The Use of Immersive Virtual Technologies for Public Engagement: A State-of-Practice Review of U.S. State Departments of Transportation

A Research Project with VDOT and University of Virginia

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VASITE Annual Meeting | June 3, 2026

AGENDA

- ➔ Background
- ➔ Virginia Application
- ➔ State of Practice Responses
- ➔ Next Steps

RESEARCH TEAM

- UVA Faculty Principal Investigators:
  - T. Donna Chen, Associate Professor of Civil & Environmental Engineering (Sustainable Transportation Systems)
  - Arsalan Heydarian, Associate Professor of Civil & Environmental Engineering (User-Centered Design, Construction, and Operation of Intelligent Infrastructure)

- Student Researchers:
  - Carreen de Cárdenas, Ph.D. Candidate in Civil & Environmental Engineering
  - Arman Hosseini, Ph.D. Candidate in Systems & Information Engineering

- VDOT Team:
  - Hari Sripathi, P.E., Director of Strategic Innovation
  - Mark Hill, P.E., Project Manager

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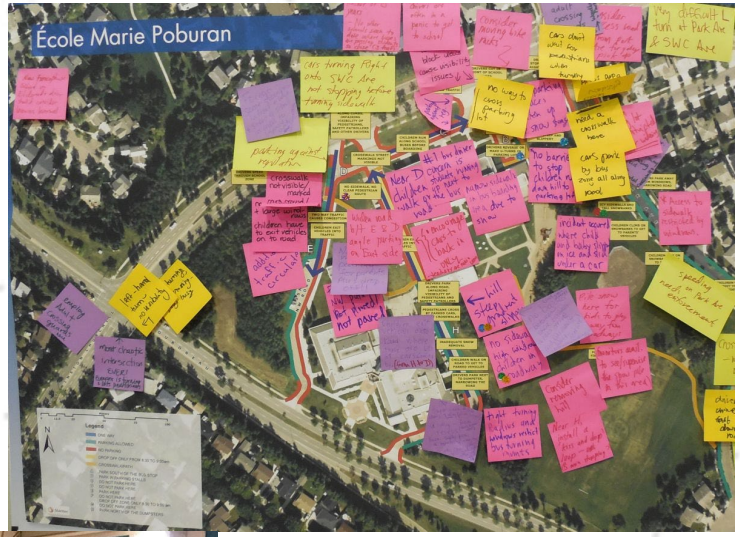
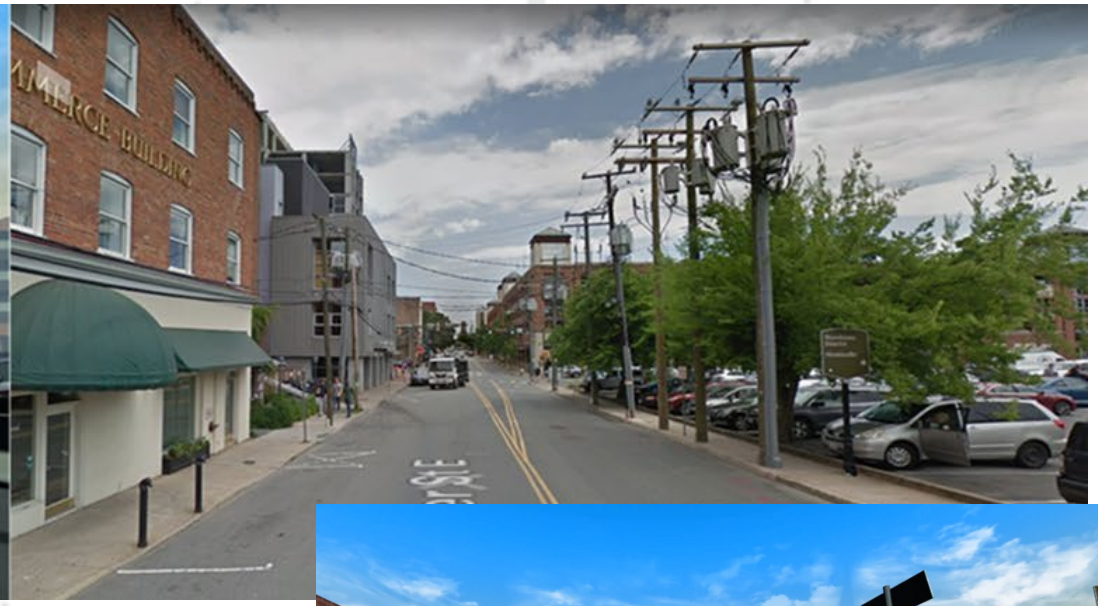
PROJECT BACKGROUND

