AASHTO Innovation Initiative

[Proposed] Nomination of Innovation Ready for Implementation

Sponsor

Nominations must be submitted by an AASHTO member DOT willing to help promote the innovation. If selected, the sponsoring DOT will be asked to promote the innovation to other states by participating on a Lead States Team supported by the AASHTO Innovation Initiative.

1. Sponsoring DOT (State): Utah Department of Transportation

2. Name and Title: Paige Nussbaum, EIT - Rotational Engineer

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Innovation Description (10 points)

The term “innovation” may include processes, products, techniques, procedures, and practices.

3. Name of the innovation:

Aerial Imagery-Based Pavement Evaluation

4. Please describe the innovation.

A new evaluation process for portland cement concrete pavements that is safer, more efficient, and more accurate than traditional methods. Unmanned Aircraft Systems (UAS) are utilized to capture

geo-referenced images. The collected images are processed into a dynamic GIS map with embedded feature layers and attributes that engineers can use to identify and quantify the necessary repairs. Images can be reviewed without requiring multiple visits to the project site, and the maps can be shared with designers and contractors to clearly relay project information.

5. What is the existing baseline practice that the innovation intends to replace/improve?

Current practice in most DOTs requires walking or driving on the shoulder of the road to document pavement conditions, approximate location as fractions of mileposts, and to estimate the size of needed repairs. Closure of travel lanes is sometimes required to document these pavement conditions.

UDOT contracts a service to annually measure pavement distresses on state routes. Data collection is constrained to one lane per direction of each route. While this data is helpful for generating the Statewide Pavement Management Program, it is not suitable for project development and delivery. Existing aerial imagery is useful for identifying edge of pavement and basic geometry when survey is not available. However, it is not detailed or current enough to assess pavement condition.

6. What problems associated with the baseline practice does the innovation propose to solve?

The baseline practice for pavement condition evaluation exposes personnel to live traffic and other roadside hazards and often causes confusion, distraction, and delays for the traveling public.

Traditional pavement evaluations can also result in imprecise repair quantity estimates during the project design and delivery process. The stresses of working in live traffic conditions, including high traffic volumes and distorted viewing angles, often complicate data collection.

An aerial imagery-based method of conducting pavement condition evaluations provides improved safety and efficiency. DOT personnel avoid high-speed traffic and potential hazards to the traveling public are mitigated when this innovation is implemented.

UAS pilots can position their equipment farther away from live traffic and fly over the roadway median and shoulders. Rather than walking or slowly driving down the roadway, the evaluation can be conducted on a computer from an office. Lane closures are not required to perform pavement inspections with UAS.

7. Briefly describe the history of its development.

Digital pavement condition data has been collected by UDOT since 1997. The data is processed and summarized as index values for every segment of state routes. When project-specific pavement evaluations are needed, the Region Pavement Management Engineer conducts an in-field evaluation to identify approximate locations and sizes of required repairs.

Pavement evaluation using UAS had been considered in the past, but was not then feasible due to software and equipment limitations.

UDOT Region One has since acquired a drone and successfully implemented the proposed Aerial-Imagery Based Pavement Evaluation for a project in November 2021. A pavement assessment was needed for a preservation project on I-15 in Davis County, Utah. This 5-mile segment includes four general purpose lanes and one express lane in each direction, as well as two interchanges. Narrow shoulders, maintenance of traffic, and safety of UDOT employees and the traveling public were of primary concern.

The Region One GIS Group first conducted UAS flight missions over the project limits. Geo-referenced images were collected using a DJI Phantom 4 Pro RTK UAS. These images were then used to create a dynamic GIS map with embedded feature layers to identify and categorize locations of pavement distresses and the recommended repairs. Polygons were drawn around damaged areas to calculate repair quantities.

During imagery-based evaluation, the locations of the repairs are marked with both mileposts and GPS coordinates with greater accuracy than can be obtained from traditional concept-level measurements. Increasing the accuracy of quantities leads to more exact project cost estimates, enriched plan sheets for construction field inspection, and fewer change orders.

