DEVELOPMENT AND ANALYSIS OF EFFICIENT DELIVERY LANES AND ZONES IN TRUCKLOAD TRUCKING

by

G. D. Taylor, Ph.D., P.E., T. S. Meinert, R. C. Killian,

G.E. Gangluff, and J.R. English, Ph.D., P.E.

ABSTRACT

In this report, the authors discuss a unique research program involving academe, industry, and government to conduct research in the area of logistics systems with a specific focus on truckload trucking operations in North America. It is demonstrated herein that logistics research is both timely and necessary for those companies seeking strategic advantage during this time of rapidly changing manufacturing and distribution paradigms. The change agent that we have selected for research involves the use of alternative delivery mechanisms. We focus on the use of regularly scheduled delivery capacity in the form of delivery lanes, hubs, or zones. Herein, we motivate applied collaborative logistics research and present the results of important research contributions leading to strategic marketing and operational initiatives in the field.

THE GROWING IMPORTANCE OF BUSINESS LOGISTICS

One of the world's most rapidly growing industrial sectors is that of business logistics systems. Historically, logistics has been considered to be primarily the procurement, production, and distribution of materials and products in a timely fashion. More broadly defined, logistics systems include the full-stream life-cycle flow of goods, information, and payments. Logistics is a major industry worldwide.

In the United States, more is spent annually on logistics related issues than for defense, health services, or social security.

The growth of logistics is brought about partially by improvements in transportation and communications systems. It is also the result of changing organizational paradigms such as agile manufacturing systems that promote the use of rapidly reconfigurable manufacturing entities on a large geographical scale. Consequently, manufacturing systems are increasingly more global and increasingly more transient in nature. This means that the logistics systems which support manufacturing are rapidly becoming key elements in the determination of which manufacturing systems can be competitive in terms of both price and customer service.

One of the implications of the growth and increasing status of logistics systems as components of strategic manufacturing initiatives is that research into effective logistics systems is increasingly important and especially timely. Manufacturing is increasingly geographically diverse, while financial and competitive pressures no longer allow manufacturers to use inventory in the form of large safety stocks to decouple manufacturing entities. Popular manufacturing strategies such as Just-in-Time (JIT) manufacturing techniques (e.g., Schonberger, 1982) have created the need for more reliable pickups and deliveries with decreasing acceptable schedule tolerance. Improvements to material and information flow systems to ensure that the right business entities are available at the right places, at the right time, and in the right quantities provide the best means of achieving competitiveness and gaining market share. Logistics providers must become a partner with other business entities in this process.

In this report, the authors focus on one very important component of business logistics systems; the truckload (TL) trucking industry in North America. As indicated above, customer service expectations in all areas of logistics systems are rapidly evolving. According to Schwartz (1992), the most significant of these changes in the TL trucking industry in the United States has occurred as result of industry deregulation following the 1980 Motor Carrier Act. Previous to this time, Schwartz argues that government regulation caused inefficiencies in routes, service authority, commodity authority, carrier selection by shippers, and rates. Because of the relatively small investment required to enter the truckload trucking market, the post deregulation industry is very competitive. Market share is gained or lost based on cost and service. Pragmatic research must therefore address ways to reduce cost and increase value to customers.

Logistics research must also extend into academic curricula. Logistics companies are now a major employer of college graduates, yet most colleges and universities do not adequately address logistics in coursework or research. This is another reason why the work described herein is especially timely.

CHALLENGES IN TRUCKLOAD TRUCKING LOGISTICS

In this section, the authors outline a research agenda to examine some daunting problems in the truckload trucking industry in North America. We focus on improvements to the driving job and to service quality to customers. We make extensive use of case information supplied by J.B. Hunt Transport, Inc., the largest publicly held TL trucking company in the United States, in seeking improvements to driver job quality and customer service needs.

Schwartz (1992) cites driver recruiting and retention as a key truckload trucking business strategy in the 1990's. This is an opinion shared by most researchers and by officials in the truckload trucking industry. As pointed out in Mele (1989a, 1989b), turnover rates can range from 85% to

110% per year in the truckload industry. There are two reasons for this turnover. First, random over the road (OTR) drivers often have very long tour lengths (See Powell et al., 1988 for more information on OTR dispatching). Secondly, the quality of life on the road is low. Generally speaking, the driver is either driving, eating, or sleeping at all times. In contrast, Mele points out that Yellow Freight System, a less-than-truckload (LTL) trucking company, has a turnover rate of 4.5% for city drivers and slightly above 10% for linehaul drivers. The reason for this increased loyalty seems to be the fact that the LTL driving job is much more regular, with driving routes to support the same end-of-line or breakbulk terminals daily. The resulting short tour lengths make the job much more attractive.

