
The Use of Optimization to Improve Freight Railroad Service Reliability

IMA Workshop on Optimization in Travel and Transportation

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Outline

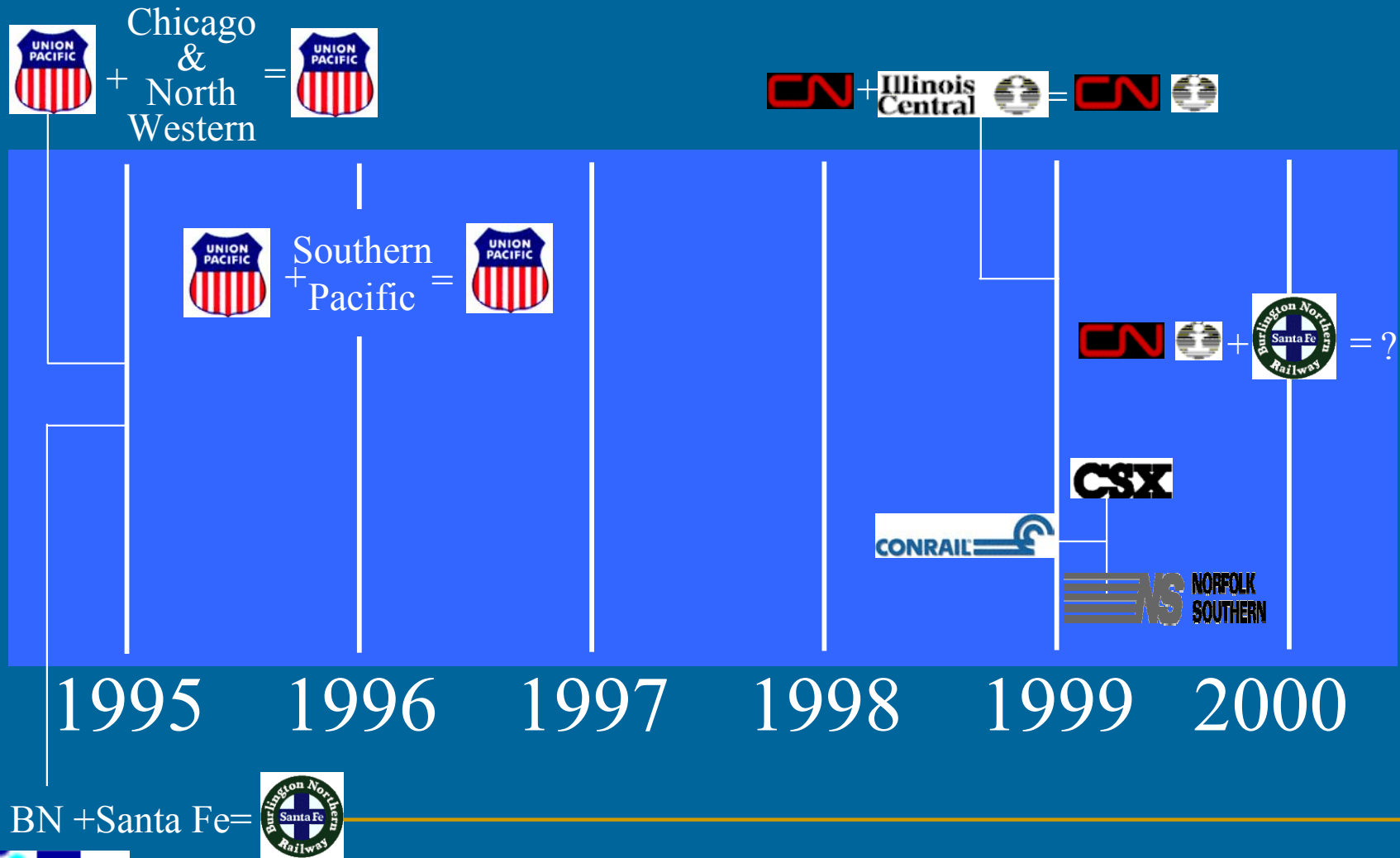
- *North American rail industry overview*
- *Importance of Service Reliability*
- *Railroading 101: How does a car get moved and other decisions*
- *Comparison of Railroads and Airlines*
- *Dynamic Car Scheduling*