8. What resources—such as technical specifications, training materials, and user guides—have you developed to assist with the deployment effort? If appropriate, please attach or provide weblinks to reports, videos, photographs, diagrams, or other images illustrating the appearance or functionality of the innovation (if electronic, please provide a separate file). Please list your attachments or weblinks here.

This innovation has been shared within UDOT through the Utah Learning Portal: Ideas, Innovations, Efficiencies Group. Region One GIS Group created a “Technical Lessons Learned and Best Applied Practices” document to assist others in the use of this technology. The UDOT Statewide Pavement Management Group has incorporated this method of inspecting concrete pavement as a preferred practice in the UDOT Pavement Management Manual.

Weblinks:

UPLAN Map

Quick Technical Summary (lessons learned/best practices)

Attachments:
Ideas, Innovations, Efficiencies Report
UDOT Pavement Management Manual 4.8.5.4 Concrete Preservation Aerial Imagery

Attach photographs, diagrams, or other images here. If images are of larger resolution size, please provide as separate files.

State of Development (40 points)

Innovations must be successfully deployed in at least one State DOT. The AII selection process will favor innovations that have advanced beyond the research stage, at least to the pilot deployment stage, and preferably into routine use.

9. How ready is this innovation for implementation in an operational environment? Please select from the following options. Please describe.

☐ Prototype is fully functional and yet to be piloted

☐ Prototype has been piloted successfully in an operational environment

☒ Technology has been deployed multiple times in an operational environment

☐ Technology is ready for full-scale implementation

Aerial Imagery-Based Pavement Evaluation methods were used to inspect a 5-mile segment of I-15 to quantify and classify required pavement repairs. Maps of distress locations were used to create a more accurate cost estimate and incorporated into the project contract documents to aid in construction.

This innovative method was also later deployed to document the condition of the surface course and concrete layers of a composite pavement on a different 8-mile segment of I-84 in Box Elder County during a micro-rotomill and bonded wearing course overlay project.

10. What additional development is necessary to enable implementation of the innovation for routine use?

Battery life of the drones and airspace clearance procedures in Northern Utah create some difficulty for flight missions. UDOT Region One's boundaries include several airports and Hill Air Force Base, which create additional airspace restrictions. Other DOTs may have similar challenges when implementing this technology near sensitive locations.

Aerial Imagery-Based Pavement Evaluations have been performed in multiple operational environments within UDOT including preliminary project concept definition, construction, and in-service performance evaluation. While evaluating flexible pavements may be more consistently feasible in the future, the lower altitude necessary to collect useful imagery requires lane closure at this time.

11. Are other organizations using, currently developing, or have they shown interest in this innovation or of similar technology?? ☐ Yes ☒ No

If so, please list organization names and contacts. Please identify the source of this information.

Organization	Name	Phone	Email
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.
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Potential Payoff (30 points)

Payoff is defined as the combination of broad applicability and significant benefit or advantage over baseline practice.

12. How does the innovation meet customer or stakeholder needs in your State DOT or other organizations that have used it?

Aerial Imagery-Based Pavement Evaluation results in more prudent use of public funds. Data collection using this method is more efficient than conventional practice. Time saved is most valuable when project sites are in more remote areas and fewer trips to the site are needed to collect the images. Aerial Imagery-Based Pavement Evaluation removes the requirement for lane closures to conduct inspections and the corresponding potential hazards for both the traveling public and UDOT personnel. Safer and more efficient approaches to pavement evaluation contribute to UDOT's strategic goals of Zero Fatalities and Preserving Infrastructure.

13. Identify the top three benefit types your DOT has realized from using this innovation. Describe the type and scale of benefits of using this innovation over baseline practice. Provide additional information, if available, using quantitative metrics, to describe the benefits.

Benefit Types	Please describe:
Improved Safety	Minimized roadside exposure to traffic.
Improved Quality	Repair quantity estimates are more accurate and fewer change orders are made during project construction.
Organizational Efficiency	Evaluation can be completed in less time than is required with current practices.