- Public involvement is essential in transportation planning to incorporate ***community perspectives into project decisions***
- Traditional 2D plans and maps often fail to clearly ***communicate complex technical*** information to the public
- Immersive Virtual Technologies (including VR and AR) offer ***enhanced ways to visualize*** design alternatives and simulate future transportation environments



PREVIOUS LAB WORK: WATER STREET IN CHARLOTTESVILLE,



- One-to-one scale representation of built environment
- Different scenarios easily created in virtual environment

➔ VDOT was interested in if this work could be beneficial for public engagement

Virginia Application:

- Applying Technology to Proposed Roundabout Project in Bristol, VA
- First roundabout project in Bristol

High profile project

Need for explaining design to public

PROPOSED DESIGN IN 2D

PROPOSED DESIGN IN VR

Bike Simulator

Public Engagement Meeting

- Attendees indicated that ***Bike and Pedestrian Simulator*** and ***Floor Map*** were the most helpful in giving a sense of how the future corridor would look

- Simulators helped:
  - Visualizing the proposed changes
  - How roundabouts function
  - Understanding how to interact with vehicles in the crosswalk - safety of splitter island
  - Looking around and not limited to one fixed perspective
- Floor map and 3D Videos
  - gave aerial view and sense of the whole layout

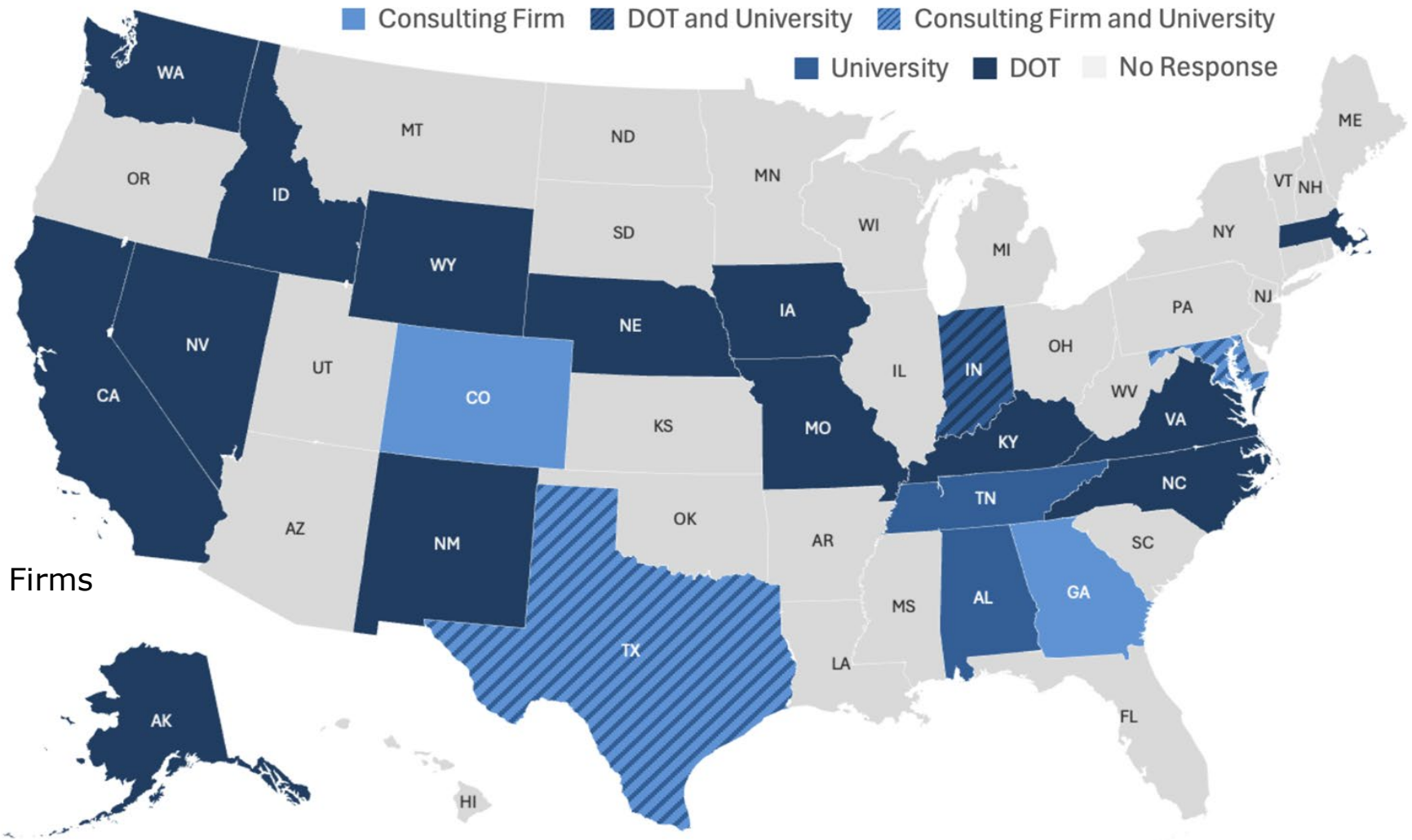
Study Objectives

➔ Assess current practices in the use of immersive virtual technologies for public engagement in transportation projects

- Identify ***institutional, technical, and practical barriers*** to implementation across state DOTs
- Document perceived ***benefits, limitations, and lessons learned*** from practitioners with direct experience using these tools

➔ Provide recommendations to support more effective and widespread use of immersive technologies in transportation planning and public involvement