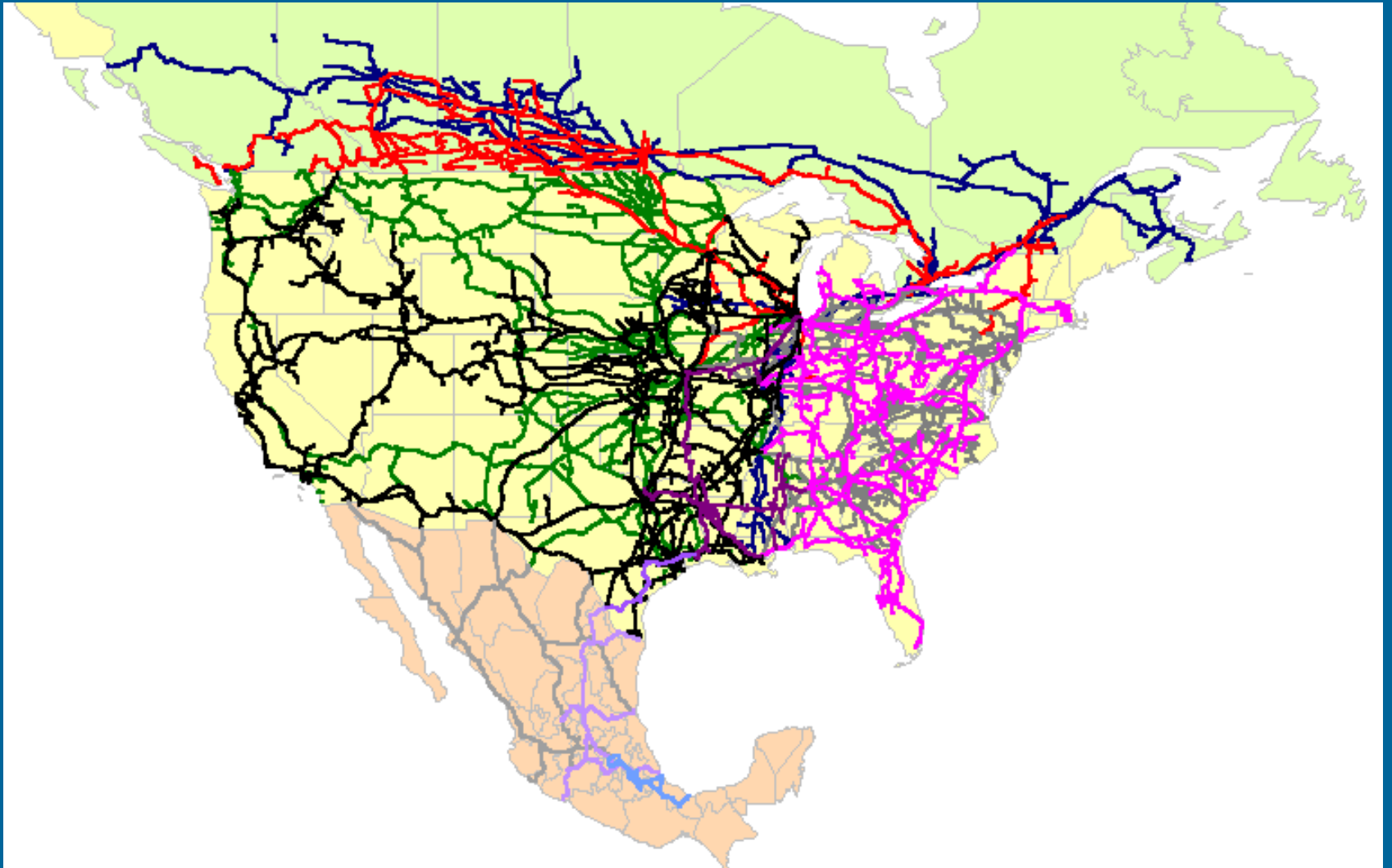
North American rail: *Prior to 1992, there were 5 major US railroads after years of consolidations*



