National University Rail Center - NURail
US DOT OST-R Tier 1 University Transportation Center

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Multimodal Course Enhancement and Distance Education

By

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DISCLAIMER

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TECHNICAL SUMMARY

Title

Multimodal Course Enhancement and Distance Education

Introduction

Given the resurgence and importance of rail transportation in the United States, as well as the relative paucity of curricular opportunities at colleges and universities, the University of Kentucky is using NURail Education Funds to expand its railroad offerings. The purpose of this education project is to incorporate multimodal learning modules into a semester course on railroad operations, and to incorporate elements of distance learning.

Description of Activities

The target group for the multimodal course is undergraduate senior civil engineering students and others with interest and permission of instructor. For some time, CE 433, Railroad Operations, has been offered as a rail-only course. The focus of this projects is to expand the scope of the class to include multimodal and intermodal operations. The main approach is to develop several new lectures with accompanying background information. Secondarily, the purpose of the project is to incorporate elements of distance learning with an ultimate goal of making the course available on-line to remote students. The main deliverables are the new lectures in power point format as well as course notes and voice-over power points for selected lectures.

Outcomes

The deliverables of the project are summarized in the appendices to this report, which include:

Appendix A: Syllabus for CE433

Appendix B: Highway Motor Transportation Lecture

Appendix C: Overland Conveyors Lecture

Appendix D: Pipelines Lecture

Appendix E: Waterways 1 Lecture

Appendix F: Waterways 2 Lecture

Appendix G: Air Transportation Lecture

Appendix H: Intermodal Lecture

Appendix I: Brittany Stewart MS Project Report, "Development of a Multimodal Course"

Appendix J: List of other education-related papers and presentations produced

Conclusions/Recommendations

The principal conclusion of this project is the effective implementation of the new learning modules for the multimodal operations class (fall semesters, 2014 and 2015). Further development is recommended to include continuous update of materials, additional voice-over for all lectures, addition of multimedia (videos), and online implementation.

Publications/Examples

Appendix J provides a list of other education-related papers and presentations produced (not counted as part of UKY NURail research products) for calendar years 2015 and 2016.

Primary Contact

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Appendix A: Syllabus for CE433

COURSE SYLLABUS
CE 433-001

University of Kentucky	Fall Semester 2014
Department of Civil Engineering	MWF 9:00 - 9:50 a.m.
Jerry G. Rose, OHR 261	OHR C057
257-4278 jerry.rose@uky.edu	www.engr.uky.edu/~jrose

Railway Freight & Passenger Operations and Intermodal Transportation

PRIMARY INSTRUCTOR

Dr. Jerry G. Rose, Professor of Civil Engineering, serves as the primary instructor. Approximately one-half of the course will be devoted to Freight Railway Operations and Management. The other half of the course will be devoted to the emerging growth of the Intermodal Freight and Rail Passenger/Transit Systems and the other basic transportation modes. The instruction will be complemented with special speakers, out-of-class tours, and supplementary materials and presentations.

TEACHING ASSISTANT

A civil engineering graduate student, Jordan Haney, serves as the Teaching Assistant. His office is OHR C216, across the hall from my office. The office phone is 257-4349 and his e-mail address is jordan.haney@uky.edu. He will advise you of his office hours. He will conduct a limited number of classes in addition to reviewing out-of-class and other assignments.

INTRODUCTION

The course emphasises the transportation engineering aspects of railway operations – efficient movement of freight and passengers – and complements the existing "Railroad Facilities Design and Analysis" class (CE 533), which is offered in the spring semesters and places emphasis on the engineering aspects of railroad infrastructure. It provides students with instruction in the critical concepts and planning of railway operations. Students are exposed to the processes used for managing local railway operations to managing system-wide operations. The key planning roles of railroad professionals are stressed. Equal emphasis is placed on the increasing reliance on intermodal (multi-modal) freight transportation systems and the re-emergence of rail passenger, commuter, and transit systems, and their roles for the 21st century.

NOTE: This course is being modified slightly to include more Multi-Modal Transportation. Somewhat less emphasis will be placed on Railway Transportation and additional emphasis will be placed on the other basic transportation modes – Water, Air, Motor-Freight, Pipeline, and Conveyor. The Intermodal section is being expanded to include these other transportation modes. This aspect of our total transportation system in the country is commanding more attention with emphasis on selecting the most economical/efficient use of our transportation resources.

EDUCATIONAL OBJECTIVES

The basic educational objective is to provide civil engineering students with a course emphasizing the transportation aspects of railway freight operations with additional emphasis on our nation's intermodal freight and rail passenger/transit transportation systems. It will benefit students wishing to pursue engineering employment in the railroad or rail transit industries with a railway company or governmental agency or a company providing services to the industry, such as a construction contractor, consulting engineering firm, or material/service supplier.

OUTLINE

- the basic rail route structure,
- maintenance and management of the rail infrastructure and how they affect operations,
- the key roles of the operations management personnel,
- the daily activities involved in line of road, terminal, local, and network operations,
- evaluation and measurement of service design and operations,
- extrapolate the roles of the heavy freight railroad industry and the passenger, commuter, and transit rail systems for the 21st century,
- intermodal freight transportation, and
- passenger rail/mass transit systems.

REQUIREMENTS

The textbook is *The Railroad – What It Is, What It Does,* 5th edition by John H. Armstrong.

A compilation of Outline/Reference Notes, PowerPoint Presentations, and Magazine Reference Materials are available.

Various handouts and study materials will be provided, including selected articles from *Railway Age* and *Progressive Railroading* magazines.

Class attendance is extremely important. Grades will be lowered for excessive absenteeism.

Out-of-Class assignments normally will be provided weekly by e-mail. A limited number of In-Class assignments will be given. Students are required to check their e-mail daily.

One or two field trips are planned to observe railroad and multi-modal operations. One or two guest speakers will present lectures.

This course prerequisite is CE 331 and engineering standing. It is expected that students have a basic understanding of transportation engineering and will be able to produce high-quality work.

ENGINEERING ETHICS

It will be assumed that each student subscribes to a professional code of ethics that is the basis for behavior in class. Any and every case where these ethics are violated will be dealt with according to the provisions in the Student Code. **All cellular phones or electronic communication devices must be turned off during examinations. No text messaging permitted.** (Also, see the Undergraduate Study in Civil Engineering Handbook on Student and Faculty Responsibilities.)

GRADING

Final Class Averages and Grades will be determined from class performance as follows:

30% - Exam I	90 – 100% = A
30% - Exam II	80 – 89% = B
30% - Exam III	70 – 79% = C
10% - In-Class & Out-of-Class Assignments	60 – 69% = D
	< 60% = E

COURSE DESCRIPTION

A Study of the transportation engineering aspects of efficient management of railway operations including freight, passenger, and intermodal and multi-modal transportation.

EDUCATIONAL OUTCOMES

Week	Topic
1	To provide the students with a basic understanding of how the heavy freight railroad and passenger, commuter, and transit rail systems have evolved and their effect on American industry and citizenry; including an analysis of the major objectives of a railroad's operating departments.
2	To provide details on how the rail routes and infrastructure are maintained and the effects of the infrastructure quality on operations; how the maintenance activities are planned and organized and how the quality level is measured.
3 & 4	To enable the students to understand the management, assignment, operation, and maintenance of the motive power and rolling stock; various accounting procedures for measuring efficiency; fleet cycle times; management and efficiency studies of the role of the locomotive engineer and trainmen in inspecting trains and practicing safe job procedures; and management and efficiency studies of the role of the locomotive engineer relative to safe train operating/handling practices, signal indications, safe job and train operation procedures.
5	To enable the students to understand the basics of train operations; laws and rules; generation of timetables, bulletins, and train documents; accident cause/finding; train control and signal systems; roles of the trainmaster.
6 & 7	To enable the students to understand the three types of train operations – <u>line of road operations</u>: management studies of the role of the train dispatcher; innovative tracking techniques; root cause of analysis of operational efficiency; management of <u>terminal operations</u>; role of the yardmaster; classification and blocking; and management of <u>local operations</u>; industry service; roles of the industrial development and customer service representatives.
8	To enable the students to analyze network operations; managing locomotives, rolling stock, and crews; routing mixed freight, unit trains and intermodal trains; service design; planning process; measuring productivity; administration; law; accounting; and efficiency measurements.

9 - 11 To enable the students to understand and evaluate multi-modal and intermodal transportation planning process and interfaces involved with the various other modes – oceanic and inland waterways, highway motor transport, air transport, pipeline, and overland conveyor.

12 - 14 To provide the students with a basic understanding of the various rail passenger systems – including heavy rail transit, light rail systems, rail commuter service, intercity passenger service, and high speed-rail; role of rail passenger service in this country and comparisons with other countries; demands of passengers and measurements of acceptance; directions of the rail freight and passenger systems for the 21st century; interdependences of multi-modal systems; and innovations for improving productivity.

LEARNING OUTCOMES

Upon completion of this course, the students will be able to:

- Identify the various facets of the railway freight and passenger systems in the U.S.
- Articulate the various operational management aspects of the rail transportation systems,
- Understand railway activities involved in the daily line-of-road operations, terminal operations, and local operations,
- Identify the processes and interfaces involved with the other transportation modes – international shipping, domestic water, and highway – as an intermodal seamless operation,
- Understand the various demands and measurements of acceptance for the various rail passenger systems – including heavy rail transit, light rail systems, rail commuter service, intercity passenger service, and high-speed rail,
- Compare railway operations on an international scale with those in the United States,
- Access the changing objectives and requirements necessary for the expansion of the railway industry, including intermodal exchanges, in the United States and worldwide during the 21st century, and
- Prepare technical reports relating to selected aspects of the course and orally present findings and analyses.

ASSESSMENT OUTCOMES

This class specifically relates to the University of Kentucky Civil Engineering Program Outcomes as follows:

- An ability to apply knowledge of mathematics, science, and engineering.
- An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
- An ability to function on multi-disciplinary teams.

- An ability to identify, formulate, and solve engineering problems.
- An ability to communicate effectively.
- An acquisition of a broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
- A recognition of the need for, and an ability to engage in, life-long learning.
- A knowledge of contemporary issues.
- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

CE 433-001 SYLLABUS – FALL SEMESTER 2014

Date	Topic(s) – See Educational Outcomes Section
Aug 27	Introduction
29	
Sept 1	Labor Day Holiday
3	
5	
8	
10	
12	
15	
17	
19	
22	

24	
26	
29	Examination I
Oct 1	
3	
6	
8	
10	
13	
15	
17	
20	Midterm
22	
24	
27	
29	
31`	
Nov 3	Examination II

5	
7	
10	
12	
14	
17	
19	
21	
24	
26	Thanksgiving Holiday
28	Thanksgiving Holiday
Dec 1	
3	
5	
8	
10	
12	
17	Examination III @ 8:00 a.m. (Wednesday)

CE 433 PROPOSED SCHEDULE OF TOPICS FALL 2014

RAILWAY FREIGHT, PASSENGER, AND INTERMODAL TRANSPORT OPERATIONS (approximately 2/3 of course)

Introduction to Railway Transport Operations
- CE 433 Introduction
- REES 2014-A(1) Intro. To North American Rail Transportation
- REES 2014-A(2) Safety and Efficiency
- REES 2014-C Vision for Railway Engineering Education

Railway Freight Transport Operations
- Chapters 1-2 Introduction
- Chapter 3 Introduction to Fixed Infrastructure --Track, Bridges, etc.
- Chapters 4-16 (exclude Chap. 15) Railway Operations
- Chapters 18-24 Railway Business and Management

Railway Passenger Transport Operations
- Chap 17 Rail Passenger Services in the U.S.
- REES 2014-F Passenger Rail Service

Railway Train Energy Power and Traffic Control
- REES 2014-C

Railway Intermodal Transport Operations
- Chapter 15 Intermodal Traffic
- REES 2014-D Railway Intermodal Transportation

MULTI-MODAL FREIGHT TRANSPORT (approximately 1/3 of course)

Waterways Transport Operations

Motor (Highway Truck) Transport Operations

Air Transport Operations

Pipeline Transport Operations

Overland Conveyor Transport Operations

Appendix B: Highway Motor Transportation Lecture

History

- 1913 Lincoln Highway
- 1916 1st Federal Aid Legislation
- 1919 Army Convoy took 62 days
- 1921 2nd Federal Aid Legislation
- 1925 Adopted Numbered System

  Even #s east-west routes   Odd #s north-south routes

The rest is history

History

- **WW I**: Motor carrier industry started, converted automobiles were used for pick up and delivery in local areas
  – Railroads encouraged the growth. They had difficulty with small shipments and short distances.
- **WW II**: Rail began to compete with trucking but trucking had already become the popular form of transportation
- **1950-1980**: Trucks replaced rail
  – 1950: Rail moved 1.4 billion tons of freight, truck moved 800 million
  – 1980: Rail moved 1.6 billion tons of freight, tuck moved 2 billion; significant growth of smaller truck carriers

- **1956** - Eisenhower signed bill to establish National System of Interstate and Defense Highways (interstate system) to connect major cities
  – Federal-Aid Act (funding and catalyst for the project)
    - Called for nationwide standards for design of the system
    - Increased the length of the system to 41,000
    - Set federal government's share of project cost at 90%
  – Highway Revenue Act
    - Highway Trust Fund consisting of revenue from federal gas and other motor vehicle taxes
    - Used to pay federal share of interstate and other federal-aid highway projects
- **1980s** – Deregulation, significant growth

Motor Carrier Act 1935

- Interstate Commerce Commission (ICC) had control of trucking industry
- Required carriers to file rates (tariffs) with the ICC
- New truckers had to receive a certificate from ICC to enter the industry
- Regulated rates and competition within the trucking industry.

Motor Carrier Act 1980

- Partially deregulated the industry
- Eased entry into the industry = increase in the number of carriers
- Eliminated many restrictions on commodities
- Encouraged carriers to increase or decrease rates to increase competition
- Basically removed many ICC regulations

Advantages

- Accessibility:
  - Access to any location/destination
  - Link between other modes of transportation and the final destination of goods
- Fast/speed:
  - Products can be delivered directly from the truck and without delay
  - Less delay from unloading/loading like other forms of transportation experience (rail, air, water)

- No highway constraints: trucks can travel on any designated highway unlike rail and water that have to pay fees/rates to cross over and use other company's facilities.

•Typical max. weight 80,000 + 5% pounds

- Small capacity: consumer can have lower inventory levels, lower inventory costs, and more frequent services
- Minimum Shipping Weights by Mode:

Truck	25,000 - 30,000 pounds
Rail Car	40,000 - 60,000 pounds
Barge	hundreds of thousands of tons

- Smooth ride: less chance of damage to goods
- Consumer market oriented: very responsive to consumer needs

Two Types of Carriers
A. For-Hire Carriers

- Provides a public service
- Charges a fee
- Several Types
  - Local
  - Intercity
  - Exempt
  - Truckload
  - Less-Than-Truckload

Local: pickup and deliver freight within a city zone

Intercity:
- operate in between city zones
- Often work with local carriers to pick up and deliver goods in the city zones.

Interstate:

- Truckload:
  - Volume meets the minimum weight required for a truckload shipment and truckload rate
  - Picks up and delivers the same truck load
- Less-than-truckload:
  - Volume lower than minimum
  - Consolidate smaller shipments into truckload quantities for line haul/intercity movement and separate the loads back into smaller quantities for delivery

- Common: serve general public at a reasonable rate
- Contract: under contract to serve specific shippers
- Exempt: carriers that are exempt from economic regulations
  - Determined by type of commodity or nature of its operation
  - Laws of marketplace determine rates, the service provided, and the number of vehicles provided

Classification

- Carriers are classified based on their annual gross operating revenues.

Class I	$10 million or greater
Class II	$3-10 million
Class III	Less than $3 million

B. Private (not for hire) Carriers

- Provides service to industry or company that owns or lease vehicles
- Does not charge a fee
- Motor Carrier Act of 1980:
  - Eased entry requirements
  - Could transport as a for-hire depending on the commodities carried. In this case, would be considered an exempt carrier.

Types of Vehicles

- Line-Haul -- 18 & 24 wheelers
  - Haul freight long distances between cities
  - Truck trailer combo of 3 or more axles
- City Trucks
  - Smaller than line-haul vehicles
  - Single units 20 to 25 ft long with cargo unit 15 to 20 ft long.
- Special Vehicles
  - vehicles specifically designed to meet shippers needs
  - These can be subject to special regulations
  - Ex: number of lights on the vehicles, brakes used, tire specifications, allowable length and/or height)

- **Special Vehicles:**
  - Dry van - standard trailer or truck with all sides enclosed

– Open top - trailer open for odd-sized freight
– Flatbed - no top or sides and usually used to haul steel

- Tank Trailer - liquids and petroleum products
- Refrigerated vehicles - controlled temperature

- High cube - higher than normal to increase cubic capacity

- Special - unique design to carry a specific product

Low Startup Fees

- $5,000 -10,000 to start
- Many small carriers or Class III, main reason for significant growth in the 1980s
- Class I and II have more invested because their companies are larger and require more trucks and terminals, entry into the industry is more limited than Class III
- Truckload vs Less-than-truckload: LTL require terminals to separate and consolidate shipments, therefore, their startup fee is higher and entry is more limited

Commodities

- Almost all sheep, lambs, cattle, and hogs are transported by trucks
- Food products
- Manufactured products
- Consumer goods and industrial goods
- Can transport the following but rail or water is more common:
  - Grains
  - Motor vehicles and equipment
  - paper and allied products

Competition

- Rivalry between carriers (union vs. non-union)
- Low entry fee, freedom to enter, and discounting of services have made it easy for individual trucks to compete with larger carriers
- Market oriented
  - Carriers are forced to meet demand and consumers needs.
  - Smaller for-hire carriers are more capable of giving individual attention to customers. Larger carriers are more limited in the attention they can give customers.
- Competition between modes:

  30,000 - 60,000 pounds hauled less than 300 miles → truck
  90,000 pounds or more hauled more than 100 miles → rail
  In between these ranges → rail and truck compete

Operating Ratio

- Measure of operating efficiency

$$operating\ ratio = \frac{operating\ expenses}{operating\ revenues} x100$$

- The closer to 100 the higher the need to raise rates to generate revenue
- For example, a ratio of 94 means 94 cents of every dollar goes to expenses
- Usually between 93 and 96

Issues

- Safety
  - improved safety = profit and less expensive claims for lost/damaged goods, increase in insurance, accidents, fines
  - Driver drug testing and training programs
  - Highway road improvements
- New technology
  - Social Media
  - Satellites are being used to pin point exact location throughout the movement from origin to destination.
  - Drivers can be rerouted for poor weather and/or road conditions.
  - With the movement of hazardous good, the movement can be monitored and carriers can have a quick reaction to accidents or spills.

American Trucking Association (ATA)

- Established 1933 - American Highway Freight Association and Federation Trucking Associations of America came together to form ATA

The mission of the American Trucking Associations, Inc., is:

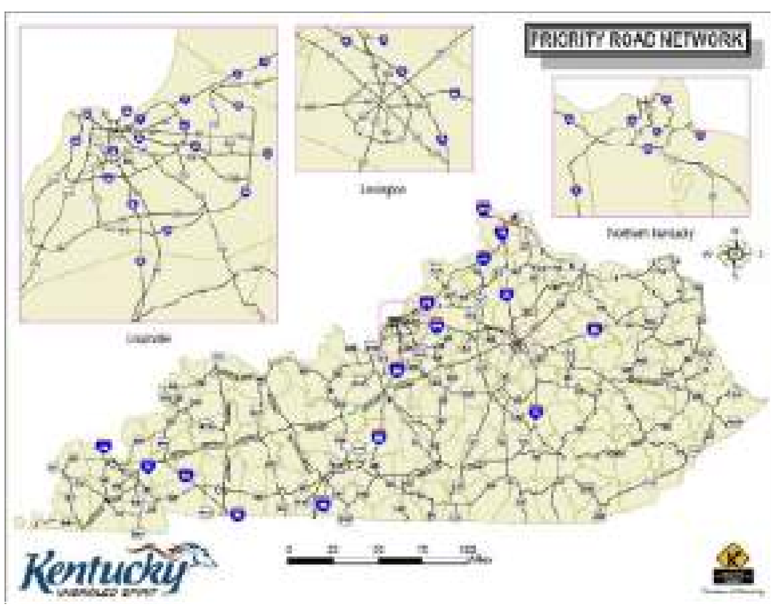
- to serve and represent the interests of the trucking industry with one united voice;
- to influence in a positive manner Federal and State governmental actions;
- to advance the trucking industry's image, efficiency, competitiveness, and profitability;
- to provide educational programs and industry research;
- to promote safety and security on our nation's highways and among our drivers; and
- to strive for a healthy business environment.

Federal Motor Carrier Safety Administration (FMCSA)

- Mission: "Prevent commercial motor vehicle-related fatalities and injuries"
- Established January 1, 2000 under the Motor Carrier Safety Improvement Act of 1999
- Activities
  - Enforcement of safety regulations
  - Targeting high-risk carriers and commercial motor carriers
  - Improving safety information systems and technologies
  - Strengthening equipment and operating standards
  - Increasing safety awareness & enhance efficiency

Kentucky's Highways

- Freight tonnage
  - 43% inbound
  - 73% outbound
- 47.2 trillion vehicle miles of travel annually
- 78, 913 miles of public roads and streets
- 9 interstate Highways
- 73% within state, 28% from state, 38% to state (by weight)



Highway Design Basics

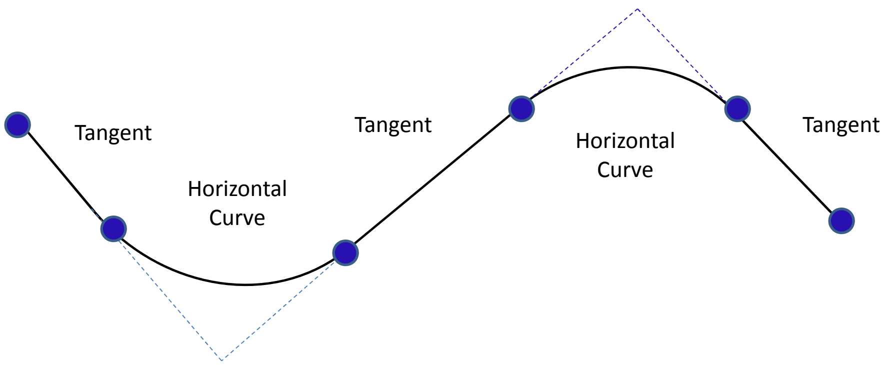
- Things to consider…
  - Type of road rural or urban
  - Functional Class
  - Design Speed
  - Design vehicle
  - Traffic Characteristics
  - Terrain
  - Scope of work or purpose for the new roadway
  - Funding

Functional Class

- Arterial: main movement; high mobility and limited access
- Collectors: link between arterials and local roads; moderate mobility and access
- Locals: allows access to properties; low mobility and high access

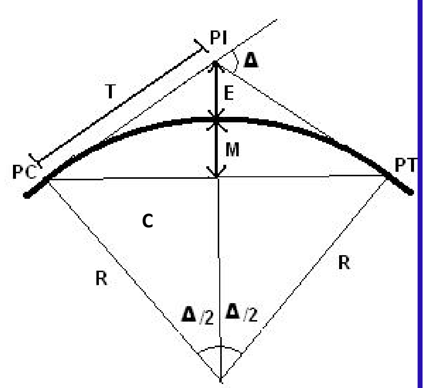
Horizontal Alignment

- Horizontal curvature of a roadway or a series of curves connected by tangents



Horizontal Alignment Terms

Point of Curvature, PC
Point of Intersection, PI
Point of Tangency, PT
Radius, R
Tangent, T
Chord, C
Interior Angle, Δ
Middle Ordinate, M
External Distance, E



Horizontal Alignment Equations

$$Sta\ PC = Sta\ PI - T$$

$$Sta\ PT = Sta\ PC + L$$

$$L = \pi R\Delta/180$$

$$C = 2R\sin(\Delta/2)$$

$$T = R\tan(\Delta/2)$$

$$M = R[1-\cos(\Delta/2)]$$

Superelevation

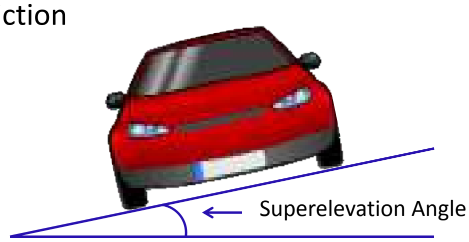
- Slope of pavement necessary to keep vehicles on the road
- $e+f_s = V^2/(15R)$

  e= superelevation rate

  f_s= coefficient of side friction

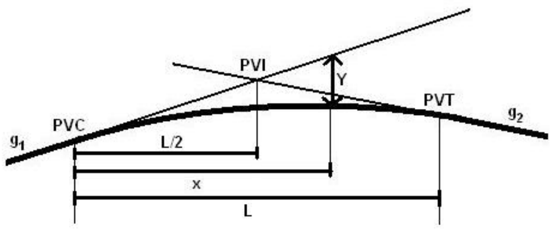
  V=design speed, mph

  R=Radius



Vertical Alignment

- Vertical curvature of a roadway consisting of tangent grades and vertical curves
- Two types: sag and crest curves



Vertical Alignment Terms

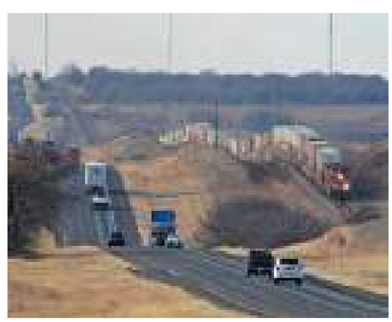
Beginning of Curve, PVC

Vertex/Intersection, PVI

End of Curve, PVT

Vertical Grade, g

Length of Curve, L



Vertical Alignment Equations

Sta PVC = Sta PVI – L/2
HPVC = HPVI – g1*L/2
Sta PVT = Sta PVI + L/2
HPVT = HPVI + g2*L/2

Minimum Curve Lengths

	Crest	Sag
SSD<L	$A*SSD^2/2158$	$A*SSD^2/(400+3.5SSD)$
SSD>L	2SSD-(2158/A)	2SSD-(400+3.5SSD)/A

**A=|g2-g1|*100 (%)
**SSD: Stopping Sight Distance

Sight Distance

- Sight Distance: length of roadway that is visible to the driver
- Stopping Sight Distance: Distance that is necessary for a vehicle traveling at design speed to come to a stop
- Passing Sight Distance: Distance required for a vehicle traveling at design speed to pass another vehicle

Stopping Sight Distance

$$SSD = 1.47Vt_r + V^2/[30(a/32.2+G)]$$

SSD : Stopping Sight Distance (ft)

V : Vehicle speed (mph)

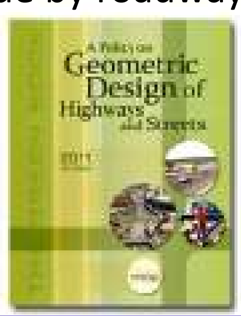
t_r :driver reaction time, usually 2.5 sec

a : deceleration rate (ft/s^2)

G : grade

Design Criteria

- All roadway design criteria is based on AASHTO's green book or *A policy on Geometric Design of Highways and Streets*
- The green book is used as a guide by roadway designers



Appendix C: Overland Conveyors Lecture

Overland Conveyors

Overview

- Belt conveyors used to haul commodities over long distances
- Efficient for consistent movement of large volumes of material

Commodities

- Large volumes of material
- Bulk material
  - Iron ore
  - Coal
  - Grains
  - Wood
  - Waste/Trash

Applications

- Mining Industry
- Power Industry
- Paper Industry
- Waste Industry
- Cement Industry

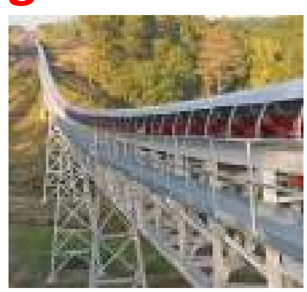
Advantages

- Efficient
- Low operating cost
- Environmentally friendly

- Works with other modes and provides a link to loading facilities
- Can serve as low cost drayage

Disadvantages

- High capital cost
- Not flexible



- High cost to move or to relocate

Competition

- Competes with water, rail, and trucks
- More efficient in terms of long term costs
- Intermodal
  - Works with other modes to overcome accessibility issues

TransKentucky Transportation Inc. (TTI)

- Short distance intermodal application
- TTI short line carries coal by rail from Paris to Maysville
- Coal is dumped onto conveyor
- Conveyor carries coal to a barge

The Rail to River Route

Bulk Commodity Reloaders

TTI

Appendix D: Pipelines Lecture

History

- Originally used to feed other modes of transportation
- 19th Century
  - Pennsylvania Railroad started the development of pipelines in oil fields.
  - Sold out to Standard Oil Company
  - Established oil companies as the major owner
- 20th Century
  - Pipelines were used to control the oil industry
  - Transportation services were not provided to new producers
- Post WWII
  - Champlin Oil Case: US Supreme Court required pipelines to be operated as common carriers.

