PRELIMINARY INVESTIGATION OF HEAVY VEHICLE (HV) PARKING DESIGN IN OREGON REST AREAS

Helena Breuer, Dr. David Hurwitz, Dr. Salvador Hernandez
Oregon State University, Department of Civil and Construction Engineering

The Oregon State University (OSU) research team investigated the optimization of striping configurations of heavy vehicle parking at rest areas to improve their utilization rate. The selected site for this study was the I-5 Northbound Santiam Rest Area, which is composed of 12 heavy vehicle parking spots angled at 45-degrees with conflicting, adjacent passenger car parking. The Oregon Department of Transportation (ODOT) provided the OSU research team with two striping alternatives. These alternatives and the existing conditions were modeled in the OSU Heavy Vehicle Driving Simulator which were tested via an experimental workshop with four experienced drivers – each containing an Oregon Commercial Driver's License and at least one year of experience. For each of three scenarios, participants executed three parking maneuvers, where each increased in level of difficulty. Collectively, the findings of this study suggest for the heavy vehicle parking lot to be restriped such that the entrance aisle width is at least 20 feet, parking spots to be 1-2 feet wider, and adjacent passenger car parking to be removed.

INTRODUCTION

Problem

- Increased heavy vehicle (HV) parking on interstate shoulders and ramps (Figure 1)
- Underutilized HV parking at rest areas
- risk of property damage incidents due to geometric conditions of Santiam Rest Area

Implications

- Obstructs sight distance for surrounding drivers
- Behaves as a stationary roadside object
- Obstacle to emergency vehicle operations

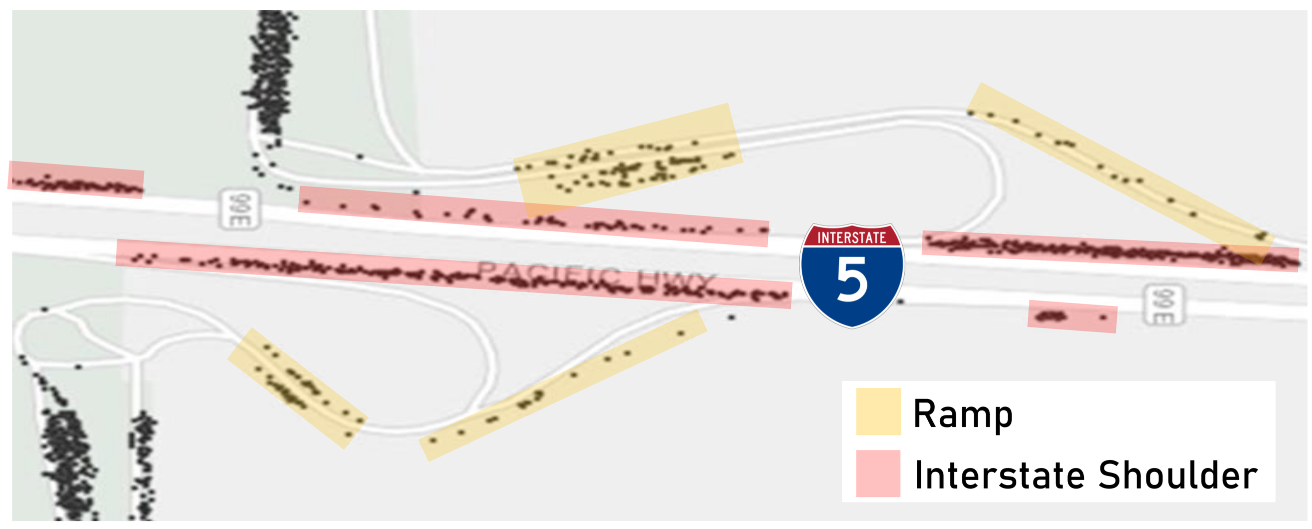

Figure 1 - Geospatial distribution of parked heavy vehicles near the Santiam Rest Areas. Each dot represents a HV parked for >5 minutes.

METHODS

Site Visit: Geocode Existing Conditions

To geocode the existing conditions, a site visit was conducted to take measurements using measuring tape of existing striping conditions and take aerial images using DJI Mavic Pro 2 Drone. These measurements and images were used to validate large-scale measurements of an aerial image from Google Earth (Figure 2).

