Proceedings of the 2004 Winter Simulation Conference
R .G. Ingalls, M. D. Rossetti, J. S. Smith, and B. A. Peters, eds.

SIMULATION ANALYSIS OF TRUCK DRIVER SCHEDULING RULES

Eric C. Ervin
Russell C. Harris

J.B. Hunt Transport, Inc.
615 J.B. Hunt Corporate Drive
P.O. Box 130
Lowell, AR 72745, U.S.A.

ABSTRACT

2004 brought a landmark event in the changes to regulations governing hours of service for truck drivers. This paper describes an effort utilizing modeling and simulation for evaluating the impact of the new 2004 Hours of Service (HOS) rules in scheduling and dispatching one of the largest random over-the-road (OTR) trucking fleets in North America. The model was comprehensive and enterprise-wide in nature, modeling unique order-to-delivery process characteristics for over 120,000 freight lanes and the continuous nature of the driver's work day. Model results provided quantification of the 2004 HOS impact on fleet utilization, cycle times and customer service. Results of the model were used to guide company strategy related to drivers, customers and operations. With five months of actual business performance collected regarding the new HOS in 2004, a post-mortem analysis has provided insight regarding the quality of simulation model forecasts done in 2003.

1 INTRODUCTION

The implementation of new rules and policies can have a significant impact on the performance of a supply chain, particularly within the transportation industry. For a large logistics operation, changes to scheduling rules will potentially impact resource utilization, cycle time and customer service measures. Furthermore, the implementation of changes to current policies might require large capital expenditures and a significant commitment of time and resources. The impact of scheduling modifications needs to be carefully evaluated to ensure changes are effectively managed from three different perspectives: customers, employees and the company.

The implementation of scheduling changes can have a significant impact on the operations culture of a continental transportation services company. These impacts include: a redefined employee workday, a modified planning process to support the order-to-delivery capability and productivity changes that will influence the profitability of current customer contracts. These changes, therefore, have to be evaluated with an approach that will provide a high degree of fidelity in the results. The approach should also be flexible in terms of level of detail included. Discrete event simulation is an approach that meets the requirements of high fidelity and high flexibility. Jain et al (2001) state the benefits and appropriateness of this approach.

Evaluating the impact of new scheduling policies and government directed HOS rules requires modeling of two important aspects: the order-to-delivery process and the truck driver's daily routine. The performance of the order-to-delivery process depends on the interaction and flow of people, equipment, material and information. For example, the order-to-delivery cycle time is impacted by the time related to: booking an order, dispatching a truck, traveling to the shipper's location, loading the truck, traveling to the receiver's location and unloading the truck. The productivity of a truck driver can be linked to both required and voluntary activities performed by the individual. For example, available driving time is dependent on: recent on-duty time spent driving, on-duty time spent not driving, required Department of Transportation (DOT) break activity, sleeper berth activity and off-duty time.

This paper describes the use of discrete event simulation for evaluating the impact of the new 2004 HOS rules on a large logistics operation. The approach models the interaction and flow of people, equipment, material and information to capture critical aspects of the 2004 HOS changes. Section 2 provides a brief background of the case and Section 3 defines the objective of the study. The approach is described in Section 4 with emphasis on the key changes associated with the 2004 HOS, the approach to modeling the logistics network and the affected business process. Section 5 presents the results of the basic 2003 HOS vs. 2004 HOS comparison, as well as, analysis of additional scenarios. Section 6 discusses insights from the model generated findings and the recommendations that were made to the company. The last section provides commentary regarding system performance differences between what was projected for 2004 and what the observed impact has actually been since the 2004 HOS rules went into effect earlier this year.

2 BACKGROUND

The subject of this study is a logistics provider servicing shippers and receivers across the continental US as well as many customers located in Mexico and Canada. Some of their most active customers include Wal-Mart, Target, JC Penney, Procter and Gamble, and Ford Motor Company. The company's OTR fleet consists of over 5000 tractors and more than 10,000 trailers.

The Federal Motor Carrier Safety Administration (FMCSA), an administration within the DOT, passed legislation in 2003 that revised the HOS rules. Effective January 1, 2004, laws that govern the drivers' allowed time to drive the tractor changed for the first time in 60 years. The changes were passed into legislation in an effort to reduce fatigue in truck drivers.

