

3. ASSESSMENT OF IMPACTS ON OPERATIONS

3.1 OVERVIEW OF ANALYSIS OF IMPACTS ON CARRIER OPERATIONS

As discussed in Chapter 2, the most important segments of the industry that will be affected by the options include solo TL for-hire drivers with random schedules, solo TL for-hire drivers with regular schedules, and solo TL private fleet drivers. Their complex patterns of operation, and the difficulty of estimating how the various provisions might interact in their effects on productivity and safety, led us to develop a simulation-based approach to analyzing these segments. We judged simulation to be more able to generate realistic combinations of behaviors than scenario-based analyses, and therefore better able to illuminate the true effects of the options.

Two other significant segments are solo LTL drivers, and team drivers. The smaller scale of the LTL segment, and the fact that its drivers tend to follow very regular schedules, led us to represent it using the results of the simulation of regular TL drivers. Because team drivers are known to be favored only in intensive long-range operations, and need to follow regular schedules, we determined that they could best be assessed using simple scenarios.

3.2 SIMULATING IMPACTS ON COMPLEX CARRIER OPERATIONS

In the simulation model used to assess impacts on the more complex types of carrier operations, a truck's progress is tracked in a computer program as the driver moves between origin and destination points, choosing new loads at the end of each run from a set of choices randomly selected from a data base representative of inter-county shipment patterns. The driver's choices are made on the basis of which loads feasibly can be picked up and delivered within specified windows, given the limits imposed by the need to stop and rest. Within feasible choices, the driver is assumed to choose (or be assigned) the load that is most advantageous in terms of its contribution to its productivity. Because the HOS rules affect which loads can be delivered, and change the amount of time that can be devoted to driving, the model is able to estimate impacts on productivity, and the accompanying changes in typical schedules.

To implement this approach, ICF developed an Excel macro-driven simulation model to simulate a commercial vehicle driver (CMV) operating in compliance with HOS regulations. The HOS simulation model simulates how a CMV operator would behave, starting from its home terminal and making various stops to pick up and deliver shipments over a pre-defined duration. The regulations are defined by the user so the model can analyze various types of HOS options to show a marginal impact of a specific regulation (e.g., adding one more hour to the daily limit on driving hours).