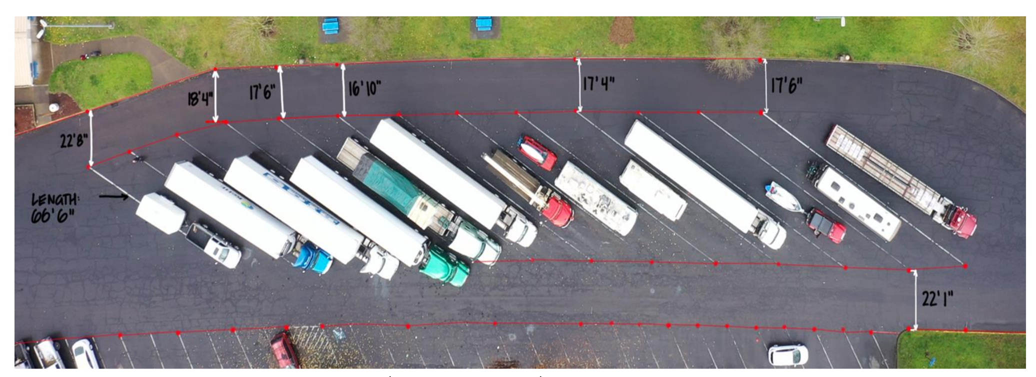
Figure 2 – Aerial Image (via Drone) Annotated with Measurements

Site Visit: Observations

During the site visit, the research team spent an hour observing the entrance, parking, and exiting maneuvers of the HV. Figures 3 shows the HV using the adjacent PC parking while exiting. Figure 4 shows the HV using an adjacent HV parking spot while entering.


Figure 3 – HV Exit Maneuver


Figure 4 – HV Entrance Maneuver

Define Design Alternatives

The research team provided the geometric conditions of the existing conditions to ODOT. Design alternatives were then generated by their corresponding design engineer given to the research team at OSU. Table 1 shows outlines these design alternatives and the design outcome per variable.

Table 1 – Independent Variables and Outcomes per Scenario

		Existing Conditions	Alternative 1	Alternative 2
Variable	θ_{Ent} (°)	33	33	45
	N	12	11	11
	PC Parking	<30% occupied	0% occupied	Removed
Outcome	*Spot Length*	l_{ex}	$l_{Alt.\ 1} = l_{ex}$	$l_{Alt.\ 2} < l_{ex}$
	Spot Width	w_{ex}	$w_{Alt.\ 1} > w_{ex}$	$w_{Alt.\ 2} > w_{ex}$
	Exit Clearance	-	Adjacent PC parking stripes are present, but all spots will be unoccupied	Greater horizontal clearance for exiting maneuvers.

Develop Simulated Environments

The schematic design process was split between two programs: *Blender* and *SimVista,* with their respective scopes outlined below. Figures 5a-5c are screen captures (in SimVista) of the parking lot for each design scenario.

1. Blender: the scope of simulated design in Blender was specific to the modeling structural, planar elements (e.g., pavement, sidewalks, curbs, mulch beds, and all pavement striping) and their respective textures (e.g., asphalt, concrete, and grass).
2. SimVista: the scope of work in SimVista included adding fixed structural elements (lighting, parked vehicles, buildings) and all landscape elements. Figures 5a-5c are screen captures taken in SimVista of the environments after these elements have been added.


Figure 5a – Existing Conditions Simulated Environment


Figure 5b – Design Alternative 1 Simulated Environment


Figure 5c – Design Alternative 2 Simulated Environment

WORKSHOP

A workshop was hosted by the research team at Oregon State University in the Heavy Vehicle Simulator in the Driving Simulator Laboratory (Figure 6). The workshop was split into two parts. The first part being the testing of the simulated environments. Following this testing, participants sat down with the research team and debriefed about their experience parking in the heavy vehicle simulator and discussed the designs of the existing conditions, design alternative #1 and #2.


Figure 6 – Student Driving through Existing Conditions Simulated Environment in the Heavy Vehicle Simulator

Sample

The workshop participants included four commercially licensed drivers in the State of Oregon. To ensure reliability and integrity in participant feedback and respective conclusions, participants were required to have at least one year of experience with operating a heavy vehicle.

Design

In each of the three scenarios (existing conditions, design alternative 1 and 2) participants drove through the environment and executed separate parking maneuvers under three simulated parking occupancy levels, equating to a total of nine trials. Shown in Figure 7, the three conditions represent the parking lot at low (Level I - Spots 1 or 2), medium (Level II – Spots 3 or 5), and high occupancy (Level III – Spot 10).

