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The US Railroads- their evolution, structure and operations

by

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Introduction

Both India and the United States of America share a common history of dominant role of railroads in the development of the economy. While the first common carrier of the US, the Baltimore and Ohio Railroad (B&O, now part of CSXT), commenced services on a 13 mile stretch in 1830, railways commenced operations in India in 1853 on the 21 mile Mumbai-Thane stretch (1). While the US railroads expanded westwards over the next fifty years to bridge the American continent, Indian railroads were also being built to connect the vast sub-continent to the major sea-ports albeit at a much slower pace.

Growth of US and Indian Railroads

Year	**1830**	**1840**	**1850**	**1860**	**1870**	**1880**	**1890**	**1900**
US railroad miles	23	2,818	9,021	30,635	52,914	93,296	163,597	193,346
Year				**1861**	**1871**	**1881**	**1891**	**1901**
Indian railroad miles				1,587	5,074	9,723	16,690	24,185

Sources: (2; 1)

Today the US railroads carry 43% of the nation's freight traffic, while operating at a far lower operating ratio and with much less manpower than the Indian Railways. The US railroads and Indian Railways have roughly the same traffic densities- 16.1 and 15.5 million traffic units/km of line respectively. (3) The average speeds of US railroads are however much higher resulting in faster turn-around time, better utilization of assets and hence higher returns and lower unit costs.

Since both countries are geographically large, have large populations and economies, the challenges and opportunities for both the US and Indian railroads are similar. Thus a study of the evolution, structure and operations of the US railroads has been undertaken in this paper to examine the possibility of emulation of few practices on the Indian Railways. (4). This paper is organized as follows: the evolution is discussed in Section 2, industry structure in Section 3, regulation in Section 4, freight traffic in Section 5, organization structure in Section 6, operation in Section 7, equipment in Section 8, technology for productivity enhancement in Section 9, followed by discussions on strategic lessons in Section 10 and conclusions in Section 11.

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2. Evolution of US Railroads

The US government has treated the transportation sector similar to any business sector of the free market economy, in tune with the US traditions of competitive liberalism. (5) US railroads were thus mostly constructed and owned by entrepreneurs. Only a few railroads were owned by Government- examples being the Alaska Railroad, Amtrak, Conrail (but subsequently divested). However, the government did play an active role in the railroad development. From 1850 to 1880, the federal government gave around 131 million acres land grants and loans of up to $48,000 for each mile of railroad track built. State governments too invested in the building of railroads through purchases of stocks or bonds or donations to railroad companies. Few states, such as Missouri, North & South Carolina Illinois, Indiana, Michigan, Georgia, Tennessee, Virginia, and Louisiana, also participated in construction of railroads. (2) By 1906, the United States had laid 222,000 miles of track which was 40% of the railway mileage in the world (2).

2.1 *Growth and Technological Innovation*

Railroad expansion in the US was also promoted by a series of indigenous technological innovations. The first completely American built locomotive “The Best Friend” was made in New York for the Charleston & Hamburg Railroad in 1830. In 1864, George Pullman developed the first Pullman sleeping car. Major Eli Janney invented the Janney coupler in 1868, replacing the dangerous link and pin coupler. George Westinghouse invented the airbrake in 1869, which was patented in 1872 and quickly became an industry standard; later the Federal Railway Safety Appliances Act of 1893 instituted mandatory requirements for automatic air brake systems and automatic couplers. The first refrigerator cars went into operation on the Southern Pacific in 1886, making it possible to deliver perishable fruits and vegetables all across the nation. The General Electric Company built the first Diesel-electric engine prototype in 1917; the American Locomotive Company built the first Diesel-electric locomotive in 1925 which started the process of replacement of steam-powered engines. In 1957, Southern Pacific emerged as the first railroad with only diesel locomotives.

2.2 *Growth and regulation*

The unfettered growth of the railroad industry led to companies operating multiple railroad services on major traffic routes. Competition for traffic led to discriminatory pricing behavior and price cutting wars to recover their investment. Initial efforts for regulation were spurred in the 1870s by efforts of an organization of farmers called the “National Grange of Patrons of Husbandry” or the “Grangers” for securing cheaper transportation rates for farmers through regulation of railroads. The federal regulatory agency Interstate Commerce Commission (ICC, now the STB-Surface Transportation Board) was thus created by the Congress in 1887 in response to complaints of discrimination in rates and service which allegedly benefitted economically powerful shippers. The ICC Act outlawed discrimination amongst shippers, required rates to be published and subjected railroad rates and service to oversight by ICC to end discrimination against places, products and shippers. The 1906

Hepburn Railroad Regulation Act prohibited railroads transporting commodities in which it had interests, imposed monetary and prison penalties against rebates and empowered ICC to inspect railroad accounts to uncover rebate abuses and establish rates which were “just, fair and reasonable”. (6) The Transportation Act of 1920 increased the powers of the ICC to help maintain adequate rates of return and stabilize the financially weak railroads. Powers granted to the ICC under this act included the powers to control entry, regulate construction and abandonment, and prescribe minimum and maximum rates. A fund was also established to assist weaker railroads. The 1920 Act also released federal control of railroad operations that were seized in 1917 during World War I.

Economic regulation was however gradually reduced with passage of 1970 Amtrak Act, 1973 Regional Railroad Reorganization 3R Act, 1976 Railroad Revitalization & Regulatory Reform 4R Act and 1980 Staggers Rail Act. The ICC Termination Act of 1995 abolished the ICC and assigned the regulatory authority for railroads to the Surface Transportation Board (STB). The 1980 Staggers Rail Act was enacted following series of failures of railroad companies. Consolidation of railroads followed the Staggers Act, with number of Class I railroads reducing from 40 to current 7 only. The total number of railroads however increased from 490 to the current figure of 559. The number of Class I railroad employees decreased from 450,000 in 1980 to 167,000 in 2007. Following the 1980 Staggers Rail Act, railroads share of freight (in terms of ton-miles) rose from 27% in 1980 to 38% in 2005.

2.3 *Consolidation*

Railroads suffered with the creation of an efficient Interstate highway system in the 1950s. As private rail businesses faced stiff rate competition from trucks and shareholder pressure to generate profits, the nation’s major railroads disinvested in lines and services with insufficient traffic density to adequately cover operating and maintenance costs. The Class I railroad system today has 172,000 miles of track, less than half the number of miles it had in the 1920s. The result of these changes is a modern, efficient “core” network geared towards profitably serving today’s freight-rail markets. But this efficiency has come at a cost. Railroad service has been withdrawn from many areas, forcing businesses to relocate or shift to truck service. Further, the entire network has become segregated into high-speed high-volume trunk lines (owned largely by Class I railroads) and low volume-low speed feeder lines. (8) This has resulted in up-gradation of track, signaling and traffic control systems only on the trunk routes while feeder lines continue to languish with “primitive” equipment. (9)

3.US Railroads Industry Structure

The US freight-rail system carries 16 percent of the nation’s freight by tonnage, accounting for 28 percent of total ton-miles, 40 percent of intercity ton-miles, and six percent of freight value. (9)

There were 559 common carrier freight railroads operating in the United States in 2006, classified into five groups. The first group includes Class I railroads, which are those with annual operating revenues of $319.3 million or more as of 2005 (amount is adjusted annually for inflation and must be reached or exceeded for three consecutive years for a firm to be considered Class I) as per STB guidelines. Class II railroads should have annual operating revenues of $25.5 million to $319.2 million as of 2005 as per STB guidelines. Railroads having annual operating revenues of less than $25.5 million as of 2005 are classified as Class III railroads as per STB guidelines. (8)

3.1 *Class I railroads*

Class I carriers comprise only 1 percent of the number of U.S. freight railroads, but they account for 70 percent of the industry's mileage operated, 89 percent of its employees, 84 percent of originating traffic and 92 percent of its freight revenue. The Class I carriers are Burlington Northern/Santa Fe; the Canadian National (which controls the merged Grand Trunk Western and Illinois Central); Canadian Pacific (which controls the Soo Line); CSX Transportation; Kansas City Southern Railway; Norfolk Southern; and Union Pacific. Now rail duopolies exist on the east (the CSXT and NS) and west (the BNSF and UP) of the Mississippi River (11).

Major US Class I railways

Parameter	BNSF Railway Company	Union Pacific	CSX Transportation	Norfolk Southern Corporation	Kansas City Southern
Track length (km)	32,000 route miles (of which 23,000 miles owned)	32,094 route miles (of which 26,223 miles owned)	21,000 route miles	21,000 route miles	6000 miles
States covered	28 US states & 2 Canadian provinces	23 US states	23 US states & 2 Canadian provinces	22 US states & District of Columbia	10 US states
Gauge	1435 mm (4ft 8.5 inches)	1435 mm	1435 mm	1435 mm	1435 mm
Employees (thousand)	35	44	30	29	6
Facilities	31 intermodal facilities	NA	NA	46 intermodal facilities	NA
Average length of haul (miles)	1108	NA	NA	NA	NA
Freight carried (billion revenue tonne-miles)	594	479	NA	159	NA
Terminal Dwell Hours	24.5	25.8	24.3	22.7	16.8
Average freight train speed(mph)	27.5	27	22	22.4	28.7
Freight composition (in terms of revenue earned)	32% consumer products 26% coal 21% industrial products 21% agricultural products	Agricultural 20%, Chemicals 16%, Energy 23%, Industrial Products 16%, Intermodal 19%, and Automotive 6%.	48% merchandise, 30% coal, 6% automotive, 13% intermodal	29% coal,coke and iron ore 25% general merchandise 19% intermodal	24% agriculture & minerals 23% industrial & consumer products 22% chemicals & petroleum 13% coal 10% intermodal 3% automotive
Administrative Divisions	thirteen divisions, which are grouped into three regions	21 “service units”	Northern Region and Southern Region each having five divisions.	NA	NA
Locomotives	6759 owned and leased	5610 owned 2740 leased	4071 (95% owned)	3833 owned 132 leased	536 owned 382 leased
Freight Cars	79,329 owned and leased	43,835 owned 39,362 leased	84,282 (60% owned)	78,333 owned 11,604 leased	3545 owned 17245 leased
Total operating	13,848	14,143	9,041	7,969	1,480

revenue (million USD)					
Total operating expenses (million USD)	10,640 32.5% compensation & benefits 22% fuel expenses 17.5% purchased services[2] 7% equipment rentals[3]	10,751 38% compensation & benefits 16% fuel 15% purchased material & services 11% equipment rents	6,756 39% labor & fringe 13% fuel 6% equipment & rents	6,007 40% compensation & benefits 12% fuel 18% purchased services 5% equipment rents	1212 27% compensation & benefits 16% fuel 14% equipment costs 14% purchased services

Most Class I's railroads have become "wholesalers" of line-haul transportation with preference for unit trains, while the "retail function" of aggregation or disaggregation have gradually been transferred to short-lines, steamship companies, motor carriers, or other third parties. BNSF reported in 2009, that over half of the freight revenues of the Company are covered by contractual agreements of varying durations, while the balance is subject to common carrier. BNSF Railway has also entered into marketing agreements with CSX Transportation, Canadian National Railway Company and Kansas City Southern Railway Company, and 200 shortline railways. CSX Transportation has agreements with 240 short-line and regional railroads.