Exhibit 3-1
Operation Cycle of HOS Model

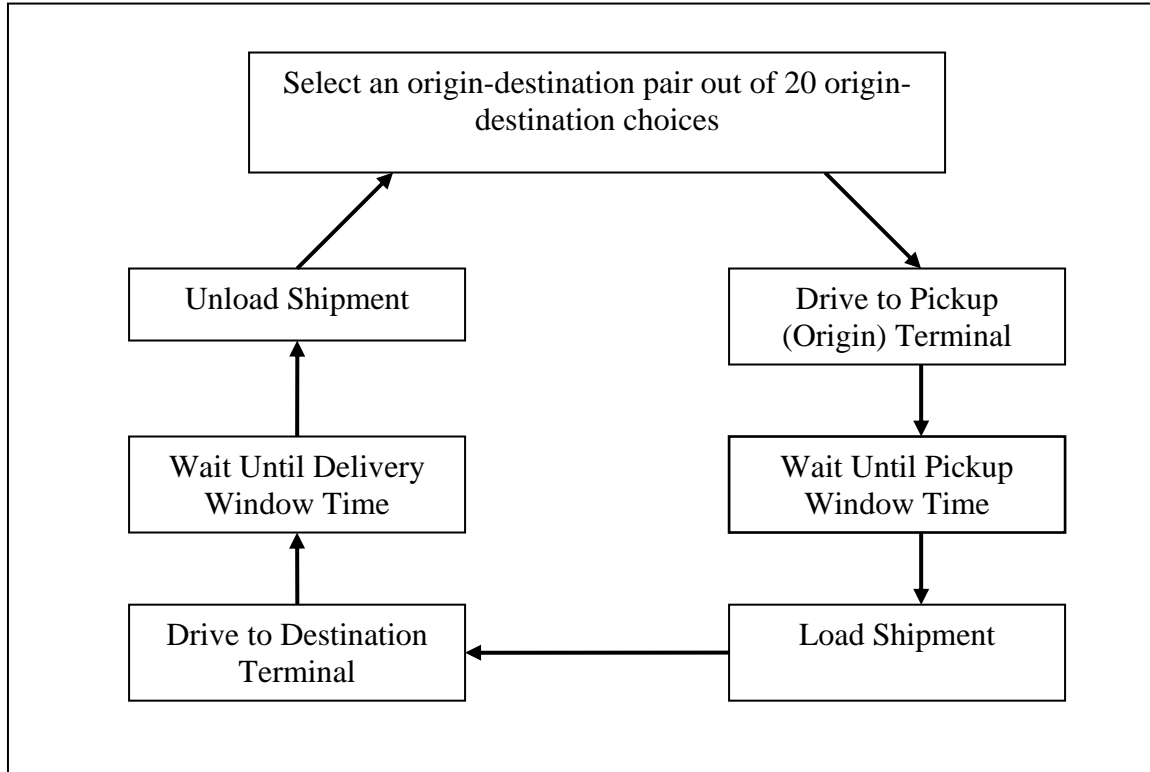


Exhibit 3-1 shows the operation cycle of the simulation model. The model starts at the user defined home terminal. Out of 20 randomly generated origin-destination pairs, it chooses the pair that best fits its schedule as well as maximizes its productivity. Then it moves to the origin terminal, waits until the pick up window time, and loads the shipment. It then drives to the destination terminal, waits until the delivery window time, and unloads the shipment. At this point, the model again analyzes another set of 20 origin-destination pairs and repeats the same procedure prescribed above for the time duration defined by the user. The movement of the truck in the model is constrained by HOS rules (i.e., all required rest periods) allowing the user to compare different facets of HOS rules with assumption of full compliance.

At the end of the simulation, the model yields an output that shows how the CMV operator behaved at each time of day. The truck's movement following the operation cycle is recorded in the schedule output table which reveals what the truck was doing at each time of the day each day during the whole simulation duration. The duration of simulation is defined by the user so the model can generate up to one year's worth of the schedule table. Exhibit 3-2 is a snapshot of the schedule table showing only a small portion of it. The table actually has over 40 columns providing details such as time of the day, day of the week, driving status, load status, origin county, destination county, cumulative duty, driving, and rest hours.

Exhibit 3-2 Schedule Output of HOS Model

Trip Day	Time of Day (24HR Format)	Day of the Week	Status	Load Status	Origin	Destn	Driving HRS Until Arrival	Load Time	Unload Time	Dummy Rest	Dummy On-duty	Dummy Driving	Cumulative On-Duty HRS	Cumulative Driving HRS
1	7.00	MON	REST	EMPTY	17,031	17,031	1.00	2.00	3.00	0	0	0	-	-
1	7.50	MON	DRIVE	EMPTY	17,031	17,031	0.50	2.00	3.00	0	1	1	0.50	0.50
1	8.00	MON	DRIVE	EMPTY	17,031	17,031	-	2.00	3.00	0	1	1	1.00	1.00
1	8.50	MON	LOAD	FULL	17,031	5,045	11.00	2.00	3.00	0	1	0	1.50	1.00
1	9.00	MON	LOAD	FULL	17,031	5,045	11.00	2.00	3.00	0	1	0	2.00	1.00
1	9.50	MON	LOAD	FULL	17,031	5,045	11.00	2.00	3.00	0	1	0	2.50	1.00
1	10.00	MON	LOAD	FULL	17,031	5,045	11.00	2.00	3.00	0	1	0	3.00	1.00
1	10.50	MON	DRIVE	FULL	17,031	5,045	10.50	2.00	3.00	0	1	1	3.50	1.50
1	11.00	MON	DRIVE	FULL	17,031	5,045	10.00	2.00	3.00	0	1	1	4.00	2.00
1	11.50	MON	DRIVE	FULL	17,031	5,045	9.50	2.00	3.00	0	1	1	4.50	2.50
1	12.00	MON	DRIVE	FULL	17,031	5,045	9.00	2.00	3.00	0	1	1	5.00	3.00
1	12.50	MON	DRIVE	FULL	17,031	5,045	8.50	2.00	3.00	0	1	1	5.50	3.50

In the following sections, more detailed description of the set-up and operation of the model is presented.