The authors of this report have examined several alternatives to random OTR dispatching in an effort to regularize the TL driving job and to improve driver retention. The first such effort was the consideration of a hub & spoke (H&S) network similar to those employed in LTL settings. Although differently motivated and designed, this work was inspired by hubbing in LTL (See Braklow et al., 1992) and airline industries (See Kanafani and Ghobrial, 1985 or Morrison and Winston, 1986). See Taha et al., 1996, or Taha and Taylor, 1994 for information about this problem, and for information about the HUBNET simulation tool developed for and employed in this analysis.

Subsequently, the HUBNET simulation system has been used to optimize H&S layout configurations in TL trucking. A sizable factorial experiment was formulated to examine the effects of various hub location methodologies, the number of hubs utilized, the rules guiding acceptable tour lengths, the allowable circuity constraints, and the number of drivers in the system. The findings indicate that while tremendous savings are possible in terms of driver tour length, the improvement comes at the expense of miles per driver per day, circuity, and first dispatch empty miles. The findings have led the academic and industrial investigators to conclude that limited implementation seems to be the best alternative for H&S usage in the TL environment. This limited implementation can be in the form of full networks carrying part of the freight or in terms of partial networks. Partial networks seem to provide the best alternatives conceptually. Furthermore, it would appear that not all loads are viable candidates for such networks. See Taylor et al. (1995) for more information regarding experimentation with the HUBNET system.

Several alternative dispatching systems have been examined subsequently and several more solution approaches are under current consideration. For each alternative, solution methodologies must consider basic performance tradeoffs. Almost any solution methodology that restricts drivers to regular lanes or service areas achieves the goal of tour length reduction. Depending upon the methodology employed, this improvement can be drastic. Many solutions also improve the ability to regularly schedule capacity along high freight density lanes. Unfortunately, almost any solution methodology that abandons point-to-point deliveries adds to load circuity. Furthermore, depending upon the solution methodology and associated parameters, first dispatch empty miles may increase or decrease, and the miles driven per driver per day may increase or decrease.

From a driver viewpoint, quality is a function of several things, but can be measured in a major way by the average tour length metric and by the miles per driver per day metric, which is directly proportional to pay. From a company viewpoint, one may be more interested in driver retention, equipment utilization, fuel efficiency, the percentage of on-time deliveries, etc. From a customer perspective, quality is a function of on-time pick-ups and deliveries, transit speed, and the availability of ‘spotted’ trailers for loading or unloading at customer convenience. Some of these multi-criteria goals may appear to compete and conflict with one another, but some strategies currently under consideration may concurrently improve quality relative to the driver, the customer, and the trucking company. Certainly, any strategy that helps with driver or customer retention is a good candidate for consideration as a long-term strategy for the company.

RESEARCH EXPERIMENTAL PLAN

In this section, the authors describe the experimental plan for the research completed to date (subsequent to HUBNET experimentation) and briefly discuss the tools used to complete the research tasks. The primary focus of the research is on driver tour length reduction. This is directly related to driver retention, a key business strategy. Therefore, any operational techniques that improve the regularity or quality of the driving job contribute to strategic cost reduction goals. Also, depending upon the methodology selected for tour reduction, the potential exists to concurrently improve on-time delivery performance to customers, thus directly serving customer service goals.

The primary research tool for use in this research is discrete event system simulation using the SIMNET II language. The language is a good choice due to the use of unique transaction flow procedures that facilitate transportation modeling, the availability of high-level programming language capabilities that alleviate the need for additional external subroutines, and the availability of very powerful and flexible file manipulation capabilities. The language also offers powerful debugging and code verification tracing tools. All simulation scenarios described herein are data driven using actual JBH historical load information. The magnitude of JBH data files necessitates the use of a UNIX simulation platform. Statistical output processing has been completed using default SIMNET II output and the SAS statistical package.

This project has five stated objectives; to provide design guidelines for alternative delivery mechanisms such as lanes or zones, to examine operational rules associated with the alternatives, to provide sensitivity analysis around key parameters, to examine the impact of alternative geographical areas, and to make all evaluations relative to standard industry metrics. All objectives have been met.