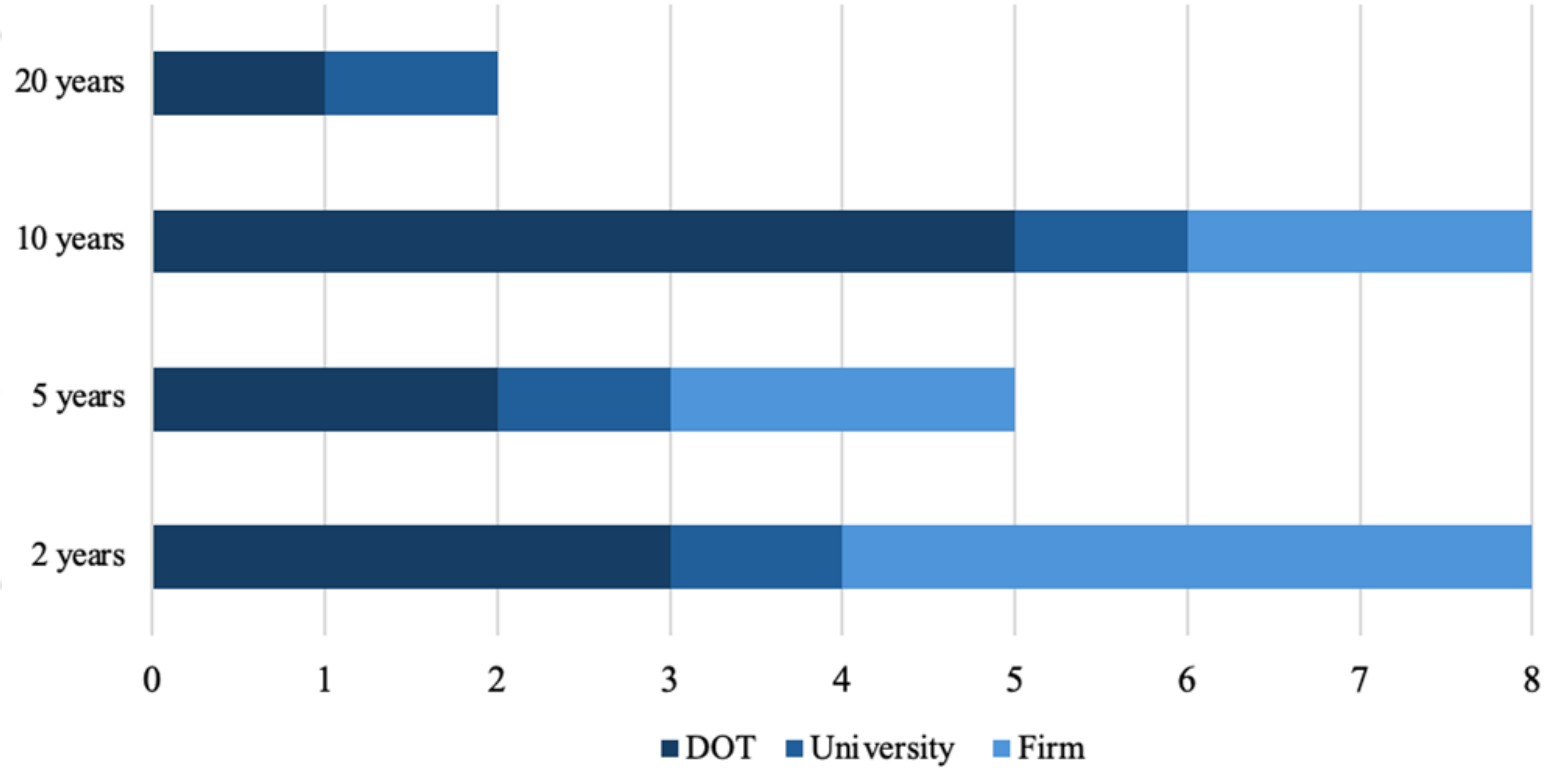
Organization Overview



- Email invitations to DOTs and Firms
- 33 responses
  - 14 DOTs Represented
  - 5 Universities
  - 4 Consulting Firms