Overview

- Limited network
- Unknown to public but vital to transportation system
- Only mode that is unidirectional
- For every pipeline incident there are 50 railway accidents

Growth

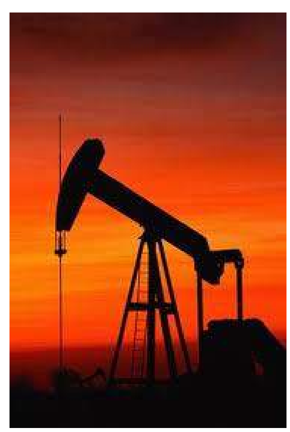
- Network grew steadily until early 1980s
- Pipeline diameter increased
- Increase in volume and amount of volume

Small Number of Companies

- High start-up costs
- Legal costs and requirements for entry
- Duplication or parallel competing lines would not be economical

Commodities

- Oil → number 1 commodity transported
- Coal
  - Moved in a slurry to utility companies for generating electricity
  - Slurry: A solid is broken up and suspended in a liquid, can be moved through a pipeline.
- Chemicals
  - Anhydrous ammonia (fertilizer), propylene (detergents), ethylene (antifreeze)



Advantages

- Low rates
- Good loss and damage record
- Pipelines can function as a warehouse
- Mostly unaffected by weather
- Mechanical failures are rare

Disadvantages

- Slow speed
- Fixed route
- No door-to-door service
- Depend on rail and motor carriers to deliver
- Limited type of commodities
- Limited to certain geographic areas

Trunk Lines

- Long-distance movement
- Crude oil, jet fuel, kerosene, chemicals, or coal
- Usually 30-50 inches in diameter
- Usually permanent and laid underground
- Two types
  - Crude lines
  - Product Lines

Gathering Lines

- Bring oil from fields to storage areas before the oil is processed into refined products or transmitted as crude oil over trunk lines
- Smaller in diameter than trunk lines; no larger than 8 inches
- Laid above ground and easier to relocate when well or field runs dry

Power Stations

- Stations that provide the power to push the commodities through the pipeline
- Interspersed along trunk line
- Station locations vary depending on viscosity and terrain
- **Compressors** for natural gas; **Pumps** for liquid items

Ownership

- Oil Companies - Main owners since Standard Oil Company bought out the Pennsylvania Railroad
- Federal government owned during WWII to ensure uninterrupted flow of oil during the war
  - Big Inch and Little Inch
  - Sold to private companies after the war
- Joint ventures are often used because of the large capital investment need for large-diameter pipelines

Preventative Maintenance

- Limits loss/damages and protects the environment
- Protective paints and resins are used for corrosion control
- Electric currents neutralize the corroding electrical forces that come naturally from the ground to the pipeline

Loss and Damage

- Pipeline's have a record of limited loss and damage due to the industry's approach to operations.
- The pipes are constructed using a high-quality alloy steel with a life expectancy of 50 years or more.
- The pipes are laid in long sections with a limited number of seams and high quality electronic welding of seams to prevent leakage.

Batching

- Used when 2 or more grades of crude oil or 2 or more products move through a system at one time
- There are 15 grades of crude oil
- The batches are separated using a rubber ball
- Batching is not always necessary because the specific grades of the products can keep them separated.
- When mixed, a higher grade item will be considered as part of the lowest grade product it is mixed with

Cost Structure

- Low labor costs – use of automation
- Low variable costs
  - Do not require vehicles therefore pipelines do not have the additional vehicle maintenance costs.
- High fixed costs
  - Right-of-way
  - Pipeline construction and power station (property taxes, depreciation, and preventative maintenance)
  - Depreciation and taxes for terminal facilities

Safety

- Environmental impact and limiting leakage
  - Mostly built in rural areas but when house needs increase people may be living closer to the pipelines and special attention will be needed.
  - Wildlife

The Office of Pipeline Safety

- Part of U.S. DOT
- Establishes and monitors pipeline activities as they relate leakage from oil pipelines.
- Each carrier develops oil spill response plans for onshore pipelines.

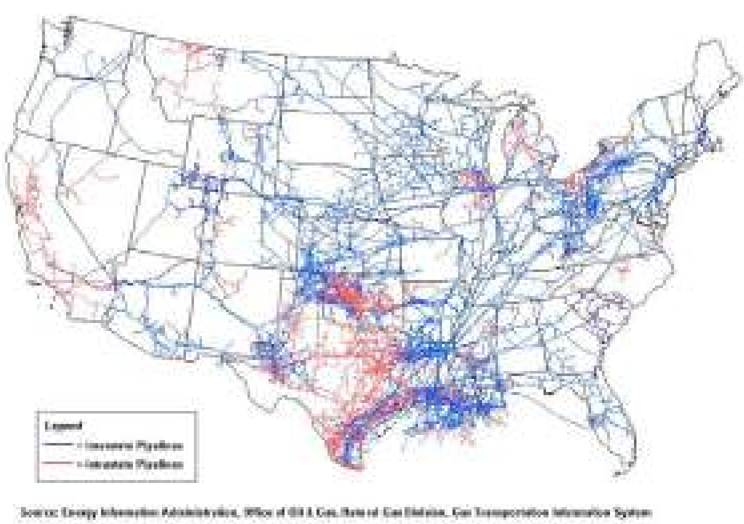
Federal Energy Regulatory Commission

- FERC
- Operate under The Interstate Commerce Act and regulates the rates and practices of oil pipeline companies engaged in interstate transportation.
- Establish “just and reasonable” rates to encourage maximum use of oil pipelines
- Prevent discrimination and ensuring shippers equal access to pipeline transportation

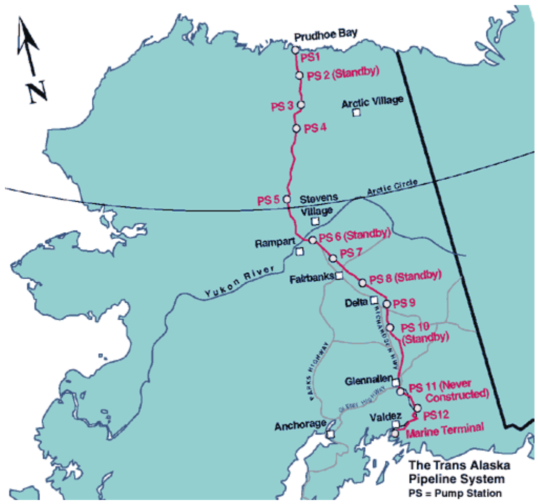
Natural Gas

- Another type of pipeline
- Usually underground
- Uses compressors for movement

Natural Gas Pipeline Network



The Alaska Pipeline



The Alaska Pipeline

- Built after oil was discovered on the North Slope of Alaska in 1968.
- $8 billion to construct can handle up to 2 million barrels of oil per day.
- 800 miles long and completed in 1977.
- ½ inch thick steel, 48 inch diameter pipe, 4 inches of fiberglass insulation

The Alaska Pipeline

- 10 pump stations, flows at 5 to 7 mph, 8 days to travel 800 miles from Arctic Ocean to Valdez where it's transferred to oil tankers.
- Temperature
  - Oil is pumped from depths of several thousand feet at 160 to 180^oF
  - Heat exchangers cool oil to 120^oF when it enters the pipeline
  - At 120^oF the pipe would be hot enough to melt the permafrost. To prevent melting, the pipeline was constructed above ground (about 400 miles)
  - Insulation keeps the temperature of oil nearly constant.

Keystone XL Pipeline Project ?

- Originally proposed by TransCanada
- 1,897 km (1,179 mile) from Canada boarder to connect to an existing pipeline in Steele City, Nebraska
- Expected to provide 5% of US petroleum consumption needs and represent 9% of US petroleum imports
- Volume of Keystone XL is equal to a train 25 miles long transporting everyday

Keystone XL Pipeline Project

- Required capacity to meet demands is 1.1 million barrels per day
- An import line to US refineries
- Will create about 20,000 construction and manufacturing jobs
- Generate more than $585 million in new taxes for states and communities along pipeline route
- Strengthen America's energy security by increasing supply of safe, secure, and reliable oil from Canada and American oil fields

Kentucky's Pipelines

- 2 million miles in US
  - 25,394 miles in Kentucky
- 861 miles for hazardous liquids
  - Gasoline
  - Diesel
  - Jet fuel

Kentucky
UNBRIDLED SPIRIT™

Appendix E: Waterways 1 Lecture

Waterways 1
Water Transportation History





Water Transportation Propulsion History

- Human (oars, poles) - - 7,000-10,000 BC
- Wind (sails) - - 3,000 BC
- Steamboat invented - - 1787 AD
- First diesel-powered ship - - 1912 AD
- Hovercraft invented - - 1956 AD
- First nuclear-powered ship launched - - 1958 AD

History in United States

- Development of the United States
- Provided early settlers with a link to markets in England and Europe.
- Major cities developed around water ports on the coast.
- Development of inland waterways provided settlements in the wilderness and connection to coastal cities

Two Major Types of Water Transportation

- **Deepwater**
  - Passenger: cruise ships, ocean liners (19 million to be served globally in 2011)
  - Freight: bulk carriers, container ships, tankers, reefer ships and roll-on/roll-off ships (8 billion tons shipped globally in 2007)
- **Lakes, Coastal and Inland Waterways**
  - Passenger: ferries (59 million served in U.S. in 2009)
  - Freight: dry bulk cargo, liquid cargo, and flat deck barges (857 million tons shipped domestically in 2009)
  - Recreational: fishing and water sports

Cargo Densities of Global Deepwater Shipping Routes

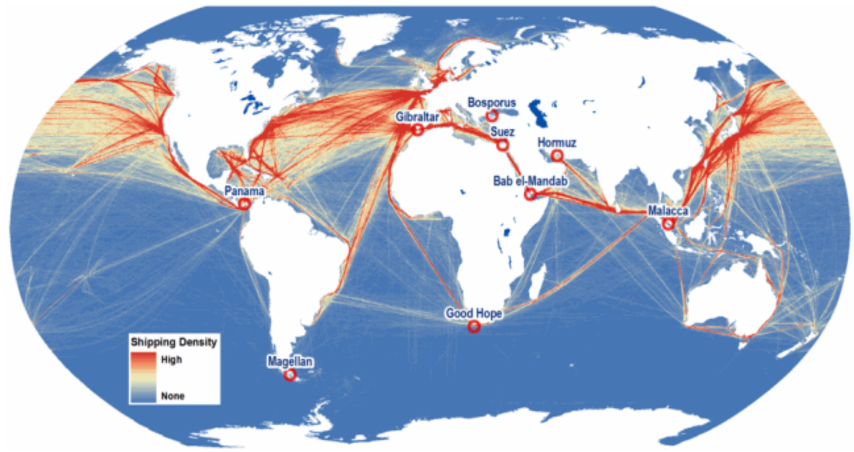


Image courtesy of U.S. Maritime Administration

Panama Canal Lock Expansion Project

- Approved by national referendum in October 2006 by 80% of Panamanians
- Scheduled completion date in 2014
- Estimated cost of $5.2 billion
- Project is on schedule and under budget
- Will double capacity of the canal
- Will allow much larger ships to traverse canal
- Will alter global shipping patterns

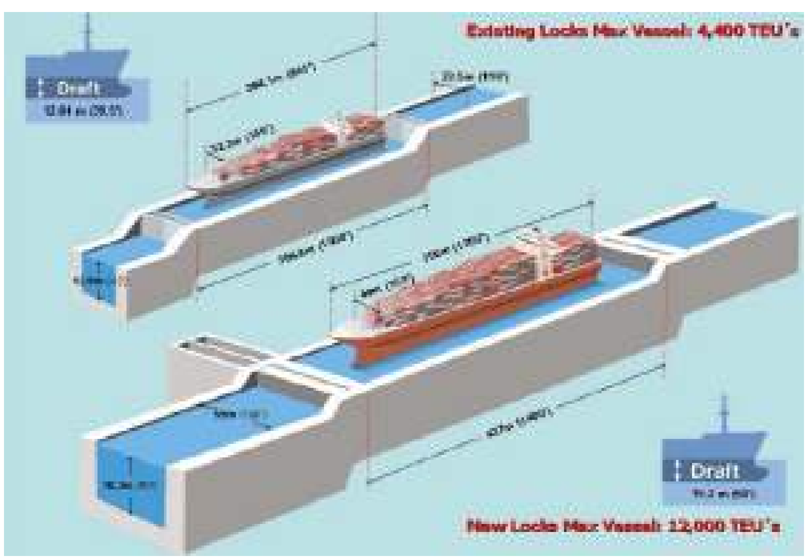


Image courtesy of U.S. Maritime Administration

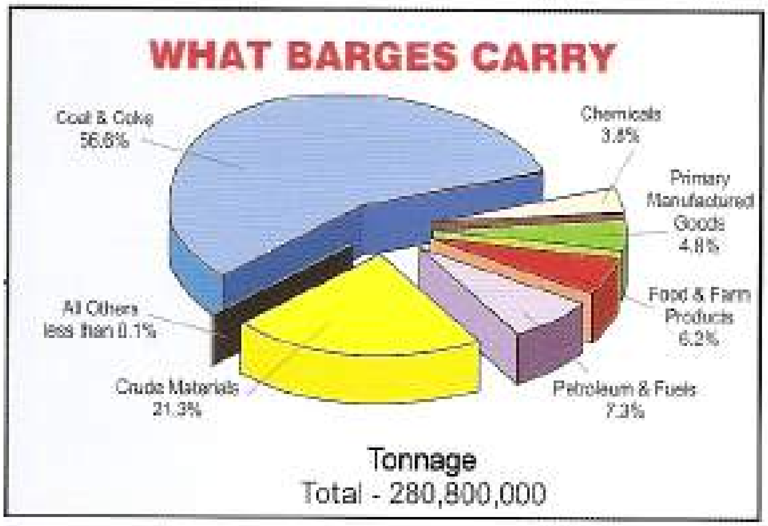
Inland/Coastal Waterways

- 12,000 miles of navigable waterways
- 240 lock sites
- Move commerce to and from 38 states

Image courtesy of National Waterways Foundation

Industry Overview

- Commodities
  - Basic raw materials dry (coal, coke, sand, gravel, stone, logs, lumber)
  - Liquid (petroleum and petroleum products) ,
  - Some high-valued products
- Competes with rail for bulk commodities such as grains, coal, ores, and chemicals.
- Competes with pipelines for bulk petroleum and petroleum products.



Inland Waterways System Components

- Navigation channel – dredging required at some locations
- Locks and dams – navigation pools (USACE)
- Ports and terminals for loading/unloading – publicly and privately owned
- Fleeting/mooring sites
- Navigation aids – channel and obstruction buoys (US Coast Guard)
- River information systems – automatic vessel identification, lock operations management, vessel-to-land communications

Types of Carriers

- Private Carriers: cannot be hired and only transports freight for the company that owns or leases the vessel
- For-Hire Carriers: are hired and charge a fee for their service
- Common Carriers: serve the general public at a reasonable price
- Contract Carriers: under contract to service a company

- Internal Carriers
  - Operate over the inland waterways.
  - Use barges, towboats, and operate over the principal rivers (Mississippi, Ohio, Tennessee, Columbia, and Hudson) and some small arteries
  - Dominate the north-south traffic through the central portion of US
- Coastal Carriers
  - Operate along the coasts serving ports on the Atlantic or Pacific oceans of the Gulf of Mexico.
  - Intercoastal carriers transport freight between East Coast and West Coast ports via the Panama Canal

Competition

- Competes with other modes of transportation
- Number of carriers in a waterway is limited so there is less competition with one another.

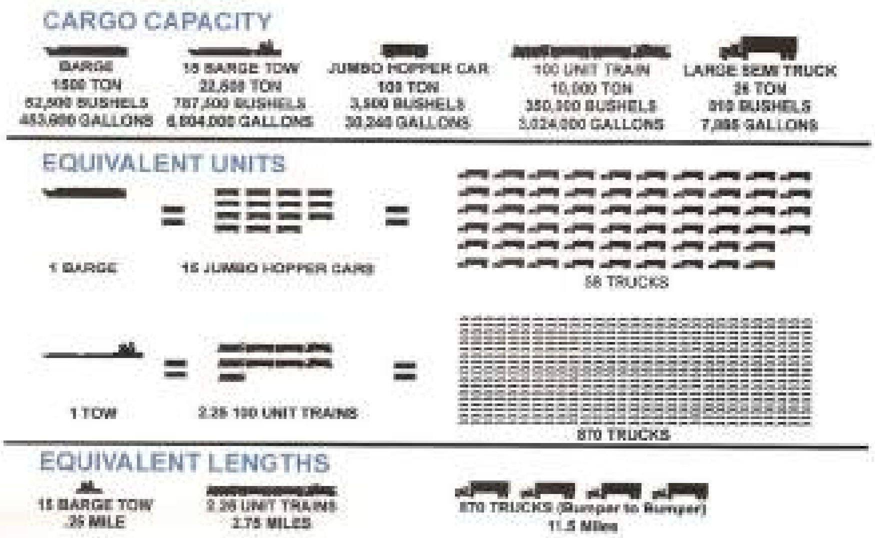
Rail: Dry bulk commodities such as grain, coal, and ores

Pipeline: Bulk liquids such as petroleum and petroleum products

Trucks: Limited competition; trucks work with water to overcome the accessibility constraints water carriers have.

Load Size

- Large capacity
- Capacity of 1,500 ton barge is equivalent to 15 railcars and 60 trucks
- High capacity allows water to operate as a low-cost service.



Disadvantages

- Speed
  - Longest transit time
- Service Disruption
  - Disruption in winter and summer months
  - Increase in costs during the winter months
- Accessibility
  - Limited network
- Packaging
  - Inclement weather, rough waters, handling

Terminals/Ports

- Public Terminals: most ports are operated by government agencies and have public storage facilities
- Shipper Terminals: High volume users may invest in private facilities

  - firms that handling commodities such as grain, coal, and oil may build docks, terminals, and handling facilities to meet their specific needs.

- Efficient Handling Materials: material improvements and specialized handling equipment to limit delays
- Ports facilitate transfer of freight from water to rail or truck
- Storage is necessary at ports and terminals because barges and ships can carry larger loads than trucks or rail cars

Cost Structure

- High variable costs and low fixed costs
- Controlled and maintained by the government. Carriers only pay user fees (lock fees, dock fees, fuel taxes).
- Variable Costs: line-operating cost, rent fees, and maintenance costs
- Fixed Costs: depreciation

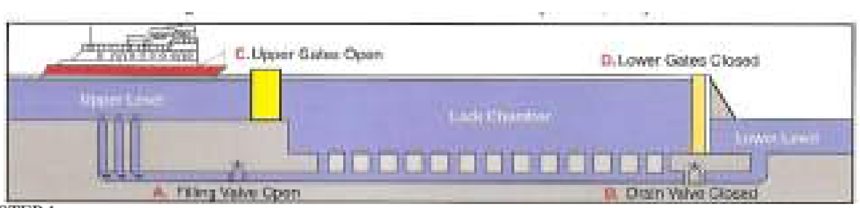
Infrastructure

- Infrastructure made possible by public aid
- Army Corps of Engineers

Locks and Dams

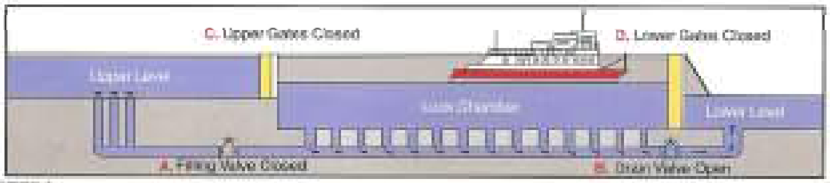
- A method for moving large ships and barges through shallow or steep waterways
- A stair step method
- Allows water carriers to transport to areas where terrain would not allow

Operation of Locks



STEP 1

The Lower Gates (D) are closed. The Drain Valve (B) is closed. The Filling Valve (A) is opened, allowing the Lock Chamber to fill to the upper level. The Upper Gates are opened, allowing the boat to enter the Lock Chamber.



STEP 2

The boat is secured in the Lock Chamber and the Upper Gates (C) are closed. The Filling Valve (A) is closed and the Drain Valve (B) is opened, allowing the water to drain out into the Lower Level. The boat is lowered as the water level lowers.

STEP 3

When the water level in the Lock Chamber reaches the Lower Level, the Lower Gates (D) are opened, allowing the boat to leave the Lock Chamber and proceed down the river.

Fuel

- Water is the most fuel efficient mode of transportation
- Consumes more fuel per mile than other modes but able to transport more ton-miles of freight than any other mode.

Number of Miles One Ton of Freight is Moved on One Gallon of Fuel

155 miles

413 miles

576 miles

Current Issues

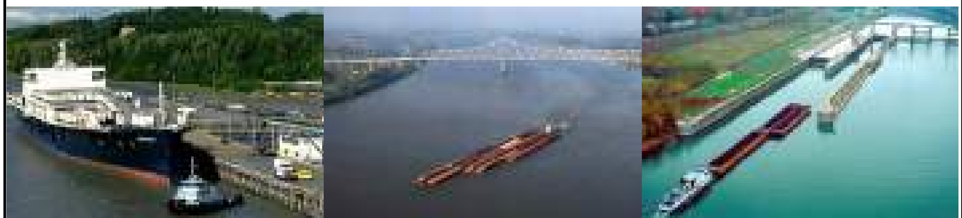
- Out of date ports and port development
  - Aging infrastructure
  - New boats and technology are making it necessary to update and improve the ports and terminal facilities

Kentucky Waterways

- 10 ferry boat operations
- 12 public ports
- 1,269 miles of navigable waterways
  - Ohio River : 664 miles
- 2% within state, 11% from state, 13% to state (by weight) shipments by freight tonnage

Seamen's Church Institute
Mariner Simulator Training in Paducah, KY

Appendix F: Waterways 2 Lecture



Waterways 2

Waterway Transportation/Marine Navigation

Types of Waterways and Conveyance Vehicles

OUTLINE

- Types of Waterways and Vessels
  - A. Open Ocean
  - B. Great Lakes
  - C. Intracoastal
  - D. Inland
- Types of Ports/Terminals
- Industry Overview
- Kentucky Waterways

A. Open Ocean

- Ocean-borne Merchant

- Vessels (Large Ships)

B. Great Lakes/St. Lawrence Seaway/ Coastal Areas/ Canals

- Lake Freighters
- Coasters (Small Ships)

C. Intracoastal Waterways/ Sounds/ Bays (Atlantic and Gulf)

- Small Ships

- Possibly Barges

D. Inland Waterways

- Towboat & Barge Combinations

Other……………….

Ocean, Lakes, Coastal & Inland Waterways

•Fishing Vessels

•Military Ships

•Cruise and Ferry Passenger Ships

•Recreation

Major Types of Shipments

Dry Bulk Cargos

- Coal
- Grain
- Ore and Minerals
- Iron/Steel/Metals
- Aggregate/Cement
- Construction Materials
- Foodstuffs

Tankers (Liquids)

- Petroleum
- Refined Petroleum Products
- Chemicals

Containers

- Primarily on Open Ocean

Types of Ports

A. Deep Ocean Ports

B. Large Lake and Bay Ports

Tampa Port Authority

C. Inland Waterway Ports

U. S. Domestic Waterways

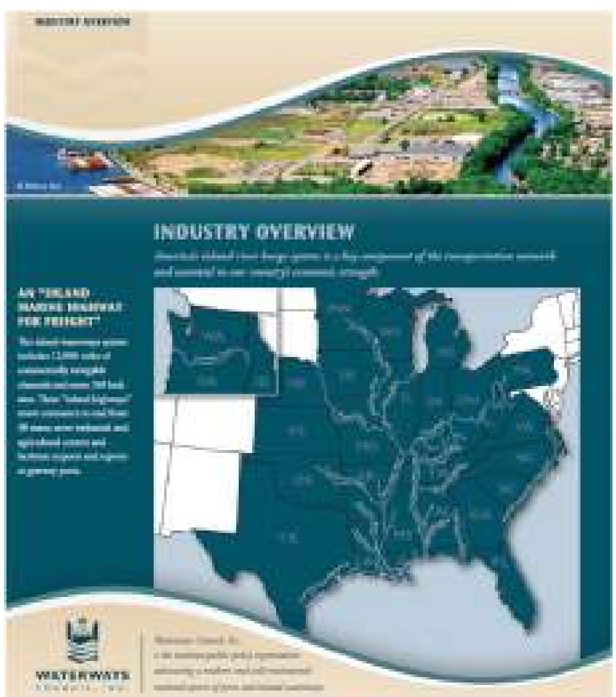
A. Inland Waterways

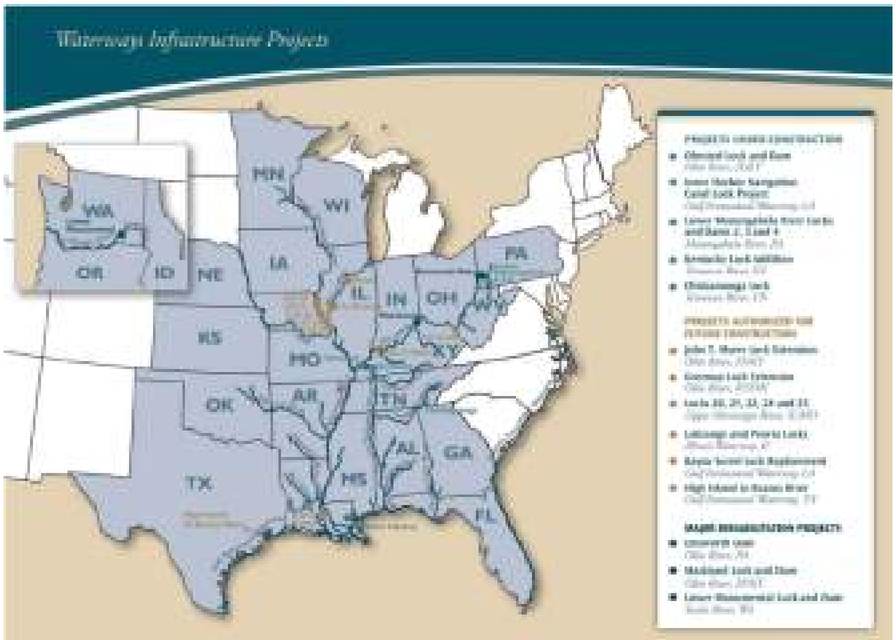
B. Great Lakes/St. Lawrence Seaway

C. Intracoastal Waterways

A. Inland Waterways in U. S.

- Lower Mississippi River
- Upper Mississippi/Missouri River System
- Ohio River System
- Tennessee-Tombigbee Waterway
- Columbia River System
- Hudson River (little commercial traffic)
- Small Coastal Rivers and Inland Waterways Tributary Rivers





Lower
Mississippi
River

Lower Mississippi River

Lower Mississippi River near New Orleans

Upper Mississippi/ Missouri River System

Upper Mississippi/ Missouri River System

Ohio River System

Ohio River System

Panorama of the Ohio at its widest point, just west of downtown Louisville, Kentucky

Tennessee-Tombigbee Waterway

Image courtesy of tenntom.org

Tennessee-Tombigbee Waterway

Aberdeen Lock and Dam

Tennessee-Tombigbee Waterway

Illinois Central Gulf Railroad Bridge

Columbia River System

Columbia River System

B. Great Lakes/ St. Lawrence Seaway

Great Lakes/ St. Lawrence Seaway

C. Intracoastal Waterways

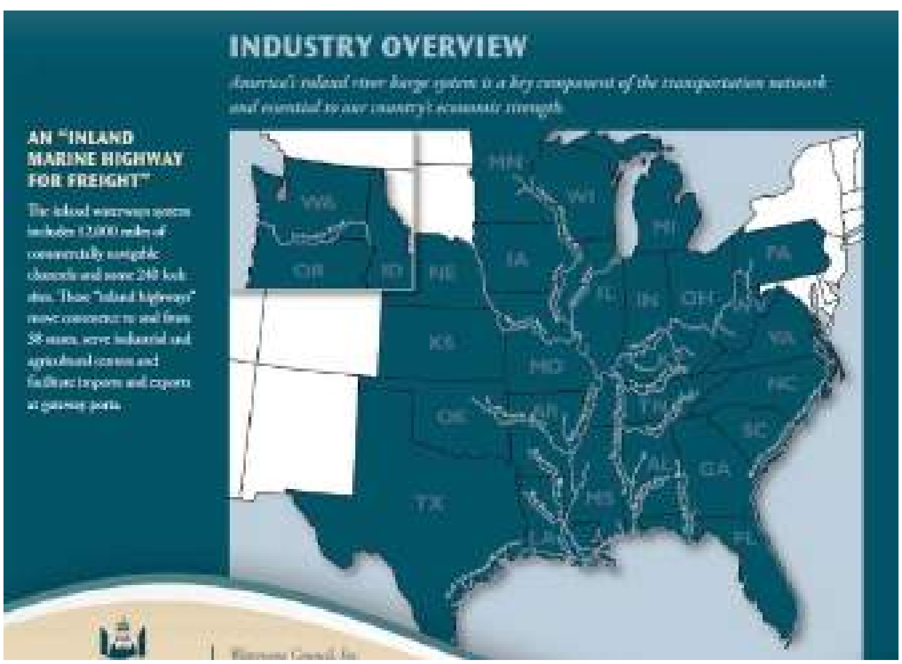
Image courtesy of U.S. Army Corps of Engineers

Intracoastal Waterways

Tug and barge on the Gulf Intracoastal Waterway

Leland Bowman Lock near Intracoastal City, Louisiana, on the Gulf Intracoastal Waterway

Intracoastal Waterway



MOVING THE NATION'S COMMODITIES

By safely and cost-effectively moving America's cargo, barge transportation makes a vital contribution to our nation's economy, environment and quality of life. Every year, roughly 624 million tons of waterborne cargo transit the inland waterways, a volume equal to about 14% of all intercity freight and valued at nearly $70 billion.