Building upon the work of the HUBNET system previously described, the authors have specified the examination of additional operational strategies for tour length reduction. Because our most basic goal is to find ways to convert OTR jobs to regional jobs, we selected and have experimentally isolated a region in the Southeast (SE) United States for initial consideration. In the primary experimental design, seven alternative formulations have been considered in an effort to find ways to improve dispatching operations and to convert OTR to regional driving jobs:

1). A ‘baseline’ model featuring point-to-point OTR tours for comparison purposes.

2). A ‘zone’ model that makes use of six SE zone perimeter hubs as drop points. The idea being that SE regional drivers pick up and deliver loads within the region while OTR drivers stop at the zone boundary. This would help to ensure that SE regional drivers could have greatly reduced tour lengths.

3). A ‘key lane’ model that moves a percentage of baseline loads along a well-defined delivery lane into and out of the SE region. The lane is selected to be conducive to a one- day drive and so that reasonable volume and balance results. One such lane considered is Atlanta, Georgia to Memphis, Tennessee. Loads that can traverse down the lane without encountering more than 20% circuity are selected for lane travel.

4). A second 'key lane' model that makes use of an Atlanta, GA to Richmond, VA lane.

5). A third 'key lane' model that concurrently considers both key lanes.

6). A 'key hub' model that uses a single Atlanta, GA hub instead of the six zone hubs as a transshipment point.

7). A 'hybrid' model that combines the key hub and zone models for an integrated solution.

The examination of these seven alternative delivery configurations provides tremendous insight into the design and operational issues with which we are concerned and helps us to achieve the first two stated project objectives. The experimentation clearly shows the efficacy of the various design approaches, physical resource configurations, and operational rules used in the experimental design. Figure 1 shows the location of the SE region, the major hub in Atlanta, GA, the six zone perimeter hubs, and the lane locations used in the primary experimental design. The third objective regarding sensitivity analysis is accomplished using additional experimentation and a secondary experimental design. The sensitivity analysis includes examination of the allowable circuity for lane participation for both single lane and 2-lane models in the SE region. Additional sensitivity analysis is performed to determine the optimal number of perimeter hub locations to use in the zone model in the SE region. The experimental design also specifies the study of an additional geographical region in the Northeast (NE) United States to meet the fourth stated objective and to ensure that solutions are not specific to a particular set of operational constraints. Standard industry metrics are used to measure performance, thus meeting the fifth objective.

RESEARCH FINDINGS

In this section, we describe the results from the research efforts outlined in the previous section. We will begin with the primary experimental design in the Southeast region. A global comparison of all metrics of interest appears in Table 1. Because all performance information presented in this section is considered to be very proprietary by J.B. Hunt Transport, Inc., all metrics are published in comparison to the baseline, point-to-point OTR scenario. A description of scenarios and performance measures used in Table 1 follows:

Scenarios:

1). BASELIN--the baseline point-to-point OTR scenario.

2). ATL-MEM--the Atlanta, GA/ Memphis, TN lane scenario.

3). ATL-RVA--the Atlanta, GA/ Richmond, VA lane scenario.

4). 2 LANE--the scenario featuring both SE lanes.

5). ATL HUB--the Atlanta, GA key hub scenario.

6). ZONE--the SE zone scenario.

7). HYBRID--the zone/key hub hybrid scenario.

The SIMNET II code for these scenarios appear as appendices to this document.

Performance Measures:

1). MAX DR and AVG DR--the maximum and average number of active drivers used in the simulation study compared to 1.00 baseline values.

2). MAX AM and AVG AM--The maximum and average number of Atlanta-Memphis lane drivers compared to 1.00 baseline values.

3). MAX AR and AVG AR--The maximum and average number of Atlanta-Richmond lane drivers compared to 1.00 baseline values.

4). MAX HUB and AVG HUB--the maximum and average number of OTR drivers external to the SE region making deliveries to/from the zone hubs compared to 1.00 baseline values.

5). MAX SE and AVG SE--the maximum and average number of SE regional drivers making deliveries to/from the zone hubs compared to 1.00 baseline values.

6). CIRC--the average circuity (excess miles per trip) for all loads in comparison to point-to-point distances (assume circuity equals zero in the baseline model).

7). % CIRC--the average percent circuity (actual miles compared to point-to-point miles) for those loads that do not travel point-to-point.

