OIG Evaluation of Human Capital Management (E-09-03) of all Amtrak employees. On page 22 of this report, it was concluded that "the current total compensation system still does not appear to address all of Amtrak's needs in attracting, motivating and retaining Amtrak's agreement covered and non-agreement covered employees." The report also stated, to address this labor issue, Amtrak needs to develop an overall compensation philosophy and strategy that will be incorporated into a labor contract negotiating strategy.

---

<sup>7</sup> Reference flow chart on page 34 of this report.

The Engineering Department labor issues are an important part of Amtrak's overall labor issues and should be included in the development of the overall compensation strategy that will help to solve the problems related to attracting and retaining qualified employees.

**Recommendation 7 a – In support of the actions recommended to develop a comprehensive Amtrak compensation strategy (reference page 22 of the OIG Report E-09-03), that the Chief Engineer identify the critical near-term and projected staffing shortfalls that need to be addressed by the comprehensive compensation strategy.**

**Recommendation 7 b - That the Vice President for Human Resources & Diversity Initiatives develop a comprehensive compensation strategy that will help attract and retain the skilled labor required by the Engineering Department to efficiently and effectively complete its infrastructure maintenance programs.**

**Finding No. 8 – Certain FRA regulations that mandate type and frequency of infrastructure inspection may be excessive and negatively impact the efficiency of Amtrak’s infrastructure maintenance programs.**

**Discussion**

Our interviews with the Deputy Chief-Engineers of Track and C & S revealed that there is a significant difference between the inspection procedures (i.e. frequency of visual inspections) used by Amtrak and that used by the majority of the European Railroads that had been visited during this evaluation. Amtrak's inspection procedures are those that have been mandated by the Federal Railroad Administration (FRA) while those of the European Railroads are primarily those that have been established by the individual railroads to insure that the infrastructure is safe, reliable, and fully functional. The European Railroads have taken advantage of the latest technology to improve both the efficiency and effectiveness of their infrastructure inspections. Our review of the European Railroad infrastructure maintenance practices revealed their use of the following procedures/technologies that have helped them to improve the way they complete their infrastructure inspections.

Track Inspection Frequencies With the exception of NetWork Rail, European infrastructure maintainers perform visual inspections of their track systems much less frequently than Amtrak. For example, some of these infrastructure maintainers visually inspect their tracks every 3 months when Amtrak would be inspecting the same classification of track twice a week. It should be noted that NetWork Rail considers their visual track inspection program (i.e. once per week) to be more aggressive than necessary, but the frequency and scope of the inspections are dictated by their federal safety regulator. ProRail determines its inspection frequencies using a grading system (1 to 8) taking into consideration asset condition, type of rail line, and asset utilization level. The European infrastructure maintainers have also utilized a combination of modern asset inspection technology (e.g. pattern recognition, track inspection trains, remote asset monitoring/diagnostics systems such as the POSS switch monitoring system in the Netherlands) and a robust asset management system to measure, record, and assess the condition of their infrastructure assets. They have been able to use this combination of modern technology and a robust asset management system to optimize their track inspection/maintenance programs, while at the same time insuring that their safety and ride quality standards are properly maintained.

**Pattern Recognition**

Pattern recognition is the use of an automated visual inspection system that records the condition of the track system and identifies any structural defects. This concept is well known at Amtrak since its own engineers applied for a patent in August 1996 for an Automated Track Inspection Vehicle and Method that uses this technology. It is also a technology that is used by some of the European Peer RR's to inspect their track system and provide a "real time" record of its condition. This information is used for decisions on slow orders and track maintenance programs, both near term and long range. Both Switzerland

and the United Kingdom have versions of the pattern recognition systems included as part of the equipment used to inspect their track system. The Swiss have included the pattern recognition system in the self-propelled track inspection vehicle shown in the following picture that was taken while the inspection vehicle was in their maintenance shop. It should be pointed out that, in addition to the pattern recognition data, this vehicle also collects a full array of track and catenary related data, such as, track alignment, cross level, gage, super-elevation, twist, rail profile, and contact wire position and wear.



Picture of self-propelled Swiss track inspection vehicle that includes pattern recognition system, in addition to a full array of track and catenary related inspection technology.

### Unattended Geometry Measuring Systems

The overall infrastructure maintenance philosophy of NetWork Rail, the infrastructure maintenance company for British Rail, has shifted from "find and fix" philosophy to "predict and prevent" philosophy. To be able to predict when asset failures will occur, NetWork Rail has developed a comprehensive set of tools to measure and report upon the condition of their infrastructure assets. One of the tools used to measure asset condition is the unattended track geometry measuring systems installed on revenue trains. These unattended geometry measuring systems complement, not replace, the other NetWork Rail track measuring vehicles and provide a vast array of up-to-date information on asset condition at a relatively low cost. This data is then used by NetWork Rail to quantify the causal factors of asset degradation and improve their ability to predict failures and optimize their operating and capital maintenance programs. The "predict and prevent" maintenance philosophy is directed towards providing a safer, more reliable, and more cost effective railroad infrastructure.

### Video Recording of Turnouts

Similar to NetWork Rail, ProRail (infrastructure maintenance company in the Netherlands) uses modern inspection technology to help them monitor the condition of their railroad and plan for the efficient maintenance of their infrastructure assets. ProRail has the

same requirement to have up-to-date and accurate data on the condition of their infrastructure assets. Since the Netherlands has one of the busiest rail systems in the world, ProRail has a challenge acquiring the data they require without impacting the performance of train operations or risking the safety of its front line employees. ProRail has therefore successfully employed the use of video recorders to monitor and report upon the condition of their turnouts (i.e. switches on main line tracks). This technology has enabled ProRail to obtain the information they require without having to take the tracks out of service for inspection or place their employees on the track and in harms way.