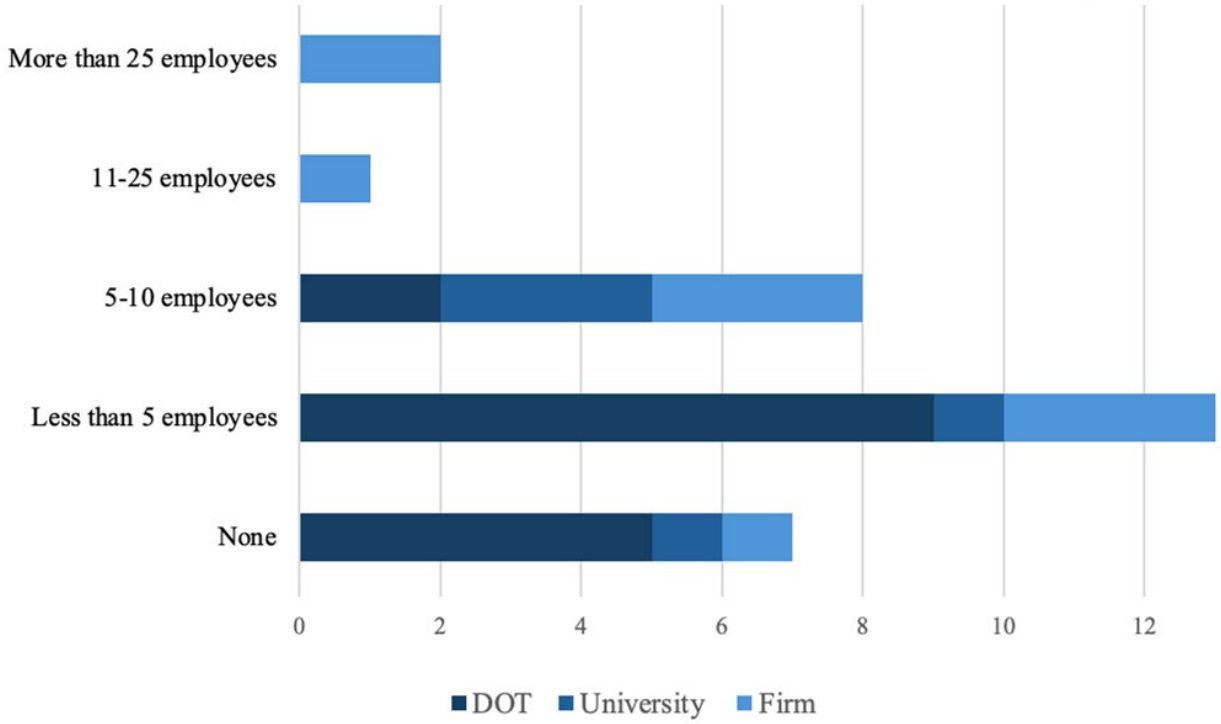
Adoption Timeline

- Majority started using the technology recently
- WSDOT and University of Alabama have been using the technology the longest



Agency Capacity

- Most DOTs report limited staff with knowledge of virtual technology - a few DOTs had internal teams:
  - WSDOT: *Visual Engineering Resource Group*
  - Caltrans: *Visualization Branch*
  - NCDOT: *Visualization Team*
- Consulting firms sometimes had teams focused on virtual technology
  - JMT: *Digital Experience Team*



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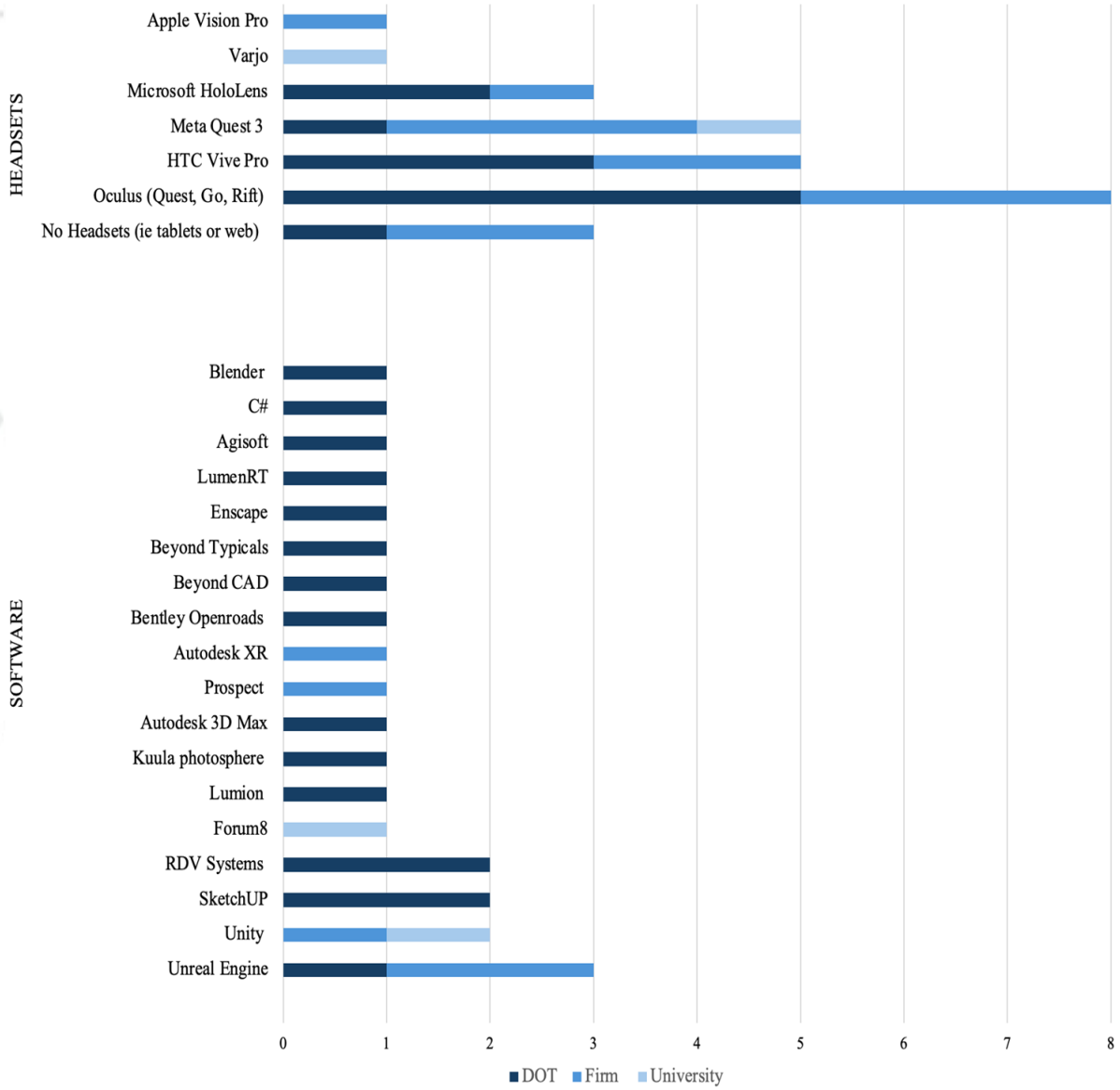
Technology + Workflow

