Introduction to Rail Transportation
Introduction

• Adequate Transportation System
• Efficient Movement of Goods and People

• Provides No Basic Intrinsic Value

• Provides “Value Added”
• Necessary for Economy and Development
Early Modes of Transportation in the U.S.

- Waterways
- Crude Roads
- Rivers/Canals 1700’s
- **Railroads 1830**
- Better Roads
  Trucks/Automobiles early 1920’s
- Air – Passengers 1950s
- Interstates
  Trucks/Automobiles early 1960s
- Railroads 2000s!!!
Current Modes of Transportation in the U.S.

- Waterways
- Airways
- Highway Trucks
- Pipeline
- Conveyor Belts
- Railways
• Railroads are America’s First Large Corporations
• Had a Monopoly on Transportation
• Heavily Regulated until 1970s/1980s
• U.S. Railroads Privately Owned
• U.S. Railroads are Primarily Freight
• U.S. Rail Passenger Service is Heavily Subsidized by the Public
Why is railroad freight transport so important now, and even more so in the future?

• Let's consider the alternatives for inland transport: truck, water, air, pipeline, conveyor belt
Waterways Pros and Cons

- **Pros:** Energy efficiency, low cost, low pollution, safety, capacity
- **Cons:** Speed, limited network
Highway Truck Pros and Cons

- **Pros**: Speed, reliability, network coverage
- **Cons**: Energy efficiency, safety, land use, pollution, cost, congestion (because of shared use of infrastructure truck transport affects auto safety and congestion as well)

How many truckloads can a railcar carry?
Airways Pros and Cons

• Pros: Speed, reliability, network coverage

• Cons: Energy efficiency, cost, limited volume
Pipelines and Conveyor Belts

- **Pros**: High volume, continuous transport possible, no vehicles needed, low labor requirements
- **Cons**: Highly constrained types of commodities, limited product flexibility, speed and network
Rail uniquely combines speed and energy efficiency.

*Plus environmentally Friendly
Rail is the principal means of economically moving large, heavy freight long distances overland.
Common Goals & Functions of the Railroad Industry

• The movement of Freight and People in the most efficient manner possible
• Principal Function in U.S.
  – Hauling Freight (~43+%)

• Characteristics
  – Fast
  – Reliable
  – Convenient
  – Economical
  – Safe/Secure
  – Fuel Efficient
  – Environmentally Friendly

• Renewed Interest in Passenger Rail
Early Regulations

• Land Grants (1850-1870)
  – Business Transactions
  – Development of Central and Western U.S.
  – Repaid

• Interstate Commerce Commission (1887)

• Surface Transportation Board (1995-1996)
Recent Significant Legislation

- **Phase 1:** Passenger
  - 1971 Amtrak
- **Phase 2:** Freight
  - 1973 3R Act
  - 1976 4R Act
  - 1980 Staggers (Deregulation)
- **Phase 3:** Multi-Modal
  - 1992 ISTEA
  - 1998 T21
  - 2004 SAFETEA-LU
  - 2008 Safety Improvements
  - 2010 Surface Transportation Assistance Act (MAP 21 – Moving Ahead Progress)
Major freight railroads

- 6 large North American freight railroads
  - CSX & NS in eastern US
  - BNSF & UP in west
  - CN & CP in Canada & central US
- KCS is a medium sized railroad in central US
- Amtrak operates passenger trains primarily on freight railroads’ trackage throughout US

(From Vantuono 2000)
North American freight transportation volume by mode

Source: AAR from Eno Foundation for Transportation
US rail freight traffic

Revenue Ton-Miles (billions)

Year

The Fundamental Principle of Rail Transport - EFFICIENCY

Implications for Economics, Energy & Environment

or

Why Rail Transport is More Important Than Ever!
US 20th Century was about CONVENIENCE
The 21st must consider EFFICIENCY as well

- **Then**
  - Abundant: energy, land, natural resources and labor

- **Now**
  - Diminishing resources:
    - Energy
    - Air quality
    - Water
    - Land
  - Congestion
    - Need more efficient use of transportation infrastructure
  - Stronger global competition
Energy efficiency truck vs. rail

- How far can each mode transport a given amount of freight for a given amount of energy?
- Specifically, how far can we transport one ton of freight with one gallon of diesel fuel?

Rail is over 3 times more efficient than truck

(AAR & FRA data)
Increased Public Interest in Rail

- Increased awareness of rail as a solution to congestion, pollution, and fuel inefficiency
- Increased motivation to invest public money in rail infrastructure
  - Heartland
  - CREATE
  - Green Power (Locomotives)
  - I81
• Next Day Service to Columbus
• Reduce Transit to Chicago by 1 Day
• Will Shave Approx. 225 Route Miles Off Each Container Move to Chicago
• Greater Efficiencies
• High Speed Double Stack
Genset and Hybrid Switchers
In the last 20 years...