Class I railroads use similar "hub-and-spoke" strategies as passenger airlines, to maximize traffic on key high-density high-profit corridors. For example, BNSF has started using 110-car "shuttle trains" loading at a limited number of elevators to move grain out of the northern plains. This replaces a system of shorter trains loading at more elevators, and places greater pressure on other modes (that is, trucking, short-line railroads, or Class I branch-line services) to pick up and deliver traffic over "the last mile." Another example is the NS intermodal network, where Harrisburg is being developed as a central terminus to serve Mid-Atlantic and Northeastern urbanized areas (9)

3.2 *Regional and Local line haul railroads*

The second group of railroads includes Regional railroads, which are line haul railroads with at least 350 route miles and/or revenue of between $40 million and the Class I threshold. There were 33 regional railroads in 2006. Regional railroads typically operate 400 to 650 miles of road serving a region located in two to four states. Most regional railroads employ between 75 and 500 workers, although four have more than 600 employees. (11) Regional railroads serve several primary customers on inter-state basis.

The third group includes Local linehaul carriers, which operate less than 350 miles and earn less than $40 million per year. In 2006, there were 323 local line haul carriers. They generally

[2] purchased service expense includes the following: ramping (lifting of containers onto and off of rail cars); drayage (highway movements to and from railway facilities); maintenance of locomotives, freight cars and equipment; transportation costs over other railroads; technology services outsourcing; insurance costs; professional services; and other contract services.

[3] Equipment rents expense includes long-term and short-term payments primarily for locomotives, freight cars, containers and trailers.

perform point-to-point service over short distances. Most operate less than 50 miles of road (more than 20 percent operate 15 or fewer miles) and serve a single state. (11)

The regional and short-line railroads are 94.5 percent private and 5.5 percent public-owned. These railroads originate 16 percent of national rail traffic, generate nine percent of railroad revenue, while operating more than 20 percent of total system mileage. Regional and short-line systems have been formed mostly through networks abandoned by the Class I railroads. The regional and short-line systems differ from Class I railroads through less stringent labor cost structures (being subject to relaxed labor rules and flexible salaries), less stringent government requirements for track and equipment maintenance and record keeping standards and business models. Many regional and short-line railroads receive public funding support. They serve an important function in providing the first and last service miles for Class I railroads. (9)

3.3 *Switching and terminal carriers*

The fourth group includes Switching and terminal (S&T) carriers, which are railroads, regardless of revenue, that primarily provide switching and/or terminal services. Rather than point-to-point transportation, they perform pick up and delivery services within a specified area for one or more connecting line haul carriers, often in exchange for a flat per-car fee. In some cases, S&T carriers funnel traffic between line haul railroads. Switching establishments, which may or may not be run by the railroads that use them, can use up to 100 track segments on which cars and locomotives are coupled and uncoupled, loaded and unloaded. In 2006, there were 196 S&T carriers. The largest S&T carriers handle hundreds of thousands of carloads per year and earn tens of millions of dollars in revenue. Industry leaders are the Indiana Harbor Belt Railroad Co. of Hammond, Indiana, Belt Railway Company of Chicago, of Bedford Park, Illinois, Missouri-based Terminal Railroad Association of St. Louis, Cuyahoga Valley Railway Company of Peninsula, Ohio, and New York-based South Buffalo Railway Co. (11)

3.4 *Trackage and Haulage Contracts*

Individual railroad companies combine, coordinate or connect their tracks and facilities to hold down overall costs. Examples are Paired tracks (two railroads have single lines between two points; both use these single lines for up and down directions), Trackage rights (pay toll or “wheelage” charges based on number of cars involved, to use other railroad’s tracks), Joint facilities (jointly owned company responsible for operation of a line), Detouring(railroads have standard detouring agreements with each other, so that trouble spots may be bypassed in emergencies) and Haulage (railroad A pays another railroad B to move its consist over another railroad B’s territory using B’s crew and power). Other examples are alliances such as the one between Canadian National and Kansas City Southern providing access to the Mexican market; BNSF also has marketing and operations alliance with Kansas City Southern. Disputes may arise in respect to these contracts, such as allegations of low priority to competitor car movements. These trackage and haulage contracts can constitute a significant network asset for a railroad company. These rights arise from contracts, exchanges or regulatory fiats. Example of regulatory fiat is the STB mandate following UP/SP merger giving BNSF trackage rights over UP's Overland Route, from Oakland, through Salt Lake City, to a connection with the BNSF network in Denver, UP's parallel main lines northeast from Houston to Memphis and beyond and trackage rights and shared UP/BNSF ownership to provide BNSF with a connection from the Texas border to New Orleans, thus serving the important "Chemical Coast" oil refineries. These contracts generally pass on intact to the new owner whenever a network is sold. (8)

3.5 *Partnerships with Road Transport Industry*

Since freight haul becomes more economical on rail for distances above 500 miles(8), truckers consolidate loads for shipments by rail over long distances. Thus major trucking companies such as Schneider, JB Hunt etc have contracts with railroads for regular scheduled shipments by rail. This initiative of trucking companies has also been driven by recent truck driver shortages. A key element of BNSF's marketing strategy, for example is to forge partnerships with other large and small railroads, motor carriers, barge lines, ocean carriers and warehousing companies to over a broad range of services to its customers. To further capture this traffic, BN and UP are following competitive strategies to achieve high trip time reliability in addition to efforts to reduce travel times and improve network efficiency. (8) Express logistics services such as UPS also have contracts with rail for shipment of low-end products by rail. However, in case of express logistics services, the contracts with the railways have penalty clauses for late delivery.

3.6 *Geographical Characteristics*

Two Mexican railroads — the Ferrocarril Mexicano and the Transportacion Ferrovaria Mexicana —which also operate on US territory would also qualify as Class I railroads if they were U.S. companies. The Kansas City Southern owns a substantial minority interest in Transportacion Ferrovaria Mexicana, while the Union Pacific has an interest in Ferrocarril Mexicano. Two Canadian railroads- the Canadian Pacific and Canadian National operate on both US and Canadian territory.

Cramer (8) has identified a few significant geographic features of US long haul rail freight traffic. The dominant eastern (CSXT and NS) and western (BNSF and UP) rail duopolies networks meet and overlap in a zone paralleling the Mississippi River; this has resulted in development of major rail hubs such as Minneapolis/St.Pauls, Chicago, St. Louis, Kansas City, Memphis, Houston, and Dallas / Ft. Worth in this area. Further the western duopolies have predominantly east-west lines, since these lines mainly connect the Pacific Ocean ports and mid-continental rail hubs (such as Chicago) ; there is very little traffic origins or destinations in the intervening arid sparsely populated regions.

Table: distribution of transport infrastructure, population and the economy in the US

	Northeast[4]	Midwest	South	West	Others
Area	5%	22%	24%	31%	18%
Population	19%	23%	35%	22%	1%
GDP	21%	21%	34%	23%	1%
Interstate Road	11%	27%	34%	25%	3%
Railroads	9%	36%	36%	19%	-

The Midwest rail hubs, of which Chicago is the largest, serves as interchange points for coast-to-coast traffic, where the West Coast Class I's must interchange with the East Coast Class I's. This costly exercise involves switching railcars from one system to another, one crew to another, and in some cases, the transshipment using dray containers from one yard to another. Class I railroads are trying to reduce this exercise through marketing agreements, trackage and haulage arrangements, and operating coordination, to enable "run through" services. (9)

3.7 *Government funding support*

Even though the railroads are entirely in the private sector, federal funding is available for the railroads programs such as Section 130 Rail-Highway Grade Crossing Program, National Highway System (NHS) Program for funding improvement of highway links, Surface Transportation Program (STP) for funding lengthening or increasing vertical clearances on highway bridges, or improving at-grade crossings, Congestion Mitigation and Air Quality (CMAQ) for funding transportation projects that improve air quality, Transportation Infrastructure Finance and Innovation Act (TIFIA) providing credit assistance (up to one-third of project cost) for major transportation investments of national significance, Railroad Rehabilitation and Improvement Financing (RRIF) provides credit assistance, National Corridor Planning and Development (NCPD) and Coordinated Border Infrastructure (CBI) programs, Transportation and Community and System Preservation Pilot Program (TCSP) and Transportation Enhancements (TE) .

3.8 *Passenger traffic*

Prior to Amtrak's creation by the Rail Passenger Service Act of 1970, intercity passenger rail service in the United States was provided by the same companies that provided freight service. At the turn of the 20^{th} century, railroads transported nearly the entire inter city passenger traffic. However growing competition from air and roadways led to lowering of passenger travel and deterioration of financial condition of railroads since in the early 1960s. Intercity passenger miles fell from roughly 30 million in early 1950s to only 6 million by the early 1970s. This resulted in state and federal agencies stepping in to support the

[4] The Northeast comprises the States of Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New Jersey, Pennsylvania and District of Columbia. The Midwest comprises the States of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, Ohio and Wisconsin. The South comprises the States of Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia, Delaware, Alabama, Kentucky, Mississippi, Tennessee, Arkansas, Louisiana, Oklahoma and Texas. The West comprises the States of Arizona, New Mexico, Nevada, Colorado, Utah, Oregon, California, Washington, Wyoming, Idaho and Montana. The other States are Hawaii and Alaska.

deteriorating passenger services, especially for commuter services in metropolitan areas. The final trigger came with the collapse of Penn Central Railroad in 1970, affecting rail services in the northeast. Congress responded with the Rail Passenger Service Act, which shifted responsibility for intercity (through creation of Amtrak) and passenger commuter service to the public sector, along with transfer of ownership of principal commuter rail networks and the Northeast Corridor (NEC) to publicly funded entities.

When Amtrak was formed, freight railroads donated passenger equipment to Amtrak and helped it get started with a capital infusion of some $200 million (approximately $760 million in today's dollars); this was in return for government permission to exit the passenger rail business and to avoid the hundreds of millions of dollars in annual losses from passenger operations they were forced to incur.

Today, Amtrak is the sole intercity U.S. passenger rail carrier in the continental United States. The vast majority of the 22,000 or so miles over which Amtrak operates are actually owned by freight railroads. Amtrak owns only approximately 750 miles of railroad, primarily from Boston to Washington, D.C. In terms of the Rail Passenger Service Act, freight railroads must grant Amtrak access to their track upon request and give priority status to Amtrak trains over other customers. Amtrak pays fees to freight railroads to cover the incremental costs of Amtrak's use of freight railroad tracks.