- Wide range of software used
- Headsets:
  - Oculus, HTC Vive Pro, and Meta Quest
- Some prefer tablets for larger public meetings
  - Hygiene concerns
  - Faster hand-off
- Visualization realism and detail determined by setting of projects
  - Urban projects with more detailed renderings of urban context vs. rural areas with less focus on surroundings.



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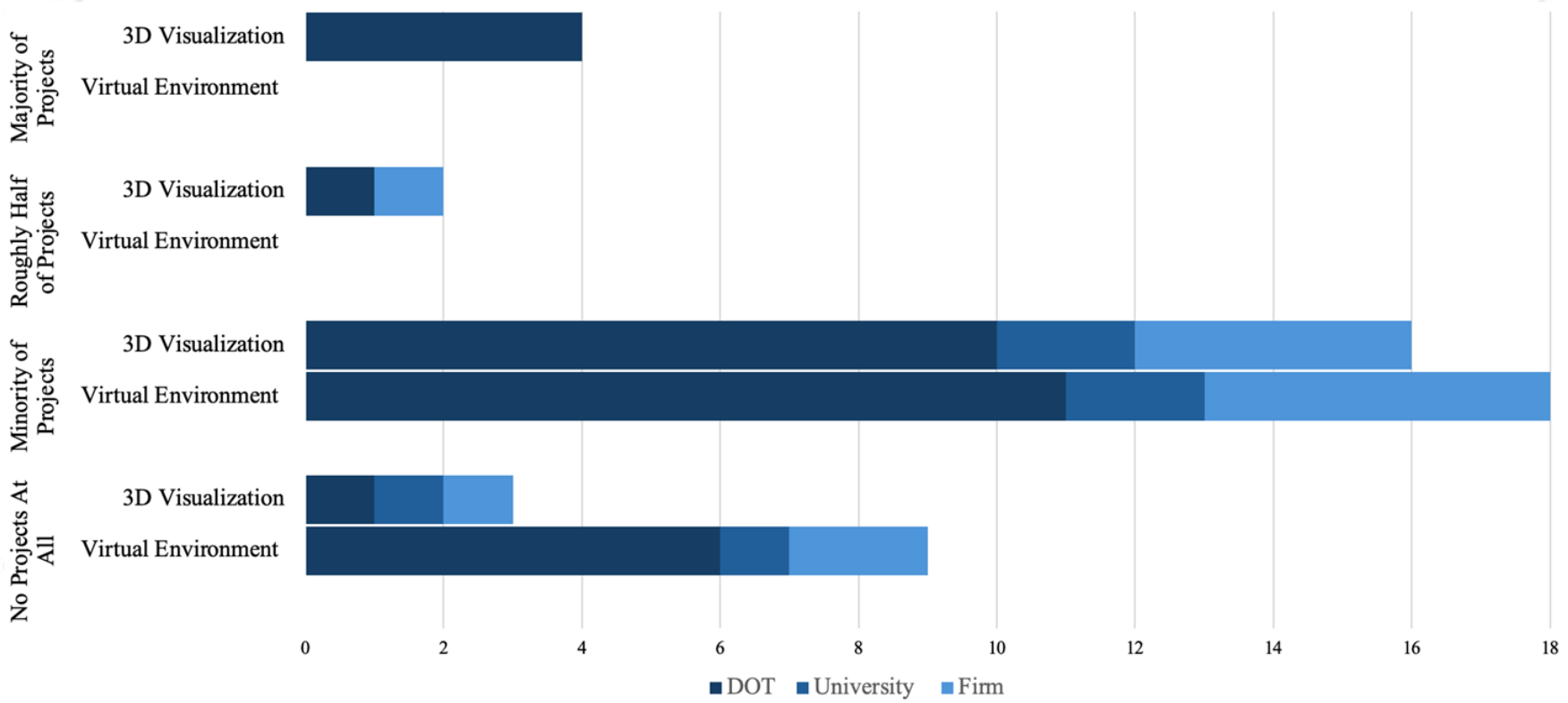
VR and 3D Visualization Adoption