### Remote Monitoring/Diagnostics

Remote monitoring of asset conditions, which is a technology that is actively used in the US trucking industry, has been applied on many European railroads to provide real-time assessments of their infrastructure condition. The benefits of this technology include improved timeliness and quality of data and reduced operating expenses. This technology enables the condition of the assets to be continuously monitored and diagnosed without requiring maintenance crews being sent to remote locations to complete similar tasks. One example of this technology is the POSS system used in the Netherlands to monitor the condition of turnouts. The POSS system measures and records the current used to drive the switch motors in the turnout. High current readings are an indication that the switch is not operating properly and requires a physical inspection and possible repair/maintenance.

**Recommendation 8 a – That the Chief Engineer identify the alternative surveillance and inspections technologies that Amtrak can use to more efficiently complete the current asset inspection procedures.**

**Recommendation 8 b – That the Chief Engineer identify the FRA regulations that are the greatest impediment to efficiency, develop the operating and financial benefits that would justify their modification, and then work with FRA administrators in an attempt to update FRA regulations so they align with current inspection technology and information systems used throughout Europe.**

**Finding No. 9 - Amtrak's current labor agreements hamper management's ability to optimize the efficiency of its labor force.**

**Discussion**

During our review, we learned that other Class I railroads in the United States, contrary to Amtrak, require their union employees to bid on the highest class of job they are qualified to perform. Amtrak allows its union employees to bid on the jobs they want, irrespective of whether or not it represents the highest class of job they are qualified to perform. This situation has the potential to cause work inefficiencies since less qualified individuals may end up performing critical tasks and the potential benefits from the investment in the training of the more qualified individual are not realized. The efficiency of Amtrak's infrastructure maintenance programs would increase by insuring that the most qualified individuals perform the critical maintenance functions.

**Recommendation 9 a -That the Chief Engineer identify the labor agreement provisions that are the greatest impediments to efficiency and then develop the operating and financial data to justify modifying these agreements.**

**Recommendation 9 b – That the Vice President for Labor Relations attempt to negotiate modifications to current labor agreements that support the assignment of employees to their highest qualified job category.**

## TECHNOLOGY

As illustrated in the flow chart on page 35, equipment technology is the third major Amtrak-controlled production driver that impacts the production rate of labor forces. The direct causal relationship between technology and labor productivity has been well known since the days of the Industrial Revolution and has been the driving force behind many of the major industries reinventing themselves. A prime example of the use of modern technology to improve both productivity and product quality is the almost exclusive use of robots in the auto industry to perform repetitive manual tasks such as welding and painting.

Our review of the practices used by the European infrastructure maintainers revealed that they have effectively incorporated the use of modern technology to help their labor forces work productively and to provide a high quality end product.

### **Finding No. 10 - Amtrak may be able to benefit by using some or all of the following technologies that are currently being used in Europe.**

#### Portable Track Geometry Gage

During our visit to Austria, the infrastructure maintenance company for OBB identified a portable system they use to measure and record data on track geometry. This system is

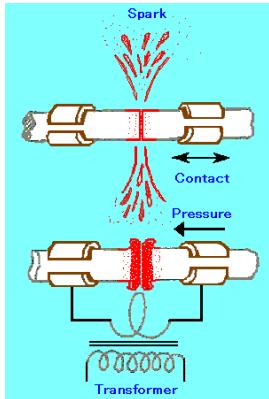
far superior to Amtrak's current system since it is more efficient to use and it provides enhanced and more reliable information. As illustrated in the picture to the left, the traditional track gage tool is a manual tool that measures only the distance between the track (i.e. track gage). The traditional process then requires the track gage and its mile post location be recorded manually at the work site and then subsequently manually input into the infrastructure data base at the railroad's data center. The OBB portable track geometry gage is a digital system that automatically measures



and records track gage, rail cross level, and the GPS coordinates. The data, which is digitally transferred to the computer infrastructure data base at the end of an inspection shift, can then be used to calculate other track parameters, such as track spiral, and to plan track maintenance and renewal programs.

## Flash Butt Welding

Flash butt welding is a technique used by railroads for joining segments of metal rail, typically performed in continuous rail territory where there are no rail joints. As illustrated in the following diagram, flash butt welding of rail occurs when the segments of rail are aligned with each other and electronically charged, producing an electric arc that melts and welds the ends of the rail segments, yielding an exceptionally strong and smooth joint. The flash butt welding process utilizes a relatively low electric voltage, a high electric current, and high pressure applied between the rail segments. Flash butt welding is the preferred method of welding rail in the "field" (i.e. along the right-of-way). The alternative method is thermite welding, which is a manual process requiring a chemical reaction in a field formed crucible to produce molten iron. Thermite welds of rail segments are considered to be less reliable and more prone to fracture or break.

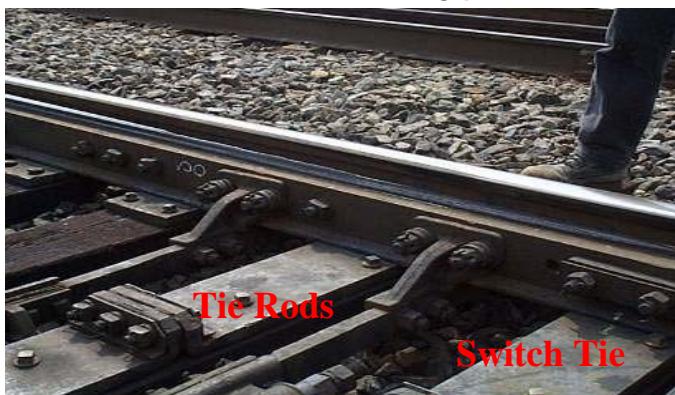


Although Amtrak currently uses a flash butt welding process, an improved system was observed during the visit to the European railroads. The flash butt welding system, which is used by Sersa in Switzerland and shown in the picture to the right, is a portable system that allows access to field locations and is computer controlled, providing improved alignment of rail sections and higher quality welds. The new system will decrease the amount of time required to complete each weld while improving weld quality, which will increase train ride quality and decrease rail wear.