Barges are ideal for hauling bulk commodities and moving oversized or overweight equipment, including:

- Coal
- Petroleum
- Project Cargoes
- Iron & Steel
- Grain
- Intermodal Containers
- Chemicals
- Aggregates

STRENGTHENING OUR ECONOMY

America's economy benefits from the cost efficiencies barge transport provides over transport by truck or rail. Approximately 60% of the nation's grain exports move by barge, helping our agricultural exports stay competitive in global markets. Barge transport also keeps our nation's vital energy sources flowing, fueling our industrial base and keeping our high-tech economy running. In fact, more than 22% of domestic petroleum and petroleum products and 20% of the coal used in electricity generation transit our inland waterways.

America's safe, reliable and efficient inland river transportation system is the envy of the world. With world-wide demand for waterborne commerce expected to more than double by the year 2025, our nation needs a strategic vision and must invest in the waterways infrastructure needed to maintain America's economic competitiveness.

Waterways carriers, shippers, ports and receivers of essential bulk commodities such as coal, grain, petroleum and chemicals rely upon a well-maintained and modern national waterway system.

A CLEAR CHOICE FOR THE ENVIRONMENT

Capacity Comparison

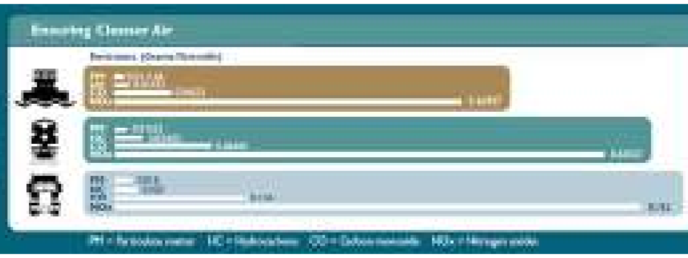
Modal Freight Use	Standard Capacity
Barge *Dry Bulk*	1,750 Tons
Rail *Bulk Car*	110 Tons
Highway *Tractor-Trailer*	25 Tons

Our waterways provide great capacity to ease congestion by carrying cargo that would otherwise travel by truck or rail. In fact, the annual traffic on America's inland navigation system carries the equivalent of 58 million truck trips per year.

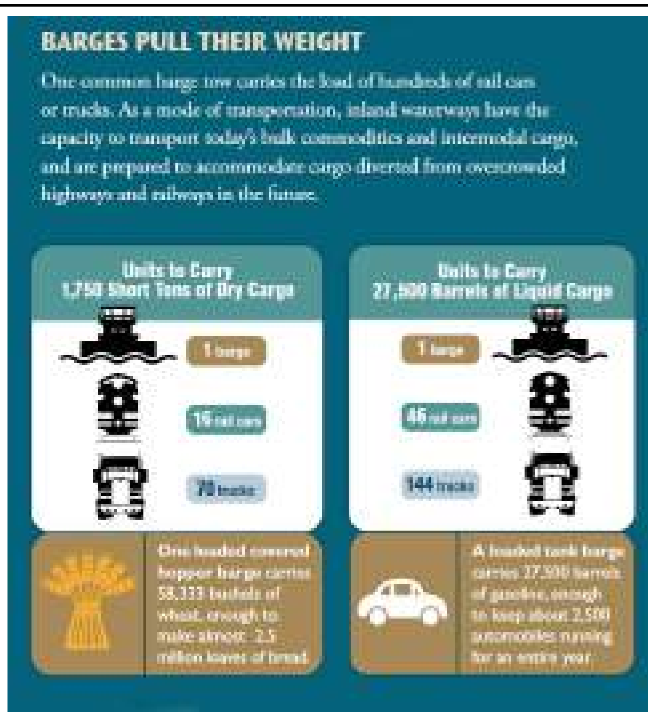
A typical cargo barge can carry significantly more cargo than a single truck or rail car, making it a mode of transportation that can keep commerce on the move, saving energy and safeguarding our environment.

Barge transport is the most energy-efficient way to move commodities such as coal, grain, iron, steel, aggregates, petroleum and chemical products. And by moving these products on America's inland navigation system, emission comparisons show that fewer air pollutants are generated.

Moving cargo on our inland waterways keeps our air cleaner.



Saving Energy
Barges can move one ton of cargo 576 miles per gallon of fuel. A rail car would move the same ton of cargo 413 miles, and a truck only 155 miles.
576
413
155
Ton-miles Traveled per Gallon of Fuel



BARGES PULL THEIR WEIGHT
One common barge tow carries the load of hundreds of rail cars or trucks. As a mode of transportation, inland waterways have the capacity to transport today's bulk commodities and intermodal cargo, and are prepared to accommodate cargo diverted from overcrowded highways and railways in the future.
Units to Carry 1,750 Short Tons of Dry Cargo
1 barge
16 rail cars
70 trucks
Units to Carry 27,500 Barrels of Liquid Cargo
1 barge
46 rail cars
144 trucks
One loaded covered hopper barge carries 58,333 bushels of wheat, enough to make almost 2.5 million loaves of bread.
A loaded tank barge carries 27,500 barrels of gasoline, enough to keep about 2,500 automobiles running for an entire year.

SYSTEM DELIVERY OF LOCK & DAM PROJECTS

Due to inefficiencies in infrastructure improvement projects, the current process to construct locks and dams is taking years longer than planned at costs that are sky-rocketing compared to projects completed only decades ago. We must find ways to improve the current waterways project delivery system and ensure transportation benefits are being realized more quickly by shippers, consumers and the American economy.

LEGISLATING INLAND WATERWAYS SYSTEM MODERNIZATION

With enactment of the Water Resources Development Act of 1986 (WRDA '86), the Inland Waterways Trust Fund (IWTF) started funding modernization of the nation's inland waterways system, beginning with the authorization of seven new lock and dam projects.

Under the 1986 Act, a diesel fuel tax increase on the barge industry - from 10 cents per gallon in 1986 to 20 cents per gallon effective January 1, 1995 - was levied to capitalize the IWTF. A cost-sharing formula was established under which one-half of project construction costs would be paid from the IWTF, with the other half paid by general revenues. The Act created the Inland Waterways Users Board to advise Congress and the Secretary of the Army about inland waterways system investment priorities and spending levels.

Locks and dams require financial support and ongoing maintenance to remain viable.

The current process to build lock and dam projects is increasingly inefficient.

WATERWAYS PROJECT DELIVERY DETERIORATION

A little more than two decades after WRDA '86 became law, an examination of five lock and dam modernization projects that are currently under construction illustrates a significant opportunity for improvement. Each of these five projects was authorized after WRDA '86, but before the most recent WRDA '07 legislation. Comparing the completed WRDA '86 projects to current post-WRDA projects is revealing. Statistics show that project delivery on the WRDA '86 inland waterway system far surpasses current performance in terms of both cost and completion time.

Where the seven WRDA '86 projects experienced an average 32.4% increase in actual costs over estimated costs, the five post-WRDA projects are currently estimated to require an average almost 120% more than what Congress authorized. And, while construction for all seven of the WRDA '86 projects proceeded at a pace that resulted in new, modernized locks becoming operational within a reasonable average of 6.3 years, the estimated time for completing post-WRDA projects has ballooned. In fact, only one post-WRDA '86 project has become operational. If current Corps estimates hold for these five projects, the average time to complete projects will be nearly 17 years – almost three times as long as was required for the WRDA '86 projects.

A NEED FOR IMPROVEMENT AND ACCOUNTABILITY

There's no doubt that our nation has a critical need for infrastructure improvements. But as we proceed, a focused effort must be made to determine why current projects take longer to complete, at costs that far surpass inflation rates, than those completed less than two decades ago.

On July 17, 2008, the Army Corps of Engineers released a study titled "Inland Navigation Construction Selected Case Studies" to the Inland Waterways Users Board. The study reveals "significant inefficiencies" and has "fostered discussions for an improved process." Waterways Council, the industry, the Inland Waterways Users Board and American Waterways Operators are committed to ongoing discussions to change the current business model and improve services on waterways completion. Only then should public policy leaders consider increasing revenue to fund these important infrastructure projects.

WATERWAYS COUNCIL, INC. | (703) 373-2261 | www.waterwayscouncil.org
801 North Quincy Street, Suite 200, Arlington, Virginia 22203

ENSURING WATERWAYS RELIABILITY

In order to keep critical infrastructure operating and performing efficiently, work must be done to adequately fund the nation's inland waterways system and address its increasing operations and maintenance needs.

Maintenance and repair of lock gates is critical to ensuring waterways reliability.

PRESERVING OUR WORLD-CLASS SYSTEM

Funding (in constant dollars) for operations and maintenance (O&M) on America's inland navigation system has remained flat for more than two decades. During this period, operations costs have continued to increase, yielding fewer funds that can be devoted to proper system maintenance. As a result, an increasing amount of routine maintenance on waterways infrastructure has been deferred.

As funding continues to stagnate, deferred maintenance becomes unfunded maintenance. Over time, this growing maintenance backlog on the nation's aging waterways infrastructure has eroded the effective capability of our world-class inland navigation system.

Earlier this decade, the continued shortfall in O&M funding led to a self-defeating cycle where an increasing percentage of available maintenance dollars went into emergency repairs—a "fix-as-fail"

Timely and adequate dredging ensures the orderly flow of commerce.

approach to systems maintenance. This reactive approach to maintenance did not account for the impact of a failure on waterways users, for whom alternate routes were often unavailable or inadequate in the event of a service interruption.

MOVING AWAY FROM "FIX-AS-FAIL"

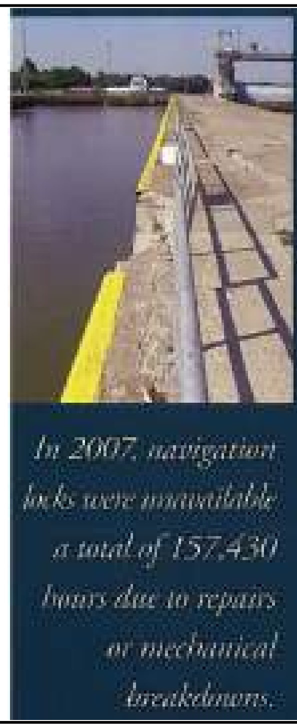
In 2003 and 2004, several high-profile lock closures raised reliability concerns among shippers, carriers, the U.S. Army Corps of Engineers and ultimately consumers who pay increased costs for expensive transportation delays. To counter the trend of emergency closures, Waterways Council, Inc. and the U.S. Army Corps of Engineers initiated Risk and Reliability workshops to develop consensus maintenance priorities on the Ohio River System, the Upper Mississippi River and Illinois Waterway and on the Gulf Intracoastal Waterway. Industry and government met together to assess critical needs on all segments of the nation's waterways system and determined maintenance priorities based upon the likelihood of a service interruption at a particular location as well as its potential impact to commerce.

MAINTENANCE BACKLOG REQUIRES INCREASED INVESTMENT

At the same time, the Inland Waterways Users Board and Waterways Council called for an increase of $100 million annually for critical O&M, and Congress responded with increased maintenance funding. However, the years of unfunded maintenance continue to adversely impact the reliability of this vital transportation system. The efforts of industry and government to prioritize maintenance projects are a positive development, but maintenance funding continues to fall short of long-term maintenance requirements.

We must stand firm on our commitment to maintain our inland navigation system, lest the benefits of reliable, low-cost transportation be "washed down the river."

An increasing amount of routine maintenance on waterways infrastructure has been deferred.



Failure of miter gates, shown here, disrupts navigation for extended periods.

Statistics

S

Stats

Inland Waterways Rule on Transport Efficiency

No Contest: the Backbone of America's Marine Highway is its Inland Waterways

Inland Waterways: They've beaten Rail & Trucks in virtually every measurable category comparing the modes for safety, fuel efficiency, stack emissions and economy of scale. In fact, it isn't even close. And, while the Obama Administration seems intent on spending more than USD $50 billion in the next five years on high-speed rail, to the ultimate detriment of the nation's intermodal system and the domestic waterfront itself, the numbers just do not add up. It just makes more sense to move bulk commodities, including all manners of petroleum and fuels, on the water. See for yourself using the chart below.

WATERWAYS COUNCIL, INC.

U.S. Inland Waterways Statistical Comparison

	Barge/Inland Towing	Rail	Truck
Economy of Scale	One 15-barge tow	216 railcars / 6 locomotives	1050 Large Semi Tractor-Trailers
CO2 Produced tons (per million ton miles)	19.3 tons	20.8 tons	71.6 tons
Fuel Expended (ton miles per gallon)	576	413	155
Injuries per accident (adj. for quantity moved)	1	125.2	2,171.5
Fatalities per accident (adj. for quantity moved)	1	22.7	155
Emissions (grams/ton-mile) NOx	0.469	0.654	0.732
Emissions (grams/ton-mile) Particulate Matter	0.01164	0.01624	0.018
Emissions (grams/ton-mile) CO2	17.48	24.39	64.96
Large Spills Across Modes (Number / 2001-2004)	25	115	643
Large Spills Across Modes (Amount in Gallons)	470,579	1,147,105	2,698,490

Source: Modal Comparison of Domestic Freight Transportation Effects on the General Public. Report Prepared for: U.S. Maritime Administration and National Waterways Foundation.

K E N T U C K Y

Water-Borne Commerce

Kentucky has one of the most extensive and strategically located waterway systems in the country. Of the Commonwealth's 49,100 miles of rivers, creeks, streams and tributaries, 1,090 are commercially navigable waterways. In fact, Kentucky has more miles of navigable waters than any state except Alaska. Six public port/terminals are located on the commercial waterways, as are approximately 168 private terminals. The Ohio River is by far the largest component of the Commonwealth's eight-river waterway system, as its 664 Kentucky miles comprise 61 percent of the total state system. Kentucky ranks fifth among the states in domestic waterborne tonnage and 11[th] in domestic and foreign tonnage.

Selected Technical Societies, Councils, Boards, Etc.

Related to

Waterway Transportation/Marine Navigation

Waterways Council, Inc.

Inland Waterways Users Board

National Waterways Foundation

Society of Naval Architects & Marine Engineers

American Waterways Operators

Kentucky Water Transportation Advisory Board

United States Coast Guard

US Army Corps of Engineers

Kentucky Association of Riverports

American Association of Port Authorities

U.S. Maritime Administration

KAR
KENTUCKY ASSOCIATION OF RIVERPORTS

Rivers have played a vital role in the historical development of the United States of America. Kentucky's 1,100 miles of navigable waterways comprise one of the most expansive and complex systems in the nation. It is the only US commonwealth to be bordered on three sides by rivers - the Mississippi River to the west, the Ohio River to the north, and the Big Sandy River and Tug Fork River to the east. Its major internal rivers include the Kentucky River, the Tennessee River, the Cumberland River, the Green River, and the Licking River.

Port Locations (powered by Google)

Kentucky has twelve public riverports, seven of which are operating ports and five of which are developing ports. Kentucky is also home to a large concentration of marine industries. A state-of-the art towing industry training facility is located in Paducah and several barge lines have headquarters and/or operations centers in Kentucky.

Kentucky 2008 Waterborne Commerce
To, from and within the State
(values in millions of dollars)

Commodity	Shipped	Received	Within	Total	Value
Coal	27,252,490	8,620,550	10,892,334	46,765,374	$1,792
Petroleum	1,526,133	7,866,981	511,874	9,904,988	$1,525
Crude Petroleum	0	**	0	**	**
Aggregates	18,483,875	2,736,497	6,093,282	27,313,654	$1,513
Grain	2,395,021	202,249	64,830	2,662,100	$473
Chemicals	565,750	2,068,427	**	2,634,177	$879
Ores/ Minerals	0	1,815,302	**	1,815,302	$146
Iron & Steel	975,613	1,400,848	262,015	2,638,476	$2,163
Other	2,818,275	1,139,380	514,418	4,472,073	$1,631
TOTALS	54,017,157	25,850,234	18,338,753	98,206,144	$10,122

*** Insufficient barge operators to release this tonnage – included in "Other Commodities"*
Source: U.S. Army Corps of Engineers Waterborne Commerce Statistics
Shipments on Ohio River Basin Waterways Only

Kentucky 2008 Commodities
Shipped by Barge to and from Other States
(values in millions of dollars)

Shipments	Commodity			Shipments	Commodity		
To	Tons	Value	Top	From	Tons	Value	Top
Louisiana	12,944,145	$1,187	Aggregates	W. Virginia	8,643,958	$822	Coal
Tennessee	12,647,791	$724	Coal	Louisiana	6,019,498	$1,324	Petroleum
Ohio	10,321,103	$614	Coal	Ohio	3,362,118	$706	Coal
Alabama	4,436,035	$229	Coal	Indiana	3,129,546	$283	Aggregates
W. Virginia	4,295,595	$276	Aggregates	Illinois	1,378,526	$255	Coal

Source: U.S. Army Corps of Engineers Waterborne Commerce Statistics
Shipments on Ohio River Basin waterways only

Kentucky 2008 Lock Tonnage
(in thousands of tons)

LOCK	UPBOUND	DOWNBOUND	TOTAL
Lock & Dam 53	37,037	39,073	76,110
Lock & Dam 52	51,788	38,272	90,060
Smithland	45,446	34,385	79,831
John T. Myers	47,037	24,939	71,976
Newburgh	52,367	21,224	73,591
Cannelton	38,953	21,129	60,082
McAlpine	39,419	19,336	58,755
Markland	31,594	24,087	55,681
Meldahl	23,404	31,752	55,156
Greenup	23,997	38,027	62,024
Kentucky	23,969	8,119	32,088
Barkley	2,902	471	3,373
Green River L/D 1	3,363	4,877	8,240
Green River L/D 2	3,169	1,152	4,321

Source: U.S. Army Corps of Engineers Lock Performance Monitoring System

Maritime Distance and Speed Measurements

Distance	*Speed*
1 nautical mile =	1 nautical mile per hour (knot) =
1852 meters =	1,852 kilometers per hour =
6076 feet (approx.)	1.151 miles per hour (approx.)

1 nautical mile = ~ one minute of arc of latitude along any meridian (and one minute of arc of longitude only at the equator)

Worldwide, the **knot** is used in meteorology, and in maritime and air navigation — for example, a vessel travelling a 1 knot along a meridian travels one minute of geographic latitude in one hour. Etymologically, the term **knot** derives from counting the number of knots in the line that unspooled from the reel of a chip log in a specific time.

The End

Ohio River at Louisville

Appendix G: Air Transportation Lecture

Overview

- By-product of the mail service
- Ideal for long distance and speed
- Relies on passenger revenue
- Speed and Competitive pricing led to growth
- Freight movement is limited. Ideal for high-value goods, perishable goods, and emergency situations.

History

- 1903: Wright Brothers 1st powered/controlled flight.
- 1905: 1st practical planes
- 1908: US Post Office began air transportation development
- WWI/Golden Era/WWII
  - Faster, Higher, Farther

History

- 1940s-50s: Jet engine/ airliners development.
- 1960s-70s: Large airliners
- 1978: Deregulation
- 1980s-beyond: Energy, environmental issues
- 9/11/2001: Security

Blue Grass Airport History

- 1920s-30s several small fields
- WWII – Current Blue Grass Field
- 1946: New Commercial Terminal.
- 1968: 1st Jet Airliners
- 2006: Runway Safety area improvement project

Blue Grass Airport

Blue Grass Airport
LEXINGTON, KENTUCKY

BGA Impacts

- 3,478 Jobs
- $104 million payroll
- $378 million output
- <1% within state, from state, to state (by weight), freight movement by tonnage

Blue Grass Airport
LEXINGTON, KENTUCKY

Kentucky Air

- Over 2.4 million passengers a year
- 13.1 billion pounds of freight a year
- 62 airports
  - 6 major ports (Louisville, Lexington, Paducah, Owensboro, Somerset, Hebron)
  - 3 major hubs (Delta, DHL, and UPS)
- <1% within state, from state, to state (by weight), freight movement by tonnage

Kentucky
UNBRIDLED SPIRIT

Kentucky UNBRIDLED SPIRIT

KENTUCKY TRANSPORTATION CABINET

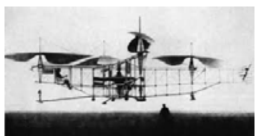
UPS

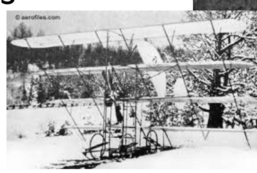
- Company founded August 28, 1907 in Seattle, Washington.
- Began providing air service in 1929.
- Fastest-growing airline in FAA history and is one of 10 largest airline in the US today
- Main US Air Hub located in Louisville, KY. Began operation in 1982.

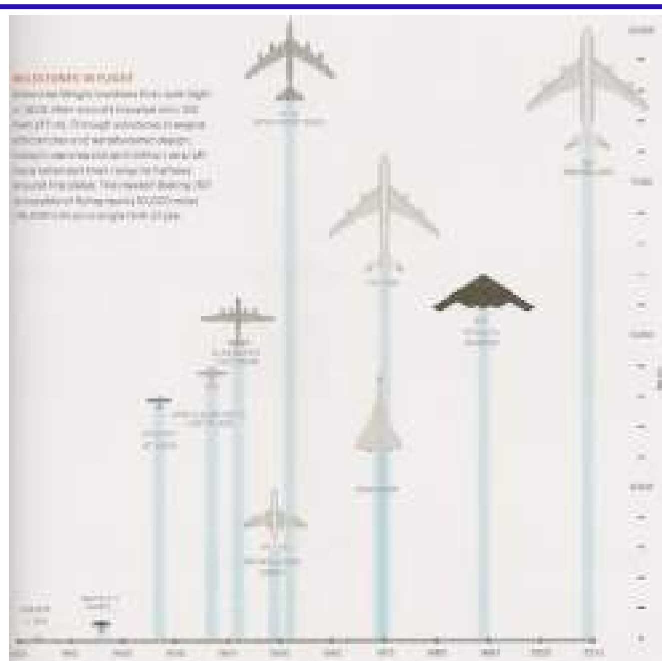
Jet Aircraft Fleet: 226
Chartered Aircraft: 292
Airports Served: Domestic - 382
International - 323

Early Problems

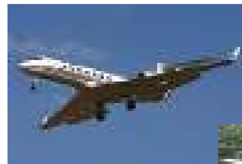
- New developing technology.
- Reliability
- Safety
- Human factors





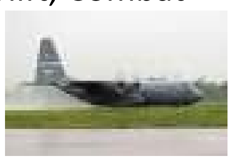
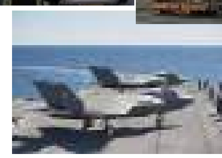


Aircraft Types




- General Aviation
  - Business, recreation
- Commercial
  - Passenger, cargo
- Military
  - Airlift, Combat



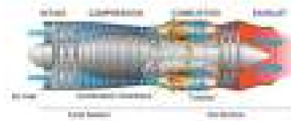
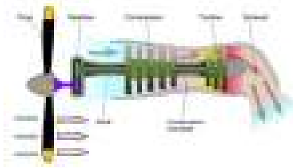
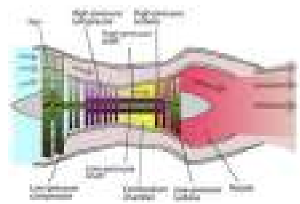
Airliner Types

- Narrow-body
  - 2-6 seats across
  - 1 aisle
- Wide-body
  - 7-10 seats across
  - 1-2 aisles

Propulsion



- Internal combustion
  - In-line, radial
- Turbojet
- Turboprop
- Turbofan
  - High and low bypass

Legislative Acts

- Air Commerce Act of 1926: 1st federal law, aided growth of industry
- Civil Aeronautics Act of 1938: Creation of Civil Aeronautics Board (CAB), regulation of rates and routes
- Federal Airport Act of 1946: Federal Aid Airport Program developed and improved airway facilities

- Federal Aviation Act of 1958: Federal Aviation Administration (FAA) was created
- Airport and Airway Development Act of 1970: Created the Airway Trust fund and established aviation taxes
- Airline Deregulation Act of 1978: Ended regulation of rates and routes and abolished the CAB
- The Airport and Airway Improvement Act of 1982: Passed to increase funding for airport construction and improvement

- The Aviation Safety and Capacity Act of 1990: Established the passenger facility charge (PFC)
- AIR-21:The Wendell Ford Aviation Investment Act for the 21st Century: Increased funding for highly congested large airports and to help smaller airports
- The Aviation and Transportation Security Act of 2001: In response to September 11th, created the Transportation Security Administration (TSA)
- Vision 100 Century of Aviation Act of 2003: Increased funding for improvements focused on environmental benefits

Deregulation

- 1978-1985: phased out of regulatory control
- Increased competition
- Easier for carriers to start up

Civil Aeronautics Board

- CAB
- Operated from 1938-1985
- Regulated routes and fares for the airways and its carriers
- Was abolished during deregulation

Federal Aviation Administration (FAA)

- Began operation December 31, 1958
- Replaced CAB
- Department within US DOT
- "Our mission is to provide the safest, most efficient aerospace system in the world. Learn more about how our mission is accomplished, the history of the FAA, and opportunities for the public to do business with the FAA"

Federal Aviation Administration (FAA)

- Mission = safety, efficiency
- HQ, Region and Districts
- Air Traffic, Airports, Policy, Administrative, Airspace

Federal Aviation Administration (FAA)