The longstanding DOT rules allowed drivers to drive for 10 hours before requiring a eight hour DOT break. Drivers were not allowed to drive after accumulating 15 non-consecutive hours of on-duty work. The 2004 rules allow drivers to drive an additional hour, but the required break was raised two hours to 10 hours. Furthermore, instead of being able to accumulate 15 non-consecutive hours on-duty and still be legal to drive, drivers have a 14 hour window in which they can drive beginning from the time they return to on-duty from being off duty. Also, under the new rules drivers are allowed to refresh or *reset* their driver log after being off-duty for 34 hours. See Table 1 for complete rule summary.

Table 1: 2003 and 2004 HOS Regulations

Description	2003	2004
Off-Duty Required Hours	8	10
On-Duty Hours	15 Non-Consecutive	14 Consecutive
Driving Hours	10	11
8 Day On-Duty Limit	70	70
Hours Idle for Reset	Not Available	34

3 OBJECTIVE

The company needed to understand exactly how the 2004 HOS regulations would affect their productivity considering the reduction in total hours the driver would be allowed to drive legally and the new law that allows drivers to reset their log books after being off-duty for 34 hours. The combination of these rules made it difficult to determine whether the changes would help or harm the OTR segment's efficiency.

The objectives of the study were to:

1. Determine the impact of the new 2004 HOS rules as they apply to driver utilization, customer on-time service and the nature of the company's freight network.
2. Develop a strategy to mitigate any negative impact on utilization and efficiency.

The impact was to be quantified using key performance indicators such as utilization, cycle time, customer service (on-time pick-up and delivery) in a comparison between performance under the longstanding HOS laws and the new 2004 HOS laws. Taylor et al. (1999) took a similar approach in previous literature utilizing simulation for the company in this case study.

4 APPROACH

The processes requiring simulation modeling were determined after meeting with subject matter experts from the field who had extensive knowledge and experience dealing with how drivers are dispatched with loads and how drivers behave with regard to the HOS rules that were in place at the time. The result was an enterprise level simulation model. There were six major processes modeled in the simulation:

1. Demand Generation
2. Capacity Management
3. Load and Tractor Assignment
4. Driver Log Management
5. Transportation Execution
6. Customer Freight Pick-up and Delivery

Network characteristics such as customer demand, transit durations, customer dwell durations and driver on-duty durations were derived from information retrieved from the company's extensive data warehouse. The freight network involved over 120,000 distinct one-way origin and destination pairs defined by zip-codes in the continental United States. Each node of the origin and destination pairs represented a local market of customers which create a demand of just under 1,000,000 loads annually.

The modeled transportation process began with the creation of a customer order. The customer's order was then intelligently matched with a driver, and the order became a customer load. Drivers were required to drive from their current location to the load's point of origination. When the load pick-up was complete the driver transported the load to the load's destination where it was delivered to the consignee. Once unloaded, the driver searched for a new load, waited for a new load or traveled home for off-duty time.

4.1 Demand Generation

Customer demand was generated over a 12 month period for each distinct one-way origin and destination pair, or lane. It represented data extracted from one full year of actual company history which was maintained in a corporate data warehouse. Each lane was assigned an annual demand with monthly seasonality. Seasonality was a very important aspect of the transportation network, so it was very important that the model reflect the fluctuation in demand in each market on a month-by-month basis. Customer demand was represented by activity between distinct zip-code pairs.

The customer demand was simulated using a Non-stationary Poisson Process and a thinning method as described by Law and Kelton (1991). The model realistically provided variability within seasonal periods as exhibited by the company's historical data.

Demand that was not accommodated due to lack of capacity waited for up to 24 hours before reneging unless capacity became available before the 24 hour delay expired.

4.2 Capacity Management

Company capacity was in the form of a driver. The model simulated the driver and not the tractor since the model is less interested in the distribution of tractors among the drivers. The model is more interested in how the 2004 HOS effect the availability of the driver to operate the tractor.

Drivers were allowed to remain on duty for a period of time after which they were directed to spend time off-duty at their home or domicile. The period of time for which a driver spent on duty was randomly distributed among all the drivers according to the distribution in Table 2.

Table 2: Probability for Assigning Driver Tours

P	On-Duty Duration
9.2%	1 week
14.7%	2 weeks
30.5%	3 weeks
45.6%	3 weeks + EXPO(9.67 days)

On-duty driver characteristics were derived from data collected from the company's data warehouse. The dataset collected represented the previous year's activity and detailed time drivers spent on and off duty. Drivers were assumed off duty for 0.281 hours for every hour spent on-duty.

