Removing Residual Lane Markings to Reduce Driver Confusion

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Primary Research Question

What is the best method for removal of pavement markings to reduce confusion among drivers?

- **Hydroblasting**
- **Grinding**

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Experimental Methods

Field Experiment

Lab Experiment

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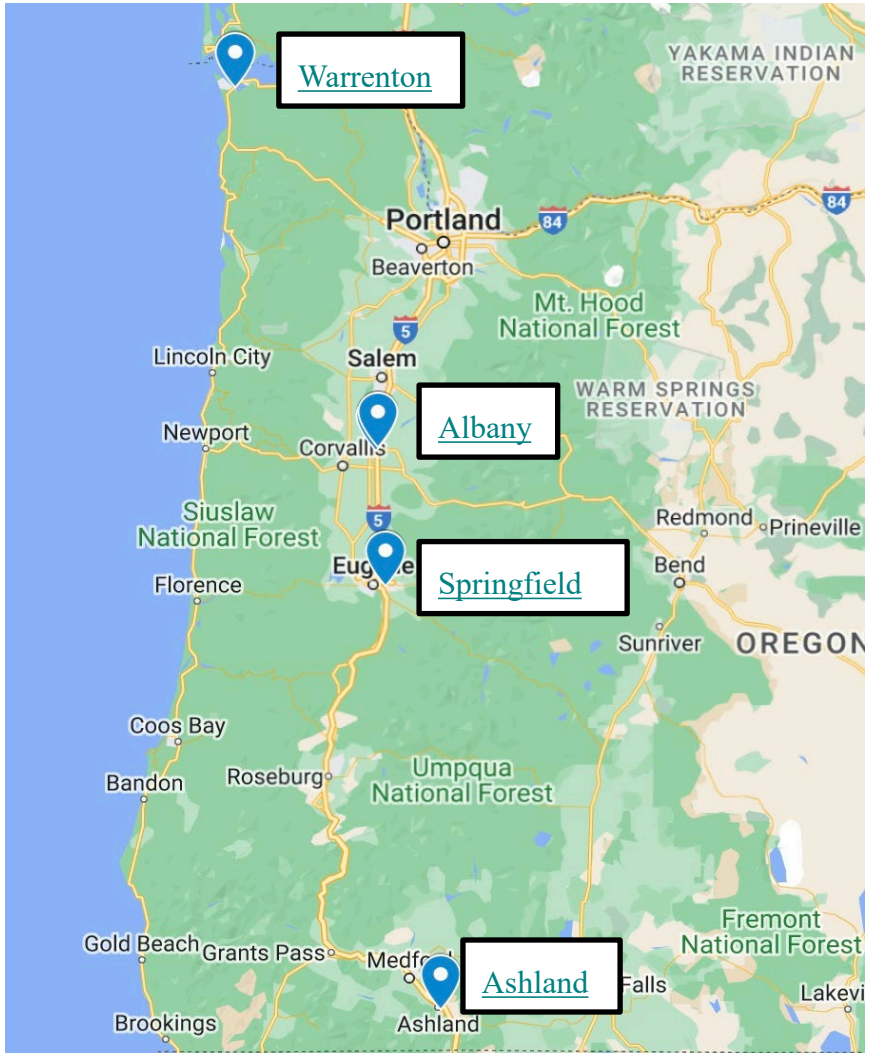
Study Sites

- Five sites throughout western Oregon
  - Warrenton
  - Albany on Airport Road
  - Albany on Santiam Highway
  - Springfield
  - Ashland
- Two types of removal methods
  - Hydroblasting
  - Grinding
- Different weather and lighting conditions
  - Daytime
  - Nighttime
  - Rain during daytime and nighttime



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US 20 – Santiam Highway in Albany

- Two travel lanes in each direction
- Hydroblasting
- 6 ½ hours of video data watched and transcribed

OR 99E –Airport Road in Albany

- One travel lane in each direction
- Hydroblasting
- 6 hours of video data watched and transcribed

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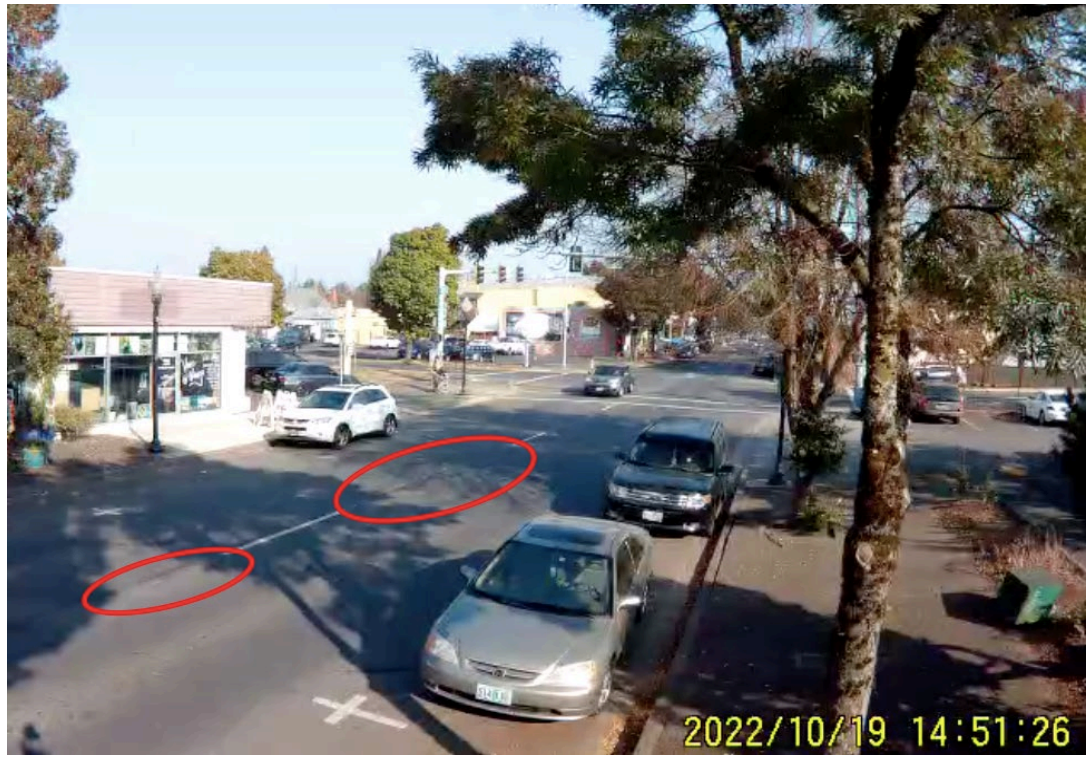
OR 126B – Main Street in Springfield

- One way with two travel lanes and on-street parking
- Hydroblasting
- 6 hours transcribed