International Civil Aviation Organization (ICAO)

- Agency of the United Nations
- Began operation in 1944
- 191 Members
- Mission
  - Safety
  - Air Navigation Capacity And Efficiency
  - Security And Facilitation
  - Economic Development Of Air Transport
  - Environmental Protection

INTERNATIONAL CIVIL AVIATION ORGANIZATION
A United Nations Specialized Agency

A. Private Carriers

- Firm that transports company employees or freight in planes the firm owns or leases
- Subject to FAA safety regulations
- Emergency freight is sometimes carried

B. For-hire Carriers

- Non-scheduled, on demand carriers
- Not privately owned
- 3 Classes (based on annual revenue)
  - Majors: More than $1 billion
  - Nationals: $75 million to $1 billion
  - Regionals: Less than $75 million

Majors

- High-density corridors
- High-capacity planes
- Serves between major cities and/or populated areas
- EX: Delta, United, and American/U.S. Air

Nationals

- Operate between less populated areas
- Shorter routes with smaller planes
- Provides a link between outlying areas to airports with majors
- Selected markets
- EX: Southwest Airlines, America West

Regionals

- Operates in a specific region of the country (Midwest, New England)
- Two categories:
  - Large ($10-75 million)
  - Medium (less than $10 million)
- EX: Mesa, Skywest, Sun Country

Regionals

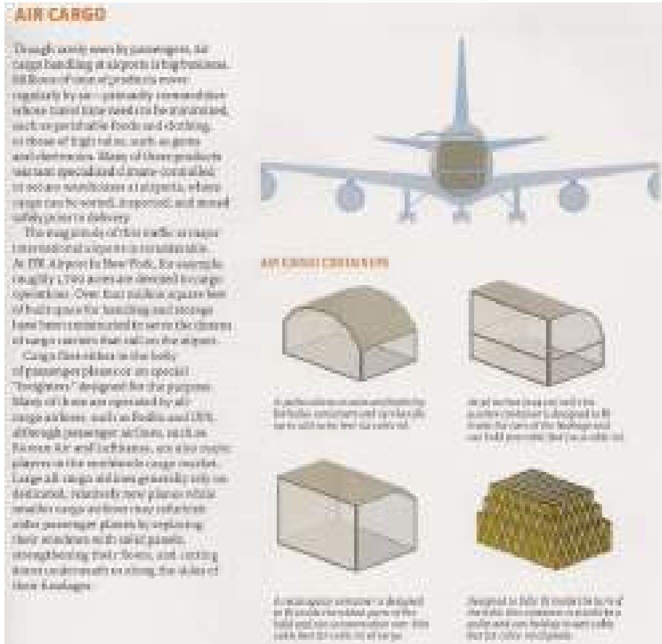
- Operate between less populated areas
- Shorter routes with smaller planes
- Often carry the “flag” of the mainline carriers
- Chautauqua (owned by Republic)
- United Express (United)
- SkyWest (Delta, American, United)

Low(er) Cost Carriers

- Operates point to point
- Minimal infrastructure
- Low overhead, low fare
- A la carte services
- Allegiant, Spirit, Frontier, Ryanair, Vision

Other Types

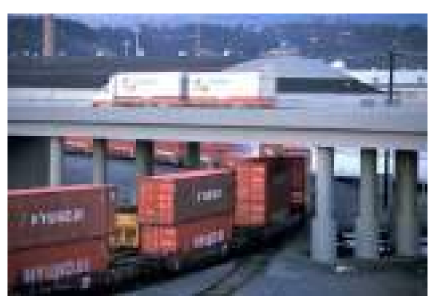
- All- Cargo Carriers
  - Transports mainly cargo
  - EX: Federal Express (FedEx), UPS
- Commuters
  - Connects small communities with larger ones with better air services
- Charters
- Private



Competition

- Intermodal Competition
  - limited because of the unique long-distance and time sensitive service air provides

- Intramodal Competition
  - Very competitive
  - Increase significantly since deregulation
  - More carriers entering = more competition



Intramodal Competition

- Increased since deregulation
- As competition increased planes had excess capacity. Discounted and lower rates were used to fill empty seats.
- Rising operating costs and lower rates resulted in a reduction in carriers especially in low-density routes/low population areas who need it most.
- Competition for flight times: 7-10 am and 4-6 pm are the most frequent

Cargo and Freight Competition

- Work with trucking to overcome limited accessibility
- Increase in freight traffic in attempt to fill excess volume.
- Cargo Pricing is dependent on weight
- Majority of freight is high-value/emergency shipments.
- EX: mail, clothing, communication products and parts, photography equipment, high-priced livestock, race horses, jewelry, and expensive automobiles
  - NOT → basic raw materials such as coal, lumber, iron ore, or steel

Airline Organization

- Typical corporate organization
  - Board, CEO, COO,etc.
  - Operations, Engineering
  - Business Development, marketing
  - Human Resources/Unions
- Very similar to Chapters 18-24 RR text
- Unions/Professional Organizations
  - AAAE, AOPA, NATA, IATA, ICAO (UN), etc.

Public Terminals

- Financed by government and/or carriers, etc.
- Carriers pay for use through landing fees, rent and lease payments for space, taxes on fuel, landed weight, turn fees, and aircraft registration taxes.
- Users pay taxes on tickets, passenger facility charges (PFCs), concessions and air freight charges.

Airport Ownership

- County
- City
- State
- Private
- Airport authority
- Federal
- Military
- Combinations of the above

Airport Organization

- Varies greatly based on size and ownership
- Typical business organization
  - Board, CEO, CFO, COO, etc.
  - Operations, maintenance, public safety
  - Accounting, business development, marketing
  - Human resources/unions, legal
  - Engineering
- Unions/Professional Organizations
  - AAAE, AOPA, NATA, IATA, ICAO (UN), etc.
  - KAA, KBT

Hub Systems

- Less populated areas are fed to hubs where connecting flights are available.
- Ex: Chicago is a hub for United Airlines, flights from Toledo and Kansas City go here where there are connecting flights to New York, Los Angeles, and Dallas
- Similar to trucking's break-bulk terminal
  - Service passengers with smaller planes on low-density routes.
  - Passengers are taken to a hub where they are then assigned to larger planes and high-density routes between the hub and major metropolitan area airports.

Cost Structure

- High amount of variable costs - 80%
  - Flying operations, maintenance, general services and administration, and depreciation
  - FUEL
- Low fixed costs – 20%
  - Government (local and state) invest in and operate airports and airways
  - Carriers pay for use of facilities through landing fees, a variable cost

Labor Costs

- About 1/3 of total cost
- Pilot wages depend on experience and equipment rating (size of plane)
- Union workers are usually paid more
- Pilots, co-pilots, navigators, flight attendants, office personnel, and management

Load Factor

- Percentage of the plane's capacity that is used
- Historically 62-65%; exceeds 80% lately

$$Load\ Factor = \frac{Number\ of\ Passengers}{Total\ Number\ of\ Seats} x100$$

- Can be affected by capacity, route, price, service level, and competition

Issues

- Regulation, regulation, regulation
- Scare du jour (disease, terrorism)
- Safety/Security
- Technology: constant need for efficient systems
  - Research and Development
- High costs (oil fluctuations)
- Accessibility

Airport Design Basics

- Many steps and factors involved in planning and design of airports
  - Type of airport
  - Critical aircraft
  - Capacity
  - Environment
  - Location
  - Runway length
  - Runway orientation
  - Pavement Design
  - Terminal design/Securit
  - Airspace
  - Special requirements: ARFF, military, intramodal, etc.
  - Non-aeronautical development

Runway Length

- Considerations to determine runway length:
  1)Government requirements
  2)Environment
  3)Specifications critical aircraft (ex: operating takeoff and landing weight)

Government Requirements

- Federal Aviation Regulations (FAR)
- Runway length determined for 3 cases
  1)Normal Takeoff
  2)Engine-failure Takeoff: runway length required for an aircraft to takeoff safely after engine failure
  3)Engine-failure Aborted Takeoff: runway length required for to accommodate landing after an engine failure

Environmental Factors

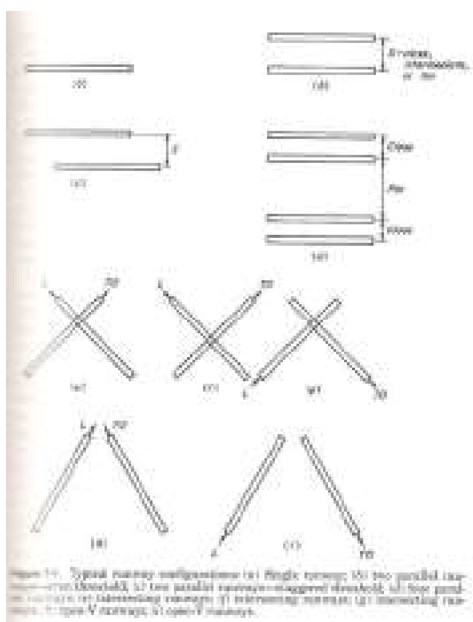
- Factors to consider when determining runway length
  - Temperature
  - Surface wind
  - Runway gradient
  - Altitude
  - Runway surface
- Runway Length must be adjusted to compensate for these factors

Aircraft Specifications

- Aircraft manufacturers publish runway length diagrams and charts for takeoff and landing requirements
- These figures take into account and adjust lengths for environmental factors as well as aircraft weights

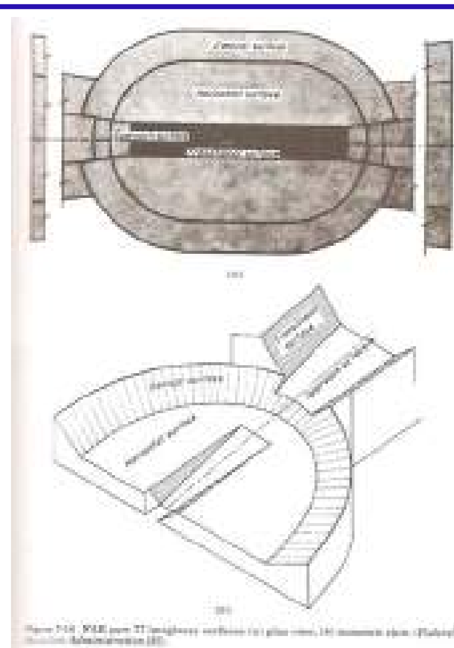
Airport Configuration

- Orientation of runways and location of terminal
- Factors to consider…
  - Wind patterns
  - Area available for development
  - Land and/or air restrictions in the area
  - Anticipated airport capacity
  - Required distances between runways, taxiways, aircraft, obstructions, etc.



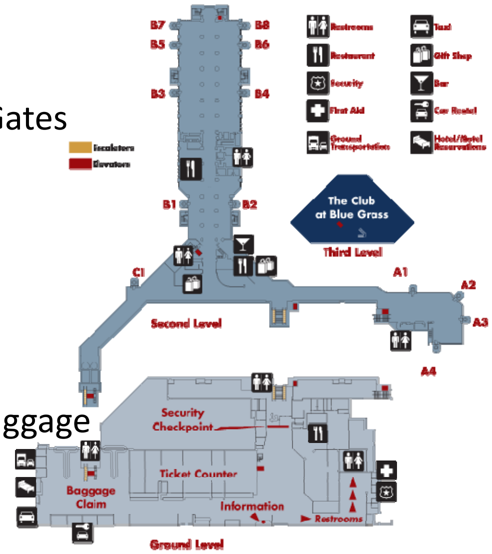
Airspace

- Imaginary Surfaces: used to determine if an object close to an airport (building, tree, etc) is an obstruction
- 5 imaginary surfaces:
  - Primary Surface
  - Horizontal Surface
  - Conical Surface
  - Approach Surface
  - Transitional Surface
- Surface size varies depending on runway classification



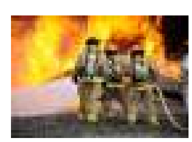
Terminal

- Airside
  - Aircraft boarding Gates
  - Airline Operations
  - Retail
- Landside
  - Parking
  - Ticket Counters/baggage
  - Security



Special Requirements

- Construction similar to highway, but “build under traffic” much more difficult
  - Aircraft on ground and overhead
- Security needs
  - Special design/construction considerations
  - Limits on personnel/equipment access
- Pavement Design[Layered Elastic Design (LED)]
- Airport Rescue and Fire Fighting (ARFF)
- Joint Military needs
- Public Coordination



Special Requirements

- Airport Rescue and Fire Fighting (ARFF) have special facility requirements
  - Example: Refill 1500 gallon Water Tanker truck in two minutes requires much higher pressure and volume flow than most industrial utility design standards
  - Special fire fighting training facilities
    - Structural fires-most larger communities have their own
    - Aircraft fires-specialized training facilities are expensive to build, own and operate, therefore rare. Blue Grass Airport has one for this region
  - Special equipment/safety/hazmat capabilities

Special Requirements

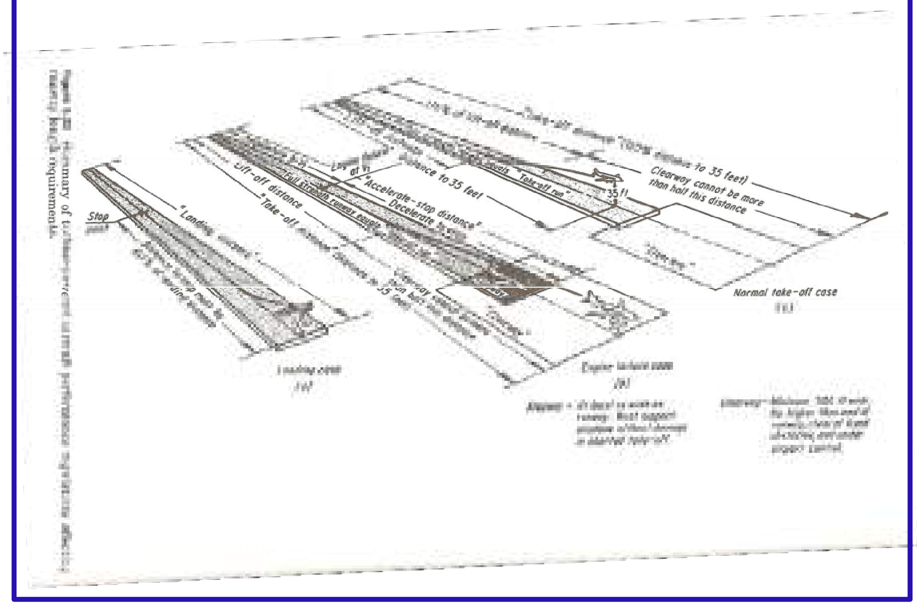
- Joint Military needs, some examples:
  - Arresting gear for emergency landings on regular airfields (not aircraft carrier landings), strictly for safety
    - Build mounting/support pads next to/on runways
    - Considered obstructions and can damage civilian aircraft, often disputed by communities
    - Quickly installed for emergencies
  - Hot Pad Refueling/Arming
    - Special areas at runway ends
  - Ammunition Bunkers
    - Structures for storing weapons/ammunition requiring special construction and large distances from other facilities

Special Requirements

- Public Relations/Coordination
  - Unlike other Transportation modes, almost everything in aviation is in public view…when something goes wrong, EVERYONE hears about it!
  - Need to notify the public about changes and problems as soon as possible…good PR needs to be practiced from ticket counter to construction to planning
- Problems/Complaints
  - Real or perceived, you have to be hyper-proactive in dealing with them. Proposed parallel runway at BGA was derailed by slow PR reaction to problems and complaints

Runway Terms and Equations

Landing distance, LD
Stop distance, SD
Takeoff distance, TOD
Liftoff distance, LOD
Takeoff run, TOR
Accelerate-stop distance, DAS
Field length, FL
Full-strength pavement, FS
Clearway, CL
Stopway, SW
Distance to 35 ft, D35



Equations

<u>Normal Takeoff</u>

$$FL_1=FS_1+CL_{1max}$$

Where

$$TOD_1=1.15(D35_1)$$

$$CL_{1max}=0.50[TOD_1- 1.15(LOD_1)]$$

$$TOR_1=TOD_1-CL_{1max}$$

$$FS_1=TOR_1$$

Engine-failure Takeoff

$$FL_2=FS_2+CL_{2max}$$

Where

$$TOD_2=1.15(D35_2)$$

$$CL_{2max}=0.50[TOD_2- (LOD_2)]$$

$$TOR_2=TOD_2-CL_2max$$

$$FS_2=TOR_2$$

Engine-failure Aborted Takeoff

$$FL_3=FS+SW$$

Where

$$FL_3=DAS$$

$$FL_3=LD$$

Landing

$$FL_4=LD$$

Where

$$LD=SD/0.60$$

$$FS_4=LD$$

Required Length

$FL = max(TOD_1,TOD_2,DAS,LD)$

$FS = max(TOR_1,TOR_2,LD)$

$SW = DAS-max(TOR_1,TOR_2,LD)$ *$SW_{min}=0$

$CL = min(FL-DAS,CL_{1max},CL_{2max})$

*$CL_{min}= 0$, $CL_{max}= 1000$ ft

Future

- Airfield Design criteria changed in 2013
- Runway safety and operations is changing drastically
- Airport security/perimeter security. This area is still maturing, primarily due to technology
- USA: Mostly improving existing infrastructure
- World: New airports and improvements

Questions?

Reference/Links

- http://www.bluegrassairport.com/
- http://www.faa.gov/
- http://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/?year=all.
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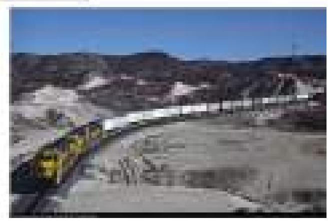
- John Cassel, majordadjohn@msn.com
- Mark Day, MDay@bluegrassairport.com

Appendix H: Intermodal Lecture

Intermodal Traffic



What is Intermodal Transportation?

"The concept of transporting passengers and freight on two or more different modes in such a way that all parts of the transportation process, including the exchange of information, are efficiently connected and coordinated."

Gerhardt Muller, Eno Transportation Foundation

What is Intermodal?

“Transportation involving more than one mode of transportation during a single journey.”

- Rail
- Truck
- Container Ship
- Barges

3

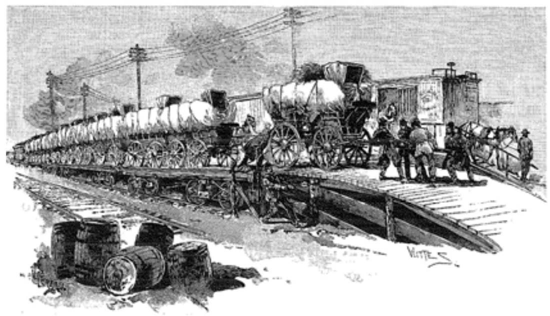
Definition

- Intermodal shipment: a freight shipment that moves between origin and destination using two or more modes of transportation
- Types of intermodalism:
  - unitized
  - bulk
- Growth of unitized intermodal shipments has been a spectacular trend in transportation

4

Beginnings

Can date back to at least 1880s
 - Long Island Rail Road



A scene from a more tranquil era. Here is the famous "Farmers Train" operated by the Long Island Rail Road in the 1890's to take goods loaded in wagons on flatcars to Gotham City. — DONALD DUKE COLLECTION

Farm Wagons on Flat Cars

Beginning of Current Intermodal

- Started with Southern Pacific in 1953
- By end of 1954 eighteen Class I railroads introduced piggybacking
- Standardization problems

A driver backs his trailer onto the Pennsylvania Railroad's first intermodal train on March 3, 1955, at PRR's Chicago ramp. It's destined for South Kearny, N.J. The circus loading process was labor- and time-intensive.

1950s

- Mid-1950s
  - Railroads created TOFC service
    - Length: 50 ft to 75 f t
    - Semi-Trailer Length: 30-35 ft
    - Secured by 40 jacks and chains

Source: http://lariverrailroads.com/freight_car/sp562114flat.jpgpg

- 1957
  - Invention of the Collapsible Trailer Hitch

7

1960s

- Length: increased to 89 ft
  - Semi-Trailer Length: 40 ft
    - Capacity: 2-40 ft trailers

8

Interstate Highway Act

- Established in 1956
- Created the interstate highway system
- Increased competition from trucks

http://www.youtube.com/watch?v=SJBpg24A6Ok

9

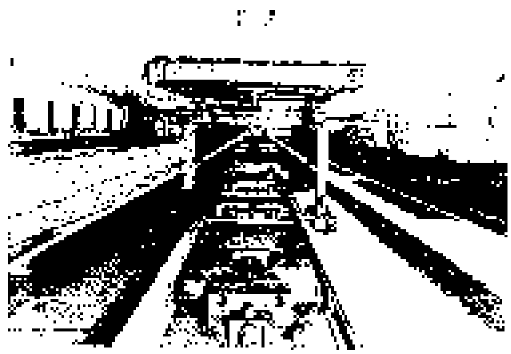
Trailer on Flat Car

- Trailer on Flat Car service was offered
- Allowed for shippers to load product in truck trailers and then ship by rail
- Required 40 jacks and chains

10

Collapsible Trailer Hitch

- Invented in 1957 by Les Robinson
- Eliminated tie-downs
- Could be lowered allowing trailers to drive over it



11

1960s

- International traffic began to develop
- 1966: 1st trans-Atlantic containers transported
- Late 1960s: 1st trans-Pacific container services began
- Railroads develop better technology to become more competitive

12

1970s

- Crane Loading/Unloading
  - Elimination of Excess Weight
    - Articulated
    - Fuel-efficient 'spine cars'
    - Composition: center sill and trucks
      - Minimal platform to support pedestals/wheels

Source: http://www.ttx.com/Libraries/TTX_Photo_Gallery/Intermodal_Spine.sflb.ashx6g

Source: http://www.rrpicturearchives.net/showPicture.aspx?id=1415415g

13

1970's—Spine Cars, Continued

- Spine Cars
  - Minimal Structure
    - Central Beam
      - "Spine"
  - Saves weight
  - Increases fuel efficiency
  - Containers or trailers

- Courtesy of Dr. Nambisan: For More Information

14

Land Bridge

- Moving freight across the country from a port on one coast to a port on the other coast

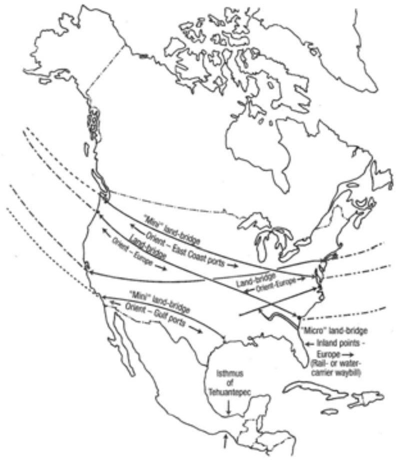


Fig. 15-1. Railhauls on all-water tariffs

15

1970s

- Shift from retailer to wholesaler
- Mechanized Loading
- Double-stack car
- 3-R Railroad Act
- 4-R Railroad Act

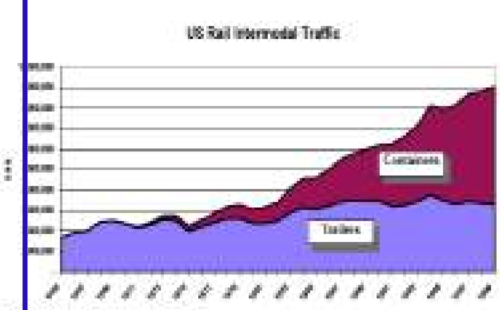
16

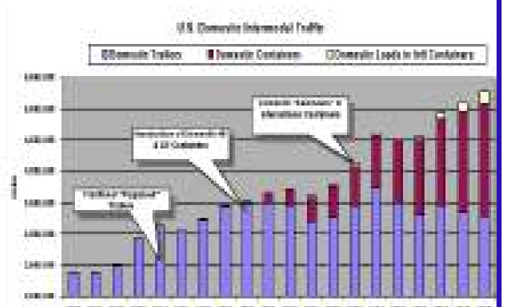
1977

- Southern Pacific, Sea-Land, and American Car & Foundry
  - Jointly Develop Double Stack Prototype
  - Stand Alone Well
  - After 1979--Articulated
- Twice the capacity of previous designs

1980s

- Deregulation via the Staggers Act (1980)
  - Allowed railroads to change price without interference
  - Become more competitive with trucks

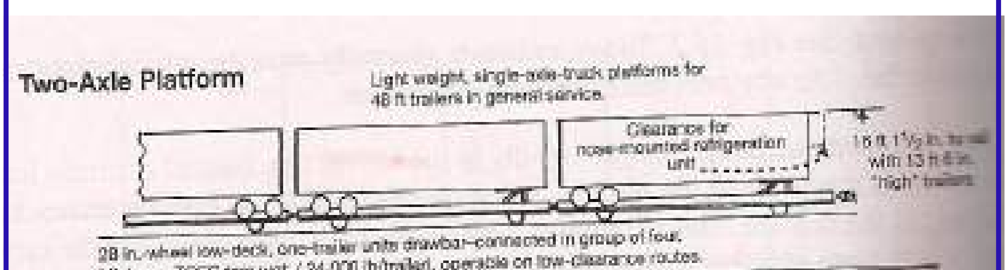




Third Generation Intermodal Equipment

19

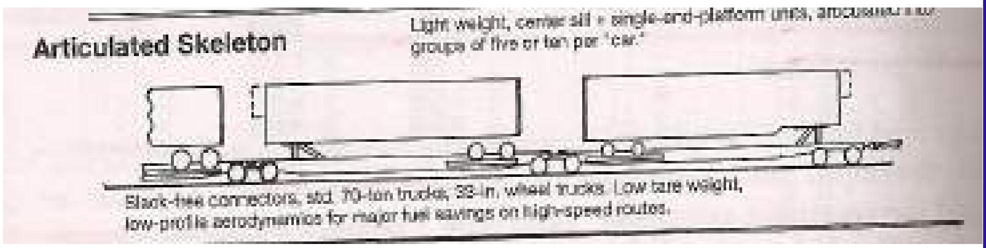
Two-Axle Platform



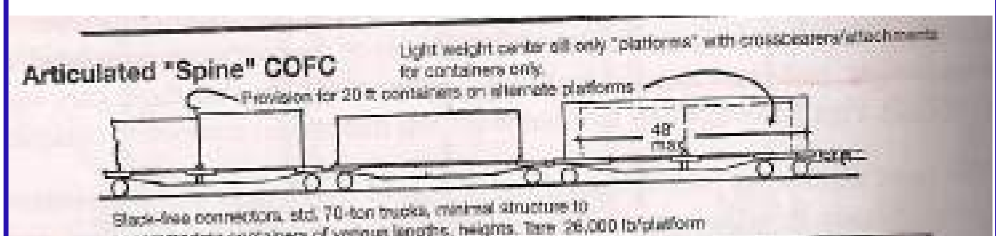
20

Articulated Skeleton

Source: http://www.translationdirectory.com/images_articles/wikipedia/railroads/A_train_of_intermodal_trailers_on_flat_cars.jpg



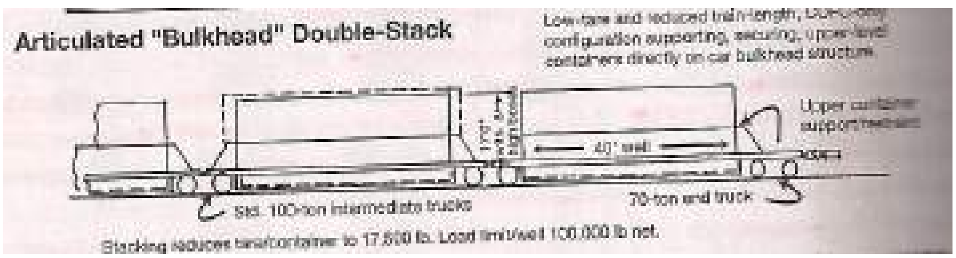
Articulated “Spine” COFC



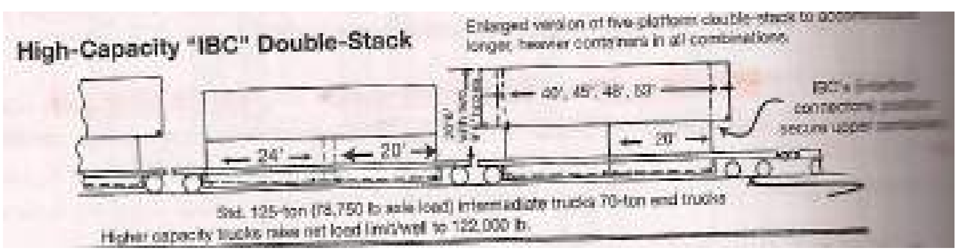
Source: hhttp://www.rrpicturearchives.net/showPicture.aspx?id=1404826g

Articulated "Bulkhead" Double-Stack

Source: http://www.rrpicturearchives.net/showPicture.aspx?id=657477

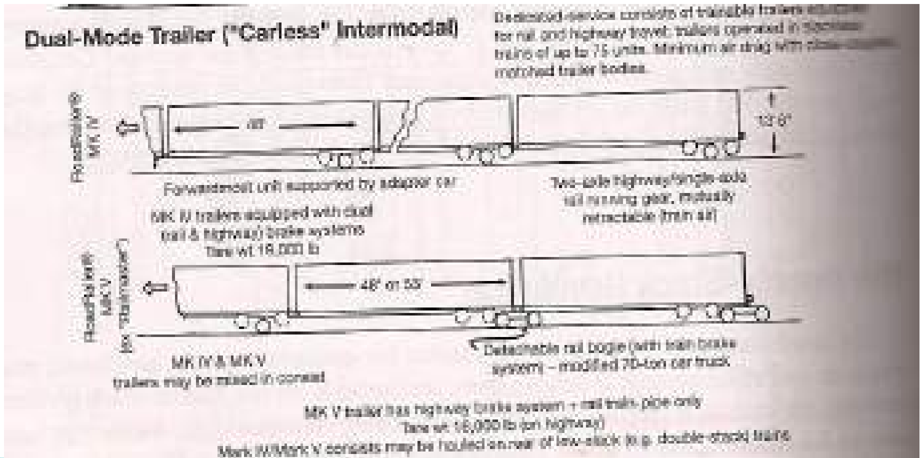


High-Capacity "IBC" Double-Stack



Source: http://www.rrpicturearchives.net/showPicture.aspx?id=961218

Dual-Mode Trailer ("Carless" Intermodal)



[Mark IV & Mark V Consist]

Source: Rees Module 4

Containers

- "ISO Containers"
  - 20 ft long by 8 ft wide by 9.5 ft high
- Volume:
  - TEU: twenty-foot equivalent unit

Source: http://www.freightmatchers.com/images/containerShip.jpg

Intermodal Trailers

- Trailer Dimensions:
  - 28 ft
  - 48 ft
  - 53 ft
- Modifications:
  - Reinforced Doors
  - Lift Rails

Trailer Loading

27

Intermodal Operations

- Service marketed by railroad, motor carrier, steamship line, or third party
- Roles of modes
  - Motor carriers perform pick-up and delivery
  - Railroads perform land-side line-haul
  - Steamship lines perform intercontinental movement
- Terminal facilities provided by port, steamship line, railroad, customer, or third party

28

Types of Service

- Railroad intermodal transportation is typically described as either:
  - Trailer on flatcar (TOFC)
  - Container on flatcar (COFC)
- These categories no longer cover all types of service (e.g., RoadRailer)
- Current intermodal rail cars don't necessarily resemble flatcars.