At any given time a driver was either on dispatch, not on dispatch or at home. If a driver was on dispatch then a load had already been assigned to the driver. Only one load was assigned to a single driver at any given time.

If a driver was not dispatched on a load then the driver was available to be matched with a customer order. Drivers first looked for a load when they became available to do so. If they did not find a load in their area then they waited for a load to become available in their area.

If the driver was at home the driver remained there without the possibility of being matched with a customer load. Upon completion of off-duty time the driver once again looked for a load in the local area.

4.3 Load and Tractor Assignment

The simulation model loosely mimicked the automated load assignment software that is used by the company to recommend available demand to be matched with available capacity in a way that maximizes company efficiency and minimizes empty miles and customer service failures. All proximity calculations were based on x, y coordinates of the longitudinal and latitudinal plane and approximated circuity in the road network.

The model avoided assigning loads to drivers who were due home soon, unless there was a load that would take the driver close to the driver's domicile. In that case, a driver who was due home soon in a load's locality would get preference to the load as long as the load did not originate too far from the driver's current area. The average distance a driver traveled empty to pick up a load was 56.1 miles which was the result of a maximum 115 miles for the load and driver to be considered for pairing. Drivers received preference for being close to the origination of the load.

The model avoided assigning loads to drivers who did not have sufficient hours available to complete the load without taking a DOT break. In the event that no drivers in the area had enough hours to complete the load the driver with the most hours available was given preference on the load. Drivers with more hours available to drive received a measure of preference over drivers with less available driving time. Furthermore, drivers which had been idle longer received a measure of preference as well.

The driver with the most preference given all of the factors involved was dispatched on a load requiring capacity. Likewise, drivers needing a load to carry chose the most desirable loads according to the loads' proximity to the location of the driver.

4.4 Transportation Execution

Once an order and a driver were matched, the transportation of the order, or load, began. The driver first traveled to the origination of the load to pick it up. The distance the driver traveled to pick up the load was determined using an equation to approximate the distance between two points, including road network circuity. Equation 1 contains an approximation distance between two points with road circuity factors.

$$D = ([71*(X1 - X0)]^2 + [65*(Y1-Y0)]^2)^.5 \qquad (1)$$

Company load history characteristics were used to determine the distance the load would travel from the shipper to the receiver for each lane.

The velocity of the transit was based on a generally accepted company assumption that the beginning of the trip will occur at lower average speeds than the rest of the trip, and as the trip continues the average velocity rises. Table 3 details these assumptions.

Table 3: Average Transit Velocity by Mileage Band

	Average MPH
The first 10 miles	20
The second 10 miles	35
The third 10 miles	42
The fourth 10 miles	45
Beyond 40 miles	52

These assumptions take into consideration congestion within urban areas and assume that longer trips will utilize expressways for the longer segments of the transit.

4.5 Driver Logs

Throughout the model the driver's hours were logged just as they were required by the DOT. Hours were logged in four categories:

1. Off-duty, general off-duty
2. Off-duty, driver in sleeper berth or at home
3. On-duty, driving
4. On-duty, not driving. Loading/unloading

Drivers times performing activities were always logged as they were completed. Drivers were not allowed to violate the HOS rules within the simulation, and upon exhausting their available hours to drive the driver was placed on DOT break. While on DOT break the driver did not progress in transit toward the destination. When the driver had completed the necessary time on break the driver resumed driving.

4.6 Customer Dwell

Customer dwell times were determined using customer history data from the company's data warehouse. Data from the previous twelve months was used to develop a distribution for each lane for pick-ups and deliveries as well as probabilities for live loads versus drop-and-hook loads.

Any time over 2 hours spent at the customer were assumed to be in the sleeper berth. Since drivers could qualify for a DOT break by combining nonconsecutive sleeper berth time, they took advantage of excess time at the customer by logging time in the sleeper.

4.7 Model Validation

The model was validated by comparing key performance indicators of the model with the known values for the previous twelve months. Key performance indicators such as utilization, cycle time, customer service were compared, and logical adjustments were made to the model until the model performance indicators closely resembled the known performance indicators.

Utilization was defined as the total miles driven under dispatch by all drivers over the course of a year, and it was measured by miles per driver per day.

Cycle time was measure in hours from the time the load was dispatched until the load was delivered.

Customer service was measured as a percent of loads that were delivered on or before the customer's appointment.

