1. **ABSTRACT**

As unmanned aerial systems (UAS) are becoming more ubiquitous due to rapid advances in technology, their potential for personal and commercial usage is expanding. Conflicts between UAS and existing infrastructure will continue to increase as more UAS enter the airspace. In particular, significant attention has been given to the interaction of UAS operations and airport facilities. Nevertheless, UAS can and do operate in close proximity to roadway infrastructure as well. One manifestation of this conflict is the potential driver distraction from UAS operations near roadways, resulting in safety concerns for road users and UAS operators alike. This research evaluates the potential for this distraction through a driving simulator study.

1.1. **Objectives**

The primary objective of this study was to evaluate the potential for distraction due to UAS operating in close proximity to roadways with different functional classifications associated roadside development densities.

1.2. **Methods**

To identify existing gaps in knowledge and to guide the design of an experiment aimed at exploring the potential for driver distraction due to UAS near roadways, a review of the literature related to the various types of UAS, the current uses for UAS, and the legal standards for UAS use in the United States at the state and national level was completed. In addition, literature related to causes of distraction and dynamic roadside distraction studies using driving simulators were reviewed to inform the experimental procedure.

Informed by the findings of the literature review, an experiment was developed in the Oregon State University (OSU) high-fidelity driving simulator to determine the potential effects of distraction by UAS operated in close proximity to roadway infrastructure. The OSU driving simulator and an ASL Mobile eye tracker were used to conduct the experiment (Figure 1).
A partially randomized counterbalanced factorial design was used. The independent variables selected included various levels of lateral distance of the UAS from the roadway, flight pattern, and density of adjacent land use. Two levels were considered for density of adjacent land use. The first level (Figure 2) represents a rural environment with light residential and agricultural land use along a two lane road. The second level (Figure 3) represents an urban environment with moderate industrial and commercial land use along a four lane non-divided road.
Subjects were exposed to various UAS interactions through the driving simulator environment based on the independent variables. The performance measure (dependent variables) of visual attention was recorded and analyzed to determine the distraction caused by the independent variables. Thirty subjects participated in the simulator study to provide statistical validity to the results. The visual attention from the eye tracking data for each of the subjects was compiled to determine the potential for distraction caused by UAS.

1.3. Results and Conclusions
This project analyzed the average amount of time the subjects visually fixated on a drone operation in the time that the drone was visible to the subject in the simulator. This metric was used to compare the different independent variables to see which drone events resulted in the greatest potential for distraction, based on surrounding land use and distance from the roadway.

The first variable analyzed was the lateral offset of the drone operation. This variable had three levels and compared the average fixation duration on drone operations located at the roadside (0ft. offset), 25ft. off the road edge, and 50ft. off the road edge. To evaluate the difference in the means between the average fixation duration of the subjects’ visual attention with the different lateral offsets, an ANOVA analysis was performed. The results of the ANOVA \([F(2, 537) = 19.64, p = <0.001]\) showed that the effect of distance on average fixation duration was significant. Subsequently, a Tukey test was performed to determine the individual comparisons of lateral offset that were significant. The results of the Tukey test are included in Table 1.

<table>
<thead>
<tr>
<th>Comparison</th>
<th>Mean Diff.</th>
<th>P-value</th>
</tr>
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<tbody>
<tr>
<td>0 ft – 25 ft</td>
<td>0.128</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>0 ft - 50 ft</td>
<td>0.163</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>25 ft – 50 ft</td>
<td>0.035</td>
<td>0.404</td>
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Table 1: Tukey Test Results
The Tukey results show that the comparisons to the 0ft. lateral offset are significant. However, there is not a significant difference in the average fixation duration between the 25ft. and 50ft. offsets. This demonstrates that, based on average fixation duration, drone operations are more likely to result in a visual distraction when the operation is immediately adjacent to the roadway, but that further away the distraction is lessened.

The second variable analyzed was the surrounding environment of the drone operation. This was a dichotomous independent variable which compared the average fixation duration on drone environments in a rural environment and an urban environment. To evaluate the difference in the means between the average fixation duration of the subjects’ visual attention in the different environments, a Welch’s T-Test test was performed. The results of the Welch’s T-Test \[ t (537) = 2.76, \ p = 0.006 \] showed that there was a significant difference in the average fixation duration for the rural (mean = 0.312) and the urban (mean = 0.249) conditions. The mean average fixation duration is higher in the rural environment. It is hypothesized that the rural environment has less visual clutter and the drone operation has more distinction in the environment.

The results of this driving simulator study show that drone operations have a higher potential for distraction in rural environments and when the drone operation is closer to the roadway. The findings of this study could provide necessary information to transportation and aviation officials as they establish statutes, policies, and procedures related to UAS operations.