Provide any additional description, if necessary:

Click or tap here to enter text.

14 How broadly might this innovation be deployed for other applications. in the transportation industry (including other disciplines of a DOT, other transportation modes, and private industry)?

Imagery collected in the demonstration project was used by a consultant during the design process to clearly show locations requiring pavement repair, simplifying the relay of information to the contractor.

Aerial Imagery-Based Pavement Evaluation utilizes skills, software, and equipment that many DOTs already possess in ways they may not have previously considered.

Market Readiness (20 points)

The AII selection process will favor innovations that can be adopted with a reasonable amount of effort and cost, commensurate with the payoff potential.

15. What specific actions would another organization need to take along each of the following dimensions to adopt this innovation?

Check boxes that apply	Dimensions	Please describe:
☐	Gaining executive leadership support	Click or tap here to enter text.
☐	Communicating benefits	Click or tap here to enter text.
☐	Overcoming funding constraints	Click or tap here to enter text.
☒	Acquiring in-house capabilities	Drones and batteries need to be acquired, survey technicians may need additional training.
☐	Addressing legal issues (if applicable) (e.g., liability and intellectual property)	Click or tap here to enter text.
☐	Resolving conflicts with existing national/state regulations and standards	Click or tap here to enter text.
☐	Other challenges	Click or tap here to enter text.

16. Please provide details of cost, effort, and length of time expended to deploy the innovation in your organization.

Cost: Drones with these mapping capabilities cost $3000-$12000. The DJI Phantom 4 Pro RTK currently used by UDOT Region One retails for $8000.

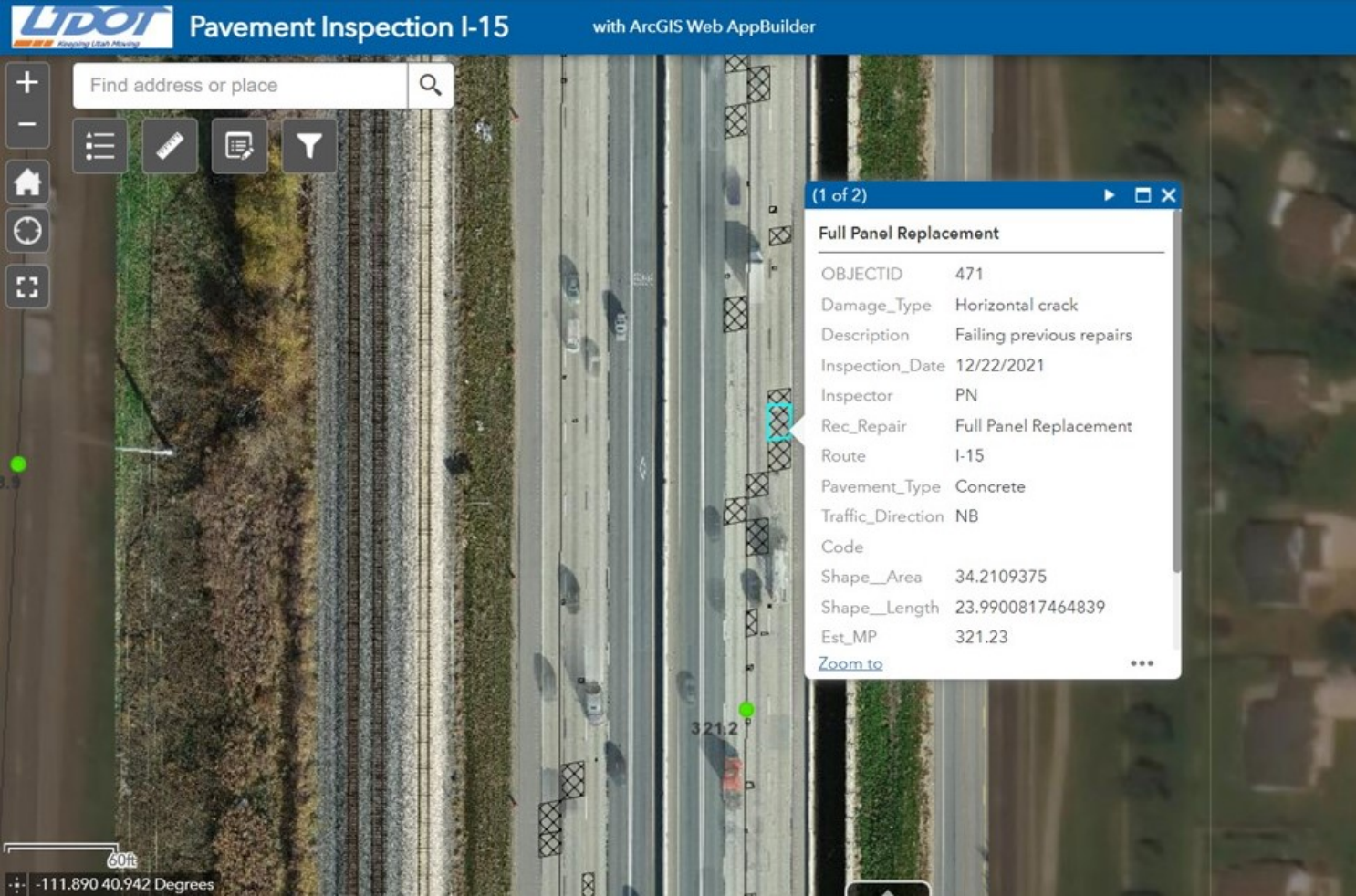
The user cost for a 1-lane closure on the 5-mile segment of I-15 is $6,000 per lane per hour. The lane rental cost for the same segment is $1,270. The cost to the DOT to provide two surveyors, a drone, and a state vehicle required to implement this innovation is considerably less compared to the expense of lane closure and provides a higher quality product.