## Hollow Switch Ties

As shown in the following picture, Amtrak's switch machines are designed with solid switch ties that require the switch tie rods to be located between the switch ties. This system exposes the tie rods to potential damage from moving equipment and also prevents the use of high speed mechanized tamping machines to level and align the switches.



In contrast to the solid switch ties used by Amtrak, Austria uses a hollow switch tie in its switch machines. The hollow switch ties are used to house the tie rods and thereby protect them from potential damage from moving equipment and it also allows the use of high speed tamping machines.



### Safety Clearance Handrail

One of Amtrak's primary goals is the safety of its personnel and customers and protecting them from hazards related to the movement of trains. As shown in the picture to the left, the Netherlands' infrastructure maintenance company uses a safety clearance handrail to physically separate a worksite from an active station track. The hand rail attaches to the track structure and clearly defines the safe working zone for the infrastructure workers. In this particular situation, a safety fence is used to define the work area in addition to the safety handrail.



### Train Approaching Warning Device

The train approaching warning device provides both a visual and an audible alarm at least 20 seconds before an approaching train arrives at the location along the right of way that is being protected. The train approaching warning device is used in Europe to help protect infrastructure maintenance employees who work on the right of way. The purpose of these devices is to reduce the risks related to working in the vicinity of live tracks and to help reduce the labor hours that otherwise would be required to provide flagging of the railroad. Based upon concepts seen in Europe, Amtrak plans to install the warning devices at its interlockings and moveable bridges since these locations have the highest safety related risk factor.

### Dual Wire Catenary Change Out System

As described on page 15 of this evaluation, a significant portion (i.e. 52%) of Amtrak's electric traction system is not in a state of good repair and consequently requires rehabilitation or total replacement. One of the most critical components of the catenary

system is the contact wire that transmits the electric traction power to the train's locomotives via the pantographs fixed to the roof of each locomotive. Of equal importance to the catenary system is the cable that properly aligns and supports the contact wire.

As illustrated in the following picture, a dual wire catenary change out system is



available that installs both the contact wire and its supporting auxiliary wire in a single working pass at the proper final operating tension and correct stagger. Compared to the use of conventional technology, this system installs these wires with a significant reduction in track possession time and, just as importantly, a reduction in man hours and capital expense. It is anticipated that the new system will support the replacement of 1 mile of contact and auxiliary wire during a single shift compared to

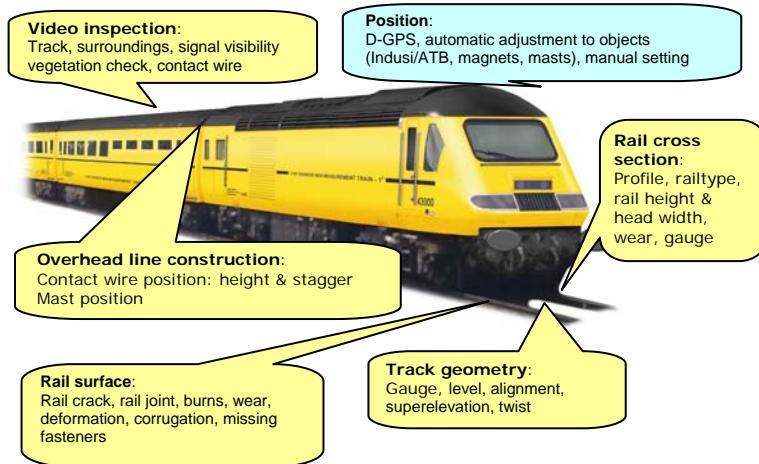
the current process that requires 15 shifts to complete. This system is currently being used by OBB in Austria for the renewal of its overhead electric catenary wires.

### Copper Magnesium Catenary Contact Wire

Amtrak uses a copper cadmium contact wire in its catenary system south of New York City and a copper silver contact wire north of New Haven. It has been reported that the copper magnesium contact wire is the preferred type of contact wire for high-speed railroads because it offers high tensile strength, good creep resistance, and high conductivity, which is expected to provide higher current levels for given levels of voltage along the catenary. The new contact wire purportedly has a longer useful service life and consequently is friendlier to the environment. Amtrak plans to install a section of the copper magnesium contact wire into the NEC catenary system and then evaluate its performance.

### Track Measurement Vehicle

The European railroads have numerous types of track inspection and measurement vehicles that they use to measure and report upon the condition of their railroad's



infrastructure. As illustrated in the following picture, Network Rail utilizes a self-propelled train (New Measurement Train) to complete the inspections of their railroad's infrastructure. Network Rail did not have all of the inspection systems on the New Measurement Train (NMT) fully functional, but they did have plans to have them operating as designed in the near future. The

NMT also provides a full array of track and catenary related data that is critical to making informed management decisions on track speeds and required maintenance programs. The benefits provided by these inspection vehicles include:

- Efficient inspection of railroad infrastructure – does not rely on the costly use of staff to perform frequent visual inspections.
- Objective results – conditions are measured and compared to acceptable standards.
- Timely information – exceptions to accepted minimal criteria are known immediately so that actions can be taken.
- Comprehensive record – a comprehensive record is maintained of the infrastructure that can be used to measure system degradation and establish the optimal maintenance and renewal programs.