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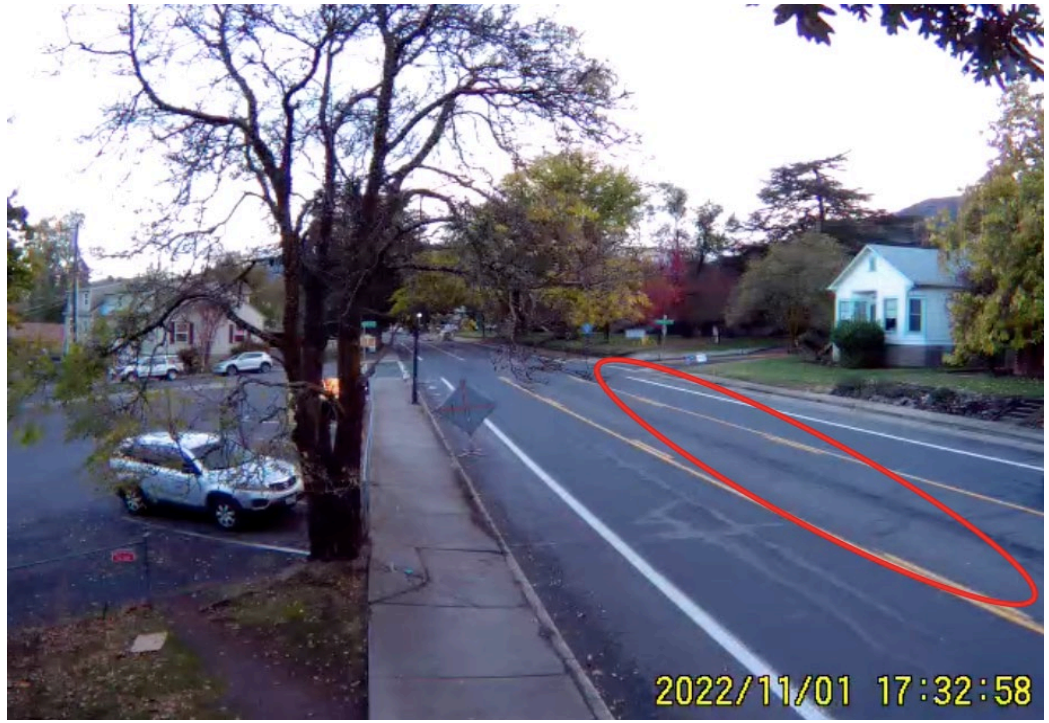
US 101 - Warrenton

- Two way with two travel lanes in one direction and one travel lane in opposing direction
- Hydroblasting
- 17 hours transcribed

OR 99 – Siskiyou Boulevard in Ashland

- One travel lane in each direction and a TWLTL
- Grinding
- 5 hours transcribed



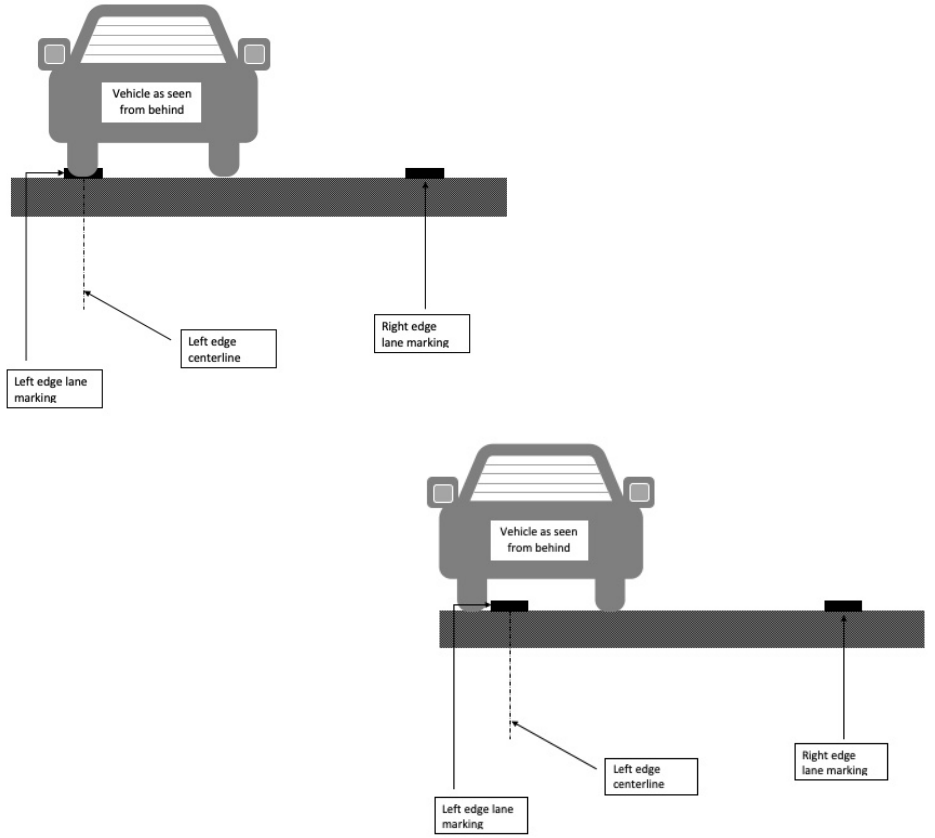
Video Data Collection Sites

Location	Type of Marking Removal	Dates of Video Data Collection	Hours Analyzed	Number of Observations (Vehicles) Recorded
US 20, Albany	Hydroblasting	11/7/2022-11/9/2022	6.5	3,166
US 99, Albany	Hydroblasting	11/22/22	6.0	3,086
OR 126B, Springfield	Hydroblasting	10/19/22-10/20/22	6.0	3,845
US 101, Warrenton	Hydroblasting	10/24/22-10/25/22	17.0	3,131
OR 99, Ashland	Grinding	11/1/22-11/2/22	5.0	5,042

Transcription: Classification for Lane Departure

Measures based on SAE J2396

- Meta data collected:
  - Date
  - Timestamp
  - Lighting and weather condition
- Performance measure data collected:
  - A – K classifications for vehicles departing a lane
  - A – G focused on passenger vehicles
  - H– K focused on larger vehicles and vehicle-trailer combinations
- Observation notes included:
  - Lane travel
  - Type of departure
  - Direction of lane departure



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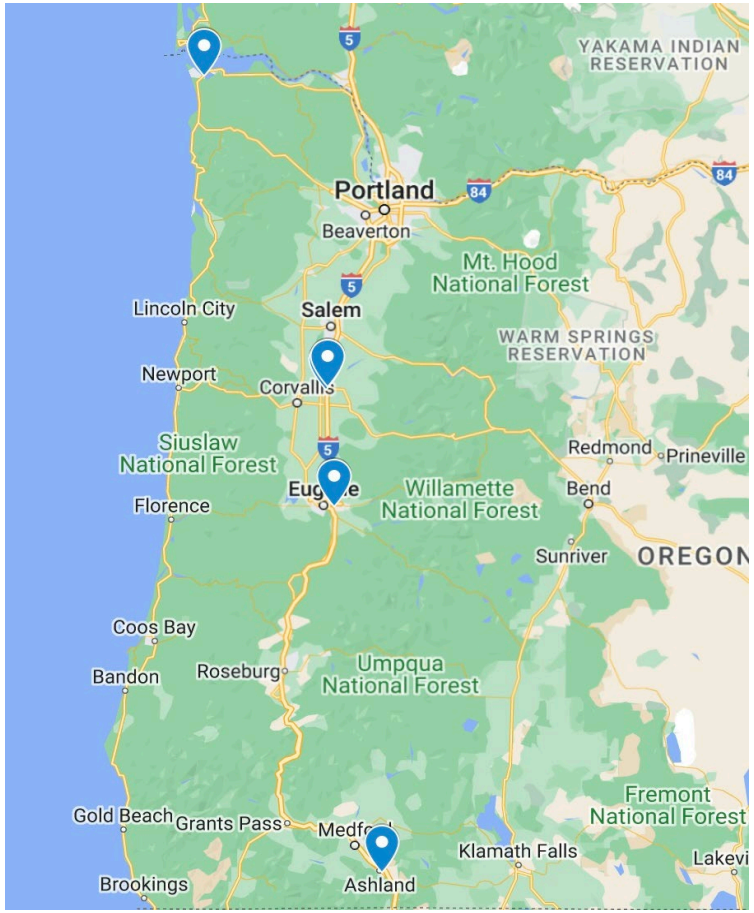
Lane Departure Distribution (LDD)