Commuter and light rail passenger service is offered in a couple of dozen cities throughout the United States. Many commuter rail operators own all or part of the railroad right-of-way (sometimes purchased from freight railroads) on which they operate. Other commuter and light rail systems operate primarily or exclusively over tracks owned by freight railroads. Moreover, to avoid the time and expense of new rights-of-way acquisition, the vast majority of proposed new commuter operations and existing commuter passenger operators that want to extend their operations typically advocate using freight railroad rights-of-way. Examples of such commuter services are Chicago’s Metra system ;Southern California Regional Rail Authority (SCRRA) was established in the Los Angeles area; Virginia suburbs of Washington, D.C; Miami/Fort Lauderdale, Florida; Seattle, Washington; Albuquerque, New Mexico; San Diego and San Jose, California; Nashville, Tennessee; and Dallas,Texas. (10)

4.Regulation of US Railroads

It is a well established principle of law in the US, that transportation service is of a public nature, whether the transportation is owned or operated by a private body. The US Supreme Court has clarified in a ruling that “the business of a public carrier is of a public nature, and in performing it the carrier is also performing to a certain extent a function of government which requires him to perform the service upon equal terms to all...Whether the use of a railroad is a private one depends in no measure upon the question who constructed it or who owns it. It has never being considered a matter of importance that the road was built by the agency of a private corporation. No matter who is the agent, the function performed is that of the state. Though the ownership is private, the use is public.” (2)

4.1 *Federal Railroad Administration*

The Federal Railroad Administration (FRA) is the principal US Department of Transportation agency concerned with railroads. The FRA has three principal offices : Office of Policy and Communications, Office of Railroad Development and Office of Railroad Safety. The Office of Policy and Communications conducts in-house analyses and research concerning railroad industry. The Office of Railroad Development acts as a conduit for Amtrak's annual appropriations, oversees Amtrak's activities as directed by Congress, manages grant and loan programs such as Railroad Rehabilitation and Investment Financing and Rail Line Relocation Grant Program (for removing busy rail lines from city centers), manages National Environmental Policy Act compliance in railroad construction projects and manages FRA's R&D programs. The Office of Railroad Safety is responsible for developing and enforcing railroad safety statutes, regulations, standards, maintaining comprehensive railroad accident reporting systems and databases, and conducting safety-related analyses and investigations. While developing or amending safety rules, the Office publishes a Notice for Proposed Rule Making(NPRM) to allow public discussion and inputs, before promulgating a Final Rule. A Railroad Safety Advisory Council (RSAC) comprising representatives of industry and labor assists in regulation development. (24)

4.2 *Surface Transportation Board*

The Surface Transportation Board (STB) was founded in 1995. STB exercises oversight functions in the following areas: (a) common carrier obligation to provide the transportation or service on reasonable request, provide written rate and service terms upon request (including the establishment of a new rate) ,provide a 20-day notice before changing these terms, (b) shippers and rail carriers are allowed by statute to enter into private contracts; terms of the contract are confidential and govern the relationship between the parties. Judicial relief is available for complaints regarding the interpretation or violation of private contracts. (c) rates: A rail carrier is authorized to establish any rate for transportation or other service provided by the rail carrier except where the STB has determined that a rail carrier has market dominance or where a rate is explicitly prohibited. (d) rail construction, operation, and acquisitions: An application to authorize construction, acquisition (other than by an existing rail carrier), or operation of a rail line must be filed with the STB.; (e) railroad abandonment: A rail carrier must also file an application with the STB if it plans to abandon or discontinue operations over any part of its line. A rail carrier may abandon or discontinue operations on any part of its line only if the Board finds that the present or future public convenience and necessity require or permit the abandonment or discontinuance.; and (f) the interchange of traffic: A rail carrier must "provide reasonable, proper and equal facilities that are within its power to provide for the interchange of traffic….". Rail carriers must construct, maintain, and operate, on reasonable conditions, switch connections and tracks upon the request of an owner of a lateral branch or a shipper when the connection (i) is reasonably practicable; (ii) can be made safely; and (iii) will furnish sufficient business to justify its construction and maintenance. The STB helps promote revenue adequacy (i.e., that the return on capital invested in railroads is at least as great as that earned on capital invested in other industries), allows flexibility in setting of rail rates in response to differing circumstances and protects shippers from the exercise of market power by railroads.

The STB determines whether the degree to which the markup of differential pricing for captive traffic above the LRMC (long-run marginal cost) is reasonable, in case rates are challenged by shippers. (13) STB is also responsible for resolving disputes between Amtrak with freight railways over access rights and payments.

The Stagger's Act made it regulatory for the ICC/STB to make an annual determination of the revenue adequacy of each railroad- the relationship of ROI to the cost of capital. The STB also uses the rail cost recovery index or rail cost adjustment factor (RCAF) as a measure of inflation; this is designed to allow railroads to adjust rates commensurate with inflation without potential for challenge by rail customers.

4.3 *National Transportation Safety Board*

The National Transportation Safety Board (NTSB) investigates serious individual transportation accidents involving any mode, including railroads. NTSB is independent of DOT or any of its agencies and has the authority to investigate serious accidents, determine probable causes and make recommendations for prevention of similar accidents in the future. For this purpose, NTSB is authorized to access accident sites, inspect and test all equipments and systems having bearing on the investigations, call for relevant records from the railroads and compel testimony under oath from witnesses. NTSB investigates almost all passenger train accidents that result in a loss of life, as well as other serious passenger and freight train accidents. It also conducts special studies of accidents with systemic safety implications requiring attention of the industry and government. However NTSB has no safety regulatory powers; it is only the responsibility of government and railroads to implement NTSB's recommendations. (10)

4.4 *Labor Regulation*

U.S. freight railroads employ approximately 177,000 people, the vast majority of whom are unionized. The 1926 Railway Labor Act first formalized the relationship between the management and unionized labor. Today, railroads are also subject to several federal laws relating to labor, employment, and employee benefits, such as:

i. The Railroad Retirement Act, a railroad counterpart to social security under which rail carriers and their employees make significantly higher rates of contribution for employee retirement than under the social security system.
ii. The Railroad Unemployment Insurance Act, a railroad-specific substitute for the state unemployment compensation laws, with contribution rates in excess of those under most state unemployment insurance programs.
iii. The 1926 Railway Labor Act (applicable to airline industry also), which governs labor-management relations on freight railroads and provides covered employees with

substantially greater rights than the National Labor Relations Act (NLRA) that governs industrial relations for private-sector employees elsewhere in the economy. The Act empowers either party to disputes to request the services of the National Mediation Board. Minor disputes regarding grievances or the interpretation or application of an agreement are handled through a prescribed arbitration process and employees cannot strike over such issues. (10)

iv. The Federal Employers Liability Act (FELA), is a unique “no-fault” workers' on-the-job injuries and occupational health problems compensation system for most employees of interstate railroads; liability is based on the negligence of the employer railroad, its agents, and employees.

v. The Rail Safety Improvement Act 2008 defines the statutory hours of duty and rest for train crews.

Railroads are also subject to Federal (monitored by EPA, TSA, PHMSA) and State environmental regulations in regard to emission standards for diesel engines, idling restrictions for locomotives (eg CA MOU) and GHG cap.

4.5 *Industry and professional associations*

Though not regulatory agencies, railroads are governed by standards formulated by few industry and professional associations, such as the Association of American Railroads (AAR), The American Railway Engineering and Maintenance-of-Way Association (AREMA). Other professional associations with railroad interests include American Society of Civil Engineers, American Society of Mechanical Engineers and Institute of Electrical and Electronic Engineers.

4.5.1 *Association of American Railroads (AAR)*

The Association of American Railroads originated from the American Railway Association (ARA). The ARA originated from the Timetable Convention which was the annual meetings of General Managers and railroad operating officials held since 1872. The ARA merged with other railroad industry groups (Association of Railway Executives, Bureau of Railroad Economics, Railway Accounting Officers Association and Railway Treasury Officers Association) in 1934 to form the Association of American Railroads.

The AAR is the industry association of Class I railroads. It represents the interests of industry in public forums (including Congress, DOT, STB), collects data of railroad performance measures on a weekly basis from all railroads. AAR also administers standards in the train industry relating to technical issues of interoperability between railroads such as data communication, train control communications, operating rules, axle loads, total weight per unit of train length, etc. It maintains and publishes a comprehensive Manual of Recommended Standards and Practices for freight cars and locomotives. It also administers standards of dimensions of consignments, bridges and tunnels in association with Railway Industrial Clearance Association of North America (RICA). (8) AAR maintains and publishes

Interchange Rules containing technical standards required to be met for rail cars to be acceptable for nationwide operations.

AAR has established a subsidiary, Railinc Corporation, to provide data services to the freight railroads, including a national register of freight equipment, nationwide freight car location information, an official register of freight car rental rates, and inter-railroad billing and payment systems. The payment systems are used for sharing freight revenue in compliance with agreed contracts, making car hire and demurrage payments applicable when a freight car is not on the owning railroad's property, making freight car repair payments, and other similar functions.

AAR has also established the Transportation Technology Center Inc(TTCI) to manage the FRA owned Transportation Test Center (located at Pueblo, Colorado), carry out railroad research and testing for AAR, FRA, suppliers, overseas clients and railroads (on areas such as passenger car analysis and testing, tests on prototype cars and locomotives, acceptance tests for cars, crashworthiness tests for FRA and Volpe Center). AAR provides quality assurance services to manufacturers of safety critical freight car components, such as wheels axles, bearings, truck frames, and brakes. The American Public Transportation Association (APTA), which is the industry association for all modes of local and regional public transportation, including commuter rail, performs functions similar to AAR. (10)

4.5.2 *American Railway Engineering and Maintenance-of-Way Association (AREMA)*

The AREMA is a professional association for individuals interested in all aspects of railroad infrastructure engineering, including railroad track, structures, and signal and train control systems. AREMA's members are professionals working with railroads, rail transit systems, research and academic institutions, consultants, suppliers, and others. AREMA publishes the Manual for Railway Engineering and Communications and Signaling Manual, which are widely used and referenced in North America and throughout the world for application on freight and passenger railroads and rail transit systems.

5.Freight Traffic Hauled by US Railroads

5.1 *Freight Traffic Composition*

The top five commodities in terms of tonnage moved by rail are coal, cereal grains, metallic ores, fertilizers and basic chemicals. The top five commodities in terms of value moved by rail are motorized vehicles, coal, plastics/rubber, basic chemicals and base metals. (12)

The composition of freight traffic in terms of tons originated (total being 1940 million tonnes) for year 2007 was 44% coal, 9% chemicals and allied products, 8% farm products, 7% nonmetallic minerals, 6% miscellaneous mixed shipments(primarily intermodal), 5% food and kindred products, 3% metallic ores, 3% metals and allied products, 3% petroleum and coke, 3% stone, clay and glass products, 3% waste and scrap materials, 2% lumber and wood products, 2% pulp, paper and allied products, 1% motor vehicle equipment and rest all other commodities. The composition of freight traffic in terms of gross revenue (total being $54,637 million) for year 2007 was 21% coal, 13% chemicals and allied products, 8% farm products, 3% nonmetallic minerals, 14% miscellaneous mixed shipments(primarily intermodal), 7% food and kindred products, 1% metallic ores, 4% metals and allied products, 3% petroleum and coke, 3% stone, clay and glass products, 2% waste and scrap materials, 4% lumber and wood products, 4% pulp, paper and allied products, 7% motor vehicle equipment and rest all other commodities. Intermodal includes shipments of goods loaded in standard shipping containers or in highway truck trailers that are carried on rail flat cars—respectively, container on flat car (COFC) and trailer on flat car (TOFC) movements. (13)

70 percent of domestically produced automobiles,70 percent of coal delivered to power plants (about 11% being hauled by trucks and the rest by barges) ,11 and about 35 percent of the U.S. grain harvest all move by rail. (13)

5.2.1 *Unit Trains*

Bulk unit trains are used to move very high volumes of a single commodity such as coal, grain, minerals, and waste. In 2000, unit trains carried 1.027 billion tons over 582 billion ton-miles. Prominent examples are of the coal unit trains plying from production centers in Wyoming's Powder River Basin to Midwest power plants and barges on the Missouri and Mississippi rivers, and from production centers in Appalachia to cities and export terminals on the Atlantic coast. (9)

5.2.2 *Mixed Carload Trains*

Mixed carload trains move a diverse range of commodities, including chemicals, food products, forest products, metals, auto parts, waste, and scrap. Rail carload equipment includes liquid-bulk tank cars, open flatcars, hopper cars, and traditional boxcars.