4.8 Runtime Environment

Specific technical notes regarding the 2004 HOS simulation model include:

- The model was developed using Arena 6.0. The CPU used for processing the model included a 2GHz processor and 1GB of RAM for this memory intense model. A single replication took approximately 4 hours on average to complete .
- Experiments typically included 4 replications.
- Experiments took at least 16 hours to complete in batch mode.
- The simulation horizon was one full year.
- Each replication included a 3 month warm-up period.
- The model required 35MB of data which were imported using VBA automation upon experiment initialization.
- Unique common random number streams were used for major factors with variation to reduce variance.

5 RESULTS AND DISCUSSION

5.1 2003 vs. 2004 HOS Comparison

Table 4 presents the change in the value of fleet utilization, order-to-delivery cycle time and customer service between 2003 and 2004 HOS simulation models. For all three metrics the new 2004 HOS impact appears to have a negative impact.

Table 4: % Change in Key Performance Indicators from the 2003 to 2004 HOS Simulation Models

Key Performance Indicator	***% Difference from 2003 to 2004 Model***
Utilization	-10.4%
Cycle Time	+8.6%
Customer Service	-4.5%

The fleet utilization impact of the new 2004 HOS is negative, showing a net decrease in capacity by reducing the average number of miles the fleet can run by 10.4%. The cycle time impact of the new HOS rules is also negative, showing a net 8.6% increase in the average time from dispatch to delivery for identical sets of business volumes. Finally, customer service is a negative impact with a net 4.5% decrease of on time deliveries.

With the serious negative impact the simulation model was projecting, a significant effort was made to better understand the results and provide the company sound reasoning behind why the model was giving these results. The analysis focused on the key differences between the 2003 and 2004 HOS: 10 hours vs. 11 hours driving per shift; 15 hours vs. 14 hours on duty per shift; 8 hours vs. 10 hrs break time between shifts; and the non-consecutive vs. the consecutive nature of on duty time. Isolated qualitative comparisons of the simulation runs are provided in Table 5.

Table 5: System Performance Impact of Key Input Parameter Changes

Input Parameter Change	***Performance Difference from 2003 and 2004 Models***
+1 Hr Max. Driving Time	Marginally Improves
+2 Hr Required Break Time	Marginally Worsens
-1 Hr Max. On Duty Time	Marginally Worsens
Consecutive On Duty Time	Significantly Worsens

Changes to rules associated with driving time, on duty time and break time provided an expected system response. The biggest finding in this analysis was the impact of the *consecutive* nature of the way on duty time is logged under the new 2004 HOS. Before 2004, a driver could log time off duty in situations when he or she was being delayed and could preserve available on duty time and driving time. With 2004 HOS, the consecutive nature of on duty time has two very important effects which negatively impact system performance:

1. Drivers have only 3 hours in their 14 hour work window to cover inspections, fueling and loading or unloading time at shipper and receiver docks. Any delays over 3 hours immediately begins to erode the 11 hours the driver has available to drive, and negatively impacts fleet utilization.
2. Drivers under dispatch are more likely to get caught in scenarios where they hit the limit of their 14 hour work window and have to take a 10 hour break before they can resume transit and make the delivery to the customer. In these scenarios, the break adds 10 hours to the order-to-delivery cycle time and increases the risk of missing the delivery appointment window and degrading customer service.

In a logistics environment freight mix and length of haul are significant factors that impact the operational efficiency and business profitability. Often, network effects can positively or negatively impact utilization and service metrics. Because utilization and service metrics for the current dispatch are often influenced by activities associated with a driver's previous dispatch, these metrics are more influenced by network performance. In order to understand the HOS impact on a load by load basis, cycle time impacts were measured in 100 mile bands. Figure 1 presents the results of the focused mileage band analysis.