### Hydraulic Switch Machines

In contrast to the current switch machines used by Amtrak (see picture on Page 44), the Austrians use a hydraulic switch machine that lies within the track profile. The following



picture illustrates a pre-fabricated crossover that incorporates a hydraulic switch machine to move the switch points. This crossover was to be cut into a section of the railroad that was undergoing a complete renovation from sub-ballast to track structure. Compared to the conventional Amtrak switch machine, it can be seen that this type of switch eliminates many of the moving parts that are maintenance intensive and a potential cause of switch operating failures. If applicable to Amtrak's operating environment, the hydraulic switches may be able to improve the reliability of these critical track systems, while reducing their maintenance requirements and operating expenses.

### Switch Point Rollers

Switch point rollers are used to reduce the amount of friction between the switch points and the plates that support the rail. The switch point roller system shown in the following picture is a SAFEROLL system. This switch point roller system facilitates the movement of the switch rail by lifting the switchblade from the tie plates during the setting movement and enabling it to move without creating sliding friction on the rollers. The advantages of this system are:

- Rolling friction instead of higher sliding friction
- Lifting of the switchblade during the movement



- Setting of movement is performed uniformly and without power peaks
- Requires no lubrication of the slide-chair plates
- Rollers have maintenance free bearings.

### Hand Held Switch Point Gage

The infrastructure maintenance department for the Austrian national railroad (OBB) has a portable hand held device that quickly and accurately measures the track gage at switch points. This system, which is shown in the picture to the left, appears to be more efficient and accurate to use than the one that Amtrak currently uses.



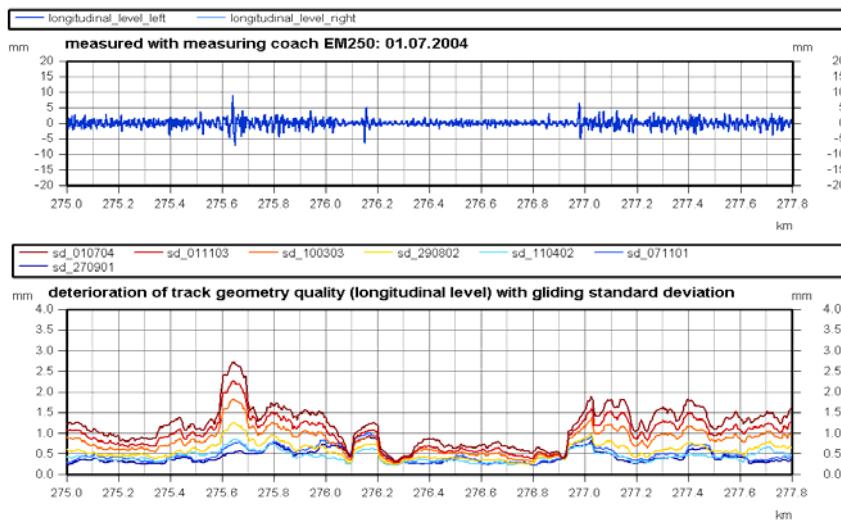
### Fixed Point Track Alignment

Both Switzerland and Austria use a fixed point reference system to insure that their railroad is maintained within very close tolerances to its original design parameters. This is accomplished by using the catenary poles along the right of way as the fixed points for aligning the railroad. The following picture illustrates how the catenary poles on Austria's Vienna to St. Polten high speed rail line include a point to attach a mirror that will be used to reflect laser beams during the track alignment process. The track tamping machines that align the tracks use a combination of video cameras, lasers, GPS systems, and computers to quickly and accurately return the railroad to its original design. This results in a railroad that has the proper track geometry and has each of its infrastructure elements (e.g. individual main line tracks) in the proper location in reference to each other. It is anticipated that the use of this system would improve the ride quality of Amtrak trains on the NEC, especially when they pass over crossovers between the main line tracks.

### Under Tie (Sleeper) Pads

Austria is installing elastomeric pads under their concrete ties (sleepers) to improve the ride quality of their railroad and/or reduce their infrastructure maintenance costs. The objective of this program is to eliminate the hard contact area that exists between the

concrete tie and the stone ballast. The hard contact area increases the pressure points



between the concrete tie and the stone ballast, which accelerates the failure of the ballast and concrete ties. OBB, Austria's infrastructure maintenance company, made an informed management decision to install the elastomeric pads based upon tests (see graphs on left) that demonstrate the ability of the pads to improve track alignment and reduce the deterioration of track geometry over time.

## Slab Track

Slab track is a relatively new technology that uses a ballast-less track bed to support the tie and rail system. Although there are numerous types of slab track, they all use a concrete base to support the railroad's tie and rail system. A good comparison of slab track versus ballasted track can be seen in the adjacent picture where the slab track for the Frankfurt to Cologne ICE train runs parallel to the ballasted track used for regional train service. While slab tracks are used in the United States primarily in tunnels, they have become common place in Europe on their high-speed passenger rail systems.

Like most new technologies, there are both advantages and disadvantages to the slab track system. The primary disadvantages of the system are its higher initial cost, uncertain useful service life and unknown replacement cost. The advantages are many:



- Allow higher train operating speeds
- The higher values for cant and cant deficiency allows small horizontal radii, which may significantly reduce construction costs in hilly territory
- Requires no track maintenance for tamping and aligning
- Reduces rail wear
- Provides constant elasticity
- Provides excellent ride comfort at high speed
- Reduces vibration and secondary airborne noises
- Improved load distribution reduces dynamic load of subsoil
- No flying or swirling ballast at high train speeds.