29

(Above) TOFC Train, Union Pacific RR, Austin TX

(Right) Double stack COFC, Norfolk Southern Ry, Greeneville, TN

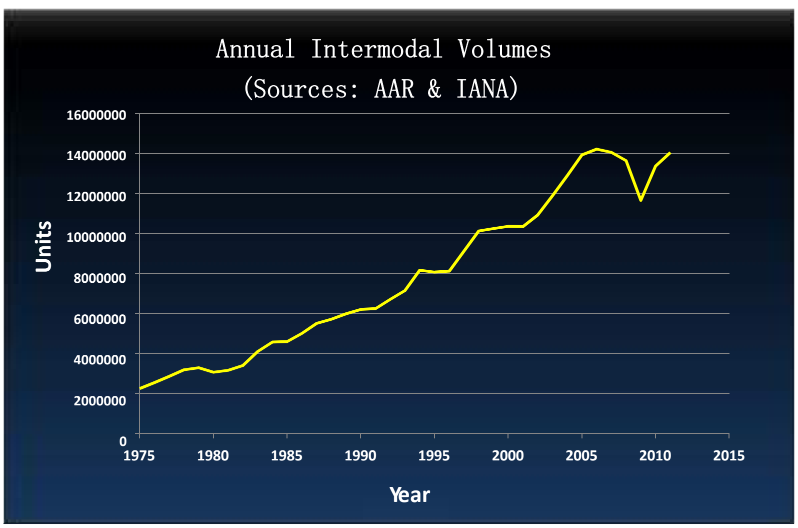
30

Rail Intermodal Traffic Growth

- Railroads began offering TOFC service in the late 1950s
  - many small, non-mechanized terminals
  - service in general freight trains
- Trailer Train Corporation (now TTX) was formed to handle equipment pool
- COFC service paralleled the rise of marine containers
- Rise of global trade propelled COFC growth during 1980s

31

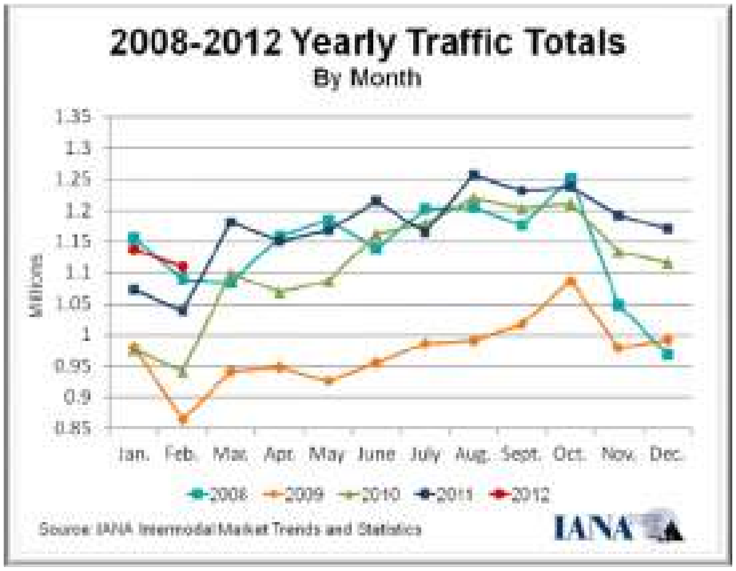
HISTORIC GROWTH



The economic recession has affected recent intermodal trends, in common with all freight movement.

32

Recent Traffic Trends



33

Intermodal Truck/Rail Comparison

Source: BNSF Railway	Truck	Intermodal Train
Unit of Shipment	1 truckload	1 train (250 truckloads)
Labor (2000 mile trip)	1 person	26 people (1 train)
Frequency of Service	Daily / Hourly	Daily (if volume warrants) Often less than daily
Annual Volume Required for Daily Service	365	91,250
Transit	Mile/day: 500 Average MPH: 50 Operates: 10 hrs/day	Mile/day: 500 Average MPH: 21 Operates: 24 hrs/day
Route Infrastructure	Unlimited use of Federal and State road system	Use of privately owned rail network with limited use of alternate networks
Route Options	Virtually unlimited: many route options between origin and destination	Normally just one viable route between origin and destination

34

Relative Costs

DeBoer provided the following cost indices for a 1,000 mile haul:

89' railcar with TOFC	**0.55**
89' railcar with COFC	**0.53**
Double stack railcar	**0.41**
RoadRailer	**0.57**
Truck	**1.00**

35

Intermodal Containers

- Allow unitized movement of goods
- Domestic and international versions
- Configurations include box, tank, flatbed
- Stackable
- Dimensions
  - length
    - 20 ft, 40 ft, 45 ft for international use
    - 48 ft, 53 ft for domestic use
  - width = 96" international, 102" domestic
  - height = 4', 8', 8'-6", 9-6"

36

40' x 9'6" Steel Dry Freight High Cube Refurbished

Sea Box, Inc. Container Types	Length		Height		Width		Door Opening	
	Exterior	Interior	Exterior	Interior	Exterior	Interior	Height	Width
40' DRY FREIGHT	40'0"	39'5 ½"	9'6"	8'9 7/8"	8'0"	7'8 ½"	8'5 1/8"	7'8 ½"

Sea Box, Inc. Container Types	Tare Weight in pounds	Payload in pounds	Gross Weight in pounds	Cubic Capacity in cubic feet
40' DRY FREIGHT	8,930	58,270	67,200	2,681

Chassis are normally used for movement of containers over the highway, although flatbed trailers can be used

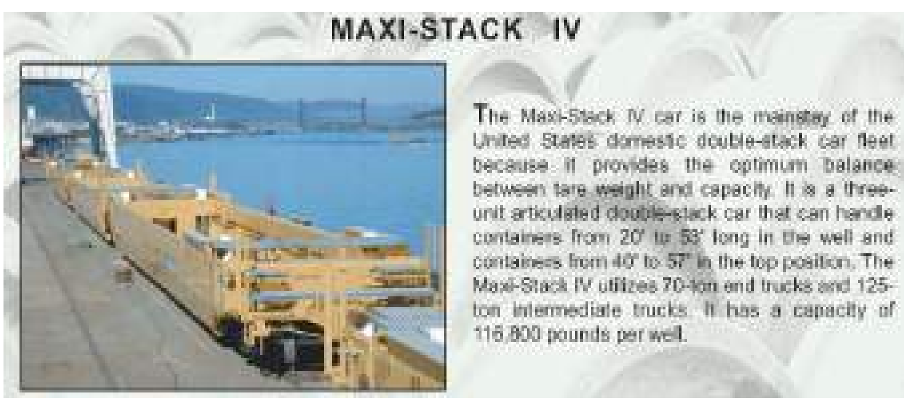
40' Gooseneck Chassis

40' 6" LONG CHASSIS TRAILER DESIGNED TO CARRY ONE STANDARD 40' ISO CARGO CONTAINER	
48" Main frame height at rear based on 48" King Pin height	
Tare Weight	6,600 LBS + 2%
Pay Load	67,200 LBS
Max Gross WT.	73,800 LBS

Intermodal Trailers

- Common lengths are 28 ft, 48 ft, 53 ft; width is 102 in max.
- 80,000 lb GVW with tractor
- Modified construction to withstand railroad service loads
  - reinforced doors
  - lift rails
- All configurations used; dry van and refrigerator most common

39



40

53' All-Purpose Double-Stack Car

The 53' All-Purpose (AP53) double-stack well car is a single unit designed to maximize flexibility. It can carry either containers or trailers. The AP53 has a 53' well to accommodate containers from 20' to 53' long. It can handle containers from 40' to 53' long in the top position. The AP53 can also accommodate two 28' pup trailers or one long trailer up to 57' long. Each car is capable of carrying nose-mounted containers or trailer refrigeration units. The AP53 has 166,000 pounds of capacity per car to handle heavy loads. It can also be configured as a 3-unit drawbar car.

Mechanized Loading Technology

- Gantry crane
  - transfer only
  - rail or rubber tired
  - 25–50 ton lift capacity
  - span 32-76 ft
  - 5-8 container lift height
- Straddle loader
  - transfer/storage
  - rubber tired
  - 50 ton capacity
  - span 15-20 feet
  - turning radius 35 ft outside
  - 2-5 container lift height
- Side loader
  - transfer/storage
  - rubber tired
  - 22–45 ton lift capacity
  - turning radius 20 ft to 52ft requires aisles 30ft min to 75ft ideal
  - 2-3 container lift height
- Reach loader
  - transfer/storage
  - rubber tired
  - 50 ton lift capacity
  - 5-8 container lift height

Marine Gantry Cranes

43

Rubber Tired Straddle Loader

44

Side Loader

45

Reach Loader

Image from Mi-Jack Products, Inc.

46

Lift Spreader Assembly

47

Double Stacks

Single- and double-stacked well cars on BNSF pass at Canadian, Texas. Double-stacking cuts door-to-door shipment costs 23 percent for a container traveling 2,000 miles.

48

Double Stacks

Supreme efficiency: Union Pacific's mammoth 3½-mile experimental double-stack train rolls through Redlands, Calif., on Jan. 10, 2010, en route from Dallas to Long Beach, Calif. Robert Royer

49

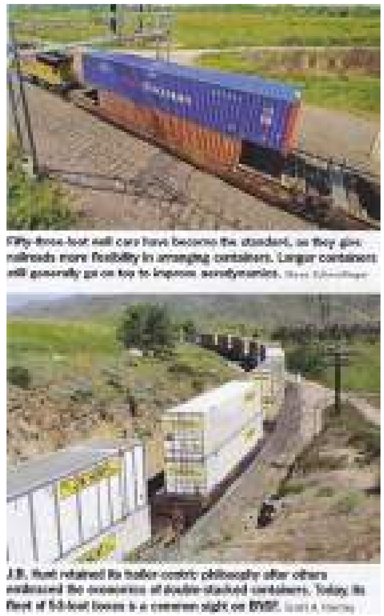
Containers

Burlington Northern Railroad became an early player in the domestic intermodal trade with its BN America line of trailers and containers; two pass Christie, Calif., on Santa Fe rails.

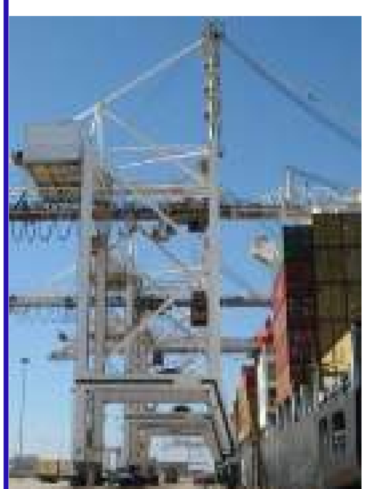
American President Lines' 40-foot "Lo-Pac" demonstration car shows how 45-foot containers can sit atop 40-foot ocean boxes in a 40-foot well car. The advent of 53-foot boxes complicated this setup. APL

50

Double Stack Containers



Moving Containers



http://us-cdn.creamermedia.co.za/assets/articles/images/resized/35747_resized_capeto~2.jpg

RESS Module 4

Rubber Tire Straddle Loader

first-tech.com.hk/eRTGC/eRTGC%20Projects.html

Side Loaders

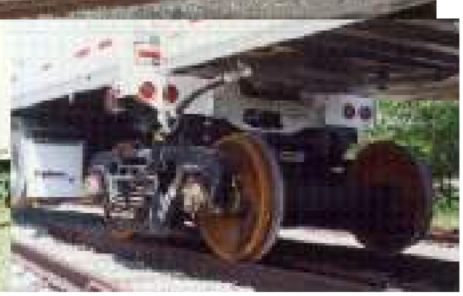
http://media.changeworkscom.co.uk/ext/1274/images/PR%20Photos/westwaste_0019.jpg

Carless Technologies

The RoadRailer® may be handled over the highway like any conventional semitrailer

55

Or coupled in trains of up to 125 units

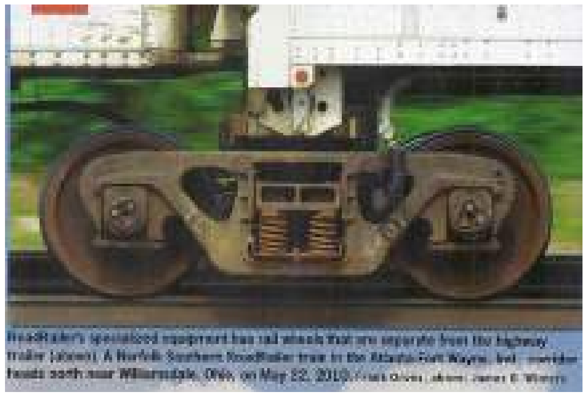



Coupler Mate

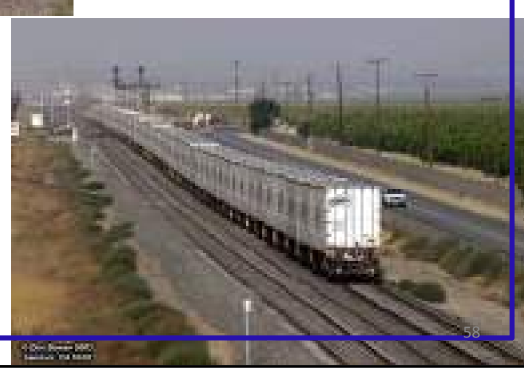
Bogie

56

RoadRailer



RoadRailer

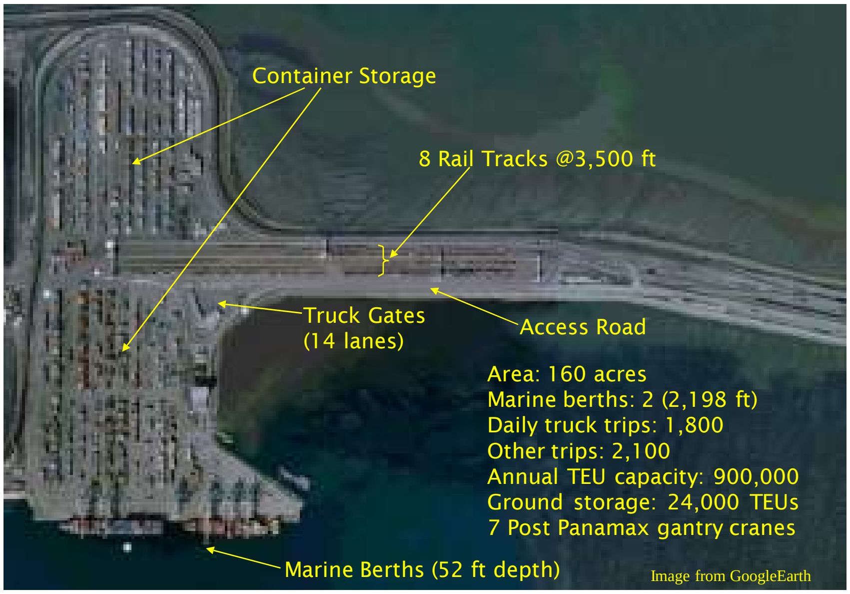


RoadRailer

Intermodal Terminal Elements

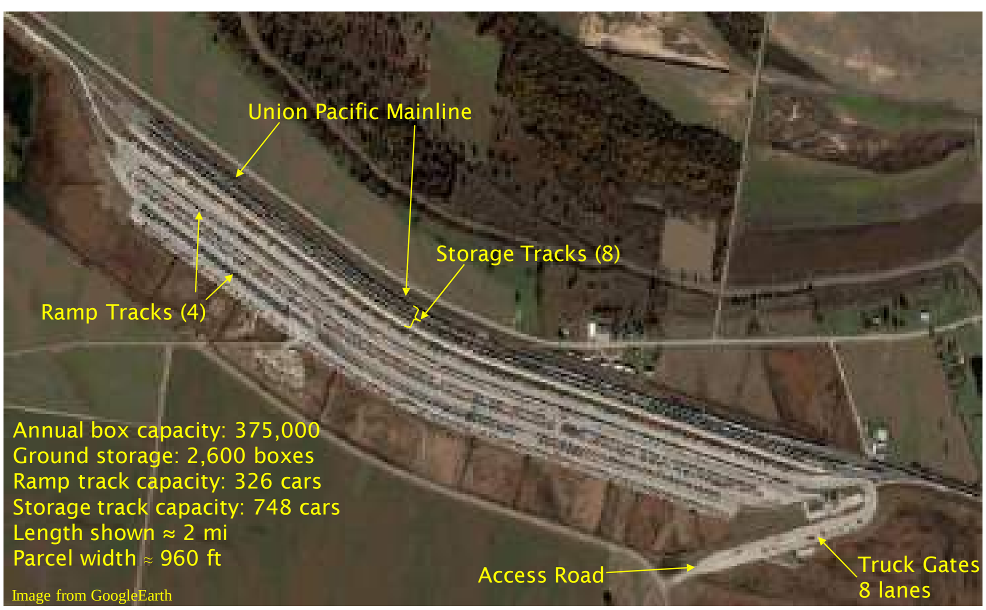
- Provision for loading/unloading railcars
- Box storage (long term or temporary)
- Vehicle storage (railcars/trailers/chassis)
- Check-in/check-out control
- Vehicle and box servicing/repair
- Security and lighting
- Office and administration
- Information systems
- Vehicle scales

Roberts Bank, BC Marine Terminal



61

Marion, AR Intermodal Terminal



62

Terminals

63

Factors in Terminal Location

- Access to railroad and highway system
- Area, configuration, and topography of site
- Cost to acquire site and provide infrastructure
- Adjacent land uses
- Proximity to customer base
- Ability to accommodate future growth
- Local support

64

Terminal Design

- Low volume (<100,000 annual lifts)
  - side loader operation
  - rail loading tracks of 500-1000 ft length
  - 110 feet separation between tracks
  - separate parking areas for road vehicles
  - one way highway traffic circulation
- Medium volume (100,000-500,000 annual lifts)
  - rail loading tracks 1,000-3,000 ft stubbed or flow-through
  - side loader or straddle loader operation
- High volume (>500,000 annual lifts)
  - rail unloading tracks 3,000 to 8,000 ft, flow through preferred
  - straddle loader or gantry operation
- In all cases, a linear design is preferable

65

Future Issues for Intermodalism

- Improving the railroad system
  - adding capacity to handle more business
  - matching truck service characteristics
  - increasing efficiency of intermodal equipment
- Funding needed improvements
  - private sector
  - public sector
  - public-private partnerships
- Developing a short-haul intermodal system
  - currently, intermodal is competitive for shipments >750 mi
  - 88% of truck trips are 500 mi or less

66

Intermodal Trains and Railway Infrastructure

- Intermodal trains must be service competitive with trucks
  - maximum speeds of 50-70 mph typical; such speeds
    - consume track capacity
    - require appropriate control system
    - require high train power/weight ratio
    - require higher track and alignment standards
  - schedule requirements provide operating challenge
- Train lengths to 7,500 ft routine; may reach 10,000 ft if conditions permit
  - adequate passing siding length needed on single track lines
  - multiple main track provides better capacity and operational flexibility, at higher cost
  - careful terminal design needed to avoid conflict with mainline operations
- Double stack trains need adequate clearances (20' 3" min)

67

Intermodal Terminals

68

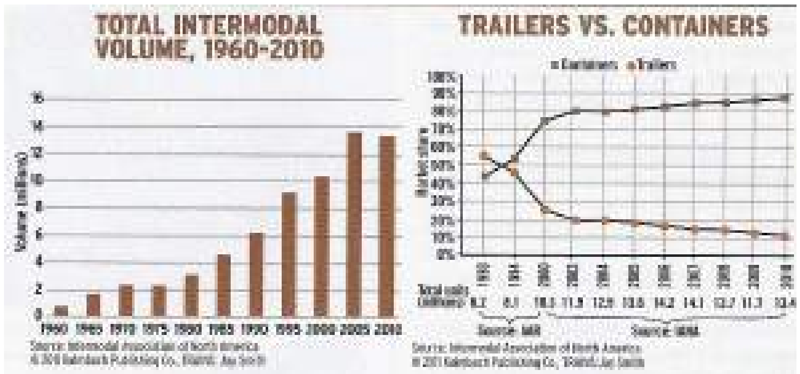
Intermodal Terminals

Yardmaster Shane Schimpff oversees the comings and goings of intermodal trains at CSX's hub in northwestern Ohio.

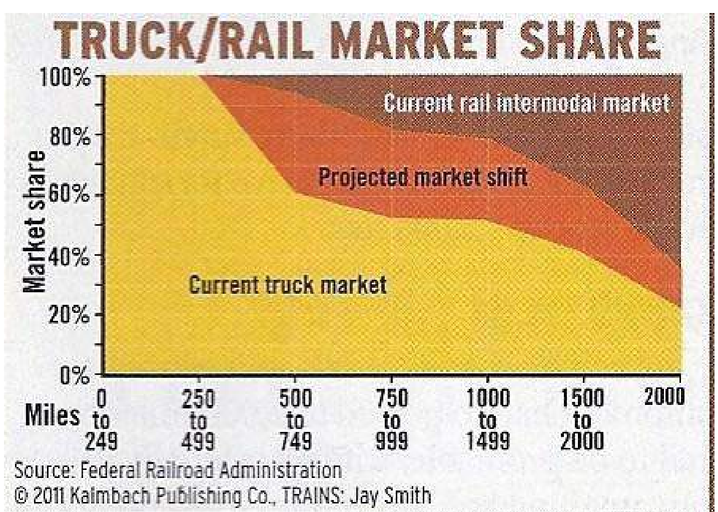
Intermodal Terminals

Compare...

- Transloading


TOTAL INTERMODAL VOLUME, 1960-2010
1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010
TRAILERS VS. CONTAINERS
Containers Trailers
100%
0%

73


TRUCK/RAIL MARKET SHARE
100%
80%
60%
40%
20%
0%
Market share
Current rail intermodal market
Projected market shift
Current truck market
Miles
0 to 249
250 to 499
500 to 749
750 to 999
1000 to 1499
1500 to 2000
2000
Source: Federal Railroad Administration
© 2011 Kalmbach Publishing Co., TRAINS: Jay Smith

74

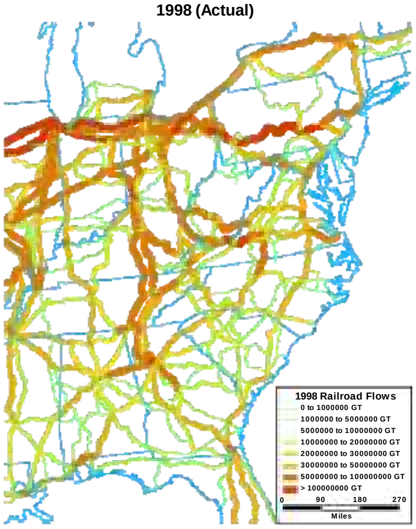
Intermodal

Trucker J.B. Hunt now stencils "Intermodal" in green on its containers. John Roskoski

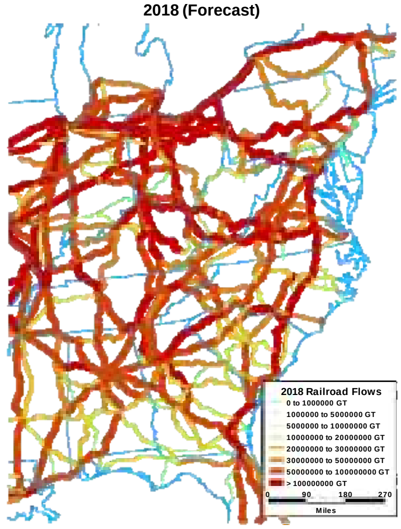
75

The Railroad Capacity Issue

1998 (Actual)



2018 (Forecast)

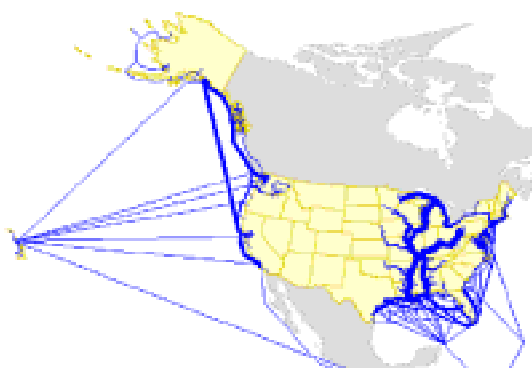


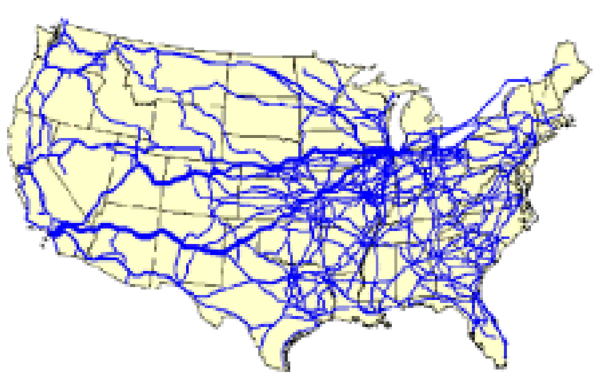
76

Major Freight Corridors by Mode

- Rail - Powder River Basin, Los Angeles to Chicago
- Waterways - Mississippi River, Ohio River
- Truck - 1-40, 1-75, 1-81, 1-65, 1-71, 1-5

US Waterways Freight Density





US Rail Intermodal Density

Intermodal in Kentucky

- Norfolk Southern Intermodal Facilities – Louisville and Georgetown
- Coal Transloading Facilities – Eastern Kentucky
- Riverports – Owensboro, Ashland, Louisville, Paducah, Maysville, etc...
- Freight Airports – Lexington, Cincinnati, Louisville, Owensboro, Paducah

79

Appendix I: Brittany Stewart MS Project Report, “Development of a Multimodal Course”

UNIVERSITY OF KENTUCKY

Multimodal Transportation

Development of a Multimodal Course

Brittany Stewart

7/22/2013

Table of Contents

Introduction

Today the country's economy is in a constant state of change. Every day industries are seeing consumer demand and are having to change their ways to stay afloat. The world of transportation is no different. In fact, transportation has seen some of the biggest changes in recent years. Fuel prices are continually on the rise with no end in sight and the going green movement is a growing concern. Looking at the trends of the transportation industry, the demands of today have taken a toll and major shifts in the industry have occurred. The industry is no longer a one man show and trucking, a dominate freight transporter, is looking to other modes of transportation for help. Other modes of transportation such as rail, water and air have stepped up to the plate and have taken a more prominent role in freight transportation. If this trend continues the country can expect to see all modes of transportation contributing to the movement of freight. It is for this reason that it has become increasingly important to improve and update the information available on multimodal transportation. Before, educational programs were focused mostly on highway motor transportation but now all modes of transportation need equal representation.