8). IMBAL--the number of loads into the SE region minus the number of loads out of the SE region compared to a 1.00 baseline value.

9). AM IMBAL and AR IMBAL--the lane imbalance into/out of the SE region on the Atlanta-Memphis and Atlanta-Richmond lanes, respectively.

10). 1 DISP--first dispatch empty miles compared to a 1.00 baseline.

11). LATE HR and LATE %--the average number of late (or early) hours per load and the percent of late loads compared to 1.00 baseline values.

12). MILES DR--the average number of miles per driver per day compared to a 1.00 baseline.

13). MILES AM, MILES AR, MILES SE, and MILES HB--the average number of miles per driver per day for Atlanta-Memphis lane drivers, Atlanta-Richmond lane drivers, Southeast regional drivers, and external OTR drivers, respectively, compared to the 1.00 MILES DR baseline.

14). % AM LN, % AR LN, and % HUB--the percent of total loads that travel along the Atlanta-Memphis lane, the Atlanta-Richmond lane, or that travel through one of the zone hubs, respectively.

The results presented in Table 1 are based on the mean value obtained from five replications of the simulation models developed for each scenario. Each replication simulates one steady-state week of truckload trucking operations. Additional information regarding the development of the baseline and key lane models can be found in Killian, 1997. Key hub and zone model development for the SE region is discussed in Gangluff, 1997. While Table 1 provides comprehensive information regarding mean values for all performance measures, the primary discussion of metrics will focus on four key metrics; miles per driver per day, the percent circuity, first dispatch empty (deadhead) miles, and average percent of late (or early) loads. Mean performance for all Southeast scenarios for these metrics is presented in Figures 2 through 5.

In Figure 2, it is clear that the Atlanta key hub scenario produces the highest level for miles per driver per day. Even so, Table 1 indicates that many of these miles are circuitous miles caused by forcing the loads through the hub. Therefore, although the key hub scenario appears strong relative to this metric, the informed observer can recognize some inefficiencies. The only other scenario comparing favorably with the baseline scenario relative to this metric is the zone model, which compares favorably, but with a much smaller level of circuitous miles than in the key hub model. Means tests on the results indicate, however, that the zone model is not statistically different from the baseline at a 95% confidence level.

Figure 3 presents the results of means comparisons for the percent circuity metric. Clearly, the key hub model is a very poor performer relative to this metric. This is one of the reasons why hub & spoke networks were never seriously considered for truckload trucking applications. The HUBNET system helped to quantify these problems. The baseline is assumed to produce no circuity because all loads are delivered using point-to-point OTR drivers. The percent circuity is therefore caused by those loads that travel along lanes or through hubs. The hybrid model compares most favorably to the baseline model for the percent circuity metric. Even so, it is statistically different than the baseline scenario at the 95% confidence level. The key lane models perform adequately, but have a relatively small lane participation (approximately 4% to 22%). The zone model produces only 10.70% circuity for zone loads with more than 90% zone hub participation.

First dispatch empty miles performance is presented in Figure 4. Once again, the zone model performs very well. It offers statistically significant improvement over the baseline model at the 95% confidence level. The key hub and hybrid models also offer statistically significant improvement compared to the baseline, but do not offer the same level of performance relative to other measures of effectiveness that continue to make the zone model an attractive alternative. The reason for the strong performance of the hub, zone, and hybrid models is that the positioning of the hubs is well coordinated with freight pick-up and delivery locations. Drops at zone hubs leave trucks well positioned for a next load pick-up.

Figure 5 compares the performance of the average percentage of late (or early) loads. Relative to this metric, only the key hub model performs worse than the baseline. The hybrid model performs best relative to this important customer service indicator, but the results are not significantly different from the baseline scenario at the 95% confidence level by a small margin. Similarly, the other scenarios that offer improvement do not do so statistically significantly in comparison with the baseline scenario.

A summary of the results from the SE region is now presented. All of the proposed alternatives to the baseline model would offer tremendous opportunity to convert OTR to regional or local jobs. If this were the only concern, each would be a viable candidate for further development. When considering all metrics, however, the zone model appears to be the best choice. We will now discuss the relative merits of each alternative considered.

The hub model produces so much excess circuity that almost all other metrics are also adversely affected. Experimentation with the HUBNET system produced similar findings. Therefore, the single hub model should not be considered further.