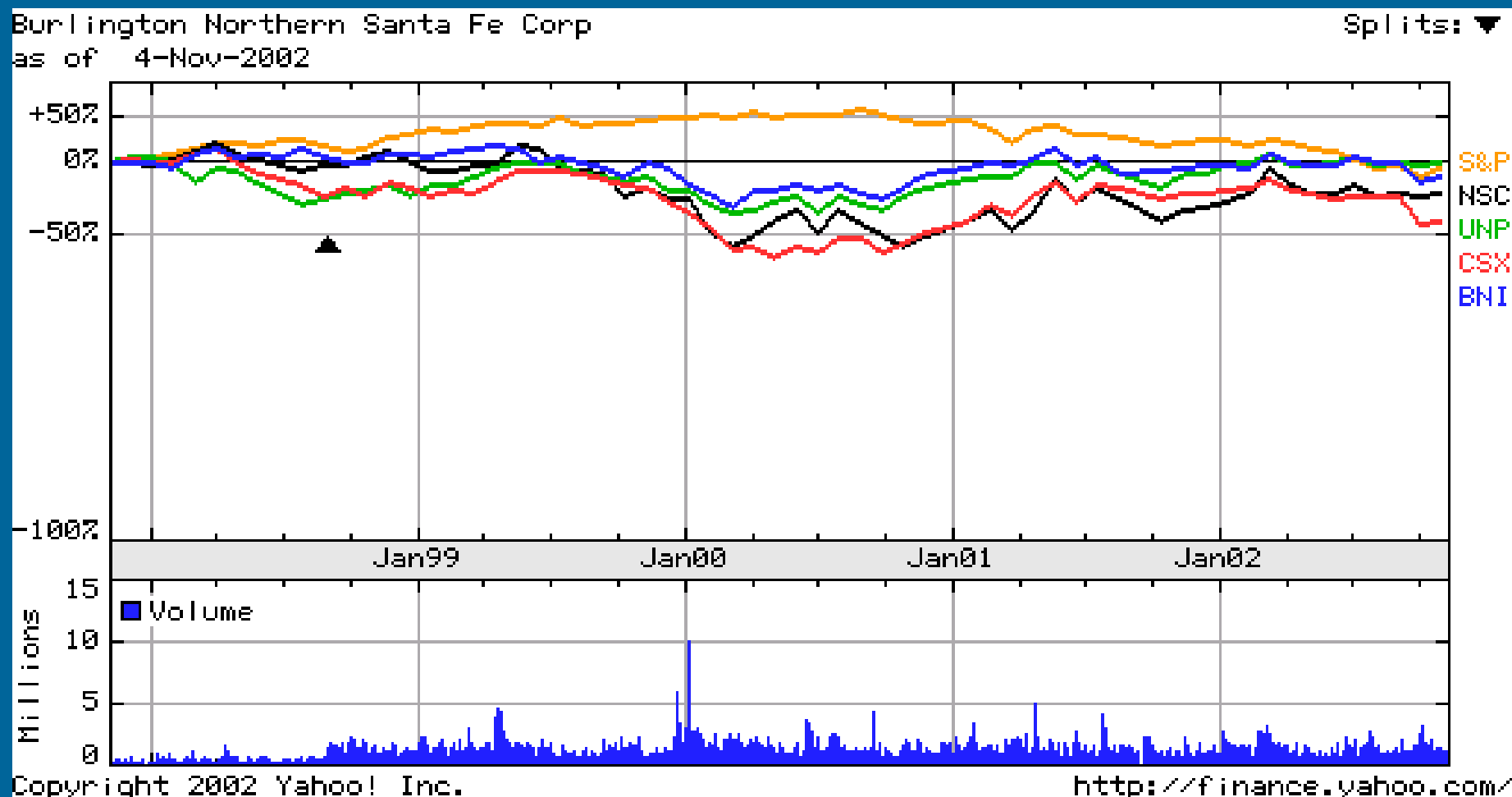
From 1995 to 2000, further consolidation took place until the STB declared a moratorium in 2000, blocking the CN/BNSF merger



Resulting in, the current North American Rail Network



- However, the stock market has not reacted favorably to these events and railroad stocks have performed quite poorly compared to the S&P 500 over the past 5 years



Major Challenge facing Railroads

- ***How to balance the needs of the stockholders with the needs of current and potential customers?***



Why is Service Reliability Important?