- Five different locations throughout Oregon
- Observation numbers were consistent for each location for a total of **18,270** observations recorded
- Departure rate varied from around 3% to 15%



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Departure Rate for Lighting Conditions

- Site departure rate vary by light conditions across all sites
- Lane departure occurred for all lighting

	Lighting Condition	Observations	Departures	Departure Rate
Albany (OR99)	Daylight	1688	56	0.033
	Dusk	746	24	0.032
	Nighttime	652	18	0.028
Albany (US20)	Dawn	487	55	0.113
	Daylight	2155	171	0.079
	Nighttime	524	36	0.069
Ashland	Dawn	423	67	0.158
	Daylight	4083	574	0.141
	Dusk	148	29	0.196
	Nighttime	388	104	0.268
Astoria (US101E)	Dawn	180	16	0.089
	Daylight	1780	35	0.020
	Dusk	135	8	0.059
	Nighttime	1035	43	0.042
Springfield	Dawn	287	13	0.045
	Daylight	2605	284	0.109
	Dusk	542	78	0.144
	Nighttime	411	54	0.131

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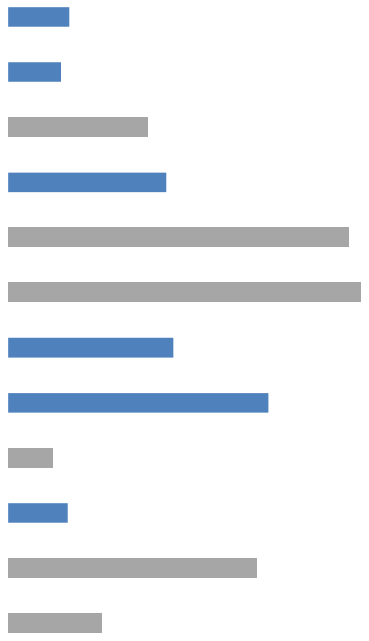
Departure Rate for Weather Conditions

- Departure rates higher during wet weather conditions
- Site variations

	Weather Condition	Observations	Departures	Departure Rate
Albany (OR99)	Rainy	385	14	0.036
	Wet	2701	84	0.031
Albany (US20)	Dry	2855	233	0.082
	Wet	311	29	0.093
Ashland	Dry	892	178	0.200
	Hail	87	18	0.207
	Rainy	793	77	0.097
	Wet	3270	501	0.153
Astoria (US101E)	Dry	804	21	0.026
	Wet	2326	81	0.035
Springfield	Dry	2397	349	0.146
	Foggy	1448	80	0.055



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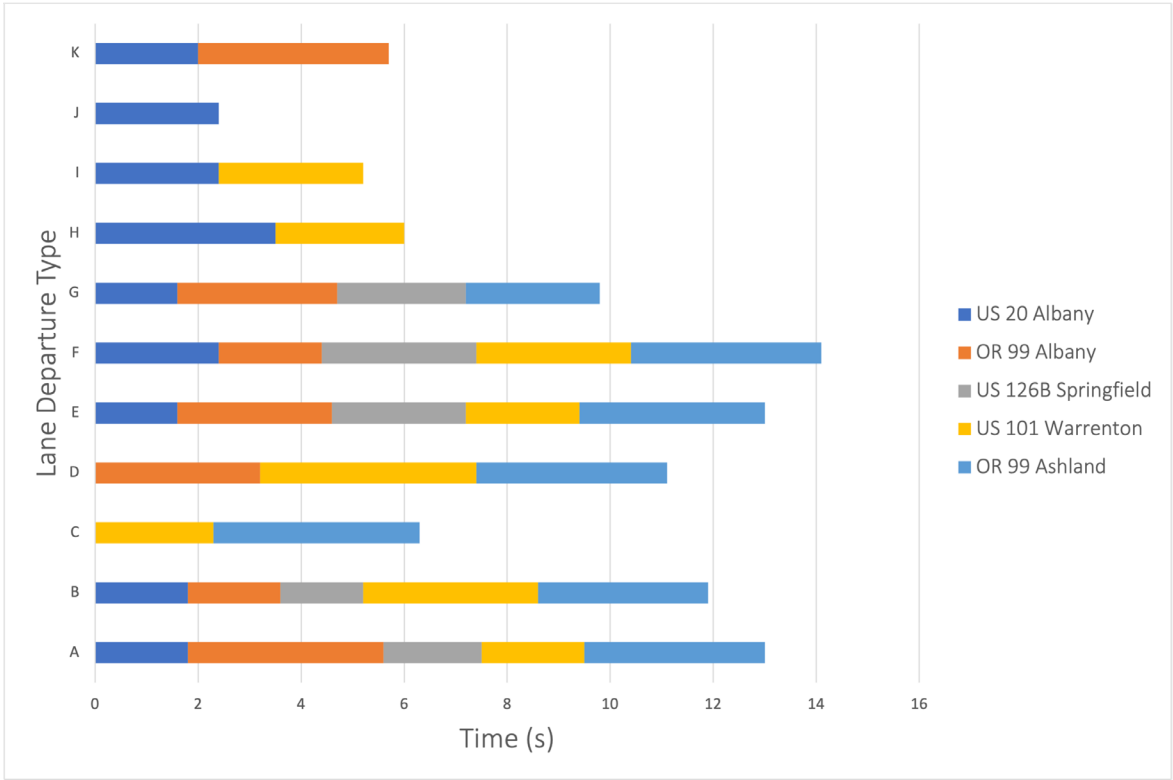
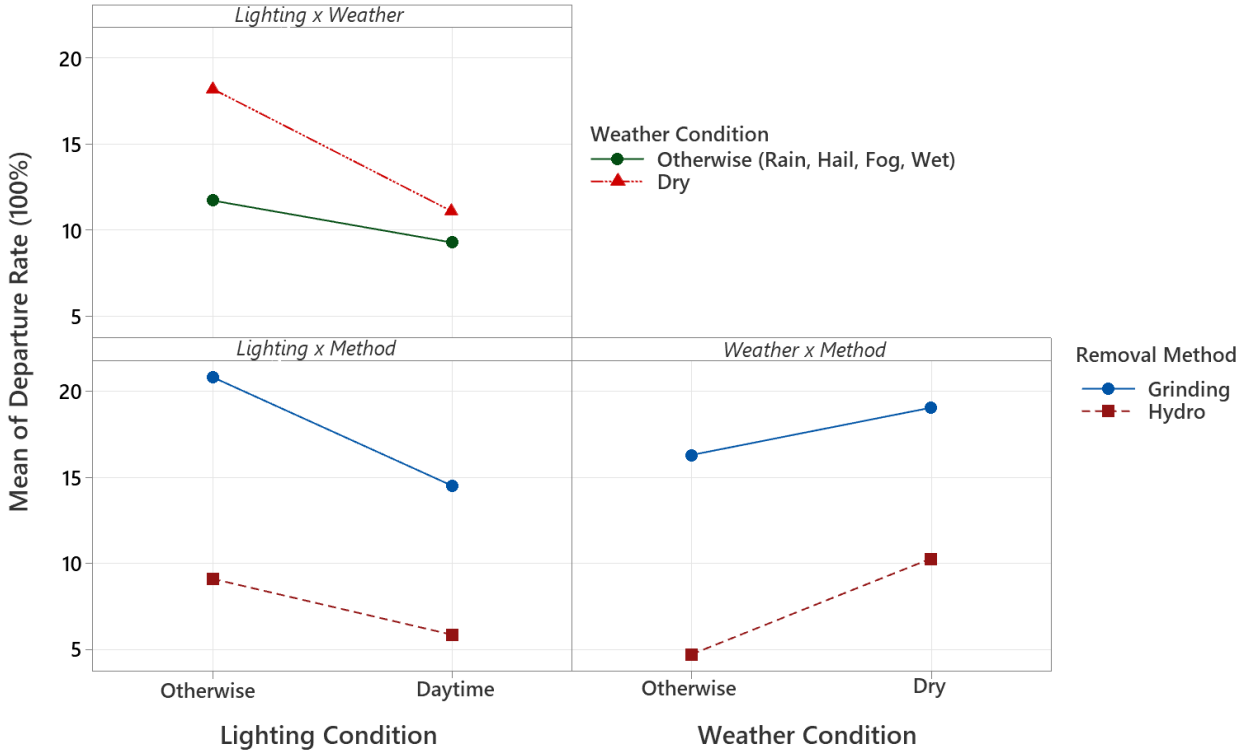
Lane Departure Duration in Seconds