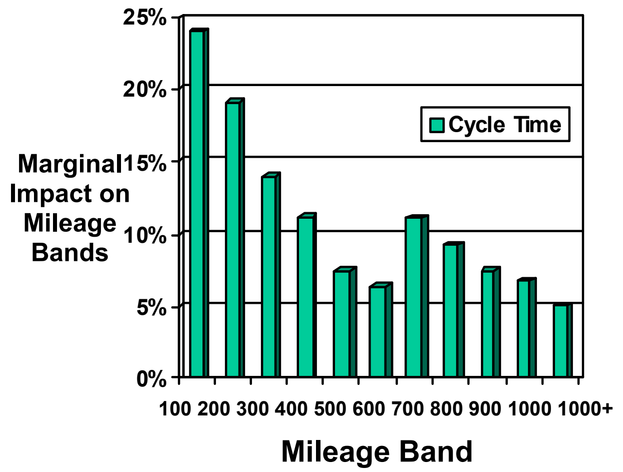

Figure 1: Cycle Time Impact of 2004 HOS

While cycle time on average increased 8.6%, the impact of the 2004 HOS varied greatly depending on length of haul. The 0-100 mileage band was negatively impacted by almost 24% and the 1000+ mileage band was negatively impacted by approximately 4%. The mileage band analysis provided further validation the simulation model by showing the influence of what is known inside the company as the "tweener" effect. The "tweener" concept is related to the operational inefficiencies associated with deliveries that take more than one but less than two driver work days. The "tweener" effect is reflected in the spike seen in the 600-700 mileage band.

In summary, the baseline 2003 HOS vs. 2004 HOS analysis projected a noticeable negative impact on the company. As a proactive measure to better understand what the company could do to mitigate the negative impact, additional scenarios were analyzed which included: the use of the new 34 Hour Reset Rule, improved loading and unloading practices at shippers/receivers and increasing the top end speed of the trucking fleet.

5.2 Application of 34 Hour Reset Rule

One new feature associated with the 2004 HOS is the creation of the 34 Hour Reset Rule. With the 34 Hour Reset, a driver can shut down for a 34 hour period and resume work with a clean slate regarding any driving time logged and accumulated prior to the 34 hour rest period. Scenarios where the driver benefits from this new rule are:

1. When a driver spends a significant amount of time waiting between loads
2. When a driver spends a significant amount of time driving in a 4-5 day window.

In either case, the 34 hour reset can be used to refresh and improve the amount of driving time available to the driver in the near future.

5.2.1 Scenario Description

In the 34 Hour Reset scenarios, the new rule was applied both "actively" and "passively". In "active" scenarios the driver was proactively forced to break and reset in situations where he or she had been waiting nearly 34 hours for the next load, or when the driver was close to exceeding the cumulative 70 hour rule. The "passive" scenario is the simplest use case. Any time the driver spends 34 hours or longer on break, the model takes advantage of the 34 hour reset.

The analysis of these scenarios included a set of experiments where the 34 hour reset rule was actively applied. Scenarios were run that forced a 34 hour break as the driver approached the 70 hour driving work week limit at 55, 60, 65 cumulative hours. Scenarios were run that forced a 34 hour break as the driver had been waiting for a load 16, 20, 24 and 28 hours. The 55, 60 and 65 cumulative hour scenarios were run in matrix combinations with the 16, 20, 24 and 28 hour scenarios in an attempt to understand what active 34 hour reset policy provided the best results.

5.2.2 Results and Analysis

The application of the 34 hour reset provision appears to improve utilization and service metrics regardless of the specific policy that was applied. Figure 2 presents the results of the 34 hour reset analysis.

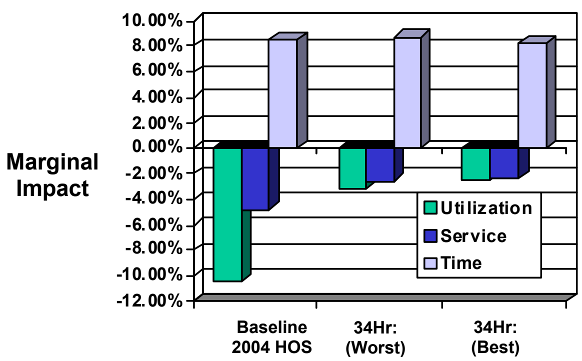

Figure 2: Impact of various 34 Hour Rest Scenarios

The application of the 34 hour reset rule appears to reduce the negative baseline utilization impact of -10.4% to between -2.3% and -3.2%. The negative baseline customer service impact of -4.5% appears is reduced to between2.4% and -2.6%. The rule appears to have no significant effect in reducing the negative average cycle time impact. A more in-depth analysis of cycle time is presented in Figure 3. Better reset policies appear to marginally reduce the negative cycle time impact for the lower mileage bands. Overall, however, the application of the 34 hour reset does not show the significant improvement in cycle times that were observed with fleet utilization and customer service.