- Vehicle travel increased 78%
- Road miles increased only 1%

Traffic congestion costs the U.S. $67 billion annually
Intermodal Definition

- Intermodal shipment: a freight shipment that moves between origin and destination using two or more modes of transportation
- Two types of intermodalism:
  - Bulk
  - Unitized
- Growth of unitized intermodal shipments has been a spectacular trend in transportation
- Domestic and internationally standardized designs for containers
Intermodal freight

Trailers

Containers

**Intermodal**  *Transportation by more than one means of conveyance, as by truck, ship and/or rail*
Basic types of unitized intermodal equipment & service

• Railroad intermodal transportation is typically described as either:
  – Trailer on flatcar (TOFC)
  – Container on flatcar (COFC)

• Although the early railcars used to transport these were flatcars, intermodal rolling stock has become highly specialized

• Also “RoadRailer”, is a system in which a container can ride directly on either highway or railroad wheel assembly, without any car at all
Summary

• Rail Industry is growing
• Rail has become a viable alternative to truck
• Spike in Public Interest due to
  — Highway congestion
  — Population growth
  — Environmental issues
  — Fuel Conservation
• Significant investment required to accommodate growth for freight and passenger
Passenger Rail Service

- **Intercity Passenger Rail**
  - trains that move passengers between cities
  - long distances, high speeds
- **High Speed Passenger Rail**
  - Short to medium distance intercity rail
- **Urban Rail Transit**
  - trains that move passengers within a city/urban area OR between the suburbs and the central city
  - several types of urban rail transit modes
Acela Express
• operates in Northeast Corridor
• Top speed – 150 mph
• Average = 82 mph W-NY
  68 mph NY-B

Auto Train
• operates between Virginia and Florida
• 855 miles, 17 ½ hrs, 49 mph
High Speed Rail (HSR)

• a rail line and service designed for high speed operation - *cruising speed* of 125+ mph

• Japanese introduced the first high speed trains in the mid 1960s – Shinkansen (Bullet Train)

• today high speed rail lines are common in France, Germany, Spain, United Kingdom, and many other countries
Skinkansen (Bullet Train) in Japan
Intercity Express (ICE) - Germany
British Rail High Speed Trains
French TGV

574 km/hr (357mph) test
High Speed Rail in the United States

- Amtrak Acela Express – Northeast Corridor, top speed – 150 mph
- several high speed rail corridors studied
- US DOT Federal Railroad Administration

www.fra.dot.gov
URBAN RAIL TRANSIT

• rail service in urban applications
• operates in a city OR between the suburbs and the central city
• several types of urban rail transit modes
  • **Commuter Rail**
  • **Rail Rapid Transit (Metro)**
  • **Streetcars and Light Rail Transit**
Commuter Rail
Chicago Metra
Rail Rapid Transit (Metro)

• high speed, high capacity trains
• multi-car trains operate on short headways (some can operate at 2 minutes or less)
• electric power taken from a third rail
• exclusive right-of-way – underground, elevated, at-grade
• sophisticated signaling
• variety of other names – *Metro*, *Subway*, *Underground*, *Heavy Rail*
Washington Metro
Light Rail Transit (LRT)

• a new name for the streetcar
• electrically powered vehicles, but may link two or more vehicles to form a train
• a variety of operating strategies:
  • share the road
  • transit only street – Transitway, Transit Mall
  • on a separate right-of-way – on the surface, underground, or an elevated structure
• typically have honor fare collection
Light Rail Transit
Minneapolis Hiawatha Line
Streetcars

• electrically powered vehicles that share the road with other traffic - power is from an overhead wire (trolley or pantograph)
• first demonstrated at expositions in Chicago and Toronto – late 1800s
• several developers/inventors (including Thomas Edison)
• also called *Tram, Trolley, Street Railway*
Automated Guideway Transit
Downtown People Mover (DPM)

- several research initiatives in the 1980s
- three systems built
  - Jacksonville
  - Miami
  - Detroit
Opportunities
Railway Transportation (Engineering and Operations)
Area of Study
University of Kentucky

Technical Elective Classes
CE 433
CE 533
CE 599

Assist on Funded Research
Undergraduate
Graduate

Co-Op and Intern Positions
Graduate Students

Since 1996=45 (Also 25 undergraduates)
Numerous Funded Research Projects

- National Asphalt Pavement Association/Asphalt Institute
- L & N Railroad/Santa Fe Railway
- CSX Transportation
- Association of American Railroads
- Kentucky Transportation Cabinet
- Norfolk Southern Corporation
- Nichols Foundation
- BNSF Railway
Measuring In-situ Pressure, Deflection and Stiffness of Trackbeds
Monitoring Performance of Trackbeds, including Sampling and Testing
Empty Coal Train at Conway

P-Cell 209 on 5 in. HMA Layer

- Pressure (psi)
- Time (s)

4 6-Axle Locos

Initial 5 Cars
In Track Placement
During First Test

Typical Pressure Distribution
Plot from Tekscan System
Resilient Modulus
25°C (77°F)
1Hz
Evaluating Various Rail Lubricants

Checking Wheel Contact With Rail

Running Tribometer @ Walking Speed
Monitoring Rail/Highway/Crossing Performance
• TriMet, Oregon
• Caltrains
• Los Angeles Metrolink
• Iowa DOT
• Indiana DOT

• West Virginia DOT
• Tennessee DOT
• Hillsborough County, FL
• KY DOT
• Michigan DOT
Kentrack

• Kentrack is a computer program designed to analyze a railroad track segment as a structure
• Uses Bousinessq’s Elastic Theory
• Uses Burmister’s Multi-Layer System and Finite Element Analysis to perform calculations
International Design Practices, Applications, and Performances of Asphalt/Bituminous Railway Trackbeds

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Proceedings of the Railway Geotechnical Engineering International Symposium (GeoRail 2011)

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Long-Term Performances of Rail/Highway At-Grade Crossings Containing Enhanced Trackbed Support

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Rail uniquely combines speed and energy efficiency

*Plus environmentally Friendly

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Thank You

Questions ???

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