5.2.3 *Intermodal Trains*

Intermodal trains move truck trailers, automobiles and containerized goods containing finished consumer goods, refrigerated foods, parts and tools for manufacturing, raw materials, post-consumer scrap; these consist mostly of higher-value consumer products and import-export traffic. Intermodal has been one of the fastest-growing segments of the rail industry. Rail intermodal traffic has more than tripled in just over 20 years, rising from 3.1 million trailers and containers in 1980 to nearly 10 million units in 2003.

Over the past decade, railroads have introduced scheduled intermodal services with guaranteed reliability (e.g., within 1.0 hours of schedule, 99 percent of the time). The most efficient and cost-effective intermodal service is the unit train, which is the preferred method for serving high-volume corridors. However this manner of unit train intermodal service depends on partnerships with trucking companies, seaports, and others in the transportation logistics chain. Here railroads handle the long-haul movement of large quantities of containers and trailers between major hubs such as seaports and major population centers, while truckers handle the short-haul movement to/from the customer's "front door."

Intermodal traffic typically results in high demand for suitable railcar equipment leading up to and during seasonal shopping periods and is centered along a relatively few, high-density corridors connecting the nation's leading container ports and its primary consumer markets. The most significant flows are from the west coast container ports of Long Beach, Los Angeles, Oakland, Portland, Tacoma, and Seattle through Chicago to New York and northern New Jersey. Container handling in US ports rose from 8 million TEUs in 1990 to 24 million TEUs in 2004; 50% of the container traffic was handled in Western Pacific ports (of which San Pedro Bay ports of Los Angeles and Long Beach alone handled 73%, with combined traffic levels of 24,000 TEUs per day; Los Angeles alone loads 10 to 12 container trains per day) which was moved to mid-Western states through 8000 feet container trains powered by multiple locomotives and operating at current maximum freight train speeds of 79 mph. In the year 2000, intermodal trains carried 199 million tons over 421 billion ton-miles. Within the commodity groups served by intermodal, rail handles over 16 percent of the tonnage. Intermodal today accounts for about 22 percent of rail revenue. (9) (8)

5.3 *Supply Chain Solutions*

Few railways have started collaborating with manufacturers for providing supply chain solutions. A prominent example is the 10-year alliance between Union Pacific(UP) railroad and Daimler Chrysler, wherein UP will oversee the distribution logistics of Daimler Chrysler through a web-based delivery management system named Insight Network Logistics. The delivery management system will track every car Daimler Chrysler makes in the United States, from the factory to the dealer, through coordinating the use of both railroads and trucks and managing the schedules involved, to ensure that Daimler Chrysler receives the most efficient and cost-effective shipping timetable. (14)

5.4 *Scheduled Freight Trains*

Canadian Railroads has adopted scheduled freight train services for carload and intermodal. Canadian National outlines seven principles guiding the philosophy of scheduled trains – (i) minimize car dwell time in yards: Scheduled freight train services bring train running close to design standards set for each district, thus reducing car cycles, yard congestion and transit time. The idea is to minimize cars in inventory, thus reducing the requirement for yard infrastructure and capital investment (ii) minimize classifications to maximum of twice per car (iii) use multiple traffic outlets between yards to keep traffic moving (iv) some cars that would be run in a unit train are placed in general purpose trains to fill capacity (v) balance train movements by direction to reduce locomotive and crew deadheading. (vi) minimize power requirements through balance of train velocity against horsepower-per-ton requirements (vii) space trains to support steady work flow through various yard processes, thus improving yard efficiency, reducing asset requirements and decreasing cascading effect of failures. CN has attributed its below average operating ratio (around 67) to scheduled services. Norfolk Southern, CSX and BNSF are also trying out scheduled freight train services. (15) (16)

6.Organization of US Railroads

All Class I railroads, plus few Class II and handful of companies that operate the multiple short lines are corporations. They have a Board of Directors, headed by a chairman, sometimes designated as a CEO responsible for long term plans and practices. The railroad president, who might not be the CEO, may also be designated as chief operating officer (COO) directly responsible to the board for running the railroad by making decisions on a shorter term basis. Reporting to the president and COO, are the CFO(chief financial officer), CCO(chief commercial officer; oversees revenue generating activities) and several other executive vice presidents(VP) or senior VPs managing key support disciplines such as government affairs, investor and media relations, law, human resources and taxation. The COO is in charge of every activity that supports revenue generation, from safety, running trains, track work, equipment maintenance, customer service centers to service design. Reporting to the COO, are the VP Transportation who keeps the railroad running, the VP Mechanical (or Chief Mechanical Officer in charge of the rolling stock maintenance), the VP Engineering (track, structures and sometimes signaling and communications also), VP Safety(might include freight claims too), VP Customer Service, VP Security, VP Purchasing, VP Labor relations and various other support group leaders.

The Transportation head quarters handles the following functions: locomotive distribution (assigns locomotives to road trains and division pools, flow locomotives to match supply and demand, routes locomotives to shops for repair and maintenance, coordinates locomotive purchase/rebuild/retirement), car distribution (forecasts car supply and demand, issues movement instructions for car flows, coordinates car purchase/rebuild/retirement), crew calling(done from head office), train dispatching, station agency(receiving bills of lading, producing waybills, arranging cars to be spotted and pulled), customer service, central yard office(track inventories, reporting train arrivals and departures), transportation planning/service design(developing “operating plans” on manner of switching into blocks (using blocking and classification tables), assembling blocks into trains, scheduling and routing trains(using train schedules);computers incorporate the operating plans in a Trip Planning or Car Scheduling module; monitoring transit time performance and transportation efficiency; support for differentiated special services eg. Intermodal and automotive shipments, unit train operations, ODC shipments, hazardous shipments), creating and monitoring transportation contracts, developing and monitoring operating rules and monitoring adherence, correcting data quality issues and designing and deploying systems to control train, yard and dispatching functions.

The VP-Engineering has three staff groups responsible, system wide, for engineering design of equipment to meet railroad’s requirements; planning and conducting tests of track and rolling stock in the field and in railroad’s research laboratory (or with AAR/FRA’s

Transportation Technology Center); methods for quality control of materials and supplies used by the railroads.

The CFO is responsible for handling funds, signing checks, keeping financial records and financial planning for the railroad. Reporting to the CFO are the treasurer (receipts, disbursements, borrowing and tax matters) and a controller for internal accounting. The CFO is responsible for maintaining cash flow, manage its investments and borrowings, maintaining a good financial rating and as low a interest rate as its operating results can support. He is also responsible for mandatory disclosures (10K annual reports & 10Q quarterly reports to Securities & Exchange Commission; these reports contain income statement, balance sheet and cash flow statement).

On the railroads, there are regional and divisional VPs, terminal superintendents, road masters (who oversee track conditions) and road foreman of engines (who keep the locomotives running and crews qualified to run them). 85% of railroaders work in the operations department.

Few railroads have "Divisional" form of organization with officers for various functions reporting to Division Superintendents. Other follow a "Departmental" form of organization where each department is organized into divisions that largely mirror the Transportation divisions, but have these officers in these functions report to senior departmental officers at regional or headquarters level. Typically the Division Engineer(in charge of maintenance and construction of track and structures), Division Master Mechanic(maintenance of rail cars, repair and servicing of locomotives) and Division Communication and/or Signal Engineer may have more than one supervisor. (18) (19) (20) (21) (22) (23)

7.Operation on US Railroads

7.1 *Typical Operating Procedures*

Here we consider the case of a customer X located at city A on EW Railway who wishes to ship 100,000 lbs of canned goods to a consignee at city AA. The EWR Car Service Division will select an appropriate car for placement at X's siding; it will most likely select a car that will be heading for its home railroad. Say, EWR selects a car belonging to Peninsular Railway (PR)- it will then have to pay mileage and per diem charges for using this car. The car mileage and per hour rates are prescribed by a formula based on car's original cost and age; as of 2007, rates ranged from $0.18 to $1.75 per hour and $0.054 to $0.12 per mile; rates are suggested by AAR's Equipment Assets Management Working Committee to STB, which retains oversight.

The car is delivered to X's siding after spotting and mechanical inspection. Once the car is delivered to X's siding, it is subject to demurrage tariff (considering 24 hrs to load and 48 hours to unload). Following receipt of car and its loading, X presents to the railroad a straight bill of lading BOL (a contract of carriage between X and EWR); if shipper pays freight charges the BOL is “prepaid”; if consignee is to pay freight charge, the BOL is marked “collect”. After receipt of BOL from X, the EWR rating system will rate the shipment (after checking appropriate tariff documents) and generate a waybill (containing information on car number, waybill number/date, origin, name of shipper, consignee, destination, route of car travel, STB code for the commodity, physical description of articles, weight of shipment, applicable rate, total freight charges, prepaid or collect). The waybill is a contract between railways moving the shipment; the junction stations indicated will determine the sharing of revenue between railroads. The last handling carrier is responsible for collection of freight charges and distribution amongst handling lines; this is tracked electronically by all handlers through AAR procedure known as Interchange Settlement System(ISS) effected in 1996. Each railroad has the opportunity to approve or question its share electronically; all objections must be settled within a fixed time frame by negotiations or it will be settled arbitrarily.

After the waybill is generated, a switch crew goes to X’s siding, picks up the car and takes it to the classification yard for switching the car into the proper outbound train. Cars are assembled into blocks for individual destinations. Each block has a destination that represents the next processing yard for the cars in that block. Blocks are combined into trains for the line haul. Trains may directly leave from the classification yard or sent to departure yard for mandatory pre-departure mechanical and air brake tests. All the waybill data for a particular train are compiled in a “wheel report” for the train conductor. The train consist data is also fed to the central computer.

Before the train departure, the crew call system identifies the crew members to be called by the crew caller, locomotive is prepared by the locomotive dispatcher and service track foreman and cars made ready by yardmaster and mechanical crews. If operating on CTC, the CTC dispatcher sets up the meets and overtakes consistent with the train’s priority relative to other trains. A train may set out or pick up blocks of traffic or both en route.