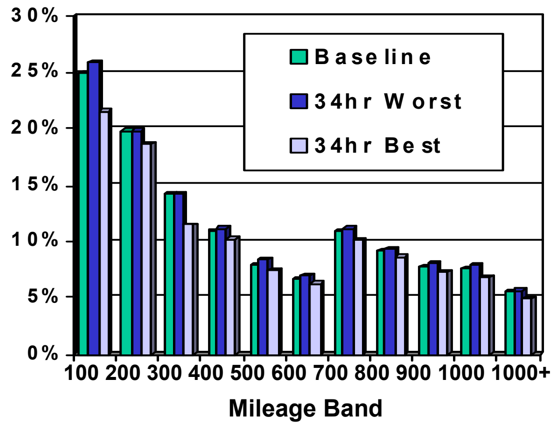

Figure 3: Cycle Time Impact on Mileage Bands with Reset

The best case policy evaluated in this analysis was to actively apply the 34 hour reset after the driver had been waiting for a load 28 hours or at 60 hours of cumulative driving time over an eight day period.

5.3 Detention Analysis

The baseline analysis indicated that the consecutive nature of logging duty time in 2004 will require an attempt to minimize the time drivers spend on duty not driving. The largest non-driving activity is loading or unloading. Loading and unloading activities are usually performed in either live or drop-and-hook modes. A live load or unload is a dock activity where the driver physically waits for the trailer to be loaded or unloaded. A drop-and-hook activity utilizes trailer/container pools. Trailers are loaded and made ready before the driver arrives. When the driver arrives he or she drops an empty trailer in the customer's pool and attaches to the preloaded trailer. Because the driver spends no time waiting to load or unload a trailer, drop-and-hook dock environments generally use a driver's time more efficiently. The objective of this analysis was to quantify the impact of customers with faster or slower loading or unloading behavior.

5.3.1 Scenario Description

This analysis evaluated three specific scenarios:

1. The baseline 2003 vs. 2004 HOS comparison discussed earlier in this paper. This contains the current mix of live vs. drop-and-hook behavior in the company's current freight network.
2. An all "drop-and-hook" scenario which assumes that all shippers and receivers in the company network take on drop-and-hook behavior.
3. An all 'live" scenario which assumes that all shippers and receivers in the company network take on live loading and unloading behavior.

In all of these cases the 34 hour reset rule was not applied and each scenario assumed identical freight demand patterns.

5.3.2 Results and Analysis

As expected, the more efficient drop-and-hook scenario out performed the baseline HOS scenario. Figure 4 represents the results of this analysis. The live loading and unloading scenario performs worse than the baseline HOS scenario.

The ability to quantify efficiencies already understood by the business in a qualitative sense was the value of this analysis. The drop-and-hook environment is more efficient than the live scenario, but the overall 2004 HOS impact is still negative for both types of loading/unloading environments. The drop-and-hook environment shows a -9.3% reduction in fleet utilization and a -4.4% reduction in customer service. The live loading and unloading environment shows a -12.3% reduction in fleet utilization and a -5.2% reduction in customer service.

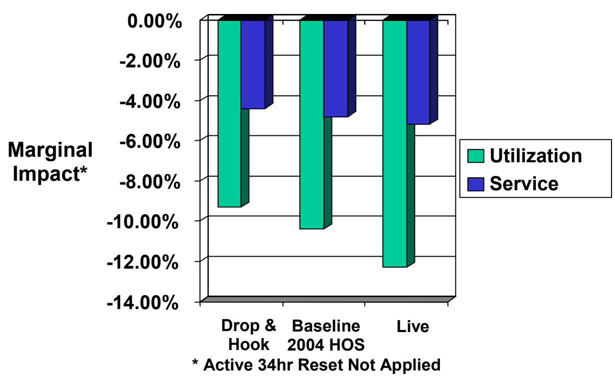

Figure 4: 2004 HOS Impact in Various Loading/Unloading Environments

5.4 Increased Maximum Speeds

The company that is the subject of this particular analysis has implemented governors that limit the top speed of the trucks throughout the fleet. The maximum speed that a tractor can operate is 62 miles per hour (MPH). Given the anticipated reduction in velocity and utilization due to the new HOS, one mitigating factor would be to increase the top speed of the trucks.

5.4.1 Scenario Description

This analysis evaluated five specific scenarios:

1. The baseline 2003 vs. 2004 HOS comparison discussed earlier in this paper. This assumes the current limit of 62 MPH.
2. 2004 HOS with a limit of 65MPH.
3. 2004 HOS with a speed limit of 68 MPH.
4. 2004 HOS with a speed limit of 70 MPH.
5. The baseline 2003 vs. 2004 HOS comparison discussed earlier in this paper. The 34 hour reset rule was not applied in these cases.