Level of Effort: This innovation is easily implemented. Most DOTs have surveyors and GIS software with the necessary capabilities to conduct drone flight missions to gather geo-referenced aerial images.

Time: The time required to complete an Aerial Imagery-Based Pavement Evaluation is equal to or less than the time currently allotted for traditional pre-project pavement inspections and results in a higher quality data set.

17. To what extent might implementation of this innovation require the involvement of third parties, including vendors, contractors, and consultants? If so, please describe. List the type of expertise required for implementation.

Involvement of third parties is not required, but imagery and classified data points can be shared between the DOT, consultants, and contractors for the benefit of the project team.


Pavement Inspection I-15
with ArcGIS Web AppBuilder
Find address or place
(1 of 2)
Full Panel Replacement
OBJECTID 471
Damage_Type Horizontal crack
Description Failing previous repairs
Inspection_Date 12/22/2021
Inspector PN
Rec_Repair Full Panel Replacement
Route I-15
Pavement_Type Concrete
Traffic_Direction NB
Code
Shape__Area 34.2109375
Shape__Length 23.9900817464839
Est_MP 321.23
Zoom to
321.2
60ft
-111.890 40.942 Degrees

UDOT Pavement Management Manual

4.8.5.4 Concrete Preservation Aerial Imagery

Partial and full depth concrete repair quantities should be gathered using aerial imagery. UDOT's GIS Division can use drone technology to collect aerial images of the pavement. These images can be used to create a dynamic GIS map with embedded feature layers to mark the necessary repairs. During inspection, the locations of the repairs can be marked with both approximate mileposts and GPS coordinates. Polygons can be drawn around damaged areas to measure area quantities. This method of quantity collection has proven to be safer and more accurate than the traditional method of driving along the shoulder of the roadway.

The quantities generated should be considered approximate. Quantities generated using Aerial Imagery should be increased by 10 percent to account for potential quantity over-runs in construction.

The dynamic GIS map should be provided to the contractor for information only and direction should be provided to the inspectors about the priority of repairs it is appears there is not a sufficient quantity in the bid to repair all damaged areas.


SURVEY
CREW