The three different lane models examined led to improvement in some areas at the expense of others. The improvement offered by these models (in addition to driver tour lengths for lane drivers) is primarily in terms of customer service. Lateness and percent lateness is generally reduced for those models that have reasonable lane participation. The problem is that this service improvement is achieved while increasing circuity and first dispatch empty miles, and while reducing the critical operational metric of miles per driver per day. The miles per driver per day metric is especially significant because a reduction here means that not only does the strategy reduce equipment utilization, but it reduces driver pay. Thus the problem contributes to the original problem of driver retention.

Subsequent sensitivity analysis relative to the lane models is completed to determine whether or not lane participation rules affect performance. Specifically, the original lane models permit lane participation on a lane for those loads that do not encounter more than 20% circuity in traversing the lane. A secondary experimental analysis has been undertaken to determine the sensitivity of the various performance metrics to the lane participation rule. In this secondary analysis, lane participation has been permitted for 15% circuity and for 25% circuity.

Table 2 presents the results from the lane participation sensitivity analysis. The experiments have been completed for all three lane models. The Atlanta-Memphis scenarios are labeled 'AM', the Atlanta-Richmond scenarios are labeled 'AR', and the 2 lane models are labeled 'BOTH' on the figure. The 20% columns in Table 2 are considered 'baseline' scenarios for the sensitivity analysis so all performance comparisons are relative to the 1.00 values in the 20% baseline. Although somewhat arbitrarily selected initially, the 20% baseline value performs well during sensitivity testing. Reducing this value to 15% generally leads to improvements in terms of miles per driver per day and in terms of the number of drivers required. Likewise, the circuity measures are improved. This, of course, is an obvious result. The first dispatch empty miles performance metric appears indifferent to the reduction in allowable circuity. The only negative performance observed for the reduction is in the customer service metrics of late hours and the percent of late loads. This negative performance is most pronounced for the AM scenarios, but is present to a lesser extent in the other scenarios. The results of increasing allowable circuity to 25% are predictable, with the only real improvements coming in the customer service metrics. Therefore, it would appear that the 20% allowable circuity rule results in a compromise between customer service and company or driver performance metrics, and the zone models appear to provide robust improvement in comparison to the lane models.

The zone and hybrid models appear to provide fairly robust improvements in some areas and do not perform as well in others. Some results are difficult to interpret. For example, the maximum number of required drivers in the SE zone model is greater than the baseline, but the average number is less. Both the zone and hybrid models perform worse than the baseline in terms of average lateness but perform better than the baseline scenario in terms of the percent late. Therefore, these alternatives lead to a smaller percentage of later deliveries. The imbalance is also increased but this result is not meaningful because direct delivery rules in the proximity of a zone hub lead to an effective change to the size & shape of the SE region (loads originating or destinating within 50 miles of a hub are subject to direct pick-up or delivery without passing through the hub). Both models lead to a statistically significant improvement in first dispatch empty miles, have strong participation in the hub programs (more than 90%), and have 'acceptable' levels of circuity given that the laudable goal of converting OTR to regional driving jobs would necessarily be accomplished with some circuity increases.

The zone model appears to perform slightly better than the hybrid model in general. The zone model operates with fewer drivers, fewer first dispatch empty miles, and less late hours. The hybrid model performs better in terms of circuity and the percent of late jobs, but most of these differences are not statistically significant. The most critical difference is in terms of miles per driver per day, where the zone model performs statistically better at a 95% confidence level in comparison with the hybrid. Based on these results, it is concluded that the zone model appears to be the best driver tour reduction technique in the SE region from among the alternatives examined.

To determine if these results are robust in general terms, an additional analysis has been undertaken using a second geographical region in the Northeast (NE) United States. Figure 6 presents pertinent information about the NE area in terms of geographical boundaries, hub locations, and lane locations. Table 3 presents the results of testing for an identical set of scenarios and performance measures to those used in the SE study. Some description of the NE region scenario names is required for understanding Table 3. The EBR-EMP lane is from East Brunswick, NJ to Emporia, VA. The EBR-AKR lane is from East Brunswick, NJ to Akron, OH. The EBR hub model is analogous to the Atlanta, GA key hub model in the SE region. Some metric titles have also changed. Obviously, NE has replaced SE in these titles. Also, EE represents East Brunswick-Emporia and EA represents East Brunswick-Akron. Figures 7-10 present mean performance results for miles per driver per day, percent circuity, first dispatch empty miles, and average percent of late (or early) loads.