3.2.1 Assumptions

User-Defined Assumptions

In the user interface page of the model, the user defines the HOS option to be simulated. The HOS option is modeled by imposing maximum duty, maximum driving, and minimum rest hours per day, minimum restart rest hours, and maximum duty hours in the last 8 days. The model is designed to be sensitive to each of these different assumptions in order to analyze the marginal impacts of any single facet of HOS regulation under different simulation settings.

The user enters the following assumptions:

Maximum duty hours in a day

- *Maximum driving hours in a day*
- *Minimum rest hours in a day*
- *Maximum duty hours since a restart rest period in the last 8 days*
- *Minimum rest hours for a restart rest period*
- *Home terminal county*
The county where the CMV operator's home terminal is located. The simulation starts from this county.
- *Operating region limit*
The maximum distance the CMV operator considers for potential shipment pick-ups. For example, if the operating region limit is the default of 100 miles, the CMV

operator only considers available pick-ups from terminals located within 100 miles of its present location.

- *Minimum shipment miles*
The minimum miles from origin to destination that the CMV operator considers for a shipment.
- *Maximum shipment miles*
The maximum miles from origin to destination that the CMV operator considers for a shipment
- *Average speed*
The speed of the truck during driving hours – the default is 50 mph.
- *Minimum sleeper hours*
The minimum duration of a split rest period, using a sleeper berth. This is equal to 10 when simulating an option that does not allow any splitting of rest periods.
- *Region*
Which of four continental U.S. regions the model will simulate: Northeast, Midwest, West, and South.²⁴
- *Time increment*
Increment of time increments, either 15 or 30 minutes, after each of which the model simulates a possible new decision and change in activity (drive, rest, load, or unload) for the CMV operator.
- *Duration for the analysis*
The user can choose for the simulation to cover a time period of 3, 6, or 12 months.

Default Assumptions

In addition to the assumptions that can be revised by the user, the model has a number of default assumptions. These are detailed in Appendix (II), and enumerated below:

- *Loading and Unloading Time* – The time required for loading and unloading the vehicle.
- *Pick-up Day of Week* – The distribution of the day of the week for shipment pick-ups, which is that pick-up days are basically evenly distributed for the weekdays while the weekends are rarely used.
- *Delivery Day of Week* – The scheduled delivery day of the week, which depends on the pick-up day of week and the travel time required to the delivery destination.

²⁴ See the Appendix for a definition of the regions.

- *Pick-up and Delivery Windows* – The pick-up and delivery windows represent the interval of time in which a pick-up or interval needs to be made

3.2.2 Model Operation

The model starts at a user-defined home terminal and selects (using a utility function²⁵) the next shipment to be carried from an array of 20 randomly generated origin-destination pairs. In addition to an origin and destination, each shipment has characteristics randomly generated to simulate the pick-up terminal, destination terminal, the pick-up and delivery days of week, pick-up and delivery terminal hours of operation, and scheduled windows for pick-up and delivery.

The origin terminals are randomly drawn from the set of all terminals that are within 100 miles of the CMV operator's current location (the home terminal for the first trip). The destination terminal for each origin is then randomly drawn based on recent data on the probabilities of various origin-destination pairs (a more detailed exposition is presented in section 3.2.3 Order Sets). The seven origin-destination pairs with the earliest feasible pick-up times are evaluated to choose the shipment with the highest utility.²⁶

The model runs a simulation of each of the seven O-D pairs and yields schedule output for each O-D pair.²⁷ The schedule output shows how the CMV operator would behave in each 15 or 30-minute time increment (whether the driver drives, rests, loads, or unloads), until the vehicle arrives at the destination. By listing the CMV operator's action in each time increment, the model can analyze whether the CMV operator is able to meet the pick-up and delivery windows and how efficiently the CMV operator is moving to the destination. If it is simulated that the CMV operator cannot meet the pick-up or delivery time windows, the model designates zero utility to that particular O-D pair and moves on to simulate the next O-D pair. When the simulations for the first seven feasible pairs are done, the model selects the origin-destination pair with the highest utility and writes its schedule output to an output table that shows the CMV operator's behavior.

Once the CMV operator arrives at the destination, the process begins again as the CMV operator is presented with another 20 origin-destination pairs and the model simulates the top seven pairs again. Thus, the model repeats the process of simulating the top seven origin-destination pairs, selecting the pair with highest utility, and writing the selected O-D pair's schedule output to the output table until the duration of the output reaches the duration defined by user in the summary page.