- Everyone selected ‘minority of projects’ or ‘no projects at all’ used VR
- NCDOT and IDOT indicated 3D visualization was used for a majority of their projects

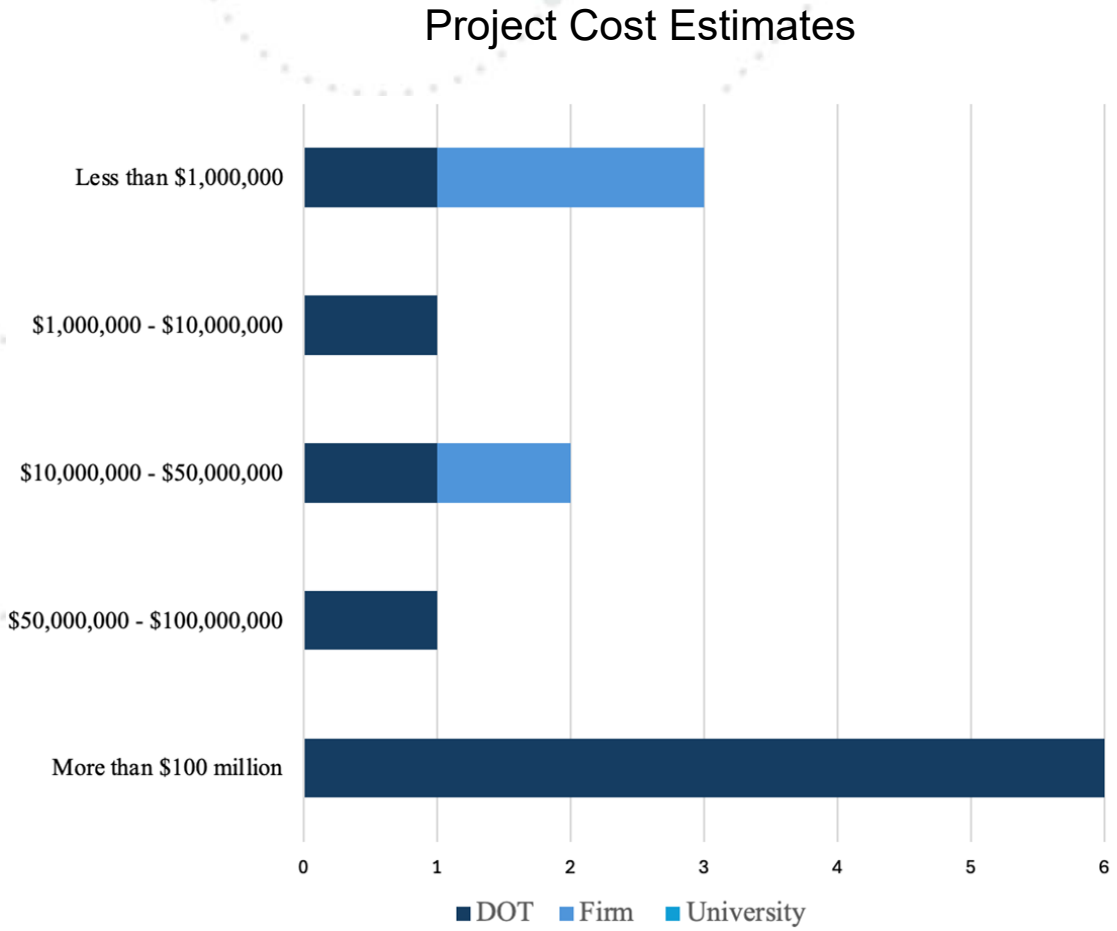


Key Factors of VR and 3D Visualization Use

Size and Complexity of Projects	*Larger and more complex projects motivate VR use*
Social and Environmental Impacts	*Greater impacts motivate VR use to address concerns*
Public Understanding and Engagement Needs	*VR helpful in enhancing engagement and alleviating opposition*
Budgeting	*Cost of VR can limit use especially for smaller projects*
Project Phase	• *Earlier phases may only require simpler visualizations while more detailed visualizations benefit projects in later phases* • *More likely to have VR or 3D visualization if modelling was part of engineering process*

Funding

- DOTs mainly used VR for higher-cost projects
- Cost of developing visualizations is relatively low and pays off by avoiding costly delays, confusion, and/or public opposition.
- Internal teams was most cost-effective
  - Hybrid approach during early adoption



Significant Public Engagement Project Examples

I-74 Mississippi River Bridge	IADOT	• Fully Interactive + Immersive VR Simulation • Drive-through and fly-through of Bridge
I-69 Ohio River Crossing	KYDOT + INDOT	• Fully Interactive + Immersive VR Simulation • VR headsets for 6 new roundabouts
Project Neon	NVDOT	• Fully Interactive and Immersive VR Simulation • Driver simulator of large corridor
I-440 Interchange Project	NCDOT	• Fully Interactive VR Simulation • Smartphone-compatible VR headset
Empathy at the Intersection	MassDOT	• Fully Interactive VR Simulation • Educational series using driver simulation
San Gregorio Creek Bridge	Caltrans	• Interactive Simulation and 3D rendering • Hotspot-based exploration with various designs

Future of Immersive Virtual Technology for Transportation

