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Design and analysis of delivery 'pipelines' in truckload trucking

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ABSTRACT

This paper examines a new dispatching alternative for the truckload trucking industry involving the use of delivery 'pipelines' with dense flow volumes. Drivers and loads are partitioned into two sets; those that utilize pipelines via a series of 'dray' moves and line-hauls, and the remaining set of random over-the-road (OTR) drivers that are dispatched by traditional methods. Alternative methods are presented to determine where delivery pipelines should be located and how they should be operated. The effects of the pipelines on the remaining OTR fleet are also examined. Results indicate that the new dispatching alternative is feasible.

1. Introduction and motivation

In the United States, the truckload trucking industry is highly competitive. With more than 600,000 registered motor carriers (United States Department of Transportation, 2005), profit margins are low and shippers often wait until the last minute to secure a carrier. This customer behavior results in a seemingly random set of dispatching needs and a general lack of advance information that might be exploited by dispatching systems. This operating environment adds considerably to the difficulty of the already daunting dispatching problem in support of random over-the-road (OTR) operations.

To complicate the dispatching task further, carriers must consider their own needs while they concurrently consider the needs of customers and drivers. The desire for cost effective dispatching decisions often leads carriers to dispatch drivers by methods that focus heavily on the minimization of empty relocation miles between loads. This methodology, however, can lead to excessively long tour lengths for drivers. This affects the quality of driver life and is a leading cause of driver turnover in an industry that considers one of its most difficult challenges to be that of retaining drivers (see, for example, Schwartz, 1992 or Richardson, 1994). The driver shortage is so acute that some researchers such as Min and Emam (2003) perform research to find which driver characteristics make them more likely to stay on the job. They then use data mining techniques to develop ways to recruit and retain drivers with those characteristics. Griffin et al. (2000) list a number of important factors in retaining drivers. Key among these factors is the location of the carrier home base, the amount of time at home, and the quality of routes that they drive. To better support driver needs for more frequent domicile returns, a great deal of recent research has focused on finding better ways to dispatch drivers. Sabnani and Hall (2002) designate specific driving routes that remain in effect for weeks or even months. This work is in the less-than-truckload environment, but the idea is sound in truckload trucking as well. Another possible way to defeat the challenges associated with driver retention would be to find alternative means of dispatching that could be used for all or part of existing OTR driving fleets.

In this paper, the authors consider the development of a dispatching alternative using driving 'pipelines' that would be the trucking equivalent of the railway portion of an intermodal shipment. These pipelines would utilize existing highway

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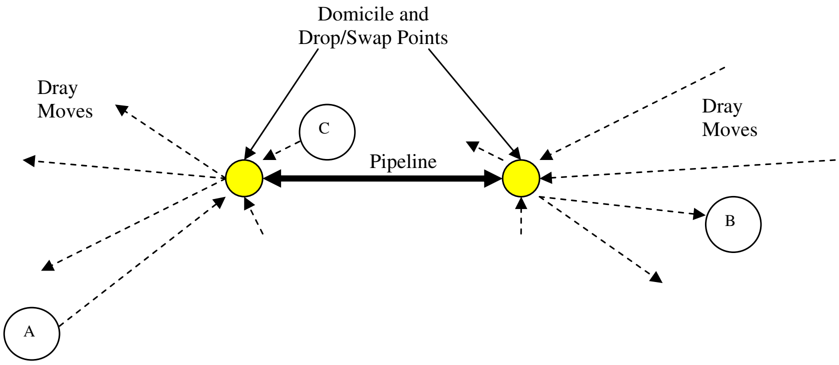

Fig. 1. Graphical example of 'pipeline' operations.

infrastructure. In this form of dispatch, the pipelines would be delivery lanes with dense and balanced flow volumes. Loads that could travel down these pipeline lanes without encountering excess circuity (out-of-route miles) would be dispatched as pipeline loads. In this case, the load would be picked up by a local or regional driver for a 'dray' move to the start of the pipeline. From there, the load would be taken to the other end of the pipeline by a 'linehaul' driver for ultimate delivery by another local or regional 'drayman'. The advantage of this type of dispatch would be that some subset of drivers could be partitioned as either draymen or linehaul drivers. Linehaul drivers would have frequent domicile returns. The local or regional drivers performing dray moves would likewise get home more frequently, particularly if they are domiciled near the endpoint of the pipeline that they support. These local or regional drivers may or may not be dispatched independently from the remaining OTR fleet. The potential disadvantage of this method is that the loads would need to have sufficient delivery 'slack' time built in to support the potentially lengthy delays at pipeline endpoints awaiting the next dispatch. As stated previously, this type of dispatch is similar to intermodal dispatching with two exceptions; linehauls are accomplished via truck instead of train, and loads travel independently instead of being consolidated for larger concurrent shipment during the linehaul segment. A graphical representation of the pipeline delivery system can be found in Fig. 1.

In Fig. 1, the solid bold line represents the pipeline. The length of the pipeline would ideally be a convenient 1/2-day or 1-day driving distance so the pipeline drivers could return to their domicile either daily or perhaps every other day. The dashed lines represent potential dray moves to feed the pipeline. Ideal pipelines would have more or less equal amounts of freight traveling in each direction so imbalance issues will not arise with linehaul drivers. Pipelines should also be of sufficient length of haul that they would be convenient in terms of driver requirements and governmental regulation. For example, the linehaul segment should be short enough to permit a driver to complete a full out-and-back journey or a one-way journey in a single day without stopping for a required break for sleep. The length of haul should also make sense in terms of economics and customer concerns. An excessively long linehaul, for example, would often not be cost effective in comparison to an intermodal move with rail. Clearly, the pipeline fleet partition would not support all loads or all drivers, but it may provide a potentially important new means of dispatch in the truckload trucking industry.

2. Related literature

Traditional truckload trucking dispatch systems heavily weigh the next dispatch empty travel distance as a criterion in load-to-driver matching problems. In practice, other varied criteria are also considered and weighted so that each load-driver combination can be assessed a point value. The objective is to make driver assignments that are as globally near optimal relative to these point values as possible. Ronen (1997) points out that distance minimizing approaches are 35% more expensive than corresponding cost minimizing dispatching approaches so this more inclusive approach is warranted. Given the size of many dispatching problems, both in terms of the number of loads and drivers involved, as well as the geographical separation that exists in a dispatching problem of continental scale, dispatching systems often solve a series of smaller problems. As Powell et al. (2000) point out, the most common approach to the problem is to solve a series of myopic and deterministic models that result in a 'good' solution. They examine the quality of solutions while considering uncertainty in customer demands, travel times and even dispatch system user noncompliance.

Over the past few years, a number of papers have dealt with the development of alternative dispatching methods that seek to partition the OTR fleet into two categories; drivers that have regular routes or limited dispatches and those that continue to be dispatched via traditional methods. It would likely be impossible or at least very expensive to force all drivers into alternative dispatching methods. The alternatives considered include hub and spoke dispatching, zone dispatching, lane dispatching, regular route methods that use high volume freight lanes as building blocks for longer tours, and 'popcorn' dispatching (a form of random OTR dispatch with limited driver destinations permitted). The regular route dispatching methods include both heuristics and integer programming based solutions. Meinert and Taylor (1999) provide a historical view of most of these methods while Taylor and Whicker (2002) provide a description of the integer programming approach