This report provides an introduction into multimodal transportation, various modes of transportation, and insight into how the industries are working together and benefitting each other. Each section is dedicated to one mode of transportation and topics will include an introductory background, engineering design basics, and intermodal aspects. This report along with its accompanying power points and outlines may act as an educational tool that can potentially be used in a classroom setting. In the long term, a multimodal course such as this will have numerous applications and can act as an enhancement to any existing transportation curriculum.

Highway Motor Transportation

History

The motor carrier history started in WWI when converted automobiles were used for pickup and delivery in local areas. At the time, the growth was encourages by the railroad industry because they had difficulty with small shipments over short distances. By WWII the rail industry began to try to compete with trucking but it was too late. Trucking had already become the most popular form of transportation in the country. Between 1950 and 1980 trucks replaced rail. In 1950, rail moved 1.4 billion tons of freight while trucks only moved 800 million. By 1980 trucks moved 2 billion tons of freight while rail only moved 1.6 billion.

The industry became regulated in 1935 under the Motor Carrier Act of 1935. At this time the Interstate Commerce Commission (ICC) had control of the trucking industry. The ICC required carriers to file rates (tariffs) and new truckers had to receive certificate to for entry. While ICC controlled the industry, rates and competition was regulated throughout the industry.

In 1956, Eisenhower signed a bill to establish the National System of Interstate and Defense Highways (Interstate System) to connect major cities. The Federal-Aid Act funding and encourages the project. The Act called for nationwide standards for design of the system, increased the length of the system to 41,000, and gave the federal government 90% of the cost. The Highway Revenue Act was also passed to create the Highway Trust Fund. The fund consisted of revenue from federal gas tax and other motor vehicle taxes. The revenue was used to pay the federal government's share of interstate and other federal-aid projects.

The industry became partially deregulated in 1980 under the Motor Carrier Act of 1980. The ICC no longer had full control over the industry. Without the ICC, carriers could enter the industry easier and this resulted in a significant increase of carriers. The act also eliminated many restrictions on the commodities that were carried. The act served to increase competition and allowed carriers to set their rates based on the market.

Types of Carriers

There are primarily two types of carriers in the industry: For-hire and private. For-hire carriers offer a public service and charge a fee. There are several different types of for-hire carriers which include local, intercity, exempt, common, contract, truckload, and less-than-truckload carriers. Local carriers pickup and deliver freight within the city zones. Intercity carriers operate in between city zones and often work with local carriers to pickup and deliver in city zones. Exempt carriers are exempt from economic regulations. Whether or not a carrier is exempt is determined by the type of commodity or the nature of its operation. For these carriers the rates, service provided, and number of vehicles is determined by the market it is in. Common carriers are required to serve the general public and at a reasonable rate. Contract carriers work under contract for specific shippers. Truckload carriers have a volume that meets the minimum weight requirements for a truckload shipment and rate. These carriers will pickup and deliver the same truckload. Less-than-truck load carriers have a volume lower than the minimum requirement. Smaller shipments are consolidated into truckload quantities for line haul/intercity movement then they are separated again for delivery.

Private carriers provided a service to an industry or company that owns or lease the vehicles. These carriers do not charge a fee. The Motor Carrier Act of 1980 eased the entry requirements for private carriers and allowed private carriers to transport some commodities as a for-hire. Under these circumstances, the private carrier would be treated as an exempt for-hire carrier.

Motor carriers are classified as well based on their annual gross operating revenues.

Class I	$10 million or greater
Class II	$3-10 million

Class III	Less than $3 million

Low Startup Fees

Trucking is the easiest industry for a carrier to enter. To start carriers only need $5,000-$10,000. There are many small carriers or Class III's which account for the significant growth after deregulation in 1980. Class I and II have to invest more because their companies are larger and require more trucks and terminals. Therefore, entry into the industry is more limited than the Class III. Less-than-truckload carriers have a higher startup fee than truckload carriers because they require more terminals to separate and consolidate shipments.

Commodities

Trucking accounts for almost all of the transportation for sheep, lambs, cattle, and hogs to stockyards. Trucks also transport many food products, manufactured products, consumer good and industrial goods. A much smaller amount of grains, motor vehicles and equipment, paper and allied products is transported because these items usually require long distance hauls and have larger quantities. Rail and water is more common for these commodities.

Competition

Competition and rivalry between carriers is very common in the trucking industry. A low entry fee, freedom to enter, and discounting services have made it easy for individual truckers to compete with larger carriers. The industry is market driven meaning the carriers are forced to meet demand and consumers needs. Smaller for-hire carriers are capable of giving individual attention while larger carriers are more limited.

Competition between modes plays a role when large quantities of commodities are to be transported over long distances. For example, the relationship between rail and truck is shown below.

30,000-60,000 pounds hauled less than 300 miles→truck

90,000 pounds or more hauled more than 100 miles→rail

In between these ranges → rail and truck compete

Advantages

There are several advantages to highway transportation which include accessibility, speed, no constraints, small capacity, smooth ride, and it is consumer market oriented. Trucks can travel anywhere that a customer needs as long as there is a road. Trucks will work with other modes to provide a link to the final destination of the goods. With the highway system trucks can travel efficiently and products can be delivered form the truck eliminating delays from loading/unloading. Unlike other modes, trucks do not have to pay fees to drive on or cross a highway. Trucks are also ideal for consumer who have smaller shipments and want more frequent service. Other modes require much higher minimum shipping weights as shown below.

Minimum Shipping Weights by Mode:

Truck	25,000-30,000 pounds
Rail Car	40,000-60,000 pounds
Barge	hundreds of thousands of tons

Trucks also offer a smooth ride which can lower the chance of damaged good. Lastly, the industry is dictated by the consumers market. The trucks have to be responsive the consumers needs to stay in business.

Vehicle Types

There are three different types of vehicles: Line-haul, city trucks, and special trucks. Line-haul trucks are used to haul freight long distances between cities. These trucks are usually a truck trailer combo of three or more axles. City trucks are smaller than line-haul trucks and are units 20 to 25 feet long with a cargo unit 15 to 20 feet long. Trailers 20 to 28 feet long are sometimes used to deliver freight in the city. Special vehicles are designed to meet shipper's needs. These trucks can be subject to special regulations such as the number of lights on the vehicles, brakes used, tire specifications, and allowable length and/or height. The different special vehicles are listed below.

Dry van-standard trailer or truck with all sides enclosed
Open top-trailer open for odd-sized freight
Flatbed-no top or sides and usually used to haul steel
Tank Trailer-liquids and petroleum products
Refrigerated vehicles-controlled temperature
High cube-higher than normal to increase cubic capacity
Special-unique design to carry a specific product

Terminals

There are three types of truck terminals: pickup and delivery, bulk-break, and relay terminals. Pickup and delivery terminals are where freight is collected from shippers and consolidated with loads going in same direction or same destination. Shipments are line-hauled to the terminal then the load is separated and loaded onto city trucks for delivery. These terminals are also used to change shipments from one carrier to another carrier when needed. This might be necessary when a carrier does not have the authority to deliver a shipment to its final destination. Functions of this type of terminal include sales, billing, claim handling, and some limited vehicle maintenance. Break-bulk terminals are used to separate combined shipments from consolidated truckloads that arrive from pick up terminals. Here freight is unloaded and sorted by destination and reloaded for dispatch to destination. Break-bulk terminals are usually centrally located and at juncture of highways. At relay terminals one driver is substituted for another who has accumulated the maximum hours of service necessary under DOT. The regulations for drivers are shown below.

Driver Hour Regulations:

Drive maximum of 10 hours after 8 consecutive hours off duty
On duty maximum of 15 hours after 8 consecutive hours off duty
No driver can drive after 60 hours on duty in 7 consecutive days
No driver can drive after 70 hours on duty in 8 consecutive days

Cost Structure

The trucking industry costs are mostly contributed to variable costs, about 70-90%. Variable costs include fuel, wages, and maintenance with fuel and labor accounting for the majority. Labor costs about 50% of the carriers revenue meaning 50 cents of every dollar earned goes to labor costs. For intercity carriers, drivers are usually paid by the mileage driven. As long as fuel prices continue to rise, fuel costs will continue to be a major portion of the variable cost. Fixed costs are low because of the high amount of public investment in the highway system. The startup fees for carriers are low and carriers can easily adjust the number of vehicles available.

Operating Ratio

$$operating\ ratio = \frac{operating\ expenses}{operating\ revenues} x100$$

The equation above is used to measure the operating efficiency of a carrier. The closer the ratio is to 100, the higher the need to raise rates to generate more revenue. For example, 94% means 94 cents of every dollar goes to expenses. The operating ratio for a carrier is usually between 93 and 96%. If the ratio is more than 100, there is no revenue being made.

Funding

Funding for construction, maintenance, and policing of highways is paid by highway user taxes (truck and automobile drivers). The Federal Highway Trust Fund required the federal government to pay for 90% of construction costs for the interstate system and 50% for all other federal-aid costs. State taxes are collected from fuel tax (cents per gallon), vehicle registration fees, ton-mile taxes, and special use permits.

Issues

Safety is an issue with highway transportation. This included road hazards and driver safety. Highway and road improvements are a vital part in keeping the interstate safe for travel. Improved safety on the roads means higher profits and less expensive claims for lost/damaged goods, increases in insurance rates, accidents, and fines. Drivers are required to complete drug testing and training programs to insure safety. New technology is also important for continuing to improve safety and with today's technology and social media truckers can stay in touch more than ever before. Trucking companies and associations are now making a point to explore how social media apps and technology can be incorporated into the industry. Satellites are now being used to pin point the exact location of trucks throughout the movement from origin to destination. Drivers can be rerouted for poor weather and/or road conditions. With the movement of hazardous goods, the movement can be monitored and carriers can have a quick reaction to accidents or spills.

Federal Motor Carrier Safety Administration (FMCSA)

The FMCSA was established January 1, 2000 under the Motor Carrier Safety Improvement Act of 1999. The mission of the FMCSA is to "prevent commercial motor vehicle-related fatalities and injuries." Activities performed by the FMCSA are the following:

- Enforcement of safety regulations
- Targeting high-risk carriers and commercial motor carriers
- Improving safety information systems and technologies
- Strengthening equipment and operating standards
- Increasing safety awareness

American Trucking Association (ATA)

The ATA was established in 1933 when the American Highway Freight Association and the Federation Trucking Associations of America came together to form ATA.
"The mission of the American Trucking Associations, Inc., is:

- to serve and represent the interests of the trucking industry with one united voice;
- to influence in a positive manner Federal and State governmental actions;
- to advance the trucking industry's image, efficiency, competitiveness, and profitability;
- to provide educational programs and industry research;
- to promote safety and security on our nation's highways and among our drivers; and
- to strive for a healthy business environment."

Kentucky's Highways

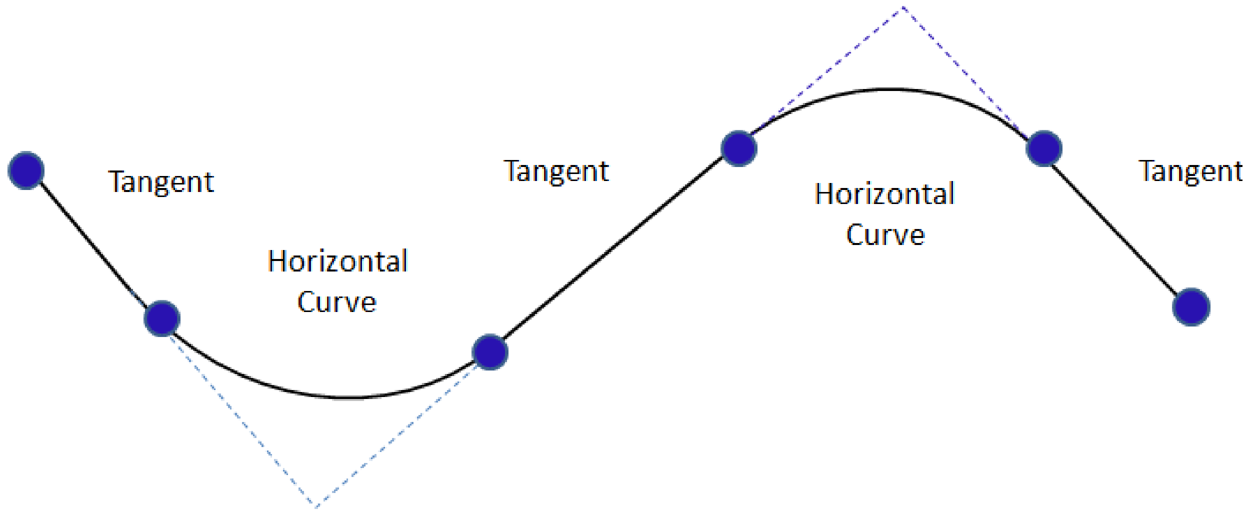
Kentucky's highway network consists of 78, 913 miles of public roads and streets, 9 interstate highways, and 10 state parkways. Highway transportation accounts for 73% through state, 28% out of state, and 38% in state of the shipments of freight by tonnage.

Highway Design Basics

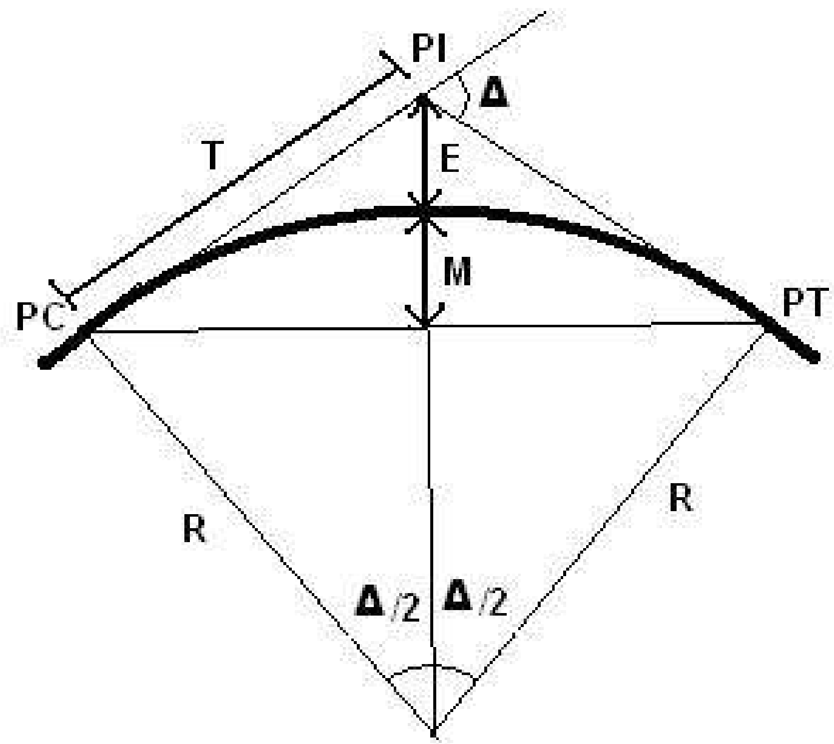
When designing a roadway there are several different criteria designers must take into consideration. Every road is different and will serve a variety of purposes. It is important that designers keep this in mind when taking on a new project. Things to consider include but are not limited to: type of roadway, functional class, design speed, design vehicle, traffic characteristics, terrain, scope of work, and funding. This type of criteria will play a major role in the design criteria and approach used in the designing process.

Roadways are classified by functional class and whether they are located in a rural or urban area. Roadway's can be defined as being an arterial, collector, or local road. Arterials include any road that has a main purpose of moving vehicles at high speeds. These roadways generally have high mobility but limited access. Collectors act as a link between arterials and locals. Collectors have moderate mobility and access. Any roadway not already classified as arterial or collector is known as a local. Locals are roadways that provide access to individual properties and houses. Locals have high access and low mobility.

Designing a horizontal alignment is the first step in the roadway alignment design process. A horizontal alignment is the horizontal curvature of a roadway and is made up of horizontal curves connected by tangents. The picture below shows an example of a horizontal alignment.



As seen in the picture, alignments consist of horizontal curves. The size and location of these curves depend on the design criteria of the roadway. A depiction of a horizontal curve and its components are shown below.



Point of Curvature, PC

Point of Intersection, PI

13

Point of Tangency, PT

Radius, R

Tangent, T

Chord, C

Interior Angle, Δ

Middle Ordinate, M

External Distance, E

Each of the components shown above are related and can be calculated by the equations below.

$$\text{Sta PC} = \text{Sta PI} - T$$

$$\text{Sta PT} = \text{Sta PC} + L$$

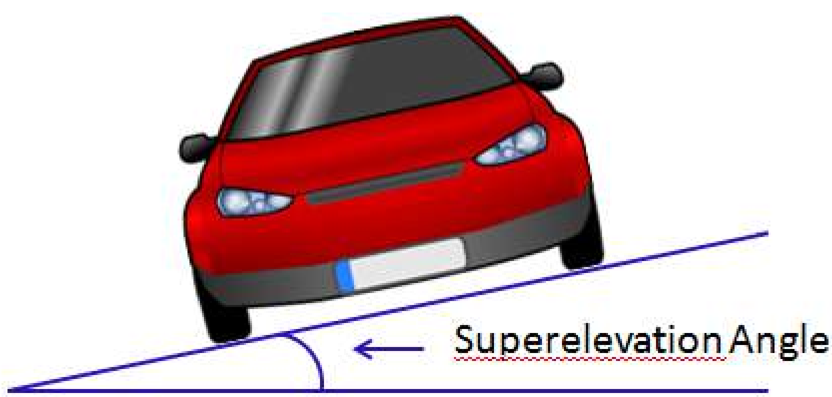
$$L = \pi R \Delta / 180$$

$$C = 2R\sin(\Delta/2)$$

$$T = R\tan(\Delta/2)$$

$$M = R[1-\cos(\Delta/2)]$$

Another design aspect to consider when designing the horizontal alignment is superelevation. Superelevation can be defined as the slope of pavement necessary to keep vehicles on the road. An exaggerated example of this is the design of NASCAR race tracks. Since racecars travel at an extremely high rate of speed, the turns of the track are designed with large superelevation angles.

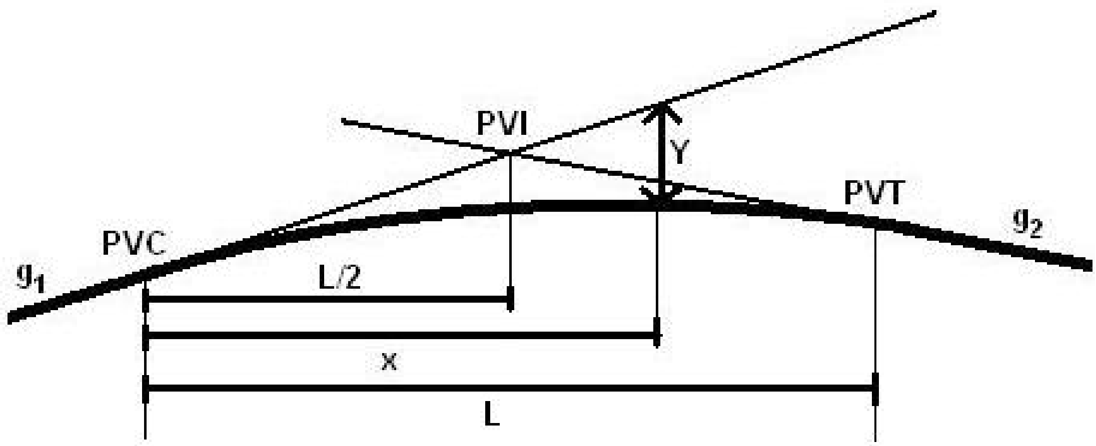


The equation for superelevation is provided below.

$$e+f_s = V^2/(15R)$$

e= superelevation rate
f_s= coefficient of side friction
V=design speed, mph
R=Radius

After a horizontal alignment is established, a vertical alignment can now be designed. Vertical alignments are much like horizontals in that they consist of curves and tangents. The difference being vertical tangents are at vertical grades and curves are parabolas. There are two types of vertical curves: sag and crest. The components of a curve are depicted and defined below.



Beginning of Curve, PVC

Vertex/Intersection, PVI

End of Curve, PVT

Vertical Grade, g

Length of Curve, L

Like horizontal curves, components of vertical curves are related and the equations are given below.

Sta PVC = Sta PVI – L/2

HPVC = HPVI – g1*L/2

Sta PVT = Sta PVI + L/2

$$HPVT = HPVI + g2*L/2$$

Minimum Curve Lengths

	Crest	Sag
SSD<L	**$A*SSD^2/2158$**	**$A*SSD^2/(400+3.5SSD)$**
SSD>L	**2SSD-(2158/A)**	**2SSD-(400+3.5SSD)/A**

**A=|g2-g1|*100 (%)

**SSD: Stopping Sight Distance

When designing both the horizontal and vertical alignments the designer must also keep in mind the needs of the driver. The most critical criteria being sight distance. Sight distance is the length of roadway that is visible to the driver. When taking this into consideration the designer will look at both stopping sight distance and passing sight distance. Stopping sight distance is the distance needed for a vehicle traveling at the design speed to come to a stop. Passing sight distance is the distance required for a vehicle traveling at design speed to safely pass another vehicle.

$$\mathbf{SSD = 1.47Vt_r + V^2/[30(a/32.2+G)]}$$

SSD : Stopping Sight Distance (ft)

V : Vehicle speed (mph)

t_r :driver reaction time, usually 2.5 sec

a : deceleration rate (ft/s^2)

G : grade

All design criteria for the designing process is based off of AASHTO's highway design manual also known as the green book. This manual is a regularly updated reference manual that is used by designers and engineers to design various components of a roadway. As mentioned in the manual's foreword, this book is a guide and as engineer and designers it is up to them to make decisions accordingly.

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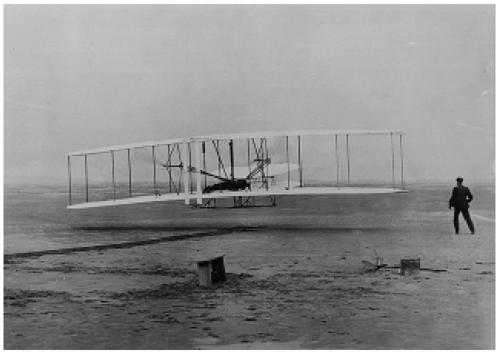
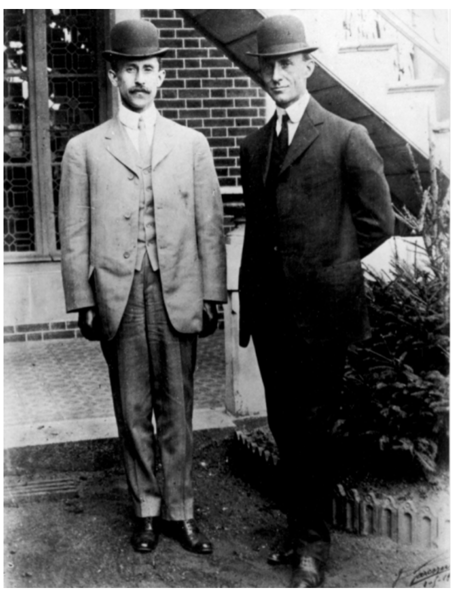


Air Transportation

History and Overview

On December 17, 1903, Wilbur and Orville Wright made their first flight. The brothers later sold their invention to the federal government and the first practical plane was built in 1905. The flight, which only lasted 12 seconds, marked the beginning of air transportation. In 1908, the U.S. Post Office showed an interest in starting as air mail service and during WWI aircraft proved to be a useful tool as a military tool. WWI along with the U.S. Post Office jump started interest and development of the air transportation industry.



Air transportation is a valuable transportation made in terms of distance and speed. The speed at which a plane can travel as well as the industries competitive pricing led to the growth of the industry. Passenger service in the industry started as a by-product of the mail service. Passenger movement by air is ideal for long distances when time is a factor. The industry is dominated by passenger revenue and freight movement is limited. However, freight movement by air is ideal for high-value goods, perishable goods, and in emergency situations.

Legislative Acts

Air Commerce Act of 1926

This act was the first federal law passed for the air industry. The general purpose of this first act was to encourage and aid the growth of aviation in the country. Under this act all aircraft was to be registered, aircraft and airmen were to be certified, air traffic rules were established by the Secretary of Commerce, and the Secretary of Commerce established, operated, and maintained lighted civil airways. The rates were regulated by the Interstate Commerce Commission (ICC). Registration and certification were to be handled by the Bureau of Air Commerce.

Civil Aeronautics Act of 1938

This act created and transferred authority to the Civil Aeronautics Authority and regulated air rates and routes. This agency was later split into two separate agencies: the Civil Aeronautics Board (CAB) and the Civil Aeronautics Administration (CAA). The CAB was responsible for the regulation of rates, safety rule-making, and accident regulation. The CAA was responsible for traffic control, safety programs, and airway development.

Federal Airport Act of 1946

This act was passed to develop and improve airway facilities. Under this act the CAA was given the task of administering a Federal Aid Airport Program which provided annual funds for airport construction and improvements. In order to receive aid the proposed projects had to be approved by the CAA.

Federal Aviation Act of 1958

The Federal Aviation Administration (FAA) was created and replaced the CAA. The CAB remained but its safety rule-making responsibilities were transferred to the FAA.

Airport and Airway Development Act of 1970

As the air industry grew, the demand for more airports and funding grew and the federal aid under the Federal Airport Act of 1946 did not meet this demand. In response to this growing demand, the Airport and Airway Development Act was passed to meet funding needs. This act created the Airport and Airway Trust Fund and established aviation taxes.

Airline Deregulation Act of 1978

This act removed government control over rates, routes, and carrier entry into the industry. The CAB, which regulated these criteria, was to be abolished by 1985. The purpose of the act was to increase competition and decrease the federal control on the industry.

The Airport and Airway Improvement Act of 1982

This act, like the Airport and Airway Development Act of 1970, was passed to increase funding for airport construction and improvement under a program called the Airport Improvement Program (AIP). The act increased the funding to more than $14 billion for the period from 1982 to 1992.