In summary, the driver follows the pattern of operation shown in Exhibit 3-1.

²⁵ A detailed exposition on the utility function, which incorporates direct and indirect economic costs and non-monetary desires, is presented in Section 3.2.4 and in Appendix (II).

²⁶ The model thus discards the other 13 pairs because they were infeasible or otherwise presumed to lead to lower utility. While theoretically not necessarily true, it is believed that this type of practical rule of thumb is an accurate simulation of actual CMV operator behavior.

²⁷ In a few cases, none of the 20 origin-destination pairs that the CMV operator faces are initially feasible. Please see the Model Operation Note in the Appendix for how this is addressed.

3.2.3 Order Sets

The process of obtaining a representative sample of the US truck transportation industry's movements began by obtaining data sets containing the total tons shipped to and from every county in the country, sorted by FIPS code²⁸. It was decided to base the sample on the total tons shipped to and from each county to best represent the number of truckload moves. The shipments to and from each county were combined to create a table relating each county to the total tons shipped associated with it. This data set provided 3,141 data points from which to create a sample. This data set was then simplified to a sample size of 1,000, to speed model computation time, using a method that insured freight movement patterns were maintained with correct geographic representation and a mix of small and large counties. Details of this method are provided in Appendix (II).

3.2.4 Utility Function

For those segments of the industry (long-haul and regional random truckload) for which the simulation selected the next shipment immediately following the completion of the previous shipment, a utility function was used to simulate the next shipment decision. The utility function was used to monetize the total value of each of the shipment alternatives available to the driver at the decision moment. The utility function included the monetary operating costs of the vehicle, labor and labor-related costs, capital costs, revenue to be earned, and monetized penalties for the driver's time and distance away from its home and the driver's status in terms of working hours remaining before fulfillment of the 70 hour work limit.

For each available alternative of a shipment from an origin "O" to a destination "D", several total utilities were calculated (and expressed in dollars), based on the different choices the driver could make regarding resting, waiting, or driving prior to actual pick-up of the shipment. The different alternative work schedules within each origin-destination shipment were compared to determine the highest utility available for a given shipment. The different alternative shipments were then compared, with the driver assigned to perform the shipment with the highest calculated utility.

The full details including the specification and cost elements of the utility function are included in Appendix (II).

3.2.5 Algorithms

In addition to the model operation components more generally described above, a number of algorithms were used to carry out some of the specific model components. These are detailed in Appendix (II), and enumerated below.

Destination Algorithm - The shipments' origins and destinations are based on recent empirical data regarding the actual probabilities of commercial truck movement from county to county in the continental United States.

²⁸ FIPS codes generally represent counties, parishes or districts. The term county is used interchangeably herein to also represent FIPS code areas, parishes and districts.

Load Choice Algorithm - As explained in the operation section (3.2.2), the model allows the user to see actual behavioral pattern of the driver in each of 15 or 30 minute time slots as the vehicle hypothetically would “move” from each of seven origin terminals to their destination terminal. The algorithm also ensures the driver complies with all of the HOS regulations.

Schedule Algorithm - The schedule algorithm includes all the decision-making procedures within the choice algorithm. The schedule algorithm writes the selected origin-destination pair to the output table.

Feasibility Algorithm - The feasibility algorithm screens out the 13 O-D pairs that would lead to the lowest utility, as well as eliminating all O-D pairs that are infeasible because of a driver’s individual rest needs vis-à-vis his status in the HOS duty/rest cycle.

Longer Restart Rest Period Algorithm - In actuality, many commercial truck drivers take longer restart periods than the minimum required by the 2003 HOS rule presumably in order to start their next working period in the morning or at a convenient or accustomed time. Therefore, the model reflects the longer restart rests by imposing a specific pattern of longer restart rests.

Break Time Algorithm - In order to make the model more closely reflect the driving patterns of actual truck drivers, a break period of either 30 minutes or one hour is imposed whenever the CMV operator drives four straight hours with more than one hour left until the destination.

Split Sleeper Berth - When the HOS option being considered allows, the model initiates the split sleeper berth algorithm whenever the CMV operator arrives at the pick-up or destination terminal and still has some time until the pick-up/delivery hour window.