## Work Area Fencing

To help reduce the risks associated with working in the vicinity of live tracks, many of the European infrastructure maintainers erected barriers that clearly defined the safe work zone for its employees. In Switzerland, the safe work zone was defined by red and white safety tape and actual fences were used to define the safe work zone at projects in Austria.

## Turnout Design

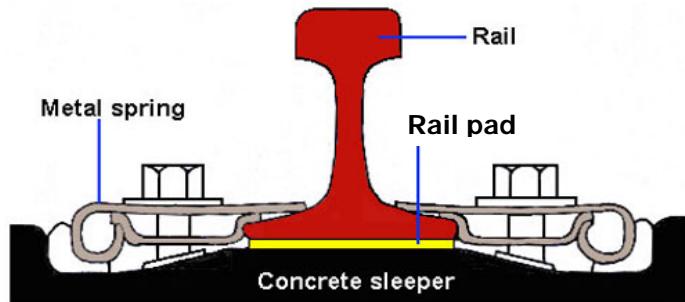
Amtrak's NEC is one of the busiest, if not the busiest, rail networks in the United States and is used by a wide range of train services that vary from the high-speed Acela train service, to Commuter train services, and even to freight train service. To be able to accommodate the various types of train services that have dissimilar operating characteristics (i.e. train speed, train length, station stops, etc.), the NEC uses a high density of turnouts. For example, the density of turnouts along the NEC Spine exceeds that of over 50% of the 15 European Railroads included in the Benchmarking Study.

European turnouts are designed for higher train speeds than the maximum allowable speeds through Amtrak's NEC turnouts. The higher permissible speeds results from the turnouts being built with higher cant, smaller turn radii, and higher tolerance standards. As witnessed by the Amtrak benchmarking team, the European railroads have been able to operate their trains through these turnouts at higher speeds and maintain a very high ride quality on the train. The design of turnouts is a very critical factor in the NEC since it impacts train on-time-performance, train schedules, and customer satisfaction. It is anticipated that Amtrak would experience significant operating and financial benefits if it is feasible to utilize some of these turnout design concepts on the NEC.

## Softer Rail Pads

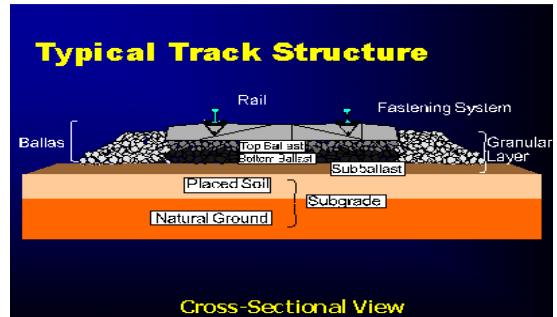
Amtrak and other rail infrastructure owners/maintainers place an elastomeric pad between the rail and the concrete sleeper, as illustrated in the following diagram, for improved train ride quality and infrastructure performance. The European Railroads have been using a softer rail pad than the one that Amtrak has been using and may provide superior performance. The rail pads will:

- Reduce train noise and vibration to improve ride quality
- Provide resilience and impact attenuation to increase concrete tie (sleeper) service life
- Reduce the possibility of rail foot corrosion and concrete tie erosion
- Provide resistance to rail creep
- Provide electrical insulation.



## Subgrade Replacement Machine

The long term performance and reliability of a track structure is only as good as the subgrade that supports the primary track structure, which includes the sub-ballast, ballast, ties, rail, and rail fastening system. The purpose of the subgrade is to provide sufficient support to the track structure so that the deflections from train operations are minimized, preventing any significant horizontal or vertical displacements from being transmitted to the track structure. As illustrated in the following diagram, the subgrade includes both the natural ground and the placed soil that lie directly beneath the track structure's sub-ballast. If a track structure has a poor sub-grade, then it is possible that the upper components of the track structure will not be properly supported, that the ballast could migrate into the sub-grade, or that fine particles in the sub-grade could migrate into the ballast causing mud spots. In any case, these conditions could impact the stability of the track and its ability to hold horizontal and lateral alignment.



The infrastructure maintenance company for OBB, Austria's national rail system, uses a system (similar to that of Amtrak's track laying system) to replace the sub-grade of its track structure on a production line basis. The following picture illustrates one portion of the



system when the geotechnical fabric is being laid down and the sub-grade stone is spread over the fabric. This function is being performed after the system has lifted the rails and ties and removed both the ballast and sub-grade, but before the sub-grade is tamped, the ties and rail put in place and ballast added to the track structure. When this operation is completed, the track structure has a completely renewed sub-grade and the track structure is ready for tamping to insure the rails have been properly aligned. Amtrak has never attempted to renew the sub-grade of its track

structure on such a grand scale and has only completed spot renewals when the conditions warranted the investment of time and money.

There are major one-time costs associated with the total replacement of the sub-grade of a railroad's track structure. There are also major operating and financial benefits that would be derived from this type of program. The operating benefits include improved ride quality and train reliability and the financial benefits would include improved ridership/revenue and reduced operating expenses resulting from the reduced amount of effort required to maintain the track's design geometry. Although the benefits may be significant, Amtrak should attempt to quantify both the costs and benefits of this type of program before it invests in the required equipment, manpower, and materials.