The Aviation Safety and Capacity Act of 1990

This act established the passenger facility charge (PFC). The PFC program allowed airports to impose a charge to every passenger. The revenues from the PFC could be spent by that airport on any project approved by the FAA. This allowed larger airports to still have funding while also leaving larger amounts of AIP funding to be spent at smaller airports that needed it most.

AIR-21: The Wendell Ford Aviation Investment Act for the 21st Century

In 2000, airport funding was increased with the Wendell H. Ford Aviation Investment Act. The funding was specifically for highly congested and large airports and to help smaller airports preserve commercial air service.

The Aviation and Transportation Security Act of 2001

This act was passed in response to the terrorists acts on September 11, 2001. The act created the Transportation Security Administration (TSA). The TSA established requirements for passenger and luggage screening. Funding for the new policies and the TSA came from a surcharge that is collected through ticket purchases. This act, along with the new security requirements, greatly impacted the design and layout of airports. It is for this reason, that funds collected also went to airport development and improvement to accommodate new security procedures.

Vision 100 Century of Aviation Act of 2003

AIP was reauthorized in 2003 by this act. Annual AIP increased up to $3.7 billion by 2007. AIP and PFC funds were broadened to include airport improvements with an environmental benefit, fund debt-service to projects funded by bonds, and to attract air service to airports that were underused.

Deregulation

Deregulation of the air industry began with the passing of the Airline Deregulation Act of 1978. The act eliminated economic regulation of the industry and intended to increase competition in the industry. The act also eliminated the Civil Aeronautics Board (CAB) by 1985. The CAB was responsible for regulated rates, routes, and carrier entry into the industry. After deregulation, the industry saw an increase in the number of carriers, increase in competition, increase in markets, and lower airfares. Without the CAB, air carriers could freely enter and set their own schedule and rates.

Types of Carriers

There are two types of carriers in the air industry: private and for-hire. Private carriers are firms that transport personnel or fright in planes that it either owns or leases. Private carriers are subject to safety regulations by the Federal Aviation Administration and are sometimes used to transport emergency freight.

For-hire carriers are non-scheduled, on demand carriers that are not privately owned. For-hire carriers are divided up and divided into three revenue classes by their annual revenue as shown below.

Majors – annual revenue of more than $1 billion

Nationals – annual revenue of $75 million to $1 billion

Regionals – annual revenue of less than $75 million

Majors are usually high capacity planes that operate in high-density corridors and provide a service between major cities and/or populated areas. Some examples would be Delta, United, USAir, and American.

Nationals are usually smaller planes and operate between less populated areas and major cities. These carriers provide a link for passengers in outlying areas to airports in major cities. A few examples would be Southwest Airlines and America West.

Regionals operate within a specific region of the country (Midwest, New England) and connect less populated areas to larger cities. Regionals have two categories: large ($10-75 million) and medium (less than $10 million). Some examples would be North American, Aspen, and Sun Country.

For-hire carriers have several different types: all-cargo carrier, commuters, and charters. All-cargo carriers transport primarily cargo. All-cargo carriers were deregulated in 1977. This allowed all-cargo carriers to set rates and routes. Cargo pricing is usual dependent on weight. They were also allowed to any use any size plane dictated by their market. A few examples are FedEx and UPS. Commuters are regional and work with other carriers to connect small communities with little or no air service to communities with better service. Charters are larger planes that are used to transport people are freight. A major customer for charters is the Department of Defense to transport personnel and supplies. However, there was a decrease in charters after the Vietnam War.

Competition

The air industry has very little intermodal competition but has a lot of intramodal competition. Competition with other modes is so small because of the fact that air offers a unique service. The limited intermodal competition comes from automobiles for passenger service. The air carriers can be very competition with each other which accounts for the intramodal competition. This competition has significantly increased since deregulation since more carriers freely entered the industry. As competition increased, carriers began to experience excess capacity on flights. As a result, rates were discounted and lowered to fill empty seats. Even though operating costs have increased, carriers have continued to lower prices to fill seats and this has forced some carriers to go out of business. Competing carriers also compete for flight times. The most popular/frequent being 7-10 am and 4-6 pm.

There has been an increase in freight traffic in recent years to fill the excess volume caused by competition and increase plane volume. With this increase there has been some cargo competition. These carriers work with truck carriers to overcome limited accessibility and to provide a door to door service. Freight carried is considered high value or emergency shipments and may include mail, high-priced livestock, race horses, jewelry, and expensive automobiles. Items not carried include basic raw materials such as coal, lumber, iron ore, or steel.

Terminals

Public terminals are financed by the government. To use these terminals carriers pay for use through landing fees, rent and lease payments for space, taxes on fuel, and aircraft registration taxes. The passengers pay taxes on their ticket and pay an air freight charge.

Hub systems are terminals where passengers from lesser populated areas are fed to a hub where connecting flights are available. For an example, Chicago is a hub for United Airlines. Flights from Toledo and Kansas City go here where connecting flights can take passengers to New York, Los Angeles, and Dallas. These hubs are very similar to trucking's break-bulk terminal. Passengers are transported along low-density routes with smaller planes. The planes arrive at a hub where passengers are assigned to larger planes and transported along high-density routes to larger airports/cities.

Basic Terminal Operation:

- Passenger, cargo, and aircraft servicing
- Passengers are ticketed, loaded. Unloaded, and luggage is dispersed and collected
- Cargo is routed to planes or trucks for shipment to destination
- Aircraft servicing includes refueling; loading of passengers, cargo, luggage, and supplies; and maintenance (major maintenance is done at specific airports)

Cost Structure

Most of the cost with air transportation can be contributed to variable costs. Variable costs include flying operations, maintenance, general services and administration (passenger service, aircraft and traffic servicing, promotion and sales, and administrative), and depreciation. There fixed costs are low because the government (state and local) invest in and operate airports and airways. The carriers pay for use of these facilities which is considered a variable cost. Labor costs account for about a third of the total cost and includes the payment of pilots, co-pilots, navigators, flight attendants, office personnel, and management. Union workers are usual paid more and pilot wages depend on their experience and equipment rating (size of plane). Fuel is a major factor in the industry cost. As fuel cost continue to increase there has been an increasing demand for more efficient planes. Some routes have been eliminated or planes have been downsized because they were not cost effective. The increase in competition has forced airlines to operate more efficiently by cutting costs where possible and to decrease labor costs since airlines tend to be more labor intensive.

Load Factor

$$Load\ Factor = \frac{Number\ of\ Passengers}{Total\ number\ of\ Seats} x100$$

The equation above is used to measure the percentage of a plane's capacity that is utilized. Usually the load factor is 62-65%. The type of plane (capacity), route, price, service level, and competition can affect the load factor. The load factor has increased in recent years in an effort to use freight to fill excess plane volume.

Issues

Even though air transportation is fast and reliable, there are a few issues the industry faces. Safety has become a major issue ever since September 11th and the air industry has made it a priority to make air travel safe for its passengers. New security regulations and procedures have made it safer but safety improvements and new regulations are always possible in the future. Technology is another issue and air is dependent on new technology to make air travel safer, efficient, and more cost effective. Air transportation is often described as expensive and rising costs of fuel, equipment, and safety procedures will continue to make air the most expensive mode of transportation. Air has also been forced to look to other modes to overcome accessibility problems. Teaming up with trucking, rail, and water gives customers the option to have a door to door service which they cannot have with air transportation alone.

UPS

UPS was founded on August 28, 1907 and has become the world's largest package delivery company. UPS was the first to offer air service on privately operated lines in 1929. Due to a low volume and the Great Depression the service ended the same year but was resumed in 1953. UPS was the fastest growing airline in FAA history and is one of the 10 largest airlines in the United States today. The main US Air Hub began operation in 1982 and is located in Louisville, KY.

UPS's Jet aircraft fleet consists of 226 planes, Chartered Aircraft consists of 292 planes, and it serves 382 domestic airports and 323 international airports.

Kentucky Air

Kentucky's airway network consists of 62 regional or local airports and has 6 major airports. Over 13.1 billion pounds of freight is handled annually by the airways. Airways account for less than 1% through state, in state, and out of state of the shipments of freight by tonnage.

Kentucky UNBRIDLED SPIRIT™

	City
Air Carrier Ports	
Barkley Regional	Paducah
Blue Grass Airport	Lexington
Cincinnati/Northern Kentucky International	Hebron
Lake Cumberland Regional	Somerset
Louisville International-Standiford Field	Louisville
Owensboro-Daviess County Regional	Owensboro
General Aviation Airports	
Addington Field	Elizabethtown
Ashland Regional	Worthington
Bardstown-Nelson County-Samual Field	Bardstown
Big Sandy Regional	Debord
Bowling Green-warren County Regional	Bowling Green
Bowman Field	Louisville
Breckinridge County	Hardinsburg
Capital City	Frankfort
Columbia-Adair County	Columbia
Cynthiana-Harrison County	Cynthiana
Falmouth-Pendleton County	Falmouth
Fleming County-Mason County	Maysville
Fulton	Fulton
Georgetown-Scott County Regional	Georgetown
Glasgow Municipal	Glasgow
Grayson County	Leitchfield
Hancock County	Lewisport
Henderson City-County	Henderson
Hopkinsville-Christian County	Hopkinsville
Julian Carroll (Jackson/Breathitt County)	Jackson
Kentucky Dam Lake State Park	Gilbertsville
Kyle-Oakley Field	Murray
Lake Barkley State Park	Cadiz
Lake Cumberland Regional	Somerset
Lebanon-Springfield	Springfield
Leitchfield-Grayson County	Leitchfield
London-Corbin Airport Magee Field	London
Madison County/Richmond	Richmond
Madisonville Municipal	Madisonville
Marion-Crittenden County	Marion

Mayfield-Graves County	Mayfield
McCreary County	Pine Knot
Middlesboro-Bell County	Middlesboro
Morehead-Rowan County	Morehead
Mt. Sterling-Montgomery County	Mt. Sterling
Muhlenburg County	Greenville
Ohio County	Hatfort
Owensboro-Daviess County Regional	Owensboro
Pike County - Hatcher Field	Pikeville
Princeton-Caldwell County	Princeton
Providence-Wester County	Providence
Rough River State Park	Falls of Rough
Russell County	Jamestown
Russellville-Logan County	Russellville
Samuels Field	Bardstown
Stanton-Powell County	Stanton
Stuart Powell Field	Danville
Sturgis Municipal	Sturgis
Taylor County	Campbellsville
Tompkinsville-Monroe County	Tompkinsville
Tradewater	Dawson Springs
Tucker-Guthrie Memorial	Baxter
Wayne County	Monticello
Wendell H. Ford Regional	Hazard
West Liberty	West Liberty
Williamsburg-Whitley County	Williamsburg

Airport Design Basics

The design and planning of airport facilities is an extremely detailed and lengthy process. A number of factors must be taken into consideration and researched thoroughly before an airport can be designed. Everything from the most obvious details to the less obvious details, such as sound pollution and air obstructions, will come into play during the design process. Some of the important design criteria planners must consider are listed below.

- Type of airport
- Critical aircraft
- Capacity

- Environment
- Location
- Runway length
- Runway orientation
- Terminal design
- Airspace

A critical step in the design process is the design and calculation of the runway length. When determining the necessary runway length, designers must know the critical aircraft (most frequent), environment of the site (temperature, wind patterns, runway surface, altitude), and the government requirements. Three methods are used to calculate the required runway length: using government regulations, by considering environmental factors, and designing for the critical aircraft specifications.

To calculate the required runway length by governmental standards the designer must look at standards from the Federal Aviation Regulations, or FAR. The FAR examines three scenarios a runway might see:

1) Normal Takeoff
2) Engine-failure Takeoff: runway length required for an aircraft to takeoff safely after engine failure
3) Engine-failure Aborted Takeoff: runway length required for to accommodate landing after an engine failure

For calculation, the runway is broken down into sections. A figure and definitions needed for this method are shown below.

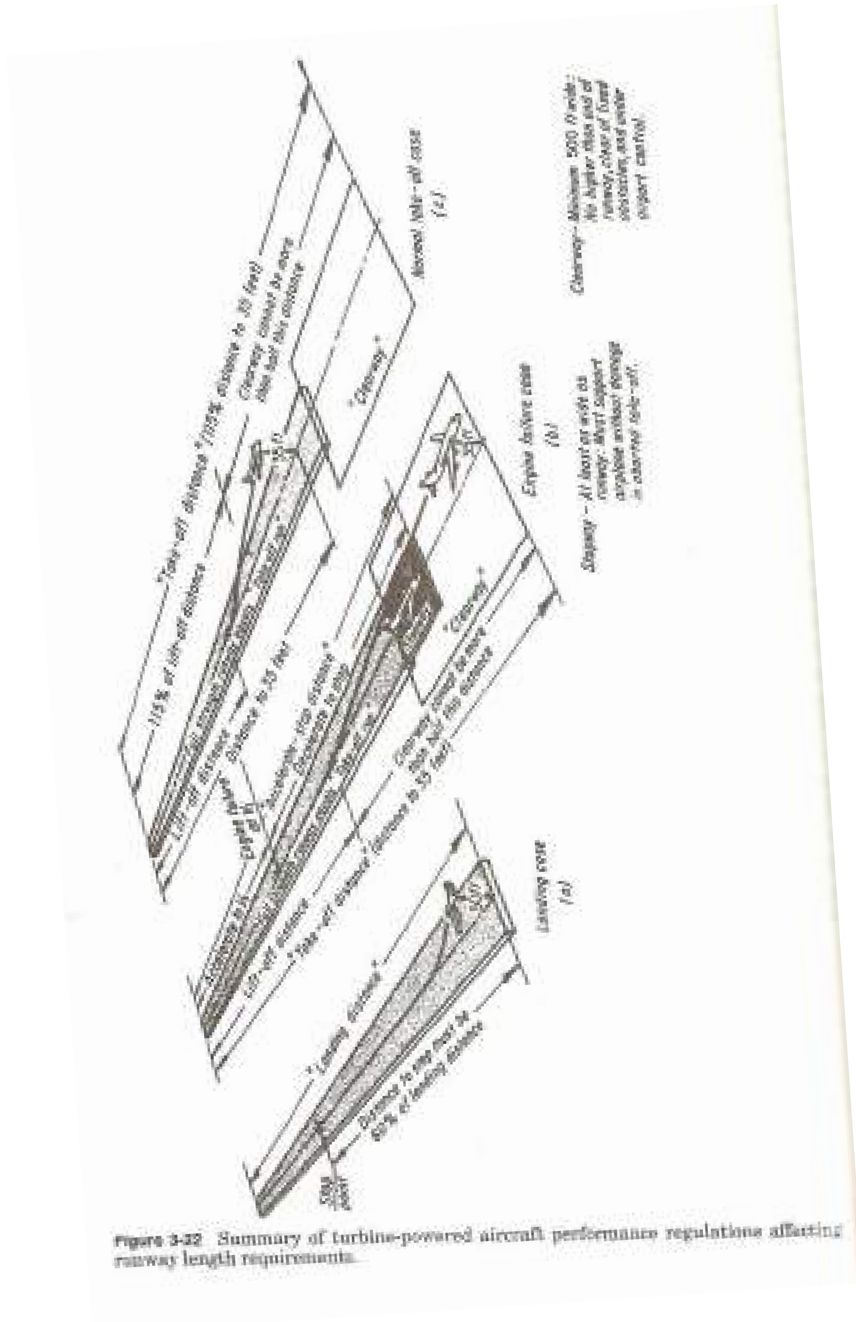


Figure 3-22 Summary of turbine-powered aircraft performance regulations affecting runway length requirements.

[Source: Horonjeff, Robert, and Francis X. McKelvey. Planning and Design of Airports. 4th ed. New York: McGraw-Hill, 1994. Print.]

Landing distance, LD

Stop distance, SD

Takeoff distance, TOD

Liftoff distance, LOD

Takeoff run, TOR

Accelerate-stop distance, DAS

Field length, FL

Full-strength pavement, FS

Clearway, CL

Stopway, SW

Distance to 35 ft, D35

Each of the distances/sections listed above can be calculated by using a set of equations from FAR. Using these equations, the required lengths can be calculated for the three takeoff cases as well as a normal landing case. By doing so, the overall required field length, full-strength pavement length, clearway length, and stopway length can be determined. The equations used for this method can be found below.

<u>Normal Takeoff</u>

$$FL_1=FS_1+CL_{1max}$$

Where

$$TOD_1=1.15(D35_1)$$

$$CL_{1max}=0.50[TOD_1- 1.15(LOD_1)]$$

$$TOR_1=TOD_1-CL_{1max}$$

$$FS_1=TOR_1$$

Engine-failure Takeoff

$$FL_2=FS_2+CL_{2max}$$

Where

$$TOD_2=1.15(D35_2)$$

$$CL_{2max}=0.50[TOD_2- (LOD_2)]$$

$$TOR_2=TOD_2-CL_2max$$

$$FS_2=TOR_2$$

Engine-failure Aborted Takeoff

$$FL_3=FS+SW$$

Where

$$FL_3=DAS$$

$$FL_3=LD$$

Landing

$$FL_4=LD$$

Where

$$LD=SD/0.60$$

$$FS_4=LD$$

Required Length

$$FL=max(TOD_1,TOD_2,DAS,LD)$$

$$FS=max(TOR_1,TOR_2,LD)$$

$$SW=DAS-max(TOR_1,TOR_2,LD) \qquad *SW_{min}=0$$

$$CL=min(FL-DAS,CL_{1max},CL_{2max})$$

$$*CL_{min}=0,\ CL_{max}=1000ft$$

The critical aircraft for an airport will play a major role in determining the design of the runway. Aircraft manufacturers publish data and specifications on aircraft landing/takeoff weights and required runway lengths. Another factor to account for is the environmental factors. Any needed adjustments due to temperature, surface wind, runway gradient, altitude, and runway surface must be reflected in the final runway length. The aircraft specifications will provide charts and diagrams that will provide the necessary data needed to determine runway length while taking into account aircraft characteristics, altitude, temperature, and runway surface. This data can be found on the manufacturer's site or at the Federal Aviation Administration.

Airport configuration, or the orientation of runways and the location of terminals, is another step in the airport design process. Much like runway design, the configuration of the airport is a process that can be influenced by many different factors. Wind patterns, area for development, land and/or air restrictions, and airport capacity all affect how and where an airport facility is built. The FAA and FAR regulates the distances required between runways, taxiways, aircraft, and obstructions and each area of the terminal and runway must be designed accordingly. Runway orientation relies heavily on wind patterns and airport capacity. Capacity will determine how many runways are needed and wind patterns will determine the direction the runways will face. The following figure shows a few examples of potential runway orientations.

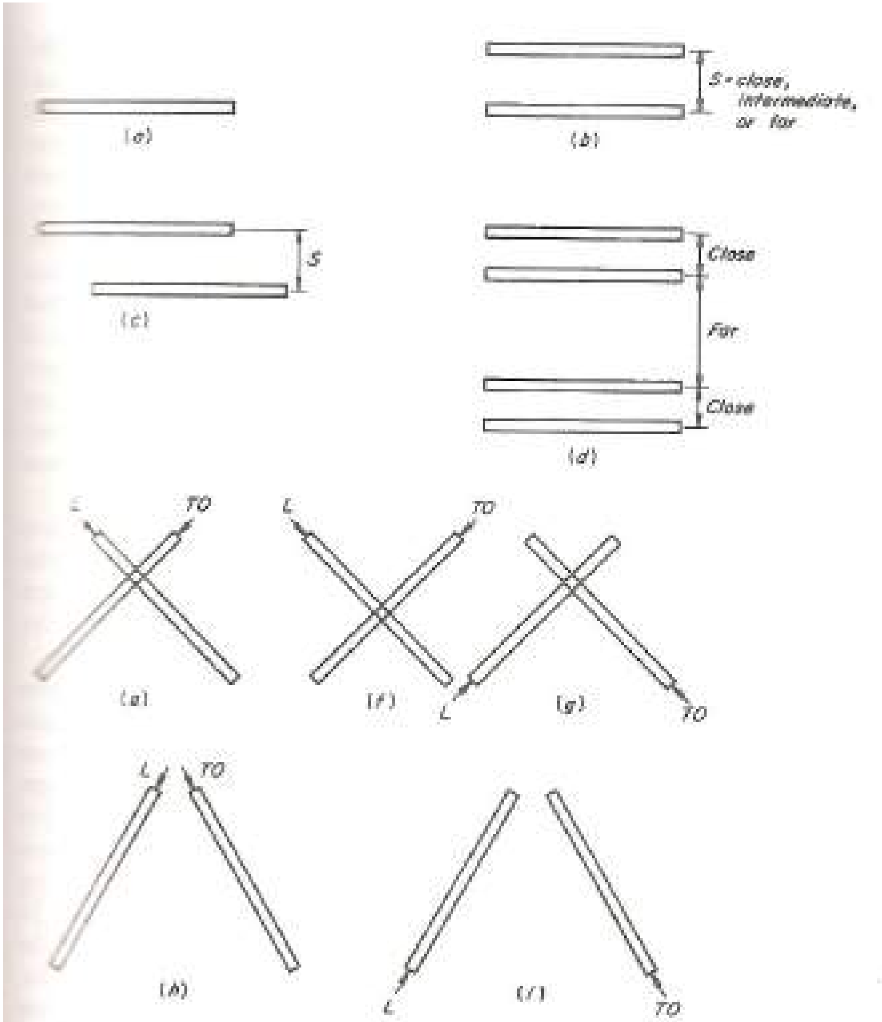


Figure 7-1 Typical runway configurations: (a) Single runway; (b) two parallel runways—even threshold; (c) two parallel runways—staggered threshold; (d) four parallel runways; (e) intersecting runways; (f) intersecting runways; (g) intersecting runways; (h) open-V runways; (i) open-V runways.

[Source: Horonjeff, Robert, and Francis X. McKelvey. Planning and Design of Airports. 4th ed. New York: McGraw-Hill, 1994. Print.]

Another important aspect of the design process is the airspace around the airport. The airspace of an airport resembles an upside down cake and consists of imaginary surfaces that represent the boundary of the airport's airspace. The airspace has 5 surfaces: the primary surface, horizontal surface, conical surface, approach surface, and transitional surface. The surface sizes vary depending on the runway classification. Each surface must be carefully examined to insure that no objects (buildings, trees, power lines, etc) will act as an obstruction to aircraft. A picture of the imaginary surfaces is shown below.

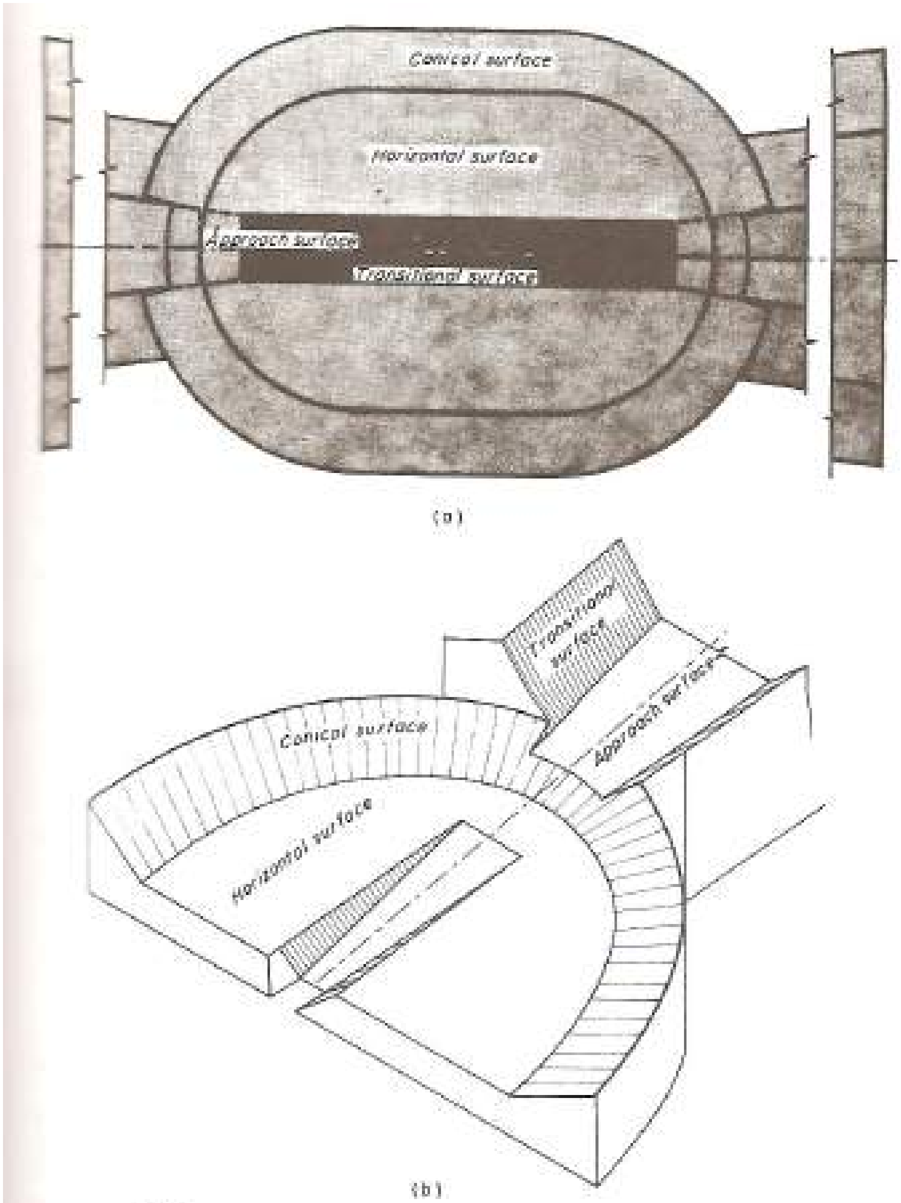


Figure 7-14 FAR part 77 imaginary surfaces: (a) plan view, (b) isometric view. (*Federal Aviation Administration [8]*).

[Source: Horonjeff, Robert, and Francis X. McKelvey. Planning and Design of Airports. 4th ed. New York: McGraw-Hill, 1994. Print.]

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Water Transportation

History and Overview

Water transportation is the earliest form of transportation and played an important role in the development of the United States. Using water routes, early settlers were provided a link to markets in England and Europe. Major cities developed around water ports on the coast because of the transportation available by water. The development and use of inland waterways provided settlements in the new areas and provided a connection to coastal cities.

Water is the most fuel efficient mode of transportation. They often consume more fuel per mile but the water carriers are able to transport more ton-miles of freight than any other mode. The basic commodities transported by water are basic raw dry materials (coal, coke, sand, gravel, stone, logs, and lumber) and liquid products (petroleum and petroleum products). Sometimes high-value products such as electrical equipment and photographic equipment can account for a small percentage. Water competes with rail for the movement of bulk commodities such as grains, coal, ores, and chemicals and competes with pipelines for the movement of bulk petroleum and petroleum products. Infrastructure of waterways is made possible by public aid and is maintained by the Army Corps of Engineers.

US Army Corps of Engineers®

Types of Carriers

Water can be divided into different types of carriers. Private carriers cannot be hired and only transports freight for the company that owns or leases the vessel. For-hire carriers are carriers that charge a fee for their service. Common carriers serve the general public at a reasonable price and contract carriers are under contract to service a company. Internal carriers are carriers that operate over the inland waterways. These carriers usually use barges and towboats and operate over the principal rivers (Mississippi, Ohio, Tennessee, Columbia, and Hudson) and some small arteries. Internal carriers tend to dominate the north-south traffic through the central portion of the United States. Coastal carriers operate along the coasts serving ports on the Atlantic or Pacific oceans of the Gulf of Mexico. Intercoastal carriers transport freight between East Coast and West Coast ports via the Panama Canal.