3.3 SCENARIOS RUN

3.3.1 Long-haul and Regional Truckload, Random Schedule

Three basic scenarios were run with different lengths of haul:

- short-regional: minimum run: 120 miles, maximum run: 300 miles, average: 223 miles
- long-regional: minimum run: 260 miles, no maximum, average: 465 miles
- long-haul minimum run: 400 miles, no maximum, average: 708 miles

Minimum and maximum runs were imposed for the short-regional case. No maximum was imposed on the model for the long-regional and long-haul scenarios. A minimum was specified for these scenarios, and the difference in lengths of haul came from setting the long-regional and long-haul scenarios in different geographic territories.

The short and long-regional scenarios were set in the same geographic territory for the simulations run so far. This region is roughly the northeastern quadrant of the United States, starting with Illinois on the western end and extending to the East Coast through Indiana, Ohio, Pennsylvania, New Jersey and Delaware, plus New York and all of New England. The home terminal is in Cook County, Illinois. The long-haul scenario includes part of the Midwest—

Illinois, Indiana, and Ohio—and all the states west of the Mississippi. The home terminal is in Cook County, Illinois. In terms of the default regional definitions set up in the model, the short- and long-regional scenarios included the Northeast and Midwest regions and the long-haul scenario included the Midwest and West regions.

As discussed in Section 1.2, four regulatory options were assessed. Option 1 is the current HOS rule, allowing 11 hours of driving within a 14-hour tour of duty; allowing each 10-hour off-duty period to be split into two periods of at least 2 hours each, provided a sleeper berth is used and certain other requirements are met; and allowing drivers to re-start their 60- or 70-hour on-duty count after 34 hours of consecutive off-duty time. We conducted simulations both allowing and disallowing sleeper berth splitting, and then took a weighted average of the results. This approach allowed us to match results to actual driver behavior, which we have found to be split between drivers who use split their sleeper berth periods frequently and others who rarely or never do so. Chapter 6 discusses how we weighted the results from each run.

Option 2 places strict limits on the splitting of off-duty time in sleeper berths. We found that the advantages of splitting would arise only in very rare cases (in which 2 or 8 hours of sleeper berth rest makes an otherwise infeasible shipment a feasible shipment), and therefore excluded splitting from our analysis of Option 2. This exclusion meant that the effects of Option 2 could be assessed by comparing the runs with and without allowing sleeper berth splitting which were conducted for Option 1. (Additional runs were conducted for a more restrictive variant of Option 2 which allowed only 10 hours of driving within a 14-hour tour of duty. This variant is discussed in Section 6.8.1.)

For Option 3 and 4, we were able to model precisely as the options are stated. Option 3 does not allow more than 10 hours of driving or the splitting of off-duty periods, and requires 58 hours off before restarting. Option 4 does not allow more than 10 hours of driving or the splitting of off-duty periods, and requires 44 hours off before restarting.

For all four options, the model is simulated with the operating region limit of 100 miles and the simulation duration of 1 year.

3.3.2 Trucks Following Regular Schedules

Four scenarios were run with the four options discussed in the previous section. The first and second scenarios were for trucks following daily schedules and the third and fourth scenarios were for trucks following weekly schedules. In the first scenario, a truck works on weekdays and returns home at the end of each work day. In the second scenario, a truck works on Saturdays in addition to weekdays and returns home at the end of each work day. Similar to the first two scenarios, in the third scenario, the truck leaves home on Monday, picks up and delivers shipments on weekdays, and returns home on Friday evening to spend the weekend at home. The fourth scenario is very similar to the third scenario, but the operator returns home on Saturday and spends only Sunday at home.

The trips in the daily model have a minimum distance of 75 and maximum of 200 miles with the average of 154 miles. The trips in the weekly model have a minimum distance of 120 miles and maximum of 400 miles with an average distance of 270 miles.

For these scheduled scenarios, the simulation model was adjusted so that there would not be any waiting time at the pick-up or destination terminals. It was also assumed that there would be only 30 minutes each of loading and unloading time, since the operators are following a predictable schedule, with coordination of the shippers, receivers, and carriers. These loading and unloading times may be shorter than generally seen, but were set to allow the model to generate realistic levels of use of the 11th hour of driving (which is usable only for drivers with relatively little loading, unloading, and waiting time in a 14-hour duty period). These scenarios were also run with the operating region limit of 100 miles and the simulation duration of 1 year.