## Bridge Painting

Amtrak owns and maintains 1,327 undergrade bridges that are constructed from steel, concrete, or masonry and have build dates ranging from about 1890 to the present. In addition, Amtrak owns and maintains thirteen moveable bridges that are constructed primarily from steel and have build dates ranging from 1901 to 1984. Similar to Amtrak, the European Railroads have railway bridges built from a variety of materials over a wide span of time. As an example, the number of railroad owned and maintained bridges in Switzerland

are plotted by construction type and age category in the following bar graph. This graph illustrates that the oldest bridges are masonry bridges and that the primary type of bridge construction is concrete. The European railway maintainers stated that, in spite of their relatively lower age and population size, steel



bridges were their greatest maintenance challenge because of corrosion and rust, which is intensified wherever the steel bridges are located near bodies of salt water.

Our visits to the European Railroads revealed that there was not a common, unified approach to maintaining steel railroad bridges. Some of the European railroad infrastructure maintenance companies do not have a scheduled maintenance program to paint their steel bridges to protect them from corrosion. Most of these infrastructure maintainers understood the importance of painting their steel bridges, but due to budget constraints, chose to defer this type of maintenance.

In contrast, the Swiss infrastructure maintainer had a defined maintenance program to paint their steel bridges. The strategy of the Swiss program was to use state-of-the-art corrosion protection technology to produce an economical steel bridge maintenance program. To implement this strategy, the Swiss analyzed the available corrosion protection technologies and maintenance schedules to provide:

- Durable and robust bridges
- Low operating maintenance expenses
- Minimal life cycle costs (LCC)

The analysis took into consideration asset service life, renewal expenses (i.e. labor cost, material cost, set-up cost), consequences to train operations, and environmental impact.

## Bridge Reinforcement

As previously stated, Amtrak owns and maintains 1,327 undergrade railroad bridges, which include concrete bridges that cumulatively span almost four linear miles. When exposed to sufficiently aggressive environmental conditions, the structural concrete in these bridges will eventually deteriorate and lose strength. Aggressive environmental conditions for bridges involve cycles of freezing and thawing, and cycles of wetting and drying that is common to the northeast portion of the US. Banverket, the infrastructure maintainer in Sweden, utilizes carbon fiber technology to reinforce its bridges because of the high strength to weight ratio of carbon fiber. This technology may provide significant operating and financial benefits since reinforcing concrete bridges with carbon fiber may extend the service life of these bridges and reduce their overall life cycle costs.

## Concrete Catenary Structures

OBB, the national passenger railway system in Austria, utilized a comprehensive 15 year process to plan and initiate the construction of their high speed rail line between Vienna and St. Polten, Austria. This process analyzed traffic, technology and alignment alternatives trying to optimize the balance between environmental, operating, and financial factors. One of the many design concepts utilized in the Vienna to St. Polten rail line is the concrete catenary pole. The picture to the right shows a partially completed portion of the rail line that has an asphalt sub-grade, concrete catenary poles, and cable box raceway. OBB has chosen to use concrete catenary poles because, in Austria, they cost less than steel poles, they require less maintenance, and they are more aesthetically appealing. Amtrak should investigate if the same factors would apply for the use of concrete catenary poles in newly electrified rail lines in the United States.



Prefabricated Temporary Bridges During major bridge rehabilitation and replacement projects, OBB diverts the rail traffic to off-the shelf type prefabricated bridges that have been temporarily put in place during the construction projects. The use of the temporary railway bridge (see adjacent picture) enables the construction project to proceed efficiently while minimizing the impact to train operations over this portion of the rail line. When required, Amtrak



currently designs and then has built temporary bridges for each specific bridge project. There may be some time related and cost related benefits to using an off-the-shelf type prefabricated bridge compared to a design-build type prefab bridge.

Advanced Radio Systems The European infrastructure operators are in the process of installing an advanced radio system (GSM-R) on their rail lines as one part of a suite of programs supporting the UIC goal to operate trains seamlessly between European countries and across the continent. This system is being installed in combination with the European Rail Traffic Management System (ERTMS) and the European Train Control System (ETCS), which are also required to support the UIC inter-operability goal. In addition to improving the reliability of the train radio system, GSM-R will also:

- Allow the train controller to not only speak directly with the train engineer, but also to the passengers on the train via the train intercom.
- Allow the train engineer to contact the train controller with one push of a button.
- Allow the train controller to call multiple trains at one time.
- Allow the train controller to make a railway wide emergency call using the red emergency button.

Amtrak may be able to benefit from the increased reliability and functionality of these advanced radio systems.

Safety Inspection Platform As described on page iii of this evaluation's introduction, the Netherlands was identified as the country to visit regarding the best practices related to bridge maintenance programs because of their high density of both fixed and moveable bridges. Their railroad system has a total of 4,880 bridges, overpasses, and tunnels, which amounts to almost 3 of these major infrastructure assets per network mile. To improve the safety and efficiency of the bridge inspections, the railroad infrastructure maintainer (ProRail) uses permanently installed platforms (see picture to right of moveable platform beneath the lift bridge at Dordrecht) to inspect the support structure of bridges. The inspection platform enables the ProRail employees to safely inspect the supporting structure of this lift bridge without impacting the rail operations of this key rail line.



Output Based Contracts Most of the European infrastructure maintainers rely heavily on the use of outside contractors (i.e. non-railroad employees) to complete their major capital improvement projects and consequently have extensive experience contracting out this work.

Banverket, Sweden, has determined that the use of "output based" contracts offers the greatest opportunities for them to obtain the infrastructure improvements they have paid for. Coincidentally, a 2007 survey conducted in the United States by the International Association for Contract and Commercial Management revealed that over 50% of the respondents were using output based contracts. The unique aspect of this type of contract is that it focuses on what the deliverables are rather than how they should be delivered, and consequently allows the contractor to utilize the most cost effective technologies and processes to deliver the product/services. ProRail has also begun to use performance (i.e. output) based contracts and has gained valuable experience in how best to define performance indices and to incorporate performance incentives/penalties.