- For decades, railroads have provided low cost transportation for commodities that did not require reliable service
 - Coal
 - Grain
 - Forest products
 - Chemicals
- However, there is little growth opportunity in transporting these products. New industries require highly reliable service, similar to that delivered by trucks
 - Just-in-time manufacturing
 - Finished, high value products
- In order for revenue to grow, railroads must offer service products that appeal to non-traditional customers



How have railroads improved Service Reliability?

- Most railroads understand the importance of Service Reliability and have undertaken steps to improve in this area
- These steps have included:
 - Monitoring yard performance to develop standards for making connections
 - Employing extra sections when volumes overflow capacity
 - Tracking performance of critical customers or shipments for which performance is guaranteed
 - Instituting reservation approaches to guarantee car availability
- While these steps have improved performance, many of them have also incurred additional costs beyond that of the normal scheduled operation
- To understand the potential of optimization models to improve reliability, let's examine how a car moves on a typical freight railroad



Railroading 101: How does a car get moved?

- Suppose a customer wants to ship a car from one place to another. Steps involved:
 - Customer calls railroad and requests an empty car of a given type
 - Railroad delivers car to customer on a local train working out of the nearest yard
 - Customer loads car and contacts railroad to let them know it is ready to be moved
 - Railroad picks up loaded car with another local from nearby yard
 - Local train delivers car to nearby yard
 - Car Scheduling process develops a “trip plan” for the car
 - Car is switched into the first “block*” on trip plan
 - Yard jobs switch block onto first train on trip plan (assuming there is room for the car on the train*)
 - Block is moved by train to block destination yard where it is set off
 - Yard switches car into next block and the process continues until destination yard is reached
 - Final yard delivers car to customer at destination (consignee) using a local train
- Interesting Factoid: In 1996, on average, only 14% of the time taken to go from shipper to consignee was spent on a moving train



Railroading 101: Decisions to be made

- Behind the scenes, several decisions are being made by either models or people:
 - Which empty car should be used? (Car Management)
 - What should trip plan be? (Car Scheduling)
 - What blocks should be built at a given yard? (Service Design)
 - What blocks should be moved by a given train? (Service Design)
 - What customers should be served by which yard? (Marketing)
 - What locomotives should be used on which train? (Locomotive Management)
 - What price should be charged for the service? (Sales)
 - If railroad doesn't provide service all the way to destination, what other railroad should participate and where should the interchange take place? (Service Design, Marketing)



Uses of OR Models

- Merger studies and support
 - Traffic flow models, primarily Multi Modal's MultiRail, are used to evaluate various scenarios
 - ALK models are also used but with a diminishing frequency
 - Logit choice models used to model customer choice behavior
- Operating plan development
 - MultiRail is major player here
 - Sabre's CNAM model was used at Conrail, but not used since merger
- Car management
 - Sabre (PTCG) developed model used at CSXT
 - In house models used at other railroads
- Train dispatching
 - Little new research done here
 - Some work done 10 years ago incorporated into MultiRail component, but largely unused
 - Poor linkage between planning tools and real-time tools can cause solutions to be developed in planning timeframe that can't be implemented in real life



Uses of OR Models, cont.

■ Terminal modeling

- Some terminal simulation models have been developed for individual terminals
- No “generic” terminal simulation model available
- Project management approach to modeling terminals developed in 1994 at CSXT, but not used elsewhere

■ Revenue management

- Union Pacific test marketed RM on their Pacific intermodal corridor in 2000 and are moving towards implementation
- Other railroads looking into RM, but mostly using home grown approaches



How do Airlines and Railroads Compare?