- Average lane departure was between 2 and 3.3 seconds
- Minimum duration across all sites was 1 second
- Maximum duration lasted around 5 seconds



Interactions of Independent Variables

- Departure rate was lower during daytime hours by 3.5%
- Departure rate was higher during dry weather conditions by 5%
- Lowest departure rate, 11%, for locations using hydroblasting



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Key Takeaways

- Five sites with varying methods of pavement marking removal
- Video was collected at each site
- Included different weather and lighting conditions
- Data was analyzed to determine lane departure frequency and type

Proportions of lane departures ranged from 3.2% to 15.3%

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Equipment and Setup

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Footage

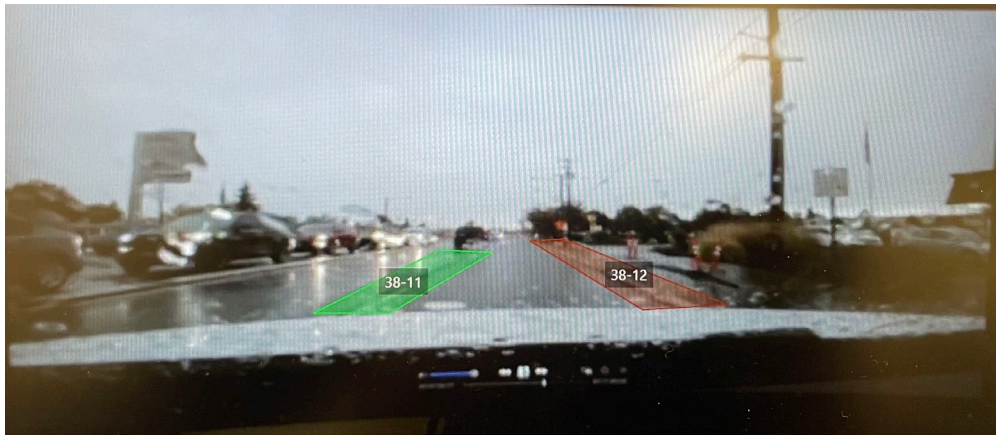
- Three locations
  - OR 99E, Albany
  - US 20, Albany
  - OR 99, Ashland
- Weather and lighting condition combinations
- Two removal methods
  - Hydroblasting
  - Grinding
- Total of 12 scenarios captured

Experimental Variables

Independent Variables

Variable	Condition
Location	Albany – Airport Road and Highway 99 Ashland – Siskiyou Boulevard Albany – Santiam Highway
Weather	Dry Wet/Rainy
Lighting	Daytime Nighttime

Dependent Variable: Eye-tracking AOIs



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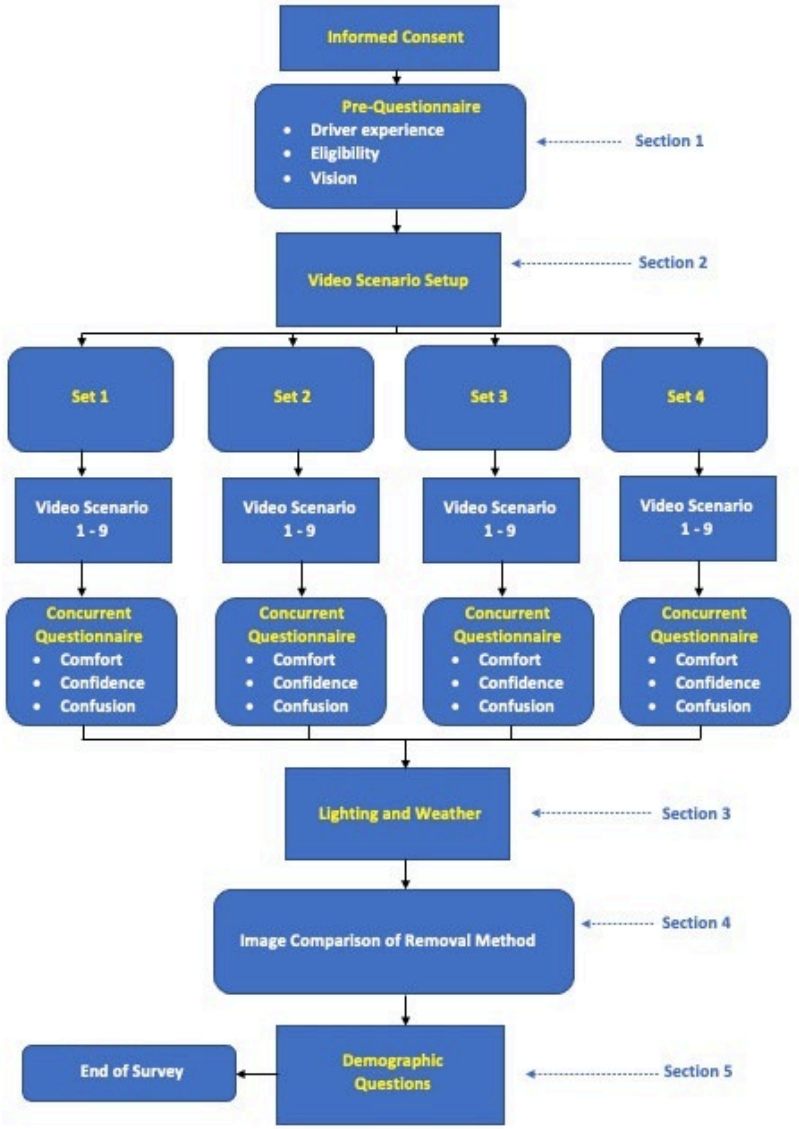
Video Scenarios

