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system uses minimization of cost as its objective function. The system is designed to interface with APC's existing data systems to obtain its input data, and for the distribution of its output results. It operates in a daily decision support mode, assisting the distribution staff by providing recommendations of when and where to send each type of equipment to meet current and future needs. It makes these recommendations while fully taking into consideration the total system needs for equipment on both a global and local basis over the coming two week period. Additionally, it can be used in a "what if" and strategic planning mode for analyzing the profit potential of additional rail cars, trains, and corridors.

RAILS is an interactive menu driven package which will allow the user to move freely within its confines. It operates within the APL2 interactive language environment and inside of the Princeton Transportation Network Model (PTNM), a transportation computer graphics package.

- *A Decision Support System for Train Dispatching: An Optimization-based Methodology*
  by Dejan Jovanovic
  Burlington Northern Railroad
  and Patrick T. Harker,
  University of Pennsylvania

Poor on-time performance and the resulting low level of service is one of the most important problems of railroads in many developed countries; in developing countries, inadequate capacity of mostly single-tracked railway lines and scarce funds for capital improvements are becoming the major problems. This paper addresses these issues by presenting a methodological framework and decision support tools aimed at improving capacity utilization through optimal computer-aided train dispatching (CAD) in real-time operations.

The biggest obstacle to the successful implementation of an optimal CAD system is the combinatorial nature of the optimal train dispatching problem and the need for optimization algorithms that could provide good solutions in real-time environments. Having previously developed novel lower-bound based algorithms for the minimum tardiness cost train dispatching problem, this paper illustrates how such an algorithm can be used in a CAD system to handle larger traffic volumes and cover longer planning horizons and larger dispatching territories than is possible with the current state-of-the-art while providing for optimal or near-optimal ways to move the trains over the railroad line.

The optimal train dispatching framework proposed in this paper attempts to fill the void in the literature regarding the use of and the benefits from a CAD system. It is argued that the primary purpose of dispatching tools is to allow trains to arrive on-time rather than to minimize total train delays. The potential of optimal CAD to minimize train lateness is illustrated by examples. In addition, these examples illustrate the importance of the lateness criteria in operating rail lines in the competitive environment which railroads now face.

Trucking Competition

Session Moderator: B. Starr McMullen, Oregon State University

Summary by Session Moderator

This session had three papers which dealt with various aspects of trucking competition. The first paper examined the impact of LTL discounts on the demand for LTL traffic. Discussants noted that the model generated demand for LTL service by diverting traffic from multiple stop TL competition. A representative from one motor carrier firm pointed out that his firm engaged in both LTL and TL service and that he needed information on how to price to two types of services simultaneously. It was suggested that future research might focus on optimal joint pricing strategies for LTL and TL service in an individual motor carrier firm.

The second paper demonstrated that differences in shipper and carrier rankings of motor carrier sales representative attributes did not change much following deregulation. The major question here was why motor carrier firms seem to value sales person appearance over the knowledge characteristics valued more highly by the shippers. In

an increasingly competitive market environment for trucking, successful motor carrier firms would be expected to adapt more quickly to addressing the concerns of shippers.

The final paper discussed the marketing of intermodal rail services. As noted in other TRF sessions, one of the largest components of the cost of intermodal shipments is local drayage. High drayage costs are attributable, in part, to excess time spent in pick up and delivery. If these costs can be reduced, intermodal transport may be able to better compete with TL trucking. The group agreed that railroads will have to market their intermodal services more efficiently if intermodal rail is to remain competitive with TL motor carriage.

- *The Impact of LTL Discounts on LTL Demand in the Context of Multiple-Stop TL Competition: A Methodology and Exploratory Study*
  by John Pooley
  Eastern Washington University,
  and Steve Dunn,
  Penn State University

In the decade since transportation deregulation, less-than-truckload (LTL) and multiple-stop truckload (TL) motor carriers have begun to compete for the same set of industrial shipments. Both of these carriers covet shipments which weigh between 1,000 and 20,000 lbs. This paper outlines a methodology to empirically test how changes in LTL pricing (i.e., discounts) influence LTL demand in the context of multiple-stop truckload competition. Carriers, shippers and policymakers can use this methodology to investigate different types of managerial and research questions. The methodology links empirical demand and cost data to a computer simulation model and a vehicle routing algorithm. This approach has the flexibility to incorporate the wide variety of variables and interactions which characterize realistic transportation systems. The use of a computer model gives researchers the ability to experiment with data which may not be available through other means. Another strength of the methodology is that it can explicitly account for questions about consistency and objectivity.

