

Exhibit D

Research Project Submission Template

Recipient/Grant (Contract) Number: University of Illinois Urbana-Champaign / University at Buffalo / Grant No.: 69A 355 234 8333

Infrastructure-Driven Inspections of Precast Concrete Bridge Decks using Connected Automated Vehicles (CAVs)

Center Name: Transportation Infrastructure Precast Innovation Center (TRANS-IPIC)

Research Priority: Improving the Durability and Extending the Life of Transportation Infrastructure

Principal Investigator(s): Chaozhe He

Project Partners: N/A

Research Project Funding: \$105,000 (\$70,000 Federal and \$35,000 Non-Federal)

Project Start and End Date: 01/16/2026 – 01/15/2027

Project Description:

This project aims to develop a system that performs automatic inspection of precast concrete bridge decks. The bridge deck accounts for much of the maintenance cost of the bridge, and prompt inspections are critical to identify early risk and reduce maintenance costs. Bridge deck inspections are labor-intensive, especially with recent element-level inspection requirements. We propose to leverage AI and connectivity to utilize connected automated vehicles' (CAVs) forward-facing camera and develop a robust algorithm for assessing cracking condition states (CS). With vehicle-to-everything (V2X) communication, the bridge could supply bridge properties data to facilitate cracking CS assessment and aggregate the results reported by the CAVs. With the system, we will also generate an open-source dataset that facilitates crack detection. We aim to cross-validate the system against existing manual inspection results, showcasing its performance to help bridge owners create implementable solutions. This project aligns with TRANS-IPIC's mission to optimize the precast concrete maintenance process.

US DOT Priorities:

Bridges are critical infrastructure for transportation systems. According to the National Bridge Inventory (NBI), 42% of the nearly 620,000 bridges in the United States were built more than 50 years ago, 12% of all bridges were built more than 80 years ago, exceeding their intended design life of 75 years. To prevent potential safety hazards caused by bridge deterioration, Federal regulations mandate routine inspections every 24 months to ensure safety. Manual inspections are still the predominant means of inspection. Manual inspection is a professional task that requires detailed training. Since the release of The Specification for the National Bridge Inventory (SNBI 2022), element-level inspections are added, i.e., assigning a condition state to each element in the bridge at inspection. This increases the complexity of manual inspections even further. Considerable money is spent on inspection, but also on streaming inspection and asset management. Advanced and intelligent inspection methods, including drone and ground vehicle inspections, leverage a suite of advanced, non-intrusive sensors such as high-resolution cameras, LiDAR, thermal imaging cameras, and ground-penetrating radars (GPRs) and advanced AI algorithms. While these approaches have demonstrated impressive inspection performance and significant cost savings, the subsequent task of complying with SNBI rating still needs to be determined by humans. An automated end-to-end solution that detects and assigns a condition state (CS) to damage according to SNBI will be beneficial to streamline detection. More importantly, it enables continuous inspection as a supplement to the biannual manual inspection, allowing early detection of potential hazards and promoting more efficient dispatch of manual inspections.

Considering this need, our team proposes developing an end-to-end automatic framework to assign SNBI CS to bridge damage. As a target use case, we focus on a **precast-concrete bridge deck element, and**

use connected automated vehicles as the sensor (“inspector”), leveraging computer vision techniques and connectivity to assess SNBI CS to cracking damage. The framework to be developed will serve as a pilot that is transferable to other types of damage for precast concrete infrastructure, through more suitable sensors with different techniques. It could also enable continuous inspection practices to identify early signs of severe damage between scheduled routine inspections. It aligns with the strategic goal of TRANS-IPIC on “Advance the field of building information modeling (BIM) using new technologies” and is aligned with the broader mission of USDOT in creating safe and resilient transportation systems.

Outputs:

The main research outcome would be (1) a prototype infrastructure-driven CAV-based precast concrete bridge decks SMBI CS assessment system; (2) a comprehensive dataset for crack detection. The broader outcome is a foundation for scalable, infrastructure-initiated monitoring that enhances safety, reduces maintenance costs, and extends the service life of precast decks.

Outcomes/Impacts:

This project promises a tangible and implementable precast concrete bridge decks assessment system. Infrastructure oversight agencies, such as federal and local DOT offices, are our primary users. Our intention to work closely with DOT throughout the project to evaluate progress and acquire feedback will enable the system to be developed close to its customers. With our partner from Bot.Auto based in Texas, we will also explore the possibility of testing the proposed system on their fleet and showcasing it to TXDOT. Key stakeholders of the developed system also include regulators and vendors for V2X and CAV, vehicle manufacturers, and precast infrastructure manufacturers. We will work with V2X vendor Commsignia and CAV company Bot.Auto on implementation attempts. Ultimately, this project's success will align the interests of all stakeholders. Leveraging the US DOT's Nationwide V2X technologies deployment initiative and CAV, we are well-positioned to implement the system rapidly on existing transportation infrastructure, enhancing its durability and paving the way for widespread adoption.

Final Research Report: URL link to the project's final report will be provided upon the completion of the project.