Scenario	Location	Weather	Lighting	Removal Type
1	Albany – Airport Rd and Hwy 99	Dry	Day	Hydroblasting
2	Ashland	Dry	Day	Grinding
3	Albany – Santiam Highway	Dry	Day	Hydroblasting
4	Albany – Airport Rd and Hwy 99	Dry	Night	Hydroblasting
5	Ashland	Dry	Night	Grinding
6	Albany – Santiam Highway	Dry	Night	Hydroblasting
7	Albany – Airport Rd and Hwy 99	Wet	Day	Hydroblasting
8	Ashland	Wet	Day	Grinding
9	Albany – Santiam Highway	Wet	Day	Hydroblasting
10	Albany – Airport Rd and Hwy 99	Wet	Night	Hydroblasting
11	Ashland	Wet	Night	Grinding
12	Albany – Santiam Highway	Wet	Night	Hydroblasting

Survey

- Qualtrics
- 32 questions
- Mix of open-ended and close-ended questions
- Consisted of:
  - Pre-questionnaire
  - Video scenario concurrent questionnaire
  - Lighting and weather
  - Image comparison
  - Demographic questions



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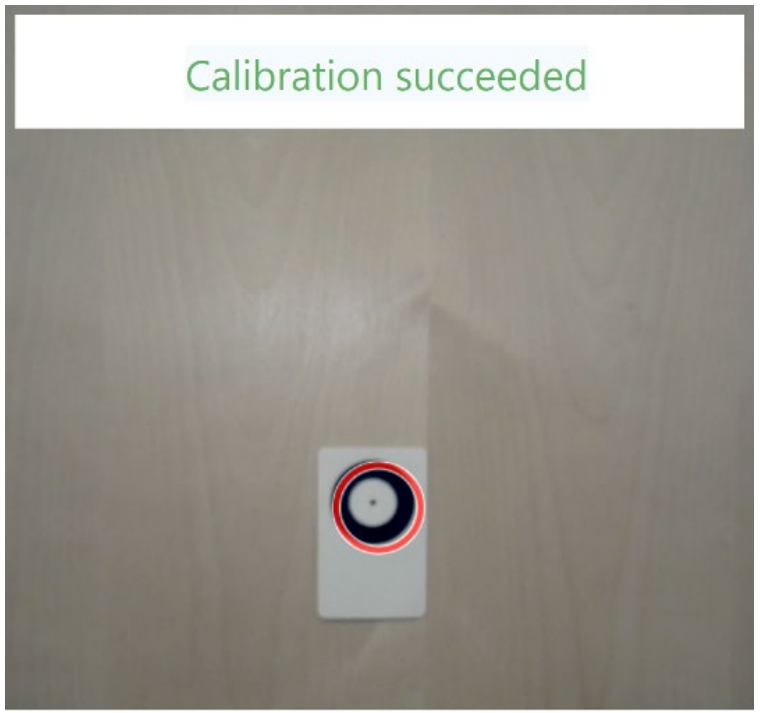
Experimental Protocol

- 41 participants
- Over 18 years of age and valid license
- Obtained consent
- Administered pre-drive questionnaire
- Calibrated eye-tracking equipment
- Participants viewed 9 scenarios
- Concurrent questionnaire was given after each scenario
- Post-drive questionnaire at the end



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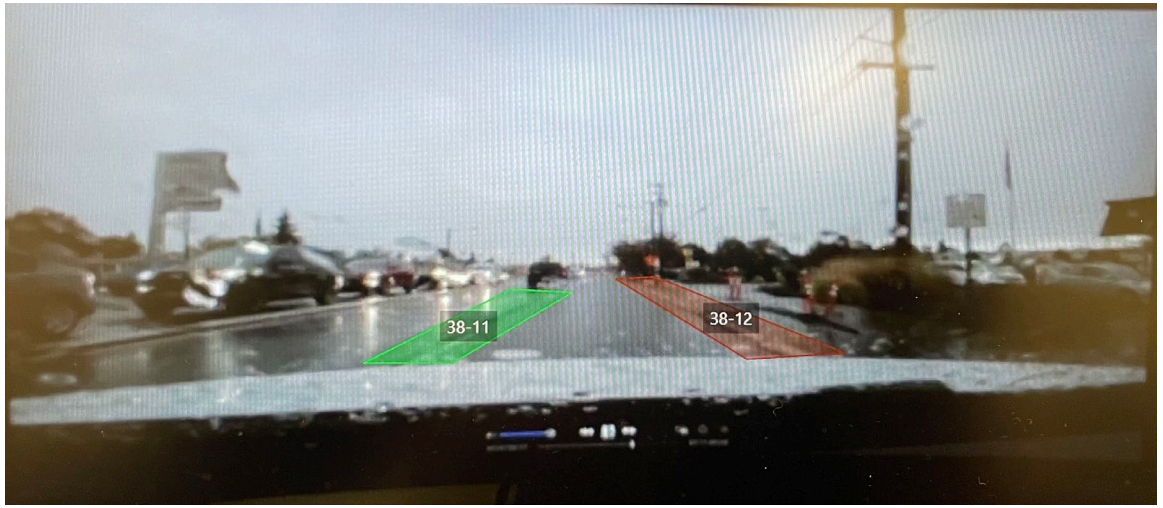
Data Reduction: Eye-Tracking

- Looked at dwell times for each area of interest (AOI)
- Used iMotions software
- Provided total time participants looked at markings
- 30 seconds to 1.5 minutes of clip length
- Manually coded polygons
- AOIs were removed markings to left and right of lane