An exploratory study using the methodology illustrates the validity of the methodology in an actual distribution system and generates testable empirical results. Analysis of variance (ANOVA) statistical tests of these results accepts the hypothesis that percentage reductions in LTL price create equal percentage increases in LTL demand. In economic terms, this finding implies that the price elasticity of LTL demand for this firm is unit elastic. The methodology and exploratory study provide a base to empirically study transportation policy and management questions.

- *Motor Carrier Salespeople: A Comparison of Shipper and Carrier Views Before and After Deregulation*
  by Peter M. Lynagh,
  University of Baltimore,
  Paul R. Murphy,
  John Carroll University, and
  Richard F. Poist,
  University of Maryland

One result of the Motor Carrier Act of 1980 has been the increased emphasis placed on the marketing function by the trucking industry. Given this renewed interest, it can be postulated that motor carriers should have altered their sales practices in response to deregulation. The paper investigates this hypothesis through a pre- and post-deregulation comparison of shipper (i.e., customer) and carrier (i.e., supplier) views as to the desirable attributes of motor carrier sales personnel. Such a framework allows for determination of the extent to which customer needs and wants are being satisfied, as this is the essence of the marketing concept, and the extent to which sales force practices have changed over time.

Overall, the study results indicate that shippers and motor carrier sales managers have maintained very different perceptions regarding desirable salesperson attributes, with shippers advocating less emphasis on personal traits and more attention to service and knowledge-related attributes. This suggests that motor carriers, in general, have been slow to adapt their sales management policies and practices to the contemporary transportation environment.

- *Railroad Intermodal Marketing: Techniques and Practices*
  by Leland S. Case,
  The City College of New York

This paper critically examines the sales and marketing organization and practices of railroad domestic intermodal. Interviews with six major railroad intermodal executives generated background data for this paper.

Explicit comparisons are made between railroad intermodal marketing techniques

and those used generally in the truckload motor carrier industry. Several conclusions are drawn, based on the analysis, regarding the ability of domestic railroad intermodal to effectively compete with motor carriers.

This paper develops the following points:

1. Railroad intermodal sales and marketing is oriented toward a wholesale customer in which the railroads have little control over the terms of service and price.

2. Railroad sales efforts are tied to a bureaucratic marketing/analysis organization that hinders prompt decision making for customers. Despite its extensiveness these analytical efforts often produce ambiguous results.

3. The interface of sales and marketing with rail operations is generally weak. Intermodal is often treated on an incremental basis within overall rail operations. Insufficient attention is given to network technology, capacity utilization and alternative equipment configurations.

4. Railroads have not been successful with the existing organizational styles in solving problems associated with marketing through multiple channels, in particular a retail channel. Many efforts are underway to change railroad intermodal organizations to deal with the issues which have been raised.

5. Lessons for the railroad industry can be drawn from the relatively successful truck-load motor carrier sales and marketing organizations with which they compete.

Air Transportation Safety

Session Moderator: C. Phillip Baumel, Iowa State University

• *A Comparison of Aviation Safety in Canada and the United States*

by Clinton V. Oster, Jr.
Indiana University

Commercial airline safety must be viewed in the context of an industry undergoing rapid and fundamental changes in its economic operating environment. Prior to the mid-1970s, air transportation throughout the world was regarded as inherently monopolistic needing economic regulation in the tradition of a public utility. In the early years, passenger airline service was considered an infant industry requiring protection from other competing modes in order to develop and grow. Some countries still regard their airlines as needing protection from other airlines in international markets. Throughout the industry's development, part of the rationale for restricting competition rested on safety arguments. According to the conventional wisdom, only a large and profitable carrier operating in a stable environment could provide an adequate level of safety. Unrestrained competition, it was feared could lead to cost-cutting shortcuts in maintenance and training that might unintentionally compromise safety.

The United States made the first major break from this tradition in 1978 with the Airline Deregulation Act that removed, over a period of several years, almost all economic regulation. Although all safety regulation was left intact in the U.S., economic deregulation was accompanied by concerns about potential safety degradation. To date, deregulation has not been accompanied by an increase in the rates of airline accidents or passenger fatalities, but the issue continues to cause concern in many circles.

More recently, less restrictive economic regulation has extended beyond the U.S. to several other countries including, in 1988, Canada. As in the U.S., relaxing economic regulation has heightened concerns about safety. While it is too soon to assess the impact of these changes on safety, it is timely to examine the state of Canadian air safety and to compare it to that in the U.S. The assessment and comparison will provide some insight into air safety in both countries, will point to areas for potential safety improvement, and will provide a baseline for a future assessment of changes in Canadian air safety. This analysis examines variation in safety rates among segments of the Canadian aviation industry and compares the Canadian experience with similar segments of the U.S. industry. By disaggregating the industries in both countries into subsets of similar operating characteristics rather than relying solely on industry-wide figures, differences in