- Clear recognition of the benefits and potential of using immersive virtual technology
  - Nevada DOT + NCDOT now incorporate virtual immersive technology to some extent in all projects following successful use.

- Transforming public engagement
  - Technology evolving rapidly will make it more welcoming
  - Particularly helpful for unfamiliar infrastructure like DDIs or roundabouts.
  - A JMT employee believes it will be as 'ubiquitous as people starting to use smartphones'

- Augmented Reality has limited existing use but commonly mentioned for potential.
  - Digital overlay at proposed project sites would benefit stakeholder support.

- Potential use for environmental permitting at early stages of projects and construction inspection in later stages of project

Conclusion

- Adoption of VR and AR is still in relatively ***early stages for many organizations***
  - Overwhelming majority of VR applications was for public engagement
  - Design review and other applications were limited
  - Little consistency in software and hardware used
  - Lack of metrics to measure efficacy and value of technology use

- ***Strong potential*** for Immersive Virtual Technology to transform public engagement in transportation
  - Enhances understanding of complex projects and reduce opposition
  - Effective communication and transparency with community
  - Efficiency of project management - especially with early adoption

- Barriers
  - Cost and resource limitations (can be mitigated by bringing visualization to earlier project phases)

Interested in learning more?

- National Transportation Visualization Working Group
  - Started Summer 2025
  - Quarterly Meetings
  - https://sites.google.com/view/nationalvizgroup

- Omni-Reality and Cognition Lab
  - https://engineering.virginia.edu/labs-groups/omni-reality-cognition-lab
  - cad3ev@virginia.edu

THANK YOU

Any Questions?