In order to send X’s consignment to AA, it will have to be turned over to the SW&AA Railroad at city G. Before the train reaches G, the EWR yardmaster in G has already received the consist report from the computer. Using this report, he makes up a switch list for his switching crews. Once a new train is formed after switching at G, EWR personnel will enter a interchange delivery report in the computer confirming handing over to SW&AA Railroad. Once the SW&AA train reaches AA, the consignee is notified that the car from X has arrived. A freight bill is prepared for the consignee (on basis of waybill information), unless the charges have been prepaid.

After unloading, the car is returned back to the railroad. The equipment distributors decides its next trip and directs the railroad to send the empty to a different location. However the railroad decides how the empty reaches the location, through decision on the series of trains that the car gets attached to. One of the major problems arise when cars originate in one railroad and terminate in another. Efficient strategies are required to position the empty cars properly; an estimator of the proper positioning is the ratio of empty-to-loaded car miles.

According to current system, cars are grouped into four categories- general service, general service pools, special service and private cars; there are norms laid down by AAR for empty movement of each of each categories . (43) In order to decide the empty equipment distribution, various railroads use software. Examples are Dynamic Car Planning System (DCP) developed by Princeton Transportation Consulting Group (now part of the Sabre Group) for CSXT in 1995-97 and the Equipment Distribution Optimization system (EDO) developed internally by BNSF between 1998 and 2000. (44)

7.2 *Train Scheduling*

Scheduling consists of establishing a time and place where rail vehicles, operators and freight to be carried are matched. Scheduling is important since capacity associated with infrastructure, personnel and equipment are limited. In absence of CTC or feedback from stations enroute, trains were run on US railroads to schedules prepared days in advance of actual train departure. Since 1980s, with advent of CTC, prepared schedules are no longer in use. Train schedulers operate the rolling stock on the infrastructure (track, signals, stations) using a “software” based on the system of operating rules and procedures.

About 4000 train dispatchers schedule trains through train orders and signaling system, as well as coordinate with yards and maintenance staff. Dispatchers typically use timetables, train sheets (station vs time graphs), track diagrams/track chart/condensed profile (showing road crossing, signals, signaling system, operating rules in effect, type/size/age of rail, last ballast maintenance, culverts, grade, elevation, alignment/curves, signal location, turnout size, speed limits, track maintenance gang), tonnage table (haulage capacity of locomotives) and train order book (record of instructions issued with date/time). Other aspects could be Handling Procedures for Hazardous Materials and Labor Rules.

7.3 *Centralized Traffic Control(CTC)*

Under the centralized systems of traffic control operating on a few Class I US rail roads, the dispatching of trains over the entire territory is controlled at a centralized location, usually the corporate headquarters of the railroad.

BNSF’s James J Hill Network Operations Center (NOC) at Fort Worth provides tactical control of Business Processes & Functions (trains, crew & power) through Transportation Support Systems (TSS), asset management, strategic and tactical system wide planning. It controls 500-600 trains a day on roughly 60% of BNSF’s CTC network territory. It contains nine 18x24 screens in a 45,000 square foot fan shaped room. The central focus of the room (most consolidated dispatch centers have one, although the information can be called up on individual screens) is a 216-foot electronic display panel made up of nine screens at the front of the room. It consolidates system operating functions, dispatching and network management, in one room--a fan-shaped, tiered room that is shared by dispatchers, signal and mechanical personnel, power distributors, and grain, coal, intermodal, merchandise, Amtrak, crew management, corridor management and telecommunications personnel. Four major business processes are incorporated into the NOC: network operations management, locomotive management, crew management, and road operations management. BN defines network operations management as the planning, controlling, and monitoring of the flow of trains over the whole system, with a view to service delivery and cost control. Information technology tools, BN says, are in three major areas: strategic planning and control, resource management, and tactical planning and control. The strategic focus includes "creation, maintenance and dissemination of network schedules; monitoring network and corridor operations, and identifying and responding to schedule disruptions." Resource management tools "facilitate allocation of railroad resources in support of the network operations plan. Tactical planning tools promote schedule adherence and operations efficiency on a local level by producing meet/pass plans that minimize train lateness, by automating many dispatching functions, and by linking dispatching with corporate and network information systems." The advantage of such systems is that whenever exceptions (such as locomotive failures) occur, they allow more intelligent decision making by the dispatcher by taking into account much more information. (25) (26) (27)

Norfolk Southern has implemented a Optimized Train Control (OTC) System that integrates information from onboard and trackside monitors and integrates it with a central computer system. It enables dispatchers to wirelessly track the location of trains and remotely monitor the status of track switches through OTC's integration with the Unified Train Control System(UTCS, supplied by GE Transportation), the train dispatching system currently being deployed. If a switch is not in its expected position or is not communicating its status, the dispatcher will receive an alert and notify the train crew to stop and inspect the switch. In the later phases, it will enable electronic delivery of operating instructions from UTCS to the locomotive crew and onboard systems. As operating conditions change or the crew fails to follow instructions, warnings will be displayed. If the crew fails to respond to a warning, the braking system will automatically bring the train to a safe stop. NS has also created a modeling tool called Operating Plan Developer to help strengthen operations by quickly accounting for constantly changing variables — such as freight loads, weather and customer needs — that come into play on the railroad. (28) NS has implemented the computer aided Unified Train Control System (UTCS) which uses GE Transportation Global's Precision Dispatch System (PDS) technology. This enables optimized train movements across the network through combination of operating information with business objectives; features include automated meet pass scheduling, a "healing algorithm" to redispatch railroad in event of major disturbances, and allows minimizing of crew requirements.

CSX's Kenneth C. Duford Transportation Center, dispatches and monitors some 1400 trains a day over it's 20,000 mile system. The traditional CTC board has been replaced by computer consoles for each of the operators, and some 150 rear projection screens adorn the outside perimeter of the 150 foot diameter control room. 32 dispatchers are on the first and third floors of the center. Power managers, chief dispatchers, and locomotive mechanical personnel are on the second floor. On the top floor are the center's general manager, assistant general manager, and Amtrak passenger train coordinator.

Union Pacific consolidated its dispatching operations at its Omaha facility in 1988. The Harriman Dispatching Center (HDC), located in Omaha,Nebraska, is Union Pacific's primary dispatching facility. It is linked to regional dispatching and locomotive management facilities at various locations along the network. The HDC moves locomotives and trains,manages traffic on the network, and coordinates interchanges with other railroads. It employs Computer-Aided Dispatching (CAD) System; Using auto-routing, dispatchers assign an identity and priority to each train; the computer then takes over and routes trains according to priority, while also automatically determining the meeting and passing of trains on single-track sections. The CAD system is based on prioritized rules used by dispatchers in handling meets and passes. There are 30 dispatch centers with keyboards to enable CTC control by dispatchers. (30)

In order to diffuse the benefits of CAD, the American Rail Dispatching Center (ARDC), a wholly owned subsidiary of RailAmerica, began operation in 2003. The center controls rail traffic for both short line and Class I railroads in 19 states.

Kansas City Southern (KCS) implemented Management Control System (MCS), developed by Infosys(India), as a planning tool for transportation management from customer order entry to shipment delivery. The system is also tied with an Automatic Equipment Identification (AEI) network to keep managers informed of what happened to shipments after the service plan and schedule are prepared according to customer requirements. It also incorporates a web-based component KCSR Online Transaction for online entry of car orders and waybill data. Other components are the Locomotive Management System and Interline Service Management (ISM) (which exchanges data on shipment status and estimated time of arrival with that of other railroads through the rail industry's Railine IT base). (31)

Typical software used for CTC is the Big Picture Tools developed by DigiCon. This tool allows real-time geographical display of trains and equipment and provides views that zoom from an entire railroad to a train or station, along with details of surrounding cities or towns and major roads. Users can easily identify trains with exceptions such as running behind schedule, crew hours of service nearing completion, or failed locomotives. Clicking on any train gives details of its manifest. This tool allows analysis of operations showing capacity utilizations. Another software is the Proactive Traffic Management software which incorporates information of terminal and maintenance operations to generate an integrated movement plan, based on real time traffic conditions, slow orders, train schedules, crew hours and maintenance windows. It allows dispatchers to schedule meets and passes[5] and integrate real time planning between multiple railroads. Terminals are also benefitted with real time updates on arrivals which aid in terminal management. Other train planning tools allow managers visualize the railroad conditions over the next 4 to 12 hours; this helps in prioritizing trains, determining meets and passes and maximizes asset utilization. The

[5] Parallel lines are typically equipped with periodic double crossovers between tracks to enable faster trains to overtake smaller trains with neither train being forced to wait (8)

recently developed Optimizing Traffic Planner (OTP, by US&S) for UP optimizes movement of trains across a network to satisfy complex logistics and operation needs as well as business objectives; it considers aspects such as train schedule deviation, cost of lateness and cost of fuel; its “problem solving engine” can generate multiple train movement plans continuously, select the best one for execution, and generate revised plans based on information received from field. Domain Operations Control (DOC) carries out yard management, which includes aspects of yard automation (controling power switch machines and entry/exit routing) through data radio communication from switch positions and track occupancy I/O controllers. (32) (33) The main vendors for mainline Computer Aided Dispatching (CAD) are Union Switch & Signal, Digital Concepts(DigiCon), GE Harris, Siemens and Alstom Signaling. Likewise yard management systems are provided by companies like RailComm and Trainyard Tech (34) (35) (36) (26) Since these signal and train control systems software have serious implications of safety, FRA requires safety verification and validation methodologies. (37)

There has been some recent revision in total centralization practiced by Class I railways. Thus while Union Pacific still operates its central Harriman Dispatch Center at Omaha, its dispatchers work for and are directed by railroad’s regional executives. Centralized functions such as locomotive management, end-of-train management, crew management, intermodal, coal and grain trains are controlled from Omaha. UP and BNSF also has established satellite dispatch centers to cover the congested Houston-New Orleans Area (at Spring), the Los Angeles Basin(at San Bernardino) and the Kansas City complex. UP also has several dispatchers located at BNSF’s Fort Worth center. CN’s Edmonton dispatch control handles planning of operations, with the support of four regional dispatching offices. BNSF also has eight regional centers. The new paradigm is to allow regional operations to run services efficiently within their region, while giving top priority to inter-regional traffic planning done by central dispatching. This entire process has been aided by Computer Aided Dispatching (CAD), which allows the central and regional dispatchers see the same information simultaneously on their computer screens. Matt Rose CEO of BNSF says “railroading is a network business, and you need centralized planning and decentralized execution.” This shift in thinking has come with the realization that a purely centralized system is likely to overlook local problems and distance execution from customer needs. Decentralizing some power to regional offices helps in garnering small customers who might find it awesome to approach the central control. (38)

7.4 *Customer Service Centers*

Customer service is now a top priority on most US railroads. The Class I railroads have centralized customer service at one-call shops, where a customer gets service or information. Union Pacific centralized its customer operations at one building in downtown St.Louis; this Customer Service (CSC) operating since 1986, handles customer order processing, freight service coordination, shipment monitoring and car fleet management. CSXT has centralized customer service operations at Jacksonville; its activities include managing service contracts, issuance and completion of work orders, customer notification of car arrivals, equipment orders/releases, location tracking and switching requests. (40)