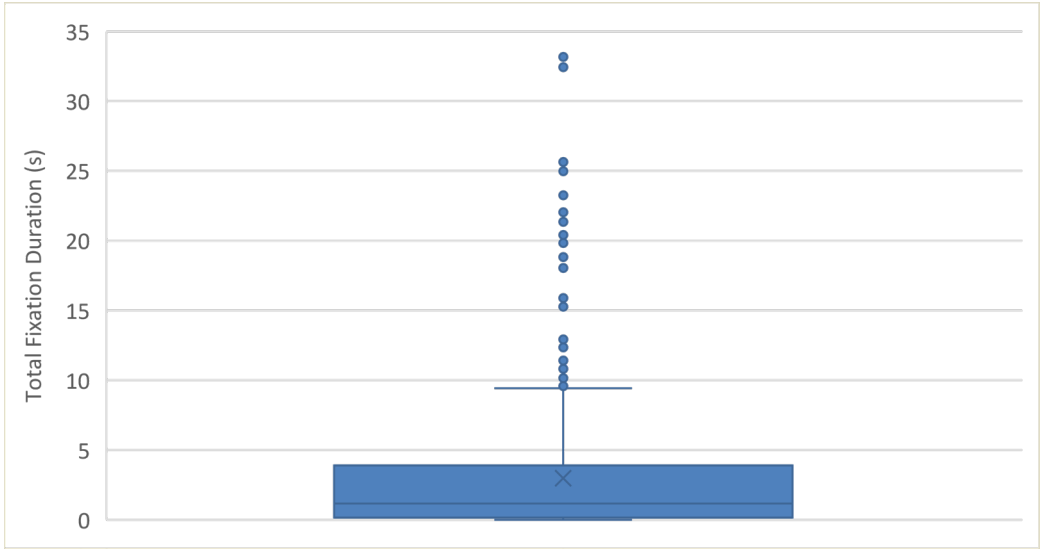
Participant Demographics

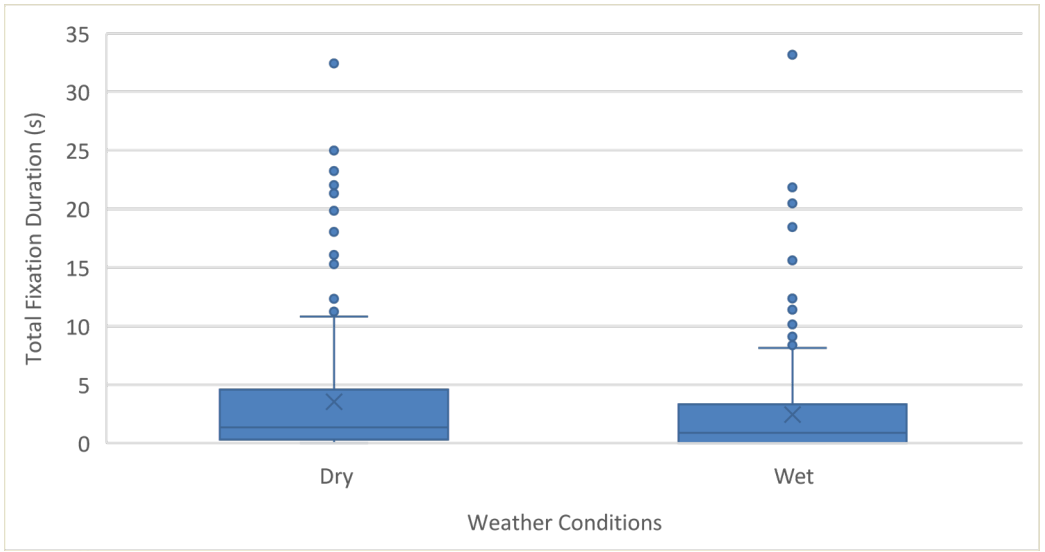
- 41 participants
- 14 male, 25 female, 2 non-binary
- 1 data not collected
- Age ranged from 19 to 76 years

	Total	Male	Female	Non-Binary
Total Enrolled	41 (100%)	14 (34.1%)	25 (60.9%)	2 (4.8%)
Data Not Collected	1 (2.5%)	--	1 (2.5%)	--
Total Usable Sample	40 (97.5%)	14 (35%)	24 (60%)	2 (5%)
Age Range	19-76			

Visual Attention

- Majority of total fixation duration (TFD) occurred between 0 to 4 seconds
- Average was close to 3 seconds
- Dry weather condition had an overall higher TFD
- Average for dry TFD is 4.79 seconds while for wet the TFD is 2.44 seconds





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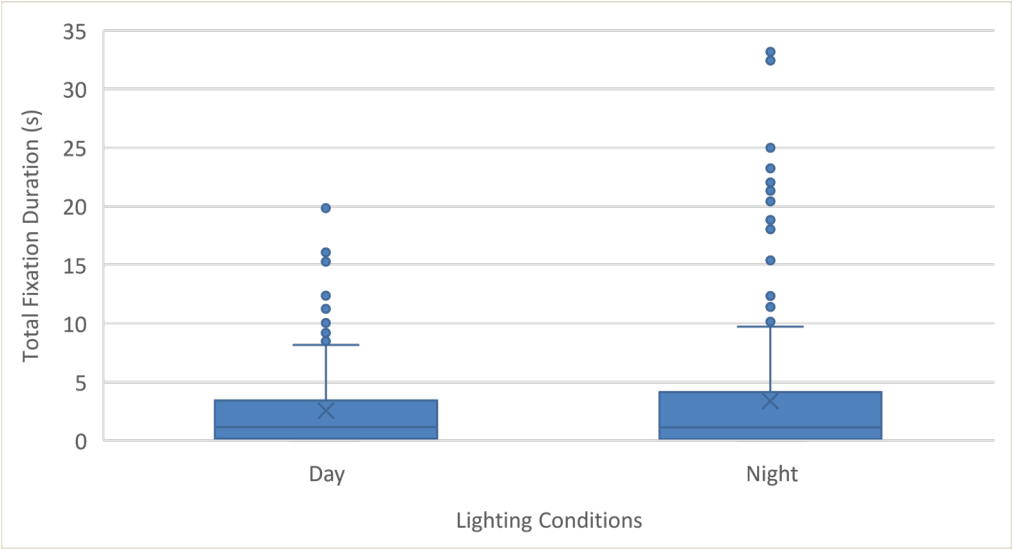
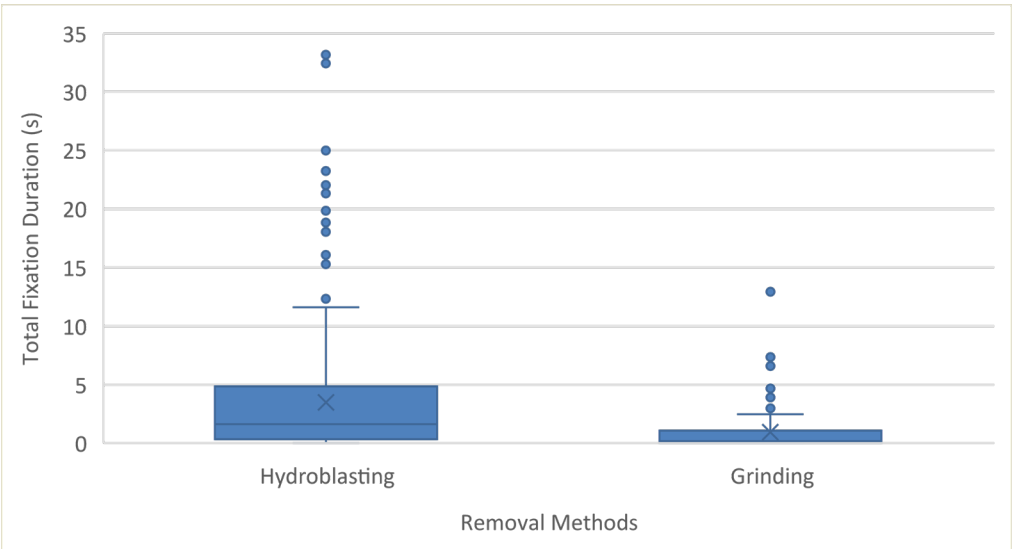
Visual Attention

- For lighting, nighttime conditions had a higher TFD with an average of 3.37 seconds to daytimes 2.57 seconds
- Hydroblasting had a significantly higher duration of fixation than grinding
- Average for hydroblasting TFD is 3.48 seconds while for grinding the TFD is 0.93 seconds