- In order to more fully understand the nature of railroads, let's compare them to passenger airlines
 - Network structure
 - Railroads are much more complex than airlines
 - Have to worry about capacity BETWEEN terminals
 - Have to deal with “meet and pass” issues
 - But, railroads get to control their networks
 - Ability to vary capacity
 - Railroads have more flexibility because locomotives can be added or removed depending on the tonnage to be moved
 - Crew rules are somewhat similar
 - RR Crews are scheduled to work 8 hour shifts, but can work overtime to 12 hours
 - Crews can run out of time while en route causing trains to stop
 - Railroads do not “schedule” crews
 - Crews on railroads are geographically constrained, not equipment constrained



How do Airlines and Railroads Compare?, cont.

□ Reliability

- Airlines measure reliability in minutes
- Railroads measure it in hours or days
- Airlines learned the importance of being a scheduled operation years ago; railroads are just now learning the importance of running a “planned” operation
- Most railroads measure reliability in two ways:
 - Adherence to trip plan
 - Closeness of delivery time to original estimated delivery time
- Railroads have difficulty saying “NO” to the customer

□ Decision Making

- Railroads cycle between centralized vs. local decision making
- Most railroads have centralized locomotive planning but local decisions as to how to deal with over-capacitated situations



How do Airlines and Railroads Compare?, cont.

- Parallel constructs:
 - Rail cars are more like bags than they are like passengers
 - Don't move themselves when there are changes in the plan
 - Don't care how they get from A to B, just whether they arrive on time
 - Are grouped together in "blocks" to reduce handlings
 - Railroads have large yards called "classification" yards that are like airline hubs
 - Primarily designed to sort inbound trains into different outbound trains
 - Many use a "humping" process to sort cars
 - Not designed for "quick" connections or turnaround
 - Usually also have maintenance capabilities
 - Railroads have smaller yards that are like smaller spoke cities
 - Primarily exist to serve customers
 - Completely different design to facility



Use of Optimization to Improve Reliability

- Railroads don't have a good understanding of the causes of service failures, but they can be categorized
 - Random events
 - Volume variability
 - Poor planning
- There are three critical areas where optimization can improve reliability
 - Development of Blocking Plans (can reduce handlings thus reducing risks of missed connections)
 - Locomotive Assignment tools (can reduce terminal delays as well as improve matching of horsepower to tonnage)
 - Dynamic Car Scheduling
- Blocking and Locomotive Assignment were both discussed in detail by Ravi Ahuja from University of Florida in an earlier workshop this fall (slides are available on the IMA website)
- Let's examine the latter of these three critical areas in more detail



How does Dynamic Car Scheduling differ from current Car Scheduling approaches?

- Current Car Scheduling systems are typically based on fixed tables that direct cars across the rail network
 - Routes are “hard-coded” based on:
 - How have those cars been handled in the past?
 - Which route has the shortest distance?
- These systems do not take into account current conditions
 - Trains that are over or under subscribed
 - Terminals that are congested
 - Classification tracks that are full
 - Trains that are delayed or ahead of schedule
- Dynamic Car Scheduling approaches take advantage of the numerous routes through the network and select the one that is best, given current conditions