8. Equipment used on US Railroads

8.1 *Wagons or Cars*

The main cars used in the US are the Box-40 foot, Box-50 foot, Box-Equipped, Gondola-Plain, Gondola-Equipped, Hopper-Covered, Hopper-Open Top Special, Hopper-Open Top General, Reefer-Mechanical, Reefer-Non-mechanical, Flat-Intermodal, Flat-Multilevel, Flat-General, Flat-Other and Tank cars. Each rake typically comprises upto 125 wagons with payload of 100 tonnes payload each, thus carrying 12500 tonnes. Average train lengths for auto trains are 64 to 57 cars, for bulk trains 86 to 112 cars, for general merchandize 81 to 82 cars and for intermodal trains 111 to 164 cars. (41)

Box cars are used for commodities requiring protection from weather or breakage. Refrigerated cars, which are similar in appearance to box cars, are used to transport perishable food products. Gondola Cars are used for loads that require little or no protection from weather. Gondola cars may have steel or aluminum bodies, may be single tub, twin tub or flat bottomed, with automatic or manual discharge options and may have rotary (can be rotated for discharge without uncoupling) or non-rotary dump options. Hopper cars may be closed or open type; they may be gravity or pneumatic discharging type or pressure differential covered or plastic pellet covered hoppers, with pneumatic discharge, or may have powered door operating devices to make them self-unloading; they may be lined with paper or plastic sheeting or humidity control equipment or externally insulated. Flat cars have lengths up to 106ft 4in and 450 gross ton loads; bulkhead cars used to transport construction material (packaged lumber, wallboard, pipe, poles, fencing)- with end-sill cushioning used to move high precision equipment such as printing presses and rocket components; few have removable hoods for moving steel products. Tank cars incorporate technology for rapid loading and unloading capabilities, sanitary cleanout, and large carrying capacity. (39)

Major car manufacturers are Trinity Industries (tank cars, gondola cars, intermodal cars, and hopper cars), Johnstown America Corp (railcars), FreightCar America, Electro Motive (General Motor division for locomotives), and Thrall Car Manufacturing Company (intermodal equipment, auto racks, aluminum coal cars, center beams, coiled steel, pressured differential, plastics, and wood chip cars). (39)

Current FRA rules allow trains to operate 1000 miles between car inspections and brake performance test. Typically unit trains carrying 12,000 net tons in 110 cars travel without change in consist over 1500 miles.

8.2 *Locomotives*

US railroads employ four main types of diesel power: (1) end cab switcher, 5% of fleet (2) four axle road switcher, 1500-3200 hp, 20% of fleet (3)six axle medium horsepower road switcher, 2400-4000 hp, 15% of fleet and (4) high horsepower six axle road switcher, 3800-6000 hp. The main suppliers of locomotives are EMD and General Electric for high-power diesel-electric freight locomotives.

In-depth inspections of locomotives are generally conducted every 92 days, planned maintenance every 184 days and major overhaul every 6 years. All locomotives are equipped with air-conditioned "comfort cab" with carefully designed features (such as positioning of chairs, controls and displays, cab lighting, toilet design) selected through a joint committee including train crew members. The locomotive is manned by an engineer and a conductor; the engineer controls the engine throttle, brake and whistle, while the conductor monitors signals. If the train is switching out loaded or empty freight cars at customer facilities, a brakeman assists the engineer and conductor. Many locomotives are equipped with Automatic Engine Start Stop (AESS) which turns off the engine if it idles more than 10 minutes.

Few railroads have entered into alliances with OEMs for equipment maintenance. GE services CSX's fleet of GE locomotives using CSX employees at various CSX owned maintenance plants, through its onsite managers for supervision and technical direction. Similarly Alstom Canada assumed management of Canadian Pacific Railway's Ogden equipment overhaul and repair shops in Calgary, Alberta. (14)

8.3 *Track*

FRA Track Safety Standards 49 CFR 213 contains numerous requirements defining minimum acceptable track conditions and inspection regimes for each track class. The maximum freight and passenger speeds allowed under FRA Track Class 3 are 40 and 60 mph, Class 4 are 60 and 80 mph, Class 5 are 80 and 90 mph and Class 6 are 110 and 110 mph respectively. Freight railroads typically maintain FRA Class 3 on secondary and lower traffic main lines, Class 4 on primary main lines and Class 5 track on routes used by higher-speed intermodal services. Class 6 is used on predominantly higher-speed passenger lines such as the Empire Corridor between New York City and Albany, New York and parts of the Northeast Corridor (NEC). Classes 1 and 2 are used for low speed branch line and yard track. (10)

8.4 *Rail Car Leasing*

The railcar renting industry emerged in the late nineteenth century in response to a growing demand for specialty freight cars. By the late 1800s, rail tracks had stretched across the nation; shippers of perishables, such as fruit, and liquids, such as oil, were anxious to take advantage of distant yet rail-accessible markets. Without refrigerator cars or liquid carrying (tank) cars, these shippers were restricted to local markets. Since the railroads were unwilling to provide these cars because of their high cost and seasonal or otherwise uneven demand, the shippers built and maintained private car fleets themselves. The larger shippers rented their cars to smaller shippers who could not afford to maintain their own fleets. Some shippers who owned small specialty fleets chose to enter sale-leaseback agreements. By selling their cars to an operating lessor and leasing them back under an operating lease, the shipper transferred all maintenance responsibility to the lessor and shed a business that was usually cumbersome to manage and unrelated to the principal revenue-generating operation.

Railcar leasing companies are intermediaries in the transportation industry. Leasing of equipment by railroad companies are guided by corporate tax implications, especially in terms of assets owned and book depreciation. Leasing companies offer two basic leasing options: capital leases and operating leases. A capital lease bestows all the economic benefits and risks of the leased property on the lessee. These contracts usually cannot be canceled and the lessee is responsible for the upkeep of the equipment. Capital leases usually amortize the value of the equipment over the life of the lease. An operating lease, also called a service lease, is written for less than the life of the equipment and the lessor handles all the maintenance and service. The operating lease usually can be canceled if the equipment becomes obsolete or unnecessary. Most railcar leasing companies are either operating or capital leasing companies, though some of the larger companies have separate operations offering both types of leases.

The largest lessor is Chicago-based General Electric Railcar Services Corp., a wholly owned subsidiary of GE Capital. A merger with Itel in 1992 left GE Railcar with a fleet of 140,000 freight cars, the largest and most diversified fleet in the industry. The company also had the most extensive repair network with 11 railcar repair facilities, 9 mobile repair facilities, and 6 wheel shops in the United States and Canada. Despite the size and diversification of its fleet, GE is best known for its boxcars. In second place is TTX Company, also of Chicago. TTX specializes in intermodal cars. In third place is GATX Financial Corp. of Chicago, the largest lessor in the specialized market of tank cars. (39)

TTX, established in 1955, is jointly owned by a number of railroads, including the seven Class I railroads. TTX also designs and modifies cars to suit customer needs, research and testing (such as conducting field trials, instrumented track testing, impact testing) TTX railcars are serviced by three maintenance divisions in Florida, California, and South Carolina (42). Thirty one Field Maintenance Operations (FMOs) also provide inspection and repair services onsite.

Cars requiring heavy repairs, are repaired by TTX shops and Field Maintenance Operations (FMO). The shops are strategically located throughout the country for Scheduled maintenance and inspections(based on car mileage), Heavy Repairs (such as Wreck repairs, Program maintenance and modifications, Car dimensioning and cambering, rebuilding, Flipping/Turning of railcars, Car scrapping, Sand blasting, painting, and re-stenciling) and Light Repairs(such as running repairs, Warranty repairs, Wheelset replacement, Truck maintenance, Brake system testing and maintenance , Articulated car maintenance, Mobile truck capability). FMOs are light repair locations equipped for Light Repairs(such as piston travel adjustment, Grating platform maintenance, side bearing adjustments and replacement, wheelset replacement, safety appliance maintenance, running gear maintenance, lading equipment maintenance), Modifications and Component Upgrades and Car and Load Inspections(such as Pre-Trip inspections for preventative maintenance, Measuring high and wide loads, Brake system testing using computerized single car test devices). Few FMOs validate load securement (Tie down configurations), and measure loads (High and Wide load measurement) for dimensional moves. TTX operates mobile repair capabilities (mobile repair trucks with various welding, cutting, and material handling capabilities) from all of the shops and many of the Field Maintenance locations to make light running repairs, without having to direct a car to a shop. Cars requiring smaller repairs, are handled by railroads and TTX mechanically generates audit packages that provide a comprehensive audit based on current AAR Rules and historical trending. TTX operates a technical hotline to assist railroads in car maintenance procedures; TTX also provides training facilities for car inspection and maintenance. TTX auditors use a web-based audit system that allows for the delivery and handling of exception letters in an online environment and permits electronic interface with repair facilities including estimates, invoices, bills, electronic controls over defect card activity, lease rebuttal activity (both payable and receivable), and shop activity. TTX has developed a Shop Car Tracking System to manage the throughput of railcars requiring repair at a shop, through monitoring individual cars through the entire shop process and ensuring that all AAR and FRA requirements are met. TTX has an established Wreck Hotline which is manned 24 hours a day 7 days a week to assist railroads when railcars are involved in derailments and possibly blocking mainlines. TTX's efficiencies and economies of operation were illustrated by the fact that, while TTX owned 8 percent of the U.S. railroad car fleet in the early 1990s, its cars accounted for 24 percent of all the car miles traveled in the United States. (39) Since there is scope of competitive abuse, TTX contracts and pooling agreements are subject to STB oversight. (8)

Unlike cars owned by the individual railroads, TTX cars do not have to be returned empty to the owning railroad after they were unloaded by another railroad. Instead, the cars can be reloaded and transported to any other destination where they can be reloaded again. If no loads were immediately available, TTX directs the movement of the empty cars to the closest location where loads are waiting. TTX manages the Reload Pool and the North America Boxcar Pool (NABP). The Reload pool, authorized by the ICC in 1981, permits railroads to pool their autorack fleets for transportation of finished vehicles; TTX manages Reload, in cooperation with automobile manufacturers and railroads and optimization software, using data provided by railroads and manufacturers to reduce empty running. The North America Boxcar Pool is a car pooling authority created by ICC which started operations in 2003; Railroads contribute their own equipment to the pool, and TTX facilitates efficient distribution across the network.

Interline repair billings are run up on cars operating in interchange service. These are charges for work done by a railroad on another company’s car that was due for preventive maintenance or develops problems on line. AAR sets the guidelines in Manual of AAR Interchange Rules on inspection standards, comparability of parts, repair and paperwork procedures and responsibility rules. The pricing of parts and repairs is determined by AAR Office Manual.