Table 3 and Figures 7-10 tend to support the thesis that the results are transferable across regions. The maximum and average driver statistics are very similar. The circuity performance is also similar, but in the NE region both lanes are heavily traveled and circuity is therefore generally higher for the individual lane models. First dispatch empty miles performance has similar trends to those observed in the SE region, but the zone and hybrid models perform even better in the NE region. The customer service metrics involving lateness are also similar, but again the zone model performs even better in the NE than in the SE. In fact, the negative performance in terms of lateness in the SE is reversed for the zone model in the NE. In the NE region, both lateness and percent lateness are improved. Both of these metrics offer statistically significant improvement relative to the baseline. Circuity is reduced in comparison with the SE, primarily because the NE region is more easily isolated from the remainder of the United States with less area to cover with perimeter hubs over a smaller collection of major roads. Consequently, almost 98% of loads traverse through a hub in the zone and hybrid models. One could argue that circuity with 'zone' methods could be further reduced by using a larger number of drop points, even to the extreme of using so called 'drop & swap' software to match one load entering the zone with one load exiting the zone. In practice, these techniques have resulted in logistical nightmares and are subject to the scheduling inconsistencies inherent to stochastic systems. The use of a smaller number of drop yards eliminates some of these stochastic inefficiencies and permits smooth flow of goods across the zone boundary. The miles per driver per day are slightly less for the zone and hybrid models than in the NE baseline scenario, but not alarmingly so and certainly not statistically significantly so.

The examination of the second geographical area not only adds credibility to the effort in terms of making claims of generality, but in fact demonstrates that some regions may be even more well suited to the strategies than the original scenario.

Sensitivity analysis has also been completed for the number of hubs used in the SE region to determine the effects of using a large or small number of hub locations. Figures 11-14 present mean performance results and 95% confidence intervals for miles per driver per day, percent circuity, first dispatch empty miles, and average percent of late (or early) loads criteria for SE zone models. This experimentation makes use of 2 to 10 hub locations. The miles per driver per day criterion presented in Figure 11 seems to perform best with 4 to 7 hubs but produces no results which differ significantly between 3 and 10 hubs. The circuity metric presented in Figure 12 is characterized by tight confidence intervals and mean values that decrease as the number of hubs increase. The first dispatch empty miles criterion in Figure 13 indicates that 3-5 hubs result in the best values for first dispatch empty miles. Scenarios with 7 or more hubs perform significantly worse than those with 3 or 4 hubs. Finally, the percent of late loads seems to be lower for scenarios with 6 or more hubs but none of the scenarios significantly differ from the others. These sensitivity analysis results seem to indicate that scenarios with 4 to 6 hubs in the SE region seem to offer the best compromise solutions relative to all four of the key metrics. These scenarios gain most of the steep improvements in circuity possible from hub increases yet do not pull drivers away from dense freight regions for strong first dispatch empty miles performance.

RESEARCH RELEVANCE AND IMPLICATIONS

The research discussed herein has made significant contributions to the literature in determining viable dispatch and delivery alternatives to the OTR system employed by most TL trucking companies. The strategies presented herein have turned into practical reality within the JBH delivery network. At this writing, a ‘key lane’ is in use in the Eastern United States, linking northern and southern marketing areas with a single east coast lane. Of course, JBH has been operating with de facto lanes for several years as a major carrier of intermodal truckloads with rail. The east coast lane is the first real attempt at a solely truckload ‘lane’. Also at this writing, a ‘zone’ system is fully approved and in the final stages of planning for use in the NE United States with expected implementation in the near future. These innovations are being directly driven by this joint collaborative research.

Other research efforts are currently being initiated through the ongoing research partnership described herein. New efforts focus primarily on marketing strategy, pricing, and intermodal synergy.

Tools ranging from Geographical Information Systems to simulation are being used to examine problems and to develop solutions.