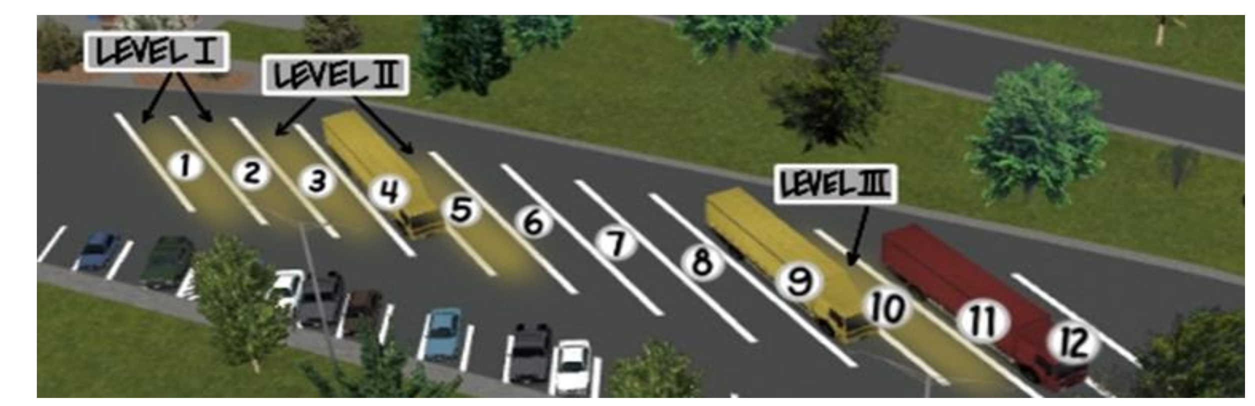

Figure 7 – Labeled Parking Spots and Corresponding Parking Levels

During the simulator study, a researcher team member assessed participants visual attention by informally tracking drivers' focus as a function of the driver's head position, and rotational offset from a neutral, forward-looking position. Following the completion of the nine simulated parking tasks, participants were asked open ended questions, with the intention of initiating discussion regarding the participants experience and alternative design preference. These post-study conversations were guided by questions to address the following set of items and concerns:

- Advantages/disadvantages of the existing conditions configuration,
- Adequacy of entrance parking aisle width and entry clearance,
- Comparison of parking spot widths,
- Comparison of parking spot entry angles (sweeping angles), and
- Impact of adjacent passenger car parking on exit maneuver.

FINDINGS

1. The width of the existing parking spots are insufficient. Participants provided feedback that the limited width of the parking spots did not allow sufficient clearance to make the iterative changes during alignment to comfortably park and exit (see Figure 4).
2. The calmer parking spot entry angle was undetectable. Participants stated that the change in entry angle (45° as opposed to 33°) was unnoticeable and had no perceived utility. The geometric implications of the increased parking spot width may give reason to the perceived utility of, or lack thereof, the reduction in entry angle. By increasing the parking spot width, drivers can enter at a reduced angle, all while having additional horizontal clearance to iteratively adjust when pulling the vehicle through to park. Conversely to an increase in entry angle, the widening of a spot does not compromise its length – further providing greater space for alignment corrections.
3. The adjacent passenger car parking constricts the allowable margin of error of exit maneuvers. Overall, the whole sample of participants stated a preference of the removal of the adjacent PC parking. The evidence is two-fold – first, during the site visit, multiple HV drivers were observed to have encroached upon the adjacent PC parking while executing the exit turn maneuver (see Figure 3). Further, all participants utilized the adjacent PC parking spot area for additional clearance when exiting in Design Alt. 1 and 2. The additional clearance buffer warranted less concerns in that participants appeared to exhibit less frustration and hesitancy during the respective exit maneuvers.
4. The HV parking lot entrance aisle is too narrow. Participants verbally indicated that its width constricts the lateral clearance available for the sweep into the parking spot. Participants indicated that the degree of error made in the entrance (to the parking spot) carries over to the in-parking spot alignment process, such that the driver can "set" themselves up for more successful alignment and exit maneuvers by entering into the parking spot with accuracy. Consequently, this reduces the risk for PDO incidents with adjacent parked heavy vehicles. Moreover, participants stated a preference of increasing the width of the entrance aisle over that of the exit aisle.

Suggestions for Site Design

- Increase parking stall entrance aisle width to 20 feet allowing greater entry sweep angle clearance
- Shift striping south such that the entrance aisle width is greater than the exit aisle
- Decrease HV parking capacity by one parking spot and widen parking spots by 1-2 feet
- Remove adjacent passenger car parking to widen the exit aisle and increase exit clearance for drivers
  - If PC parking capacity is needed, it could be restriped as parallel parking spots to ensure additional exit clearance