9. **Technology for Productivity Enhancements**

US Railroads are incorporating innovative electronic equipment and computers to improve tracking of shipments and improve reliability and availability of assets. Major examples include: (39)

a. Automated Equipment Identification program mandates that all railroad equipment are outfitted with electronic identification tags that allow each freight container to be identified by a trackside laser scanner. This system tracks freight container shipments among multiple carriers and thus eliminates the need for railroad staff to visually identify containers and manually type in shipment information.
b. Railroads are working together to create a single computer hardware package that allows customers to communicate with all their carriers. In addition, railroad locomotives are being outfitted with computers that communicate via wireless technology with the railroad's mainframe or central computer.
c. On-Board Locomotive Diagnostics. Electro-Motive Division's Functionally Integrated Railroad Electronics (FIRE) and GE's Integration Hub (IHUB) support multiple systems from multiple vendors to help standardize the industry.
d. EPA Emissions. Electro-Motive Division and GE Transportation Systems are working to develop equipment to meet EPA standards without affecting fuel efficiency and horsepower on locomotives.
e. Since elimination of caboose in late 1980s, the EOT (end-of-train) device continuously displays brake pipe pressure in locomotive cab via radio link (along with a high-visibility marker showing end-of-train, and a motion detector showing whether the end-of-train is moving). Few EOTs with two-way radio link allow initiation of brake application from rear end.

Automatic Train Control System (ATCS) networks, are based on transponders attached to tracks at certain intervals and triggered by passing trains. With ATCS, information gained from the transponders are sent via fiber-optic cable or telephone line to a regional data center or directly to the switching yard to which a passing train is headed. Once gathered, this information allows switching establishments to react more quickly to changes on the line, as well as to assign incoming trains to certain tracks in the yard. ATCS is being implemented in four areas: work order reporting, locomotive performance monitoring, track force equipment management, and positive train separation and control. Examples are the Union Pacific's rail complex in North Platte, Nebraska, the world's largest, which can deal with up to 700 trains in a day through its computerized command center and Selkirk Yard outside Albany, New York, which sorts 3,200 freight cars per day, using computer scheduling and track assignment.

BNSF uses technology to improve maintenance productivity. BNSF defines World Class Maintenance as “Know and track your assets. Predict and identify your work. Plan and execute the work. Report, measure and adjust”. Examples of this philosophy are the TPI (Track Prediction Indices) and PARS(Planning & Activity Reporting System). TPI is a single database that integrates information captured by track inspectors, track geometry cars, rail flaw detector cars along with maintenance history on a section as well as record of suppliers providing materials. PARS allows prioritizing of maintenance activities to locations where greatest needs exist. Further tools such as “eSynchronous Railroad” allows customers to access maintenance work information on BNSF website which might affect the routes on which their shipments move.

BNSF also uses condition based maintenance (CBM) of its locomotives rather than traditional planned maintenance. Examples are vibration analysis of turbines and generators, oil and water tests for viscosity and contamination, wear-particle analysis, thermographs to detect hot-spots in locomotive electric panels and sonar pressure for power assemblies. Similar CBM is also applied to the freight cars. Fault detection technologies deployed on the trackside include WBD (warm bearing detectors), HBD (hot bearing detectors), WILD (wheel impact load detectors), LAHD (low air hose detector), TPD(truck performance detector), hollow/worn wheel detectors, and TADS(trackside acoustic detectors). These accessories follow AAR’s ATSI (Advanced Technology Safety Initiative) to develop preventive car maintenance practices using wayside fault detection data.

UP has also deployed wheel temperature detectors, to detect brake settings. UP uses Lat-Lon’s RailRider technology to improve equipment performance on its Express Lane guaranteed perishable service started with CSXT. This consists of self contained units attached directly to refrigerated box cars, where they measure temperature fluctuation, excessive vibrations, and mechanical malfunction. Data is transmitted wirelessly via Aeris MicroBurst through cellular phone network. Similar units to monitor ride quality (through accelerometers) are being used for ride quality sensitive automotive parts and rolled paper shipments. This on-line fault detection reduces inbound inspection time, allowing maintenance to concentrate only on cars with exceptions. Rugged hand-held PDAs have been deployed with maintenance workers for track inspection and defect reporting, bridge inspection and signal/grade crossing inspection. (45)

In select locomotives, NS has introduced an initiative known as LEADER®, or Locomotive Engineer Assist Display and Event Recorder, to achieve optimal train operations. LEADER works by logging the operating state of a train in its computer memory to create a statistical profile of the operations over several trips. This profiled information is used to create the most efficient trip, known as the “golden run.” LEADER leverages wireless and mobile computing technologies to make this “golden run” visible on the locomotive, coaching the engineer to adjust the throttle and brakes to achieve the most efficient trip. With LEADER, NS has improving fuel efficiency, reducing operating expenses and enhancing safety. Additionally, the engineer and supervisors download this operating information for review after the trip to improve operating behaviors through training and feedback.

Other technologies being deployed by NS include Operating Plan Developer (OPD) for providing “what-if” analysis, Thoroughbred Yard Enterprise System (TYES) for assisting classification yard personnel in execution of mainline plans, Operating Plan Adherence (OPA) to measure train connection and blocking performance, Local Operating Plan Adherence (LOPA) to measure schedule car pickups and deliveries against plan, web based Commodity Transportation Management System (CTMS) for tracking and tracing cars by coal and grain customers and web based eFreight Bill and eDemurrage to allow customers to access their receivable accounts along with inquiries into freight and demurrage bills. NS has also automated its car rejection data acquisition process, allowing swift transfer of cars to maintenance facilities. (29)

Weather Forecasting for train operations: Railroads in the US operate under severe weather conditions. Typical hazards include blizzards, flash flooding, hurricanes and tropical storms. Wind speeds greater than 55 kph, might impact merchandise and intermodal traffic. Flash flood warnings require speed restrictions to be imposed, along with intensive track inspections. BNSF and CN works with a private contractor Weather Data to monitor adverse weather conditions that might impact operations. Data, customized to track locations, are sent directly to the concerned dispatcher who sets in motion activities according to protocols. Weather Data uses data from BNSF’s trackside wind detectors and temperature indicators along with other data. NS works with another contractor Weather Bank for changing weather patterns. Similarly UP works with Meteorologix. (17)

10. Strategic Lessons from US Railroads

The US railroads have evolved to the present state under a unique set of circumstances, a few of which are listed below:

a. Railroads in the US have had to battle for survival. Its primary competitors were road transport, which had the benefits of excellent road infrastructure, inherent last-mile advantages and lower investments since roadways do not have to build and maintain the road infrastructure in contrast to the railroads.
b. The US railroads have evolved in the US environment of entrepreneurship, free market economy and minimal government support. There had been government support in the initial stages of growth through land grants though. Latter instances of government support were through funding for specific projects, in which issues of safety or interfaces with other public bodies were involved. While this dispensation allowed free rein to the railroads in its decision making process, US railroads had always to ensure fair return and accountability to its investors and shareholders.
c. There was however a continual oversight by the government to ensure fair competition, fair rates, and safety of operation. The STB through its rulings restricts the ability of larger railroads to exercise market power or abuse their size. (47)
d. With the rapid evolution of air and road transport, there has been little pressure on railroads to carry passengers; railroads have thus been able to become totally freight oriented

e. There has been a rapid expansion of information and communication technologies in the last three decades, applications of which have been deployed by road and railways alike for improvement of productivity, asset utilization and customer service

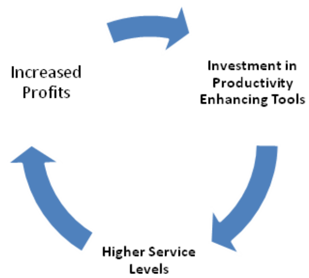
f. The evolution to the present industry structure of a few typical high density large lead distance routes (owned by Class I railroads, along with horizontal integration with feeder Regional and Short Line railroads and even truckers) has led to a spiral effect of high profits followed by high investments in productivity enhancing measures such as computer aided dispatching, automatic equipment identification, automatic fault detection devices, equipment diagnostics etc. A major reason for few high density routes in the US is its extent of urbanization; only 29.2% of population resides in urban agglomerations in India, in contrast to 81.4% in the US (48). Only 36 largest cities[6] in the US make up 39.5% of the US population; in contrast 43 largest cities[7] in India make up only 12.1 % of the Indian population. The high concentration of population in certain urban agglomerations translates into major traffic destinations, due to demand in those locations. Analysis of distribution of electricity power generation capacities shows that 48% of installed power generation is located in only the ten states of Texas, California, Alabama, Georgia, Florida, Illinois, Michigan, Ohio, Pennsylvania and New York. (49) This affects the transportation OD matrix. Thus while 74% of coal originated from the three states of Wyoming (52.2%), West Virginia(13.2%) and Kentucky(9.2%), 58% of the coal terminated in the ten states of Illinois, Texas, Missouri, Virginia, Wisconsin, Ohio, Georgia, Pennsylvania, Indiana and North Carolina. 70% of the intermodal traffic originated and terminated in the four states of California, Texas, Illinois, Washington and New Jersey. Further distances are large in the US- typical examples are the 1500-2000 miles movement of coal from Powder River Basin of Wyoming to South and Northeast US and 1500 miles movement the container traffic from Californian seaports to Texas or St.Louis markets.

g. The rapid shift of US industry towards JIT practices, with implications of smaller consignments and reliable delivery services had further made the railways inherently less competitive than roadways. However the alliances with roadways for intermodal

[6] the cities in the South (8.6% of the US population) are Atlanta(1.5), Austin(0.4), Charlotte (0.3), Cleveland(0.6), Dallas-Fort Worth(1.6), Denver-Aurora(0.8), Houston(1.4), Orlando(0.4), San Antonio(0.5), Tampa-St.Petersburg(0.8) and Virginia Beach(0.5) ; cities in the Northeast (12.4% of the US population) are Baltimore(0.7), Boston(1.4), Bridgeport-Stamford(0.3), Buffalo(0.3), New York-Newark(6.1), Philadelphia(1.8), Providence(0.4) and Washington DC(1.4); cities in the Midwest (6.9% of the US population) are Chicago(2.9), Columbus-Ohio(0.4), Detroit(1.3), Indianapolis(0.5), Kansas City(0.5), Pittsburgh(0.6) and St.Louis(0.7), ; cities in the West (11% of the US population) are Las Vegas(0.6), Los Angeles-Long Beach(4), Phoenix-Mesa(1.2), Portland(0.6), Riverside-San Bernardino(0.6), Sacramento(0.5), San Diego(0.9), San Francisco-Oakland(1.1), San Jose(0.5) and Seattle(1).