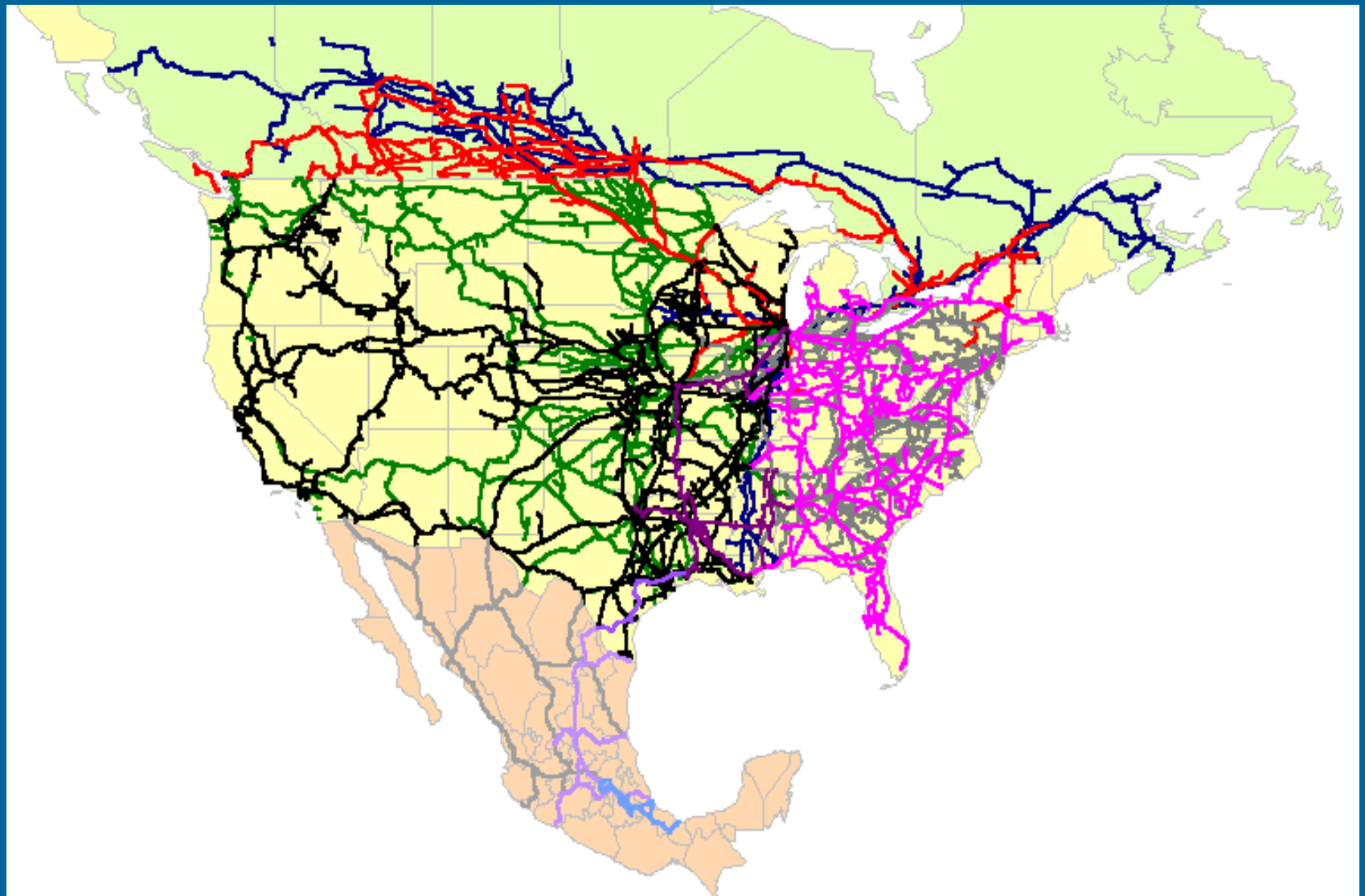


Do multiple routing options really exist?

- To examine this question, schedule data for both an eastern railroad and a western railroad were analyzed
- In this analysis, two routing options are considered to be different if they either:
 - Use a different sequence of trains
 - Make connections from one train to another at a different location
- Certain assumptions were made:
 - If a train stops at a location for more than 30 minutes, it was assumed that cars could be added or taken off the train at that location
 - If there was at least 10 hours between arrival of train A and departure of train B, it was assumed that a car arriving on train A could make the connection and depart on train B
- Before reviewing the results, let's look at the map of the railroads of North America again



Notice the difference in density between the eastern railroads and the western railroads.