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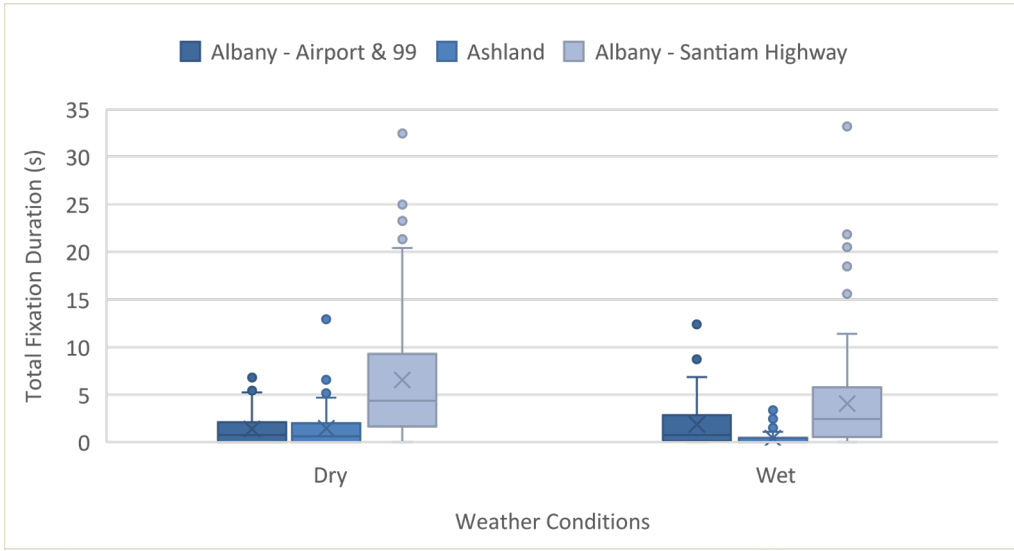
Visual Attention

- Dry weather conditions had overall a higher TFD
- The Albany – Airport & 99 location did have a slightly higher TFD during wet weather conditions



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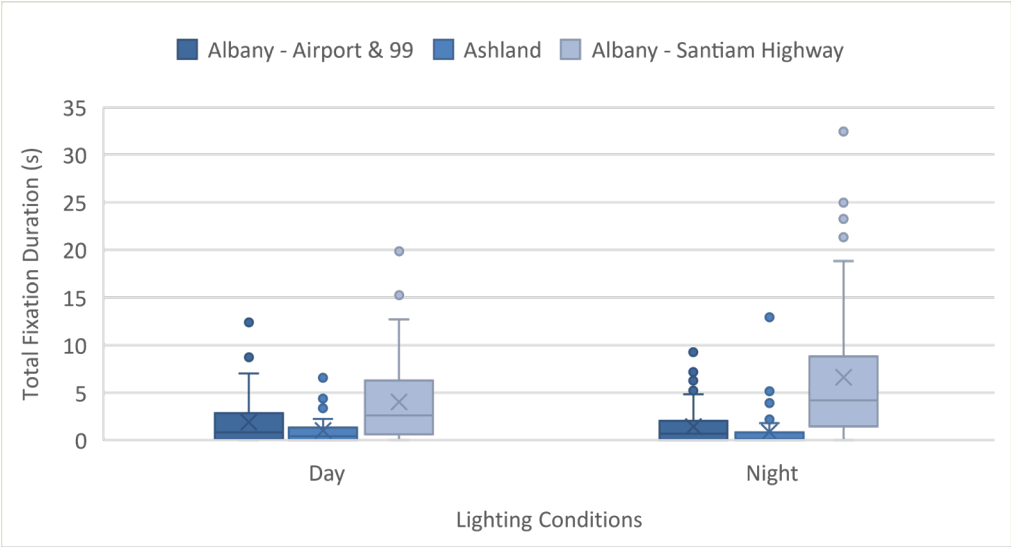
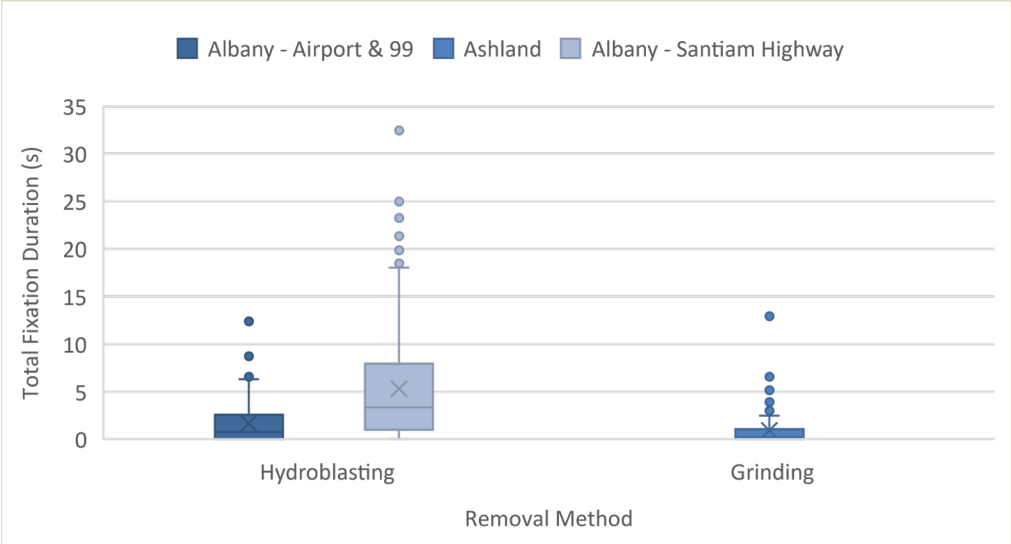
Visual Attention

- The daytime lighting conditions had a higher TFD than those of nighttime except for the Santiam Highway location
- Hydroblasting overall had a higher TFD than grinding