[7] the cities in the North are Agra(0.1), Allahabad(0.1), Amritsar(0.1), Chandigarh(0.1), Delhi(1.8), Jaipur(0.3), Jodhpur(0.1), Kanpur(0.3), Lucknow(0.2), Ludhiana(0.1), Meerut(0.1), Srinagar(0.1), Varanasi(0.1) ; West are Ahmedabad(0.5), Aurangabad(0.1), Bhopal(0.2), Gwalior(0.1), Indore(0.2), Jabalpur(0.1), Mumbai(1.6), Nagpur(0.2), Nashik(0.1), Pune(0.4), Rajkot(0.1), Solapur(0.1), Surat(0.3), Vadodara(0.2); East are Asansol(0.1), Dhanbad(0.1), Durg-Bhilainagar(0.1), Jamshedpur(0.1), Kolkata(1.3), Patna(0.2), Ranchi(0.1) ;South are Bangalore(0.6), Chennai(0.6), Coimbatore (0.1), Hyderabad(0.6), Kochi(0.1), Madurai(0.1), Vijaywada(0.1) and Visakhapatnam(0.1); North-east is Guwahati(0.1). (60)

transport and the adoption of ICT by the railways have enabled the railways to capture part of the low volume high value freight traffic. The geographical spread of the US has enabled the induction of such alliances since the necessary transshipment times and transfer costs are a negligible fraction of the total time and cost. (50) The US railroads have demonstrated their competitive ability through their ability to evolve with the markets that they serve, to rapidly develop new services that are responsive to shippers' needs and to become customer "problem solvers" not "order takers". (51) Multimodal transport has allowed also railways to increase market reach without additional investments in network expansion. (50)



h. There have been no attempts at vertical integration in the US railroad industry on the scale of the Indian Railways. Industries for manufacture of locomotives and freight cars as well as for development of automation, diagnostic and software services have grown, along with standardization efforts of organizations such as AAR. Few industries also service the locomotives and freight cars for the railroads. While this arrangement has spared the railroads in incurring capital expenses for development of such complementary industries, it has also ensured development of specialized expertise in these industries.
i. The US railroads have a single marketing organization which allows for close coordination with the customer and operations. This allows the railroads to tune packages to customer requirements and coordinate closely with operations.

US Railroads have learnt that technology choices, investment and maintenance policies have a long term bearing on the competitiveness; typical choices are number of tracks, source of motive power, maximum train speed, length of crossing loops, weight of rail, rail connections, loading gauge and method of train control. Increased axle weights, higher net/tare weight freight cars and high utilization of rolling stock are keys to higher returns on capital investment. Further railroads have become much less labor intensive along with induction of higher skill levels. Examples of higher skills are train crews who can minimize energy and maintenance costs through driving techniques, terminal staff who can drive modern materials handling equipment, train and traffic controllers who can use sophisticated IT systems, marketing staff who can manage client relations and not just waybills etc. (50)

The striking features of the US railroads have been its ability to capture a significant share of the intermodal market. This market provides significant revenues to the railways, over and above the marginal cost. This also increases rail's share in tertiary product transportation and growing involvement in the nation's economy. However a close examination indicates that this synergy has been possible only through greater deployment of information and communication technologies by both the rail and trucking companies especially in areas of waybill generation and tracking. In the US, shipment visibility is far greater today with advanced tracking technologies (such as Automatic Equipment Identification transponders for tracing freight cars) and web-based services, whereby customers can follow their individual shipments in real-time and make rerouting decisions en route if necessary.

Further US railroads have closely partnered with roadways to provide seamless intermodal transport. Freight containers are attached to truck beds for shipments to rail yards, then transported by rail to a distribution "hub," where they were again picked up by trucks for the final leg of their journey. These containers could also be transported by ship to port locations where they were transferred to rail for the journey inland. The intermodal system encourages cooperation and business collaboration between road and rail for the benefit of both industries. Intermodal transport has also been spurred by various technological innovations on the railroads, few examples of which are: (39)

a. EDI, or electronic data interchange, allows the railways to track goods and trains more closely and quickly. The primary EDI system, ATCS (advanced train control systems), controls trains using telecommunications technology and computer tracking. ATCS provides near-instantaneous data on car location, switching records, car scheduling, and other factors that affect the smooth synchronization of a vast network of trains.
b. Other innovations included ISS (Interline Settlement System) and REN (Rate EDI Network), industry-wide standards of computerized data management that enable management of revenue sharing among railroads when goods were shipped on more than one line, and speed billing and dispute resolution within the industry.

10.1 *Capacity enhancements*

Rail capacity is affected by the following factors: number of tracks, number and length of sidings, number of crossovers and other connections, type of signaling, speed limits, grades and curvature, availability of freight cars and locomotives, overhead clearances for movement of double-stack containers, traffic mix and terminal facilities. (12) Other factors affecting capacity are operating strategies (e.g., size, speed, and timing of trains), motive power and freight car capacities, reliability of infrastructure and equipment, and extent of redundancy of infrastructure and equipment. Capacity challenges can be handled either by using existing resources more efficiently or adding resources or shedding traffic or lowering service standards. (52) Increasing freight car carrying capacity and train lengths are likely to increase haulage dramatically within the same infrastructure.

Since congestion points on a network, such as congestion at terminals, ports, highly congested urban areas severely limit the capacity of a network, US railroads conduct regular studies to identify such congestion points. (13) Line capacity modeling determines where infrastructure investment is to be made. (53) BNSF uses a number of methods for capacity planning: (i) historical trend analysis incorporating run time, train length and horsepower per ton (ii) dispatch system replays (iii) marketing forecast information (iv) identifying available alternate train routings (iv) Train Performance Calculators (v) Train Dispatching Simulators. BNSF follows the following guidelines for augmentation of parallel tracks (8): (a) Single track with sidings about every 10 mile for less than 60 trains per day (b) Double track with CTC at or above this traffic level of average 60 trains and peak 75 trains per day (c) Double crossovers rated for 40mph every 10 - 20 miles at or above this traffic level of average 85 trains and peak 100 trains per day (d) Crossover spacing tightened to every 2 - 8 miles at or above this traffic level of average 70 trains and peak 85 trains per day (e) Triple-track any steep gradients or other slow sections at or above this traffic level of average 100 trains and peak 115 trains per day (f) Triple track selected low-gradient sections at or above this traffic level of average 120 trains and peak 135 trains per day.

The common packages used for rail capacity analysis on the railroads are the Rail Traffic Controller (RTC) developed by Berkeley Simulation Software and RAILSIM developed by the rail consulting firm SYSTRA. RTC software package dispatches trains at the network level taking into account different equipment types, train consists, terrain and track conditions; simulation results are displayed in graphical formats, along with intuitive interface for generation of what-if scenarios to develop operating plans, diagnose bottlenecks and recommend schedule changes, evaluation of various capital improvement scenarios and assess the impact of adding new trains to the network. (54) RAILSIM software Rail Network Planning is used for capital improvements planning, timetable and operating plan validation, line capacity analysis and signal design validation. (55)

10.2 *Service Network Design*

Service network design is another critical aspect that US railroad companies have used for competitive advantage. Railroad companies forecast demand patterns and the modal choice and design the service appropriately. (50) While designing the service, the main issue is whether to build capacity before the demand materializes or augment capacity as the demand is actually encountered. The capacity augmentation might be in terms of track or terminal capacity. Since railroad investments are lumpy, railroads rarely build capacity in advance unless there is an assured traffic through long term agreements. However such an arrangement could lead to loss of opportunity too. Further while designing the service, it is essential to consider a proper performance metric; for example BNSF uses the metric of on-time performance for intermodal, car-cycle time for coal traffic, car availability for grain traffic and adherence to trip plans for industrial traffic. (56) (27) (57)

CSX and Union Pacific railroads have used a service design software called Multi-Modal’s MultiRail system to develop interchange points and blocking schemes for reducing transit time and terminal detention of traffic between the railroads at the major interchange gateways. Both railroads claim to have recaptured traffic, such as refrigerated perishables from the West Coast as a result of this innovation. (14)

Reliable freight data (such as the origin and destination of shipments, the commodities moved, the modes of shipment, vehicle/vessel type, routing, and time of day) are essential for formulation and evaluation of decision options for service design; the data can also be used for evaluating options for mitigating congestion, changes in freight flows, environmental impacts, national security, regional development, land use planning and understanding the economic geography or infrastructure investments. Such data also spurs private sector investment in the freight logistics sector, since opportunities for returns on investment can be appreciated. In the US, data on goods movements are collected by federal agencies and other public- and private-sector entities that monitor or analyze transportation and trade activities on a regional, state, national, or international level. Examples of federal databases providing freight transportation data at the national level include the Commodity Flow Survey (CFS) from the Bureau of Transportation Statistics and the Census Bureau, the Rail Waybill Sample from the Surface Transportation Board (STB), the Vehicle Inventory and Use Survey (VIUS) from the Census Bureau, and the Waterborne Commerce of the United States database from the U.S. Army Corps of Engineers. (58) (59)

10.3 Cramer (8) has summarized the common US railroad firm strategic activities and their business goals in the table below. While activities (1), (2) and (9) in the table above are not feasible or applicable for the Indian Railways, the remaining activities are worth exploring in the Indian context.

Common US railroad strategic activities and their goals

Sl.No.	Business Activity	Business goal
(1)	Acquisition of network assets by purchase or merger, including trackage / haulage rights	Expanding firm geographic scope; acquiring better routes or connections with hubs or gateways; blocking acquisitions by competitors
(2)	Disposal of network assets by sale or abandonment	Eliminating money-losing or financially underperforming lines; complying with actual or expected regulatory objections
(3)	Managing the characteristics of network segments by implementing appropriate levels of infrastructure quality	Matching system throughput and reliability to operational needs; reducing operating costs; eliminating bottlenecks
(4)	Upgrading infrastructure for larger and heavier loads	Increasing operating efficiency through the use of cars with greater size or weight capacities
(5)	Network flow optimization, including scheduled railroading and Operations Research techniques	Improving system throughput and reliability; reducing operating costs; realizing more of the network's potential capacity
(6)	Standardization of rolling stock, including locomotives and special-purpose cars	Increasing maintenance efficiency; faster training of personnel
(7)	Use of unit trains (e.g., coal, grain, ore, intermodal)	Increasing efficiency through reduced car blocking time and cost; rapid recycling of cars
(8)	Spatial organization of management, including degree of centralization and control over business functions	Achieving best balance of central control and local autonomy for each category of business function (e.g., operations, maintenance, purchasing, marketing)
(9)	Alliances with other rail firms, including joint marketing, trackage / haulage swaps, and sharing of support infrastructure, such as yards and terminals; rail car pooling	Strengthening and extending the firm's "virtual" network; sharing scarce infrastructure and other assets with other firms; reducing some interfirm transaction costs; coping with demand fluctuations
(10)	Cultivation of new customers along the firm's existing network	Expanding revenues; exploiting existing network and local spatial monopoly
(11)	Better serving major customers through tailored rail infrastructure or train operations	Expanding revenues; exploiting existing network; "locking in" customers through specialized assets and high service quality
(12)	Public-private partnerships or other methods of obtaining outside investment capital	Financing rail infrastructure projects; reducing public opposition to changes by involving more stakeholders

11. Conclusions

The strategic actions that are recommended for the Indian Railways in the light of the US experiences can be broadly classified as either efficiency or capacity enhancing measures. Switching to centralized traffic control, marketing oriented organizations and service design could be classified as efficiency enhancing measures. Increasing capacity of freight cars, increasing train lengths or increasing speeds could be classified as capacity enhancing measures.

Further in order to enable the Indian Railways to pro-actively serve the freight market, it is essential to institute reliable freight forecasting procedures along with network capacity modeling to identify and correct capacity constraints at the earliest.

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