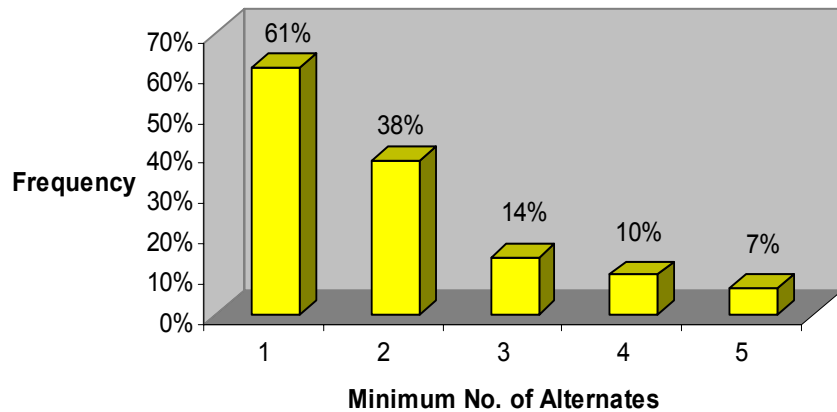
Do multiple routing options really exist?

- The paths between 50 geographically diverse cities were generated and examined for each railroad
- Paths using one, two or three scheduled trains were generated using Microsoft Access
- Comparisons were performed between each path and the shortest path (time-wise) between origin and destination
- These paths and their relation to the shortest path were then examined in more detail

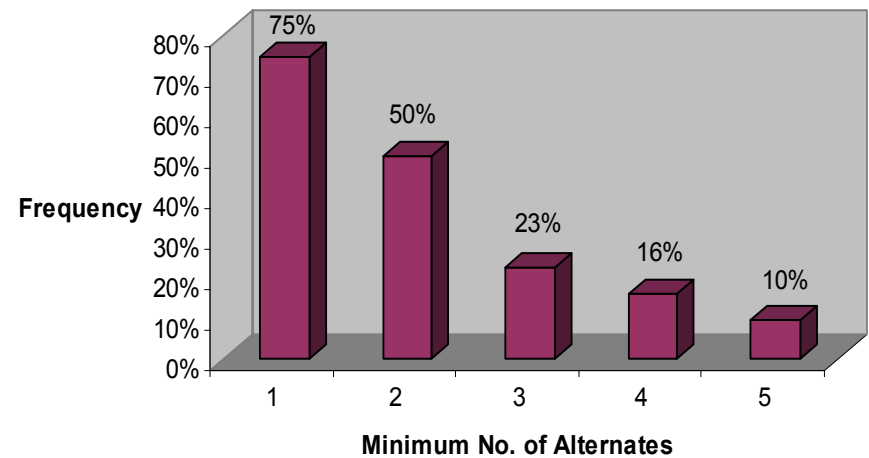


What percentage of origin-destination pairs have alternate routes that have elapsed times within 10 hours of the shortest path?

Alternate Routes within 10 Hours of Shortest Route --
Western Railroad



Alternate Routes within 10 Hours of Shortest Route --
Eastern Railroad



As we can see, there is some difference between the two railroads, but both have opportunities for Dynamic Scheduling



Dynamic Scheduling

- As we have seen, there are multiple routing options on both eastern and western railroads. But the current business processes are ill-equipped to take advantage of this.
- What is needed?
 - Understanding of the “root causes” of service failures
 - Understanding by rail management of the benefits of Dynamic Scheduling
 - Development of a “simple” Dynamic Scheduling model to demonstrate how the process would work
 - Simplistic shortest path model with penalties adjusted on a real-time basis
 - Tracking of actual performance to trigger “re-scheduling”
 - Development of a “forward looking” process to identify farther in advance when the initial schedule will not work
 - Demand forecasting (perhaps triggered by car ordering process)
 - Downstream projection of workload at each terminal



Summary

- Railroads need to find ways to improve reliability in order to address the needs of both stockholders and customers
- Optimization models can assist in improving reliability by reducing handlings and taking advantage of the network structure
- Rail management needs to be convinced that these tools can be of benefit and have a high rate of return on dollars invested in these areas
- Researchers need to shift their focus from planning models to real-time tools in order to assist in improving reliability

