Viability and Uses of UAS in Highway Design, Inspection, Construction, and Maintenance

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The United States of America's infrastructure is in a dire state of disrepair and neglect. For decades major infrastructure projects have been overlooked and underfunded. One of the most impacted has been the nation's roadways. These vital links connecting communities and the economy have been left to stagnate and decay. Poor-condition roads cause deaths, accidents, and damage to productivity and the environment. Thanks to sources such as the American Society of Civil Engineers we have a great understanding of the poor condition the U.S. finds itself in. According to the American Society of Civil Engineers "43% of our public roadways are in poor or mediocre condition." (ASCE, 2021) The ASCE has labeled the status with a letter grade of D for its overall road health and viability. This letter grade means that ASCE believes the nation's roads are overall poor or mediocre. With an ever-growing population dependent on these arteries and lack a of funding it is important that the funding that is received is used on the most critical and deserving projects. In fact, according to Elizabeth Mcnichol a writer for the Center on Budget and Policy Priorities "Improving roads and bridges alone would require $1.1 trillion more than states, localities, and the federal government have allocated." (Mcnichol, 2019) The question naturally leads to how those critical and deserving projects are determined and found. Throughout this paper, I will share how drones can be a potent tool for evaluating, observing, and assisting in the repair and construction of roadways and highways.

Evaluating the condition of infrastructure can be a costly, dangerous, and labor-intensive task. Before the advent of cost-effective and widely available drones. The most practical way to investigate road systems was by humans observing from vehicles, on foot inspections, and in rare cases aerial inspections. However, when drones are considered their cost savings and uses can be best seen as authors Fan and Saadeghvaziri put it "Very high-resolution photos or videos can be obtained since drone platforms allow for low altitude operations and they are agile and flexible

to get the objects. It is less time-consuming to inspect infrastructures or survey a job site compared to manually working on the same mission, especially for hard-to-reach parts of some infrastructure assets." (Fan and Saadeghvaziri, 2019) Instead of having multiple crews or workers inspecting roadways and bridges from equipment one drone operator can take high-resolution photos and videos that can be reviewed in the field or an engineer's office. Cost savings is another benefit of using drones for evaluating roadways. In Pinto, Bianchini, Nova, and Passoni's article it states "By using UAS, the inspection of road infrastructures becomes quicker and cheaper, its outcomes objective-since they are independent of inspector's experiences-and, above all, they become repeatable. As discussed before, collecting the data by one operator instead of needing multiple inspectors on site is significantly more cost-effective. This data is also easily shared with subject matter experts who can better evaluate the conditions. Overall drones with their cost effectiveness, low labor requirements, and ability to provide workers with safe work environments make them the best choice for mass evaluation of roadway conditions.

Once the condition of the roads has been assessed it is important to observe the traffic, and safety conditions, and evaluate solutions to poor traffic flow. Before the start of work on a stretch of road designated for repair or construction it is important to come up with a good traffic control and reroute system. In a survey produced by Chiara Garibotto and associates, they explore the viability of using drones to count and observe traffic movement. They share the benefits of drones for this application as "location management, dynamic coverage, real-time data collection and processing hurdle avoidance, and surveillance of small/large static/moving objects." (Chiara Garibotto and Associates, 2022) Whether it is a governmental agency or the contractor performing this work will better allow them to understand the traffic flow speeds and

bottlenecks of a system. This observation can also be used to plan safe times for workers to be working on certain parts of a site. In a paper published by Brahimi and Associates they share the idea that "A UAV could be used to define different construction zones based on time intervals, aiming at safer transportation throughout the construction projects." (Brahimi and Associates, 2020) Preventing workers from being in dangerous locations during peak traffic is the detailed information that drones can provide. Before the advent of road work roads should be observed for their flow and safety effectiveness. One of the interesting and potential uses drones may be able to fill in this role is utilizing a (TUAS) or Tethered Uncrewed Aerial System. This would allow for unlimited flight time and provide better optics than a person on the ground or a camera only a few feet off above the traffic. This concept is explored by Abdallah Kinero in "*Exploring the Use of Drones for Conducting Traffic Mobility and Exploring the Use of Drones for Conducting Traffic Mobility and Safety Studies Safety Studies*" (2021). Drones providing a bird's eye view provide valuable data and understanding to contractors and government agencies looking to upgrade, repair, and work on roadways.

Once the roads have been evaluated, and observed and the work has been approved drones can be leveraged in the action phase. One of the powerful tools drones can provide to contractors is a 3D scan of the site. This 3D map can be used to plan, communicate work, and highlight potential issues that may arise during the construction process. Using a 3D map according to the Federal Highway Administration contractors often claim an increase in efficiency in earthmoving alone of 15% to 25%. (p.5, 2013) With a significant increase in efficiency, costs can be lowered and environmental impacts can be lessened. Drones can also be powerful in creating documentation of work completed. One idea presented by Skoda and Holcman is called Health Checks. These health checks are oriented around "helping increase the

efficiency of projects by reducing delays and helping to avoid unplanned stoppages." (Skoda and Holcman, 2021) With the health check idea in place, errors can be caught earlier and prevent rework further into the project saving the government and contractor time and money.

Unmanned Aerial Systems are potent tools in highway design, inspection, construction, and maintenance systems. Drones are also very effective in the evaluation stage. Understanding and identifying what roads need work and providing information to government agencies capable of approving and making the necessary decisions. Drones allow for cost-effective reliable observation of road systems. Providing clear pertinent information for decision-makers in a rapid and repeatable manner. When it comes to the action phase, contractors and government agencies can rely on drones to provide 3D maps that enhance communication and raise efficiency. Drones also document progress and allow site managers to ensure the correct work is being carried out. With the vast applications, it's no wonder why quotes such as this from one from Mahajan are possible "The utilization of drones in the construction industry has a 239% development year–over–year worldwide, greater than any other commercial zone." (Mahajan, 2021) With every year technology advances and new applications are created.

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