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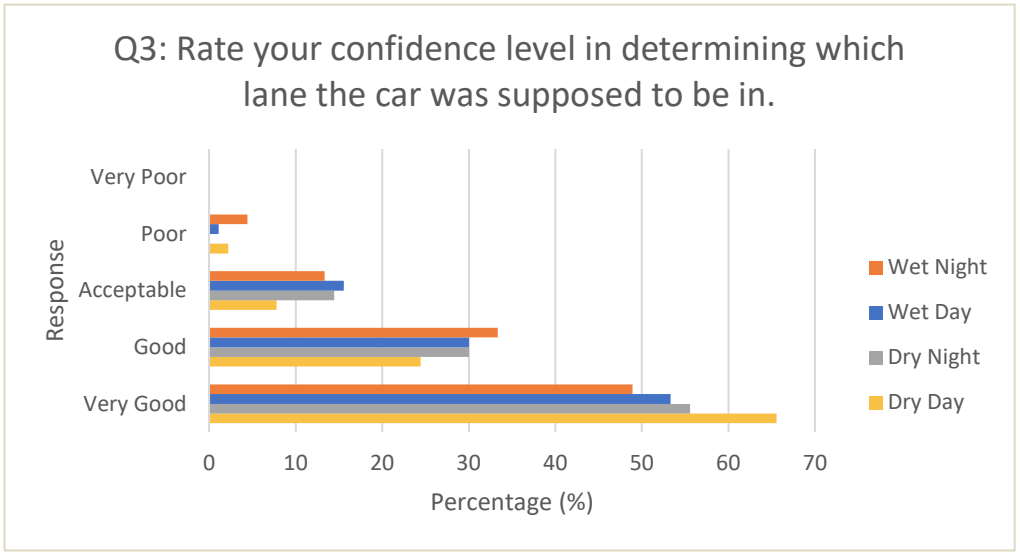
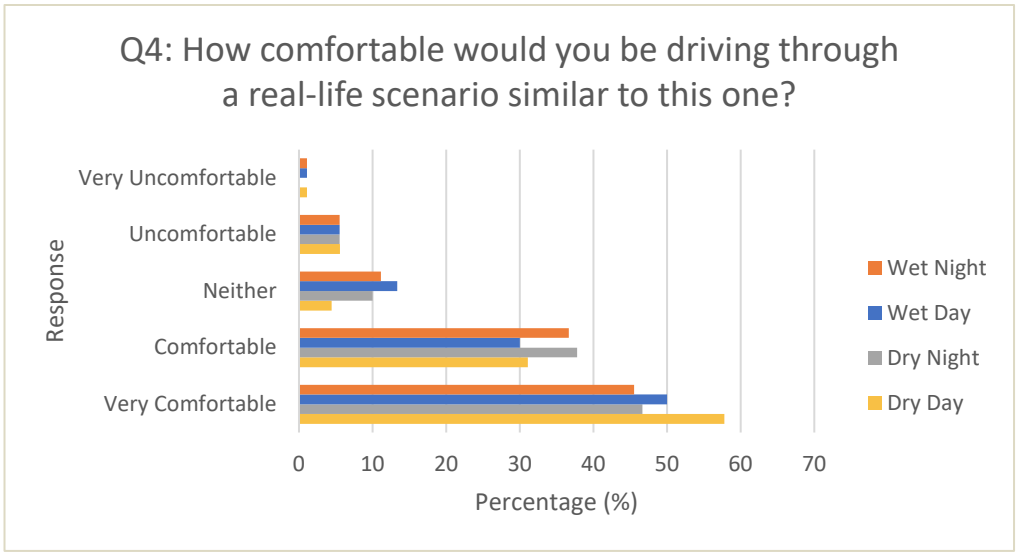
Multiple Choice Questions Results

- Overall, many participants experienced confidence in determining the correct lane in all weather conditions
- Most participants were also either very comfortable or comfortable in driving through all weather and lighting scenarios provided





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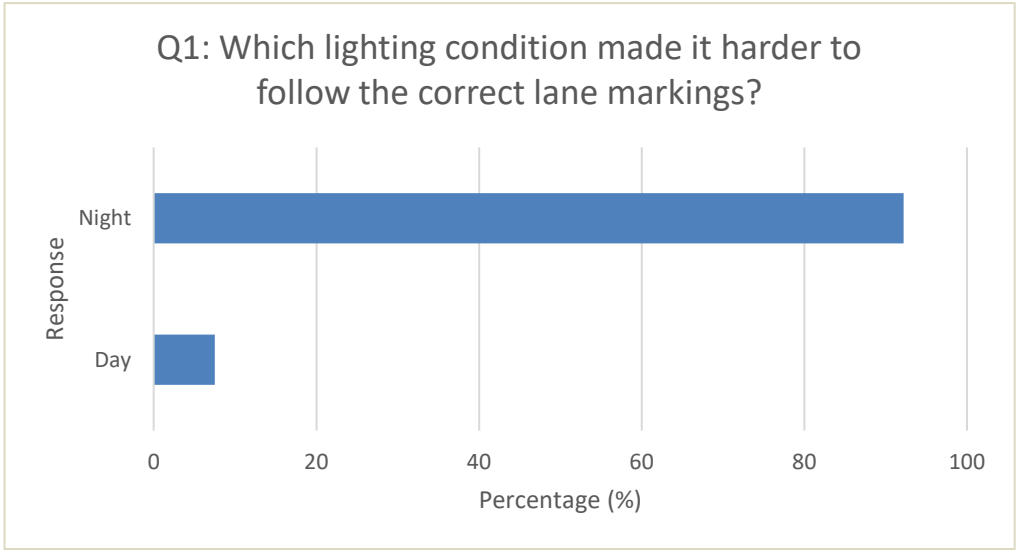
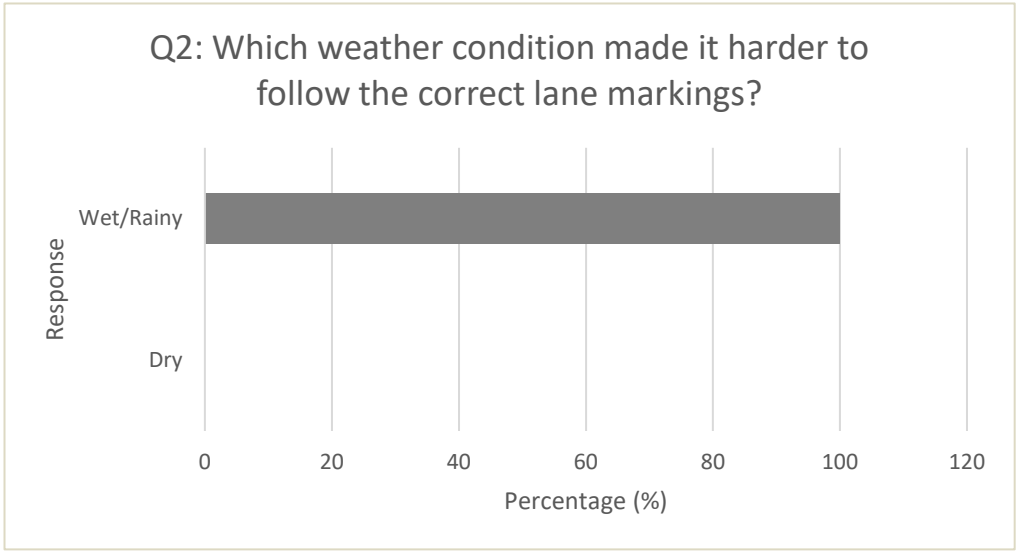
Lighting and Weather Conditions Results

- Average over the 12 scenarios given to participants
- The nighttime scenarios were the harder lighting condition to follow the correct markings
- Wet/rainy weather conditions were unanimous in replies from participants for what was harder weather condition to follow the correct lane markings
- The combination of nighttime and wet for weather and lighting conditions was chosen as the harder combination





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Key Takeaways

- Conducted in the OSU Sim Lab
- Consisted of multiple scenarios (12) from three different locations
- Variety of combinations for weather and lighting conditions
- Participants tasked with viewing 9 scenarios each
- Survey was conducted pre- and post-video along with a concurrent survey taken after each scenario
- Focused on demographics, experience with driving, and comfortability and confidence in the roadway

- **Hydroblasting resulted in significantly higher TFD**
- **Dry weather resulted in higher rate of focus on removed markings**

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Recommendations

- For the two options that were studied, hydroblasting and grinding, the hydroblasting method appeared to produce better results at the sites observed.
- Consider adoption of supplemental road reflectors to improve lane following behavior during nighttime conditions
- During construction the implementation of portable changeable message signs (PCMS) and reflective polarizer mirror (RPM) could reduce driver confusion

Limitations

- Data does not provide context as to why lane departure occurred
- Authenticity of driver reaction reduced due to data collection method for videos
- Number of locations and types of removal methods available at time of collection was limited

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Questions?

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