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# Corridor-Wide Surveillance Using Unmanned Aircraft Systems Phase II: Freeway Incident Detection using Unmanned Aircraft Systems (Part A)

Ivette Cruzado, David González, Alberto M. Figueroa-Medina, Didier Valdés, Luz G. Rivera-Pérez, and Bryan E. Ruiz-Hernández
University of Puerto Rico at Mayagüez

For more information, contact: Ivette Cruzado
Email: ivette.cruzado@upr.edu

POLICY BRIEF

## BACKGROUND AND OBJECTIVES

Automatic freeway incident detection is a novel approach that is expected to reduce response time and improve the efficiency of incident management. Unmanned aerial vehicle (UAV) platforms have been used to obtain video data and develop methodologies for incident detection. Traffic Management Centers (TMCs) also use video data to monitor freeway traffic operations and incident detection. However, TMCs are cautious about using video data due to constraints and risks, especially privacy concerns of road users. As such, there are technologies that can lower image resolution to remove private information, such as the license plate number of the vehicles. In addition, sensing technologies (e.g., thermal sensors) can collect images for extracting traffic information without capturing private information.

In recent years, UAVs have been used to monitor traffic operations and collect traffic information. Compared to traditional stationary sensors, UAV technologies allow users to select locations and different angles and elevations while collecting traffic information. Also, the mobility of UAVs makes it possible to cover long distances of freeways so both temporal and spatial dimensions can be collected, which makes it possible to apply cutting-edge learning methods to perform traffic analysis.

Due to the lack of a protocol to effectively analyze and evaluate incidents and detect vehicles in multi-lane corridors, the first phase of this study focused on developing a protocol to integrate the use of drones in real-time incident detection. For the second phase, the team collected field data at different elevations and distances from the road to analyze the performance of a background subtraction algorithm in vehicle detection. The objectives for the second phase of the study were: (1) to advance the current state of the art in freeway automatic incident detection using image data from UAVs and analyze the efficiency of a vehicle detection algorithm; (2) to update the protocol developed with lessons learned during the flight activities; (3) to identify barriers and challenges of implementing emerging technologies in automatic incident detection and provide suggestions for future research studies; and (4) to strengthen the mutual collaboration and lessons learned associated with incident management with local TMCs for the benefit of reducing recurrent and non-recurrent traffic congestion and improving corridor safety for all present and future road users.

## METHODOLOGY

The methodology was divided into several tasks. The first task was to perform the literature review, which focused on freeway concepts, UAS applications and specifications, data collection techniques, flight plans, background subtraction methods, incident detection, traffic congestion, the use of UAS in other areas, and experimental design. The second task was the selection of sites to perform the video data collection and then the dates of the field activities. The task involving the experiment design included the identification of the variables (and their values) to be studied as well as the selection of the split-plot design for data analyses. After all these steps were performed, with the information gathered the flight plan was prepared and executed. A total of six flight activities were performed in arterial and freeway segments. The protocol previously developed was used and continued to be updated with the lessons learned from each activity. Each activity had different purposes; therefore, there were different scenarios. Five of the scenarios served as test sites to understand the capabilities of the two drones available to the crew and to prepare for the study site. The test sites also helped select the variable of drone elevation and distance from the road for the study site. After all the video data were collected, the next task was to analyze the videos by running them through a background subtraction algorithm. The final task was to report the conclusions and recommendations based on the results of the analyses.

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## RESEARCH FINDINGS

The main findings obtained throughout the development of this phase of the project were:

- A proper framework must be developed to evaluate any vehicle detection method. For this project, the framework consisted of four steps: (1) defining and developing a proper flight plan for the data collection activities, once the data collection sites are identified; (2) the data collection stage, which involves going to the field and taking videos using UAS for them to be analyzed later; (3) running the videos through the vehicle detection algorithm; and (4) data validation, which entails manually counting the data vehicles illustrated in the frame and comparing them with the number of vehicles detected by the algorithm as indicated by bounding boxes.
- The results of the validation analyses show that a high detection rate with an accuracy of up to 92% can be reached using the background subtraction algorithm.
- It was observed that treatments where the drone was located at lower values for distance from the road showed higher detection rates, meaning that positioning the drone closer to the road, though not to distract drivers, is associated with higher percentages of vehicles detected by the background subtraction algorithm evaluated.
- The results of the analyses indicated that distance from the road was the only main factor to be significant at the 95% confidence level.
- The interaction plots indicated that depending on drone type the elevation can affect the detection rate. However, results showed decreased detection rates in some treatments. Some factors that can be responsible for this observance could be related to high traffic densities, colors of vehicles that blend with the pavement, and obstructions to the roadway.

## POLICY AND PRACTICE RECOMMENDATIONS

During the data collection activities, the team identified relevant issues that researchers and transportation professionals should be aware of when using drones for collecting roadway and traffic data. These issues and their respective recommendations are:

- There could be both connectivity and visibility problems between the drone, remote control, and the RPIC, either due to great distances or due to road alignment changes such as horizontal curves. It is therefore recommended to perform visibility and communication (connectivity) tests before conducting any studies.
- Depending on the capabilities of the drone, it can experience difficulties transmitting a clear image at long distances. To mitigate this situation, the RPIC and the visual observer(s) must place themselves strategically where the drone is close to both the area of interest and themselves.
- When operating a drone in a long or curved segment or mountainous terrain, one should consider that the drone must always be visible to at least two crew members. A minimum of two visual observers is recommended for these types of highway segments. In addition, it is recommended to use portable two-way radios (i.e., Walkie-talkies) or other communication devices for continuous contact between the team members.
- The entire team should use safety vests and helmets per federal regulations when operating alongside a freeway corridor.
- Hot temperatures reduce the battery life of drones. It is recommended to have additional batteries or a charging station on site.
- Wind gusts may affect the stability of the drone during operation. If a drone is tilted mid-flight, it might be necessary to land the drone and recalibrate it before resuming flight operations. It is also recommended to check the wind speed and the presence of wind gusts for the day of flight operations.
- Be prepared to cancel the flight operation due to unexpected weather conditions. Even if weather apps are checked daily, their predictions can vary.
- When investigating the distance from the road and the drone's elevation to collect traffic data, it is best to set a range of values for these variables before data collection. It is recommended to try different combinations on test sites before collecting data on the study site to narrow down the most appropriate combinations.
- The camera angle is determined once the drone is placed in its position to get the best possible view of the highway.
- For night conditions, it is best to determine the points of reference during daylight. The team members should verify that the flashing beacons on the drone are functional before deployment.
- Every flight operation has lessons learned. It is recommended to document all experiences and review them with the team members to improve future operations.