Although most research to date has focused on normal TL operations, JBH is more and more interested in pursuing a customer base that includes a high flow of regular shipment volume from large manufacturing companies or other regular shippers. The company would like to be in a position to package their services in such a way that they could regularly schedule their capacity for large customers in the form of total business logistics solutions. Ideally, engineered services could be provided by merging a controllable share of existing JBH freight with new customer freight to build dedicated, regular delivery lanes. The company would further like to anticipate customer needs to provide matching services without being asked, and would like to handle seasonality, surges, promotions, etc. without loss of quality in delivery service. To borrow from a customer service hierarchy presented by Albrecht (1994), the TL trucking industry should strive to provide leadership in offering service that goes beyond 'basic', 'expected', or even 'desired' levels of service. The goal of JBH, the TL trucking industry, and of the academic researchers is to provide operational strategies and strategic vision leading to 'unanticipated' service to customers by continuously providing new levels of service that go beyond customer desires.

The primary focus of this research is on improving the quality of driver life and customer service in the TL trucking industry but we should not forget that the synergistic partnership produces many other benefits. Key among these benefits is the value brought back into the academic classroom. Students derive tremendous benefits from the study of proven, case-driven research ideas that broaden their experience base and that permit the study of a problem from initial identification through field deployment.

The research described herein is practically motivated, funded by industry, academe, and government, and has the potential to fundamentally change the way that large truckload trucking companies operate. There is no question that the research collaboration results in a synergy that is larger than the sum of the parts. The creative marketing and operational initiatives resulting from this work are a testimony to this fact.

REFERENCES

Albrecht, K., 1994. *Northbound Train.* AMACON, New York, NY, 213 p.

Braklow, J.W., Graham, W.W., Hassler, S.M., Peck, K.E., and Powell, W.B., 1992. Interactive Optimization Improves Service and Performance for Yellow Freight System. *Interfaces,* 22 (1): 147-172.

Gangluff, G.E., 1997. *Alternative Delivery Methodologies for Truckload Trucking Operations.* Forthcoming Master's Thesis, Dept. of Industrial Engineering, University of Arkansas, Fayetteville, AR.

J.B. Hunt Transport, Inc., 1996. *Internet Home page*, http://www.jbhunt.com/ jbhhome.htm.

Kanafani, A., and Ghobrial, A.A., 1985. Airline Hubbing--Some Implications for Airport Economics. *Transportation Research*, 19A: 15-27.

Killian, R.C., 1997. *Development and Analysis of Efficient Delivery Lanes*. Forthcoming Master's Thesis, Dept. of Industrial Engineering, University of Arkansas, Fayetteville, Arkansas.

Mele, J., 1989a. Carriers Cope With Driver Shortage. *Fleet Owner*, 84 (1): 104-111.

Mele, J., 1989b. Solving Driver Turnover. *Fleet Owner*, 84 (9): 45-52.

Morrison, S.A., and Winston, C., 1986. *Economic Effects of Airline Deregulation*. Brookings Institute, Washington, DC.

Powell, W.B., Sheffi, Y., Nickerson, K.S., Butterbaugh, and Atherton, S., 1988. Maximizing Profits for North American Van Lines Truckload Division: A New Framework for Pricing and Operations. *Interfaces*, 18 (1): 21-41.

Schonberger, R.J., 1982. Japanese Manufacturing Techniques: Nine Hidden Lessons in Simplicity. Free Press, New York, NY, 260 p.

Schwartz, M., 1992. *J.B. Hunt: The Long Haul to Success.* University of Arkansas Press, Fayetteville, AR.

Taha, T.T., and Taylor, G.D., 1994. An Integrated Modeling Framework for the Evaluation of Hub and Spoke Networks in Truckload Trucking. *The Logistics and Transportation Review*, 30 (2): 141-166.

Taha, T.T., Taylor, G.D., and Taha, H.A., 1996. A Simulation-Based Software System for Evaluating Hub-and-Spoke Transportation Networks. *Simulation Practice and Theory*, 3: 327-346.

Taylor, G.D., Harit, S., English, J.R., and Whicker, G.L., 1995. Hub and Spoke Networks in Truckload Trucking: Configuration, Testing, and Operational Concerns. *The Logistics and Transportation Review*, 31 (3): 209-237.

GUIDE TO TABLES, FIGURES, AND APPENDICES

TABLES:

FIGURES:

APPENDICES:

Appendix A. Baseline Model SIMNET II Code.

Appendix B. Single Key Lane Model SIMNET II Code.

Appendix C. Dual Key Lane Model SIMNET II Code.

Appendix D. Key Hub Model SIMNET II Code.

Appendix E. Zone Model SIMNET II Code.

Appendix F. Hybrid Model SIMNET II Code.

All appendices available from Mack-Blackwell Transportation Center upon request.