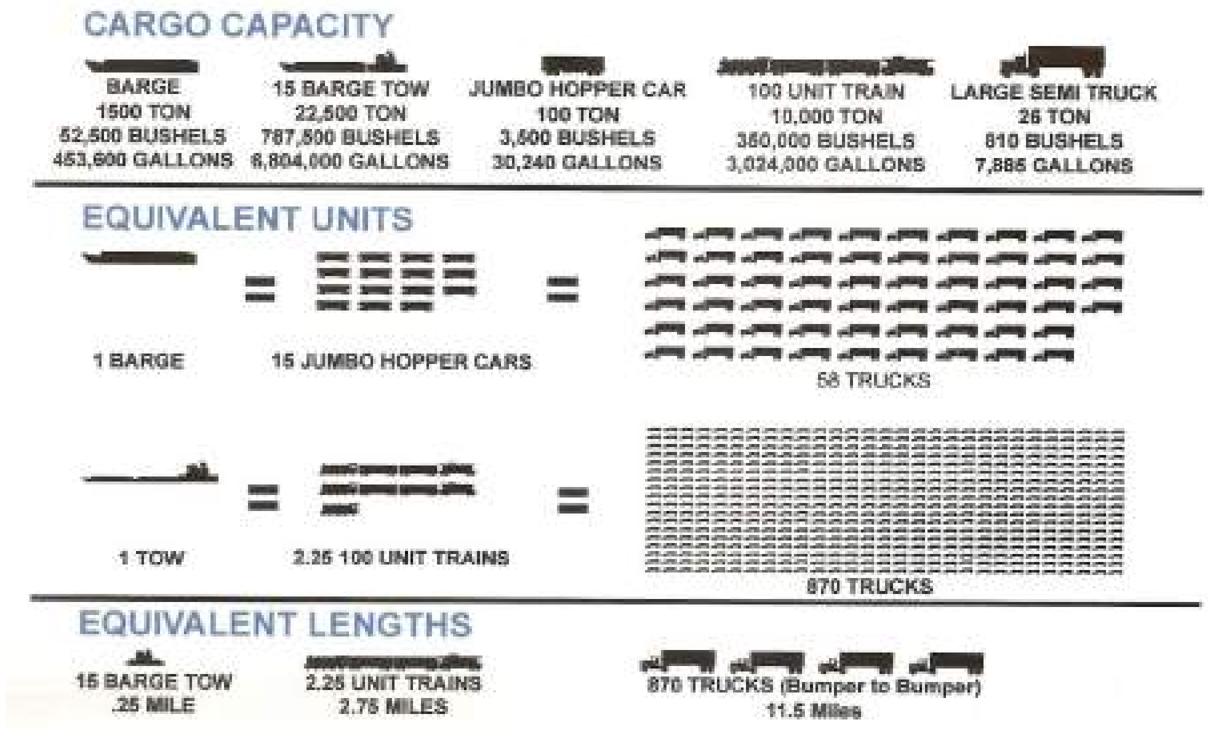
Competition

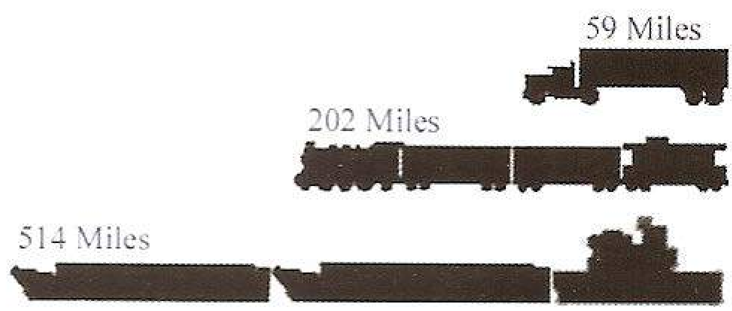
Water tends to compete with other forms of transportation more than it competes with other water carriers. Since the number of carriers in a waterway is limited there is less incentive to compete with one another. Water will compete with rail for dry bulk commodities such as grain, coal, and ores. Water also will compete with pipelines for bulk liquids such as petroleum and petroleum products. Competition with trucks is usually limited since trucks work with water to overcome the accessibility constraints water carriers have.

Load Size

The load size for water carriers vary depending on the type of carrier. The high capacity that water carriers are capable of allows water to operate as a low-cost service.

Barges: up to 3,000 tons, normal capacity of 1,000 to 1,500 tons
Great Lake carriers: 20,000 tons
The capacity of a 1,500 ton barge is equivalent to 15 railcars and 60 trucks.





Number of miles one ton is moved on one gallon of fuel

Disadvantages

There are several disadvantages when considering water as a transportation mode. Water carriers are slow moving and have the longest transit time of all the modes. Their slow speed is a disadvantage but it a major factor to the low cost service water provides. Water also has service disruptions at certain times of the year. During the winter months, icy conditions from December to March limit transportation in Northern waterways. During the summer months, drought conditions in southern waterways result in lower water levels. Inventory costs can also increase during the winter months and users must anticipate these disruptions. They will often increase their inventory shipments months prior to these months to avoid the higher cost. Water has a limited network and has poor accessibility. Truck or rail is often combined with water transportation to overcome this issue. During transport, freight is subject to inclement weather, rough waters, and handling therefore packaging and handling is demanding and can be costly.

Terminals

There are two types of water terminals: public and shipper terminals. Most terminals are public terminals because most ports are operated by government agencies and have public storage facilities. Shipper terminals are private terminals that high volume users may invest in. Such

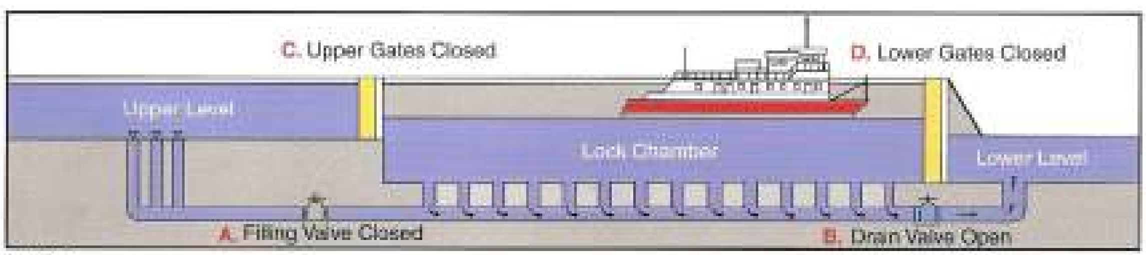
firms may handle commodities such as grain, coal, and oil. In this case, building their own docks, terminals, and handling facilities to meet their specific needs may be more economical for their company. At terminals efficient handling materials is essential to handling materials and limited delays. New material improvements and specialized handling equipment have limited delays. These ports often facilitate a transfer of freight from water to rail or truck who can finish the trip and deliver the goods to their final destination. Storage is also necessary at ports and terminals because barges and ships can carry larger loads than trucks or rail cars. The containers will be stored until another train or truck can pick it up.

Operation of Locks

When navigating through waterways there are ships and barges that can be too heavy to pass through safely. In these situations, locks and dams are used to move ships and barges through shallow or steep waterways. This operation has proved most useful in creating more navigable waters for water transport. With the use of locks and dams carriers can now travel much further than the natural terrain of the land would allow. A lock and dam system works as a staircase method where ships are moved through a series of chambers with varying water levels. The figure below demonstrates the steps involved in the operation of a lock and dam system.

STEP 1

The Lower Gates (D) are closed. The Drain Valve (B) is closed. The Filling Valve (A) is opened, allowing the Lock Chamber to fill to the upper level. The Upper Gates are opened, allowing the boat to enter the Lock Chamber.



STEP 2

The boat is secured in the Lock Chamber and the Upper Gates (C) are closed. The Filling Valve (A) is closed and the Drain Valve (B) is opened, allowing the water to drain out into the Lower Level. The boat is lowered as the water level lowers.

STEP 3

When the water level in the Lock Chamber reaches the Lower Level, the Lower Gates (D) are opened, allowing the boat to leave the Lock Chamber and proceed down the river.

Cost Structure

The water industry has high variable costs and low fixed costs. Fixed costs are low because waterways are controlled and maintained by the government and carriers only pay user fees (lock fees, dock fees, fuel taxes). However, these fees vary depending on the volume of business so user fees are considered a variable cost. Variable costs include line-operating cost, rents fees, and maintenance. Fixed costs for carriers would include depreciation.

Issues

A major issue facing the water industry is the out of date ports. The infrastructure of waterways is aging and is in need of new port improvements and development. Technology is constantly changing and more efficient boats have been created. With these new boats and technology it has become necessary to update and improve the ports and terminal facilities to better facilitate these changes.

Kentucky Waterways

Kentucky's waterway network includes 90,961 miles of rivers, creeks, streams, and tributaries 1,269 of which are navigable. The Ohio River makes up most of the network with 664 miles followed by the Kentucky River with 259 miles. There are 12 public river port authorities, seven are active and five are being currently developed. Waterways accounts for 2% through state, 11% from state, and 13% to state of the shipments of freight by tonnage.

Locks/Dams

Locks and Dams

Ohio River - Hungtington District

Captian Anthony Meldahl

Greenup

Ohio River - Louisville District

Cannelton

John T, Myers

Markland

McAlpine

Newburgh

Smithland

Lock 52

Lock 53

Green River - Louisville District

Lock 1

Lock 2

Cumberland River - Nashville District

Barkley Lock and Dam

Tennessee River - Nashville District

Kentucky Lock

Riverports

	River
Eddyville Riverport	Cumberland River Eddyville, KY
Greenup-Boyd County	Ohio River Catlettsburg, KY
Henderson County Riverport	Ohio River Henderson, KY
Hickman-Fulton County	Mississippi River Hickman, KY
Jefferson Riverport International	Ohio River Louisville, KY
Marshall County-Calvert	Tennessee River Benton, KY
Maysville-Mason County	Ohio River Maysville, KY
Meade County	Ohio River

	Harnad, KY
Northern Kentucky	Licking River Ft. Mitchell, KY
Owensboro	Ohio River Owensboro, KY
Paducah-McCraken	Tennessee River Paducah, KY
Wickliffe-Ballard	Mississippi River Wickliffe, KY

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Pipelines

History and Overview

Originally, pipelines started out being used to feed other modes of transportation. Pennsylvania Railroad initiated the development of pipelines in oil fields in the 19th century. Later they sold out to the Standard Oil Company, establishing oil companies as the major owner of pipelines. In the 20th Century oil companies used pipelines to control the oil industry by not providing transportation services to new producers. After WWII and the Champlin Oil Case, the US Supreme Court required pipelines to be operated as common carriers if there was demand for their services. The pipeline network grew steadily until the early 1980s and the diameter, volume, and amount of tonnage increased.

Pipelines are a limited mode of transportation and are the only mode that is unidirectional. Pipelines are mostly unknown to the general public but they are a vital component the country's transportation system. Pipelines account for more than 20% of the total intercity ton-miles shipped in the US which is comparable to motor carriers. On a tonnage basis, pipelines can be compared to railroads. The industry consists of a large number of companies. The reasons for this are the high start-up costs, like with rail and public utilities duplication or parallel competing lines would be uneconomic, and legal costs and requirements for entry. Large-size operations are most economical because capacity rises with increase in diameter of the pipeline and investment per mile and operating costs per barrel decreases. Pipelines are mostly operated by common carriers since the Champlin Oil Case. There are some private carriers but the industry is dominated by for-hire carriers. Common carriers account for about 92% of all pipeline carriers. Pipelines quote rates on a pre-barrel basis (one barrel = 42 gallons).

Quotes are typically point to point or zone to zone and a minimum shipment size is usually required.

Ownership

Oil companies have been predominate owners of oil pipelines since Standard Oil Company bought out the Pennsylvania Railroad. The Federal government briefly owned during WWII to ensure uninterrupted flow of oil during the war. The government owned the Big Inch and the Little Inch pipeline but sold to private companies after the war. Some pipelines are operated as joint ventures because of the high capital investment need for large-diameter pipelines. Oil companies own about 46%, joint ventures account for 27%, and railroads, independent oil companies, and other companies account for the remaining percentage.

Competition

The industry has limited intramodal mostly due to the small number of companies and the market structure of having limited price competition, joint ownership, and high capital costs. The most serious intermodal competition is water, or tanker, operations. Water come the closest to matching pipeline's costs and rates but water's limited network limits their ability to compete. Trucks complement rather than compete because trucks distribute/deliver for pipelines**.** Once pipelines have been constructed between 2 points it's difficult for other modes to compete because of the low operating costs, dependability, and limited damage to product being transported.

Commodities

Oil is the most transported commodity by the pipeline industry. Other commodities include natural gas, coal, and chemicals. Coal is moved in a 'slurry' form or is broken up and suspended in a liquid. In this form the material can be moved through the pipeline. This is generally used to transport coal to utility companies for generating electricity. Chemicals transported include anhydrous ammonia (fertilizer), propylene (detergents), ethylene (antifreeze).

Advantages **vs.** **Disadvantages**

Advantages

- Low rates: average revenues are below one-half of a cent per ton-mile which is indicative of their low operating cost
- Very good loss and damage record
- Slow service pipelines can be regarded as functioning as a warehouse
- Virtually unaffected by weather conditions
- Rarely have mechanical failures

Disadvantages

- Slow speed
- Fixed route/network, no door-to-door service
- Depend on rail and motor carriers to complete delivery
- Limited to only a very types of commodities (liquid or gas)
- Limited geographic areas and limited areas within that geographic area

Classification

Pipelines have two classifications: trunk lines and gathering lines. Trunk lines are used for long-distance movement of crude oil or other products, such as jet fuel, kerosene, chemicals, or coal. Trunk lines are considered either a crude line or a product line. Trunk lines are usually 30-50 inches in diameter are usually permanent and are laid underground. Gathering lines are used to bring the oil from the fields to storage areas before the oil is processed into refined products or transmitted as crude oil over the trunk lines to distant refineries. Gathering lines are smaller in diameter not exceeding 8 inches and are laid on the surface of the ground to make it easier to relocate them when a well or field runs dry.

Power Stations and Batching

Power stations are stations that provide the power to push the commodities through the pipeline. These stations are interspersed along the trunk lines. For oil movements, the pumps are located at stations. Station locations vary depending on the viscosity of the oil and the terrain. Compressors are used for the movement of natural gas and pumps for the movement of liquid items.

Batching is used to separate the batches. Sometimes two or more grades of crude oil or two or more products move through a system at one time and will need to be separated. There are 15 grades of crude oil with a range of products including jet fuel, types of gasoline (regular, unleaded, and premium), diesel fuel, heating oil, kerosene, and aviation fuel. The batches are separated using a rubber ball called a batching pig. This technique is not always necessary because the specific grades of the products can keep them separated. When mixed, a higher grade item will be considered as part of the lowest grade product it is mixed with.

Preventative Maintenance

Preventative maintenance is essential in limiting loss/damages and protecting the environment. Protective paints and resins are used for corrosion control. Electric currents are used to neutralize the corroding electrical forces that come naturally from the ground to the pipeline. Pipeline's have a record of limited loss and damage due to the industry's approach to operations. The pipes are constructed using a high-quality alloy steel with a life expectancy of 50 years or more. The pipes are laid in long sections with a limited number of seams and high quality electronic welding of seams prevents leakage.

Cost Structure

Much like the railroad industry, the pipeline industry has a high proportion of fixed cost with low capital turnover. The high fixed costs can be contributed to the owners having to provide their own right-of-way by purchasing or leasing land and having to construct the pipeline and stations along the way (property taxes, depreciation, and preventative maintenance). Terminal facilities also require depreciation and property taxes. Pipelines have low variable costs because the vehicle required is the pipe itself. Unlike other forms of transportation, pipelines do not require vehicles to move commodities and therefore have a low variable cost. Labor costs are relatively low because of the use of automation. For example, the Trans-Alaska Pipeline System was built at a cost of $9.2 billion and is operated by 450 employees.

Issues

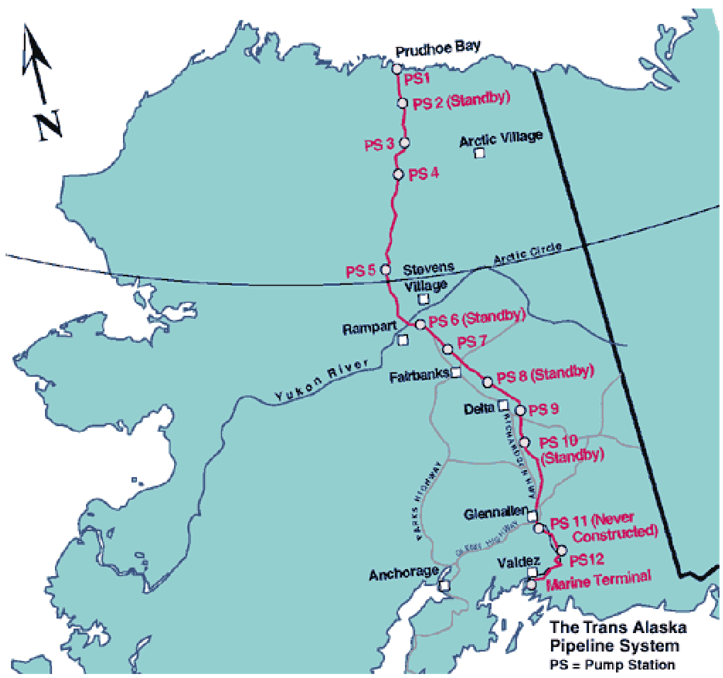
There are a few issues that the industry faces today. With the environment becoming a focus, the environmental impacts and limiting leakage of pipelines have become a concern. Pipelines are usually built in rural areas but when house needs increase people may be living closer to the pipelines and special attention will be needed. Wildlife in the area around a pipeline is also taken into consideration.

The Office of Pipeline Safety

The office of Pipeline Safety or the Pipeline and Hazardous Materials Safety Administration (PHMSA) is a department within the U.S. DOT. The PHMSA establishes and monitors pipeline activities that relate leakage from oil pipelines. The PHMSA require each carrier develop oil spill response plans for onshore pipelines.

Federal Energy Regulatory Commission (FERC)

The Federal Energy Regulatory Commission (FERC) operates under The Interstate Commerce Act and regulates the rates and practices of oil pipeline companies engaged in interstate transportation. The FERC establish "just and reasonable" rates to encourage maximum use of oil pipelines. They also prevent discrimination by ensuring shippers equal access to pipeline transportation, equal service conditions on a pipeline, and reasonable rates for moving petroleum and petroleum products by pipeline.

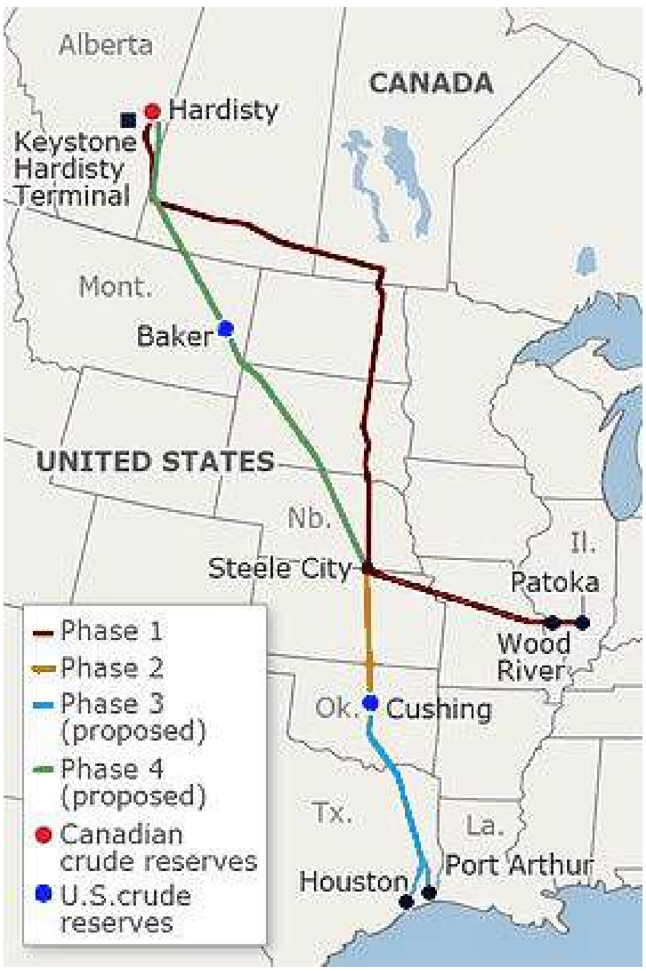


The Alaska Pipeline

The Alaska Pipeline was built after oil was discovered on the North Slope of Alaska in 1968. The pipeline cost $8 billion to construct and can handle up to 2 million barrels of oil per day. The pipeline is 800 miles long and was completed in 1977. The line is made up of ½ inch thick steel and has 48 inch diameter pipe and 4 inches of fiberglass insulation. Ten pump stations are located along the line that flows at 5 to 7 mph. That's 8 days to travel 800 miles from Arctic Ocean to Valdez where the oil is transferred to oil tankers.

Temperature of the oil was carefully considered when constructing the pipeline. Oil is pumped from depths of several thousand feet at 160 to 180ºF. Heat exchangers are used to cool the oil to 120ºF when it enters the pipeline. At 120ºF the pipe would be hot enough to melt the permafrost. To prevent melting, the pipeline was constructed above ground (about 400 miles). Insulation keeps the temperature of oil nearly constant.

Keystone XL Pipeline Project



The Keystone XL Pipeline is a proposed pipeline that was originally proposed by TransCanada. The line would be 1,897 km (1,179 mile) long and run from Canada boarder to connect to an existing pipeline in Steele City, Nebraska. The pipeline is expected to provide 5% of US petroleum consumption needs and represent 9% of US petroleum imports. The volume of Keystone XL is equal to a train 25 miles long transporting every day. For a comparison for every pipeline incident there are 50 railway accidents. The required capacity for the project to meet demands is 1.1 million barrels per day. The pipeline would act as an import line to US refineries and will create about 20,000 construction and manufacturing jobs. Once built the it would generate more than $585 million in new taxes for states and communities along pipeline route. Overall, the Keystone XL Pipeline would strengthen America's energy security by increasing supply of safe, secure, and reliable oil from Canada and American oil fields

Kentucky's Pipelines

There are a total of two million miles of pipeline in the United States and 25,394 miles of these pipelines are located in Kentucky. Hazardous liquid and gas are the only types of pipeline in Kentucky. Hazardous liquid pipelines carry fuels such as gasoline, diesel, and jet fuel. The hazardous liquid pipelines make up 861 miles of the network. Gas pipelines carry natural gas and propane. There are 7,366 miles of pipeline for gas transferred, 550 miles for gas gathered, and 16,617 miles for gas distributed.

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Overland Conveyors

Industry Overview

Overland conveyors are belt conveyors that have been designed to carry high tonnage loads over long distances. In some cases, this mode of transportation might not be desirable but can be ideal for consistent movement of large volumes of material. The most common commodities carried are bulk materials and include the following:

- Iron ore
- Coal
- Grains
- Wood
- Waste/Trash

Overland conveyors can be applicable in many different industries and can range from just a few thousand feet to several miles in length. Industries such as mining, power, paper, waste, and cement have utilized conveyors as a way to transport materials.

Advantages

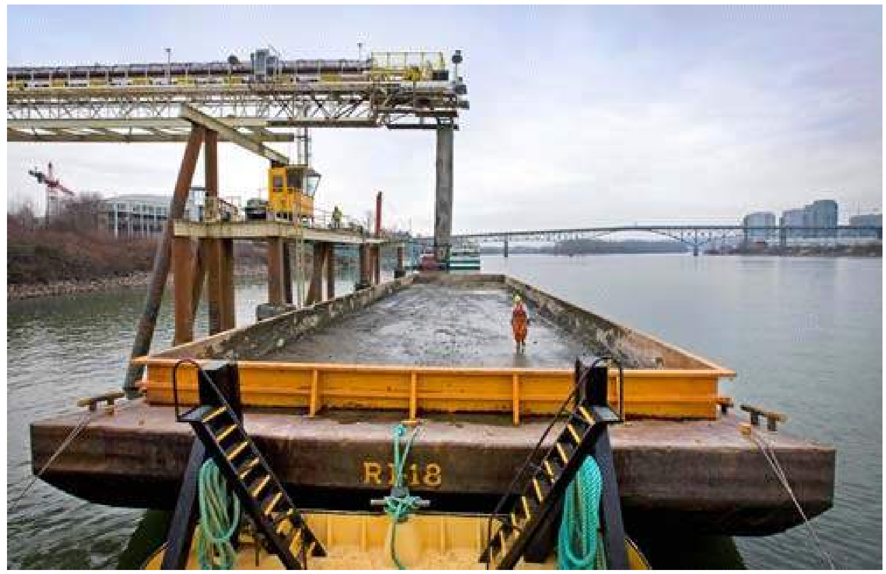
Overland conveyor can be more cost efficient than other modes of transportation. These cost advantages come into play when looking at the long term benefits. With the proper high volume and consistency, conveyors are very efficient and have a much lower operating cost than other modes. Conveyors also offer an environmentally friendly operation that doesn't stir up pollution or produce loud sounds.

Disadvantages

The main disadvantage of conveyors is that they are not flexible and have high capital costs. Conveyors are very costly to build and to move or relocate. Since they can not be moved, conveyors rely on other modes to overcome their accessibility issues.

Competition

Overland conveyors compete with water, rail, and truck for the movement of bulk materials. However, conveyors can be more efficient when looking at the long term costs. Intermodal is also an important aspect to consider. With the limited network, conveyors are forced to work with other modes to overcome the accessibility disadvantage. Many times conveyors provide a link between two modes of transportation and in this case conveyers play a major role in intermodal transportation.



TTI

Overland conveyors are an important aspect to the nation's intermodal transportation plan. An example of an intermodal application of overland conveyors close to home is the TTI short line and the transportation of coal. TTI carries coal by rail to Maysville where the coal is then dumped onto a conveyor. The conveyor carries the coal about 1000 ft to load it onto a barge. In this case, the conveyor provides a link between modes.

References

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Appendix J: List of other education-related papers and presentations produced (not counted as part of UKY NURail research products)

2015 presentations

Rose, Jerry G., “Maintaining Adequate Trackbed Structural Support: An Important Railway Infrastructure Issue” AREMA Committee 1 Meeting, Charlotte, NC (February)

Rose, Jerry G. and John K. Secor, “Anatomy of the U.S. Railway Industry – Past, Present, and Future”, 101st Purdue Road School Transportation Conference, West Lafayette, IN (March)

Rose, Jerry G., “Asphalt Railway Trackbeds: Recent Designs, Applications and Performances”, Annual AREMA Conference, Minneapolis, MN (October)

Rose, Jerry G. and John K. Secor, “An Introduction to Railway Operations and Engineering”, Short Course, Kentucky Transportation Center T2 Program, Erlanger, KY (November)

2015 publications

Rose, J. and R. Souleyrette, “Asphalt Railway Trackbeds: Recent Designs, Applications and Performances”, Proceedings of the Annual AREMA Conference, Minneapolis, MN, October 2015, 18 pages.

2016 presentations

Rose, Jerry G., “Rehabilitation of Railway/Highway At-Grade Crossings: Recommendations and Guides,” Annual Meeting of the Transportation Research Board, Washington, DC (January)

Rose, Jerry G., “Effect of Enhanced Trackbed Support on Railway/Highway At-Grade Crossing Performance”, Poster, 2016 Annual Meeting of the Transportation Research Board, Washington, DC (January)

Rose, Jerry G., “Railway/Highway At-Grade Crossing Surface Management”, 102nd Purdue Road School, W. Lafayette, IN (March)

2016 publications

Malloy, BR, Rose, JG, Souleyrette, RR, “Rehabilitation of Railway/Highway At-Grade Crossings: Recommendations and Guides”, Paper TRB 16-2711, Transportation Research Record, Journal of the Transportation Research Board, Washington, DC, January 2016, 27 pages.

Rose, JG, Malloy, BR, Souleyrette, RR, "Effect of Enhanced Trackbed Support on Railway/Highway At-Grade Crossing Performance", Paper TRB 16-2703 Proceedings of the 95th Annual Meeting of Transportation Research Board, Washington, DC, January 2016, 18 pages.

Xu, P., Q. Sun, R. Liu, R. Souleyrette, and Y. Tang, "A Model for Automating Linear Milepoint Referencing for Subway Geometry Cars", Accepted for publication in the ASCE Journal of Transportation Engineering.