For a railroad infrastructure company, examples of deliverables from an output based contract are track speed, track geometry, ride quality, and system reliability. To help insure that their contracts are successful, Banverket specifies standardized components to be used in the maintenance projects, establishes meaningful and measurable performance indices, and works very closely with the contractors to eliminate any avoidable barriers to their success. Banverket wants these contracts to be a win-win relationship and is willing to accept some near term risk to develop contracts that will provide the best infrastructure and the best price.

**Recommendation 10 - That the Chief Engineer prepare and implement a plan to investigate the feasibility and benefits that would be derived by utilizing each of the technologies currently being employed by European railroads as discussed in this section and summarized in Appendix I.**

## **SUMMARY - RECOMMENDATIONS**

### **Process**

Recommendation 1 – That the Chief Engineer continue to develop and implement an asset management process that will provide the appropriate data and business decision processes required to optimize Amtrak's infrastructure maintenance and renewal programs.

Recommendation 2 – That the Chief Engineer expand the Industrial Engineering expertise within Amtrak's Engineering Department so that it can regularly develop infrastructure maintenance programs that optimize the use of manpower, materials, and technology.

Recommendation 3 – That the Chief Engineer develop and use a comprehensive set of metrics that monitor infrastructure maintenance performance to support effective decision-making.

Recommendation 4 a – That the Chief Engineer investigate the feasibility of implementing the European practices used to optimize the productivity of its infrastructure maintenance crews.

Recommendation 4 b – That the Chief Engineer identify the civil noise and other restrictions that are the greatest impediment to efficiency and develop the operating and financial benefits that would justify their modification.

Recommendation 4 c – That the Vice President for Government Affairs & Corporate Communications work with local government jurisdictions in an attempt to modify civil restrictions that the Chief Engineer identified as hindering the efficiency of infrastructure maintenance.

Recommendation 5 – That the Chief Engineer establishes a long-term planning process that optimizes the investment of capital and operating funds for infrastructure maintenance by taking into consideration the timing of asset renewals and related asset reliability and performance.

Recommendation 6 a – That the Chief Engineer develop the operating and financial benefits that would be derived from a consistent multi-year capital funding program.

Recommendation 6 b – That the Vice President for Government Affairs & Corporate Communications consult with the Congressional appropriation committees in an attempt to obtain multi-year commitments of capital funds from the Federal Government.

## **Labor**

Recommendation 7 a – In support of the actions recommended to develop a comprehensive Amtrak compensation strategy (reference page 22 of the OIG Report E-09-03), that the Chief Engineer identify the critical near-term and projected staffing shortfalls that need to be addressed by the comprehensive compensation strategy.

Recommendation 7 b – That the Vice President for Human Resources & Diversity Initiatives develop a comprehensive compensation strategy that will help attract and retain the skilled labor required by the Engineering Department to efficiently and effectively complete its infrastructure maintenance programs.

Recommendation 8 a – That the Chief Engineer identify the alternative surveillance and inspection technologies that Amtrak can use to more efficiently complete the current asset inspection procedures.

Recommendation 8 b – That the Chief Engineer identify the FRA regulations that are the greatest impediment to efficiency, develop the operating and financial benefits that would justify their modification and then work with the FRA administrators to update FRA regulations so they align with current inspection technology and information systems.

Recommendation 9 a – That the Chief Engineer identify the labor agreement provisions that are the greatest impediments to efficiency and then develop the operating and financial data to justify modifying these agreements.

Recommendation 9 b – That the Vice President for Labor Relations attempt to negotiate modifications to the current labor agreement that support the assignment of employees to their highest qualified job category.

## **Technology**

Recommendation 10 – That the Chief Engineer prepare and implement a plan to investigate the feasibility and benefits that would be derived by utilizing each of the 32 technologies currently being employed by European railroads as discussed in this section and summarized in Appendix I.

# APPENDIX I

## SUMMARY OF EUROPEAN BEST TECHNOLOGY PRACTICES

| <b>Best Practice</b>  |
|---|
| Magnesium-copper contact wire   |
| Dual wire catenary change out machine   |
| Remote monitoring/diagnostics   |
| Use of concrete catenary structures   |
| Pattern recognition   |
| Track measurement vehicle   |
| Unattended geometry measuring systems on revenue trains   |
| Video recording of turnouts, visual inspections of the recordings as a result of safety regulations ("nobody in the track") |
| Switch monitoring system (POSS)   |
| Portable track geometry gauge   |
| Hand held switch point gauge  |
| Hollow switch tie   |
| Hydraulic switch machines   |
| Switch point rollers  |
| Increase turnout efficiency   |
| Pad under concrete tie  |
| Softer pads between rails and ties  |
| Subgrade replacement machine  |
| Asphalt subgrade layer  |
| Flash butt welding  |
| Fixed point surfacing   |
| Total track renewal   |
| Expanded use of work area fencing   |
| Self contained mobile workstation (Volker Rail)   |
| Safety clearance handrail   |
| Prefab temporary bridges  |
| Safety platform for under-bridge-inspections, permanent inspection scaffolding  |
| Bridge painting   |
| Web based asset register and maintenance program for bridges, also used by road administrations<br>Cambridge Systematics    |
| Bridge reinforcement  |
| Train approaching warning devices at the movable bridge in Dordrecht  |
| Advanced radio-system: office to train PA (public address) system   |

## **APPENDIX II**

### **Contributors to Report E-09-05**

| <u>Name</u> | <u>Title/ Function</u> |
|-------------|------------------------|
|-------------|------------------------|

#### **Amtak OIG**

Primary Author:

Jim Simpson

Chief, Inspections & Evaluations

Other Contributors:

Calvin Evans

Deputy IG, Inspect. & Evaluations

Philip Ong

Director, Inspections & Evaluations

Nico Lindenau

Director, Inspections & Evaluations

#### **Amtrak Engineering**

Frank Vacca  
Steven Falkenstein  
David Staplin  
James Richter  
Keith Holt  
Robert Verhelle  
William Bates  
Tom Denio  
Ed Simons  
Reuven Shiloh  
Bruce Willbrant  
John Pielli  
Bernie Pattay  
Jim Buechler  
George Fritter

Chief Engineer  
Deputy Chief Engineer Maintenance  
Deputy Chief Engineer Track  
Deputy Chief Engineer Structures  
Deputy Chief Engineer Communications & Signals  
Deputy Chief Engineer Electric Traction  
Sr. Director Business Improvement  
Superintendent Engineering Production  
Sr. Director Planning & Budgeting  
Sr. Director Operation Improvement  
Former Deputy Chief Engineer Maintenance  
Director Track Maintenance & Compliance  
Director Program Planning  
Director, Planning & Integration  
Deputy Division Engineer New England

#### **BSL Management Consultants**

Dr. Heiner Bente  
Klaus Wittmeier  
Frank Zschoche

Managing Director  
Senior Consultant  
Director

## Contributors to Report E-09-05 (cont.)

| Name                   | Title/ Function                           |
|------------------------|---|
| <b>SBB</b>             |   |
| Martin Aeberhard       | Head of System Design-ET                  |
| Markus Barth           | Head of Interaction Infrastructure/Rail   |
| Jean-Michel Devaud     | Head of Products and Systems              |
| Karin Frey             | Project Engineer – Asset Management       |
| Daniel Gerber          | Head of Interlocking Block                |
| Peter Guldenapfel      | Senior Engineer, Products and Systems     |
| Xaver Imwinkelried     | Area Manager, Maintenance & Construction  |
| Thomas Peter Lang      | Senior Engineer, Products and Systems     |
| Beat Pfyl              | Senior Controller, Finance – Track System |
| Heinz Rickli           | Senior Engineer, Program Manager          |
| Peter Walchli          | Head of Measuring Train                   |
| Jurg Widmer            | Senior Engineer, Asset Management         |
| Daniel Wyder           | Head of Asset Management                  |
| <b>OBB</b>             |   |
| Friedrich Cerny        | Engineering – Train Control & Signalling  |
| Thomas Simandl         | Infrastructure Service                    |
| Roman Fila             | Engineering – Bridges & Civil Engineering |
| Jurgen Stern           | Engineering – Geotechnics                 |
| Franz Stelzer          | Engineering – Permanent Way               |
| <b>OBB (continued)</b> |   |
| Dietmar Zieri          | Director Layout of Lines & Stations       |
| Klaus Leithner         | Engineering – Standardization Energy      |
| Bernhard Knoll         | Director – Permanent Way                  |
| <b>Network Rail</b>    |   |
| Jerry England          | Director – Civil Engineering              |
| Andy Kirwan            | Head of Asset Management Development      |
| Darren Wells           | Standards and Assurance Engineer          |
| Charles Hervy          | Business Planning Engineer                |
| Peter Lander           | Track and Geometry Gauging Engineer       |
| Alan Dray              | Head of Structures Engineering            |
| David Wynne            | Head of Maintenance Improvement           |
| Jonathan Ellis         | Interoperability Engineer                 |

## Contributors to Report E-09-05 (cont.)

| Name            | Title/ Function                     |
|-----------------|-------------------------------------|
| Simon Broomhead | Infrastructure Measurement Engineer |
| Eddie Locke     | Examination Resource Manager        |
| Mark Dembrosky  | Vehicle Track Dynamics Expert       |
| Tez McCall      | Engineering Development Manager     |
| Richard Owens   | Area Track Engineer                 |

### Deutsche Bahn

|                |                                    |
|----------------|------------------------------------|
| Andreas Beck   | Technology Management              |
| Knut Maisch    | Head of Maintenance and Operations |
| Jorg Schurig   | Asset Planning                     |
| Alexandra Vogl | Head of Central Asset Planning     |
| Jens Muller    | Head of Civil Engineering          |

### Banverket

|                  |                             |
|------------------|-----------------------------|
| Torbjorn Bodin   | Project Leader              |
| Valle Janssen    | Bridge Engineering          |
| Bjorn Ostlund    | Division Chief              |
| Helena Andersson |                             |
| Fredrik Markgren | Engineer Interlocking       |
| Per-Eric Metso   | Project Leader – Consultant |
| Lars Lagestam    | Chief of Signaling          |

### Banverket

|                   |                             |
|-------------------|-----------------------------|
| Johan Oberg       | Civil Engineering           |
| Robert Eriksson   | Manager in Stockholm        |
| Bjorn Kufver      | Track Engineer              |
| Sven Leijonhufvud | Coordinator-technology      |
| Jenny Holm        | Informant                   |
| Stephan Larsson   | Project Manager, Telebacken |
| Ensio Taivalkoski | Track Engineer              |
| Terje Johnsson    |                             |
| Maria Blanche     | Administrator               |

## Contributors to Report E-09-05 (cont.)

| <u>Name</u> | <u>Title/ Function</u> |
|-------------|------------------------|
|-------------|------------------------|

---

### ProRail

|                   |                              |
|-------------------|------------------------------|
| Ted Luiten        | Head Infrastructure Planning |
| Dr. Ivan Shevtsov | Specialist Rail Systems      |
| Taco Sysling      | System Manager, Track        |
| Frits Verheij     | Manager Asset Management     |
| Andre Broersen    | System Specialist            |