5.4.2 Results and Analysis

The top end speed limit needed to be increased to 70 MPH before any improvement was seen in fleet utilization and customer service metrics. Figure 5 presents the results of this analysis. The type of freight that truly benefits from an increase in top end speed is long length of haul that moves through relatively congestion free areas. This does not describe the bulk of the freight moved by the company analyzed in this study, and explains the nominal impact of increasing the top end MPH. Furthermore, the safety risks associated with the 70 MPH probably are not worth the marginal improvement that has been projected.

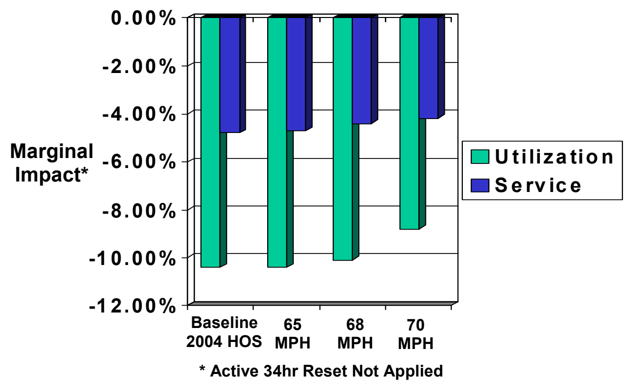

Figure 5: Impact of Increasing Top End MPH

6 CONCLUSIONS AND RECOMMENDATIONS

The results of this analysis had a significant impact on the company's approach to preparation for the new HOS rules.

The following recommendations were made for drivers, customers and the business:

1. Drivers
    a. Manage expectations that miles will drop by 2-3% and evaluate pricing/accessorial charges to make up for lost pay.
    b. Manage expectations that the amount of time required to deliver a load will go up (8-20%). Consider activity based pay for short length of haul.
    c. Communicate that MPH Analysis did not suggest time and/or miles could be made up without dangerously increasing the speed of the trucks (70MPH).
    d. Manage Expectations about the 34 hour Reset - it will be actively used about once every two weeks per driver and passively used each trip home.
2. Customers
    a. Communicate expected service level impact (-2.4%). Change tactics for setting appointment times to compensate for expected service level hits.
    b. Evaluate special fees for customers where detention is a known problem.
3. The Business
    a. Intelligently and actively apply 34 hour Reset Rule (recommend a policy of 28 hours waiting, 60 hours cumulative).
    b. Develop a company pricing strategy to factor in loss of miles (2%-3%), increased cycle time (8%-20%) and detention cost increases.
    c. Prepare for potential capacity decrease caused by less utilization.
    d. Optimize the 3 hours a driver has to cover inspections, fuelling and loading/unloading time.
    e. Consider the driver's consecutive 14 hour work window in the load assignment process to ensure loads don't get dispatched on drivers needing to shut down and break for 10 hours while dispatched on the load.

The simulation model was particularly useful helping quantify the impact of driver detention and helping establish new policies related to detention accessorial fees. The simulation projected the "break-even" point regarding detention and fleet utilization to be approximately 1 hour and 15 minutes of detention time. This finding helped change the company policy to make the first hour of detention free to the customer from the historical company policy of two hours. The hourly detention rate, as well as, the stop charges for multi-stop deliveries were increased with support from this analysis. Figure 6 presents the basis for this recommendation.

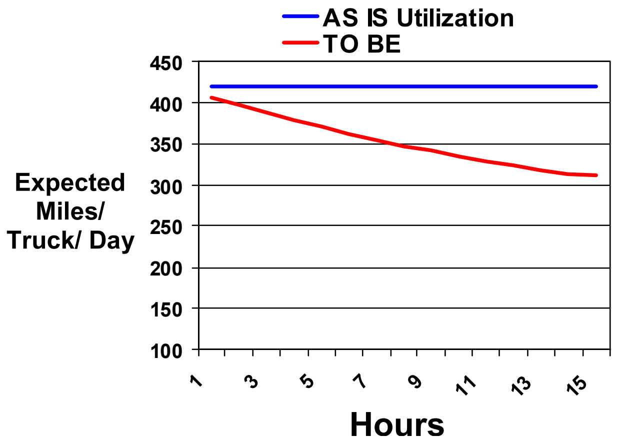

Figure 6: Trade-Offs between Detention and Utilization

7 POST MORTEM DISCUSSION

Since the 2004 HOS simulation analysis was performed in the summer of 2003, the transportation logistics industry has had the opportunity to witness first hand the 2004 HOS reality during the first five months of 2004. For the company in this study, a significant effort has been made to capture and understand the real 2004 impact. As with any large enterprise change in policy, process, technology or strategy, it is often hard to get a clear comparison between the steady state "as is" system and the steady state "to be". The following are examples that cloud the comparison in this case:

- When did the steady state "To Be" begin? The industry was given a grace period in 2004 before law enforcement would begin actively charging HOS offenders.
- Is this an "apples to apples" comparison? Freight volumes in the first quarter 2004 were up dramatically over the prior year. Utilization is actually up in 2004.
- What assumptions have changed? Assumptions related to customer behavior and company dispatching practices are actually different in 2004.

Because it is a load by load measure that is less likely to be influenced by network effects previously discussed in this paper, cycle time has been chosen as the cleanest measure for evaluating the simulation projects vs. actual 2004 performance. These comparison are made in Table 6.

Table 6: % Change in Average Cycle times between 2003 and 2004 for Simulation Projections and Historical Actuals

Key Performance Indicator	***% Difference from 2003 to 2004***
Projected Cycle Time Impact	~ 8%
Actual Cycle Time Impact	~ 4%

What explains difference between the model projections and the actual observations? The ~4% difference can probably be attributed to two things:

1. Dispatching and appointment setting practices have moved to more appointment "windows" versus firm appointment times. This was not an assumption in the simulation analysis.
2. More aggressive policies related to detention accessorials charges and multi-stop load charges have changed shipper and receiver behavior. These changes are presented in Table 7.

Table 7: % Change in Shipper and Receiver Dock Behavior Based on Actual Historical Data

Shipper and Receiver Dock Behavior (May 2004)	***% Difference from 2003 to 2004***
Volume of Live Pick-ups	- 7.3%
Average Live Pick-up Time	- 8.7%
Volume of Live Deliveries	- 1.9%
Average Live Delivery Time	- 5.7%
Volume of Multi-Stop Loads	- 31.5%

An interesting observation of the model vs. actual differences both related to changes in shipper and receiver behavior, and related to changes in appointment setting practices, is that the behavior change in part has been caused by recommendations supported by the simulation model.

In conclusion, the simulation analysis achieved its objectives by providing realistic projections of the 2004 HOS impact, and was a critical tool in helping quantify the impact and providing recommendations to help the company mitigate the impact of these changes. Going forward, the company's enterprise simulation model has been further enhanced and is used as a scenario analysis tool to evaluate logistics designs, operational policy and business process improvement initiatives.

REFERENCES

Jain, S., R.W. Workman, L.M. Collins, E.C. Ervin and A.P. Lathrop, 2001. Development of a High Level Supply Chain Simulation Model. In: Proceedings of the 2001 Winter Simulation Conference, eds: B. A. Peters, J. S. Smith, D. J. Medeiros, and M. W. Rohrer, 1129-1137, Institute of Electrical and Electronics Engineers, Piscataway, New Jersey.

Law, Averill M. and W. David Kelton, 1991. *Simulation Modeling & Analysis,* 2nd Edition, McGraw-Hill, Inc., U.S.A.

Taylor, G. Don, T.S. Meinert, R.C. Killian and G.L. Whicker, 1999. Development and Analysis of Alternative Dispatching Methods in Truckload Trucking. Transportation Research Part E 35 191-205.

AUTHOR BIOGRAPHIES

ERIC C. ERVIN is a Director of Engineering Services with JB Hunt Transport, Inc. in Lowell, AR. He has previously worked with QuestOne Decision Sciences in Bethlehem, PA and Accenture in Chicago, IL. Eric is currently working on his MBA at the Sam M. Walton College of Business at the University of Arkansas. He received a Bachelor of Science in Industrial Engineering from Iowa State University in 1995. He is member of INFORMS and IIE. His interests and experience in simulation span a range of industries and domains including pharmaceuticals, consumer goods, communications, electronics, supply chain management, transportation planning, and customer relationship management processes.

RUSSELL C. HARRIS is a Senior Logistics Engineer with JB Hunt Transport, Inc. in Lowell, AR. He has been with the company since 1999. He received a B.S.I.E. from the University of Arkansas in 1999. He is a member of IIE.