Exhibit D

Research Project Requirement Template

Surface Penetration and Imaging for Infrastructure Inspection Using Radar Sensors as UAS Payload

Recipient/Grant (Contract) Number: 69A3552348306 (CY1-OU-02)

Center Name: Southern Plains Transportation Center (SPTC)

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

Principal Investigator(s): Yan (Rockee) Zhang and Hernan Suarez, University of Oklahoma

Project Partners: University of Oklahoma

Research Project Funding: University of Oklahoma: $52,733 (Federal), $52,733 (Match)

Proposed Start and End Date: 10/1/2023 to 09/30/2024

Project Description: This project aims to improve the automatic inspection capability of infrastructure under all-weather conditions. The specific objectives include: (1) Develop and demonstrate a new low-size, weight, and power radar sensor that meets the unmanned aerial system (UAS) payload requirements and the need for surface penetration inspections; (2) Establish a formal operational procedure that can be applied to the regional and national tasks; (3) Evaluate the performance and capability of an integrated UAS system and sensing payload through data collections under different environments; and (4) Achieve dual-function (imaging and profiling) through existing signal processing and applying novel machine-learning methods. The proposed solution will bring significant benefits compared to the state of the art in the following ways: (1) Capability of inspecting underneath structure anomalies and problems; (2) Capability of penetrating the surface coverage such as dirt, rain, snow, or ice for examination of structure below; (3) Capability of operation near or within adverse weather and climatic conditions, where the infrastructures are mostly in danger; and (4) Either using radar alone or in combination with cameras, the proposed sensor package would provide a reliable solution for surface structure inspection and potentially sub-surface non-destructive testing and examination from a standoff distance, under all-weather conditions, such as snow and dust coverage.

An innovative engineering approach based on the existing wideband, lightweight radar technology is proposed. The proposed system and its design will be capable of conducting infrastructure inspections remotely in a challenging environment. This research will be conducted through four tasks. Task 1 involves a detailed requirement analysis. In this task, the research team will work with the project stakeholders and consult with the related engineering standards to perform a detailed requirement analysis. The outcome will be confirmed requirement documents about sensor performance, frequency range, size, weight and power, and imaging capability. Task 2 involves sensor system designs and lab verifications. The research team will perform a detailed engineering design based on existing prototypes, determine the tradeoffs based on the state-of-the-art components and cost targets, and evaluate an option based on a software-defined radio (SDR). Task 3 involves modeling and simulation. The research team will evaluate radar signal penetration and propagation models for different types of bridges, roads, and construction materials. The model will further refine the radar sensor configuration design and tuning. Task 4 includes initial UAS payload design and verification, including mechanical and electrical designs based on the IF1200A UAS and its payload requirements for the radar design. The outcome will be

mechanical drawings and further details on how the radar sensors would be installed into the UAS and any further improvements needed based on the initial payload designs.

US DOT Priorities: The proposed research results will address the impact of weather extremes on bridges and contribute to innovative monitoring to quantify damage accumulation. These results will address the USDOT strategic goals of Climate and Sustainability and Economic Strength and Global Competitiveness by contributing to High-Performing Core Assets. The project includes a focus on Diversity Equity and Inclusion through the involvement of key personnel, Dr Suarez, from a minority Hispanic ethnicity, involving undergraduate students from minority and underrepresented groups, direct collaboration with the Choctaw Nation's UAS test range and the Tribal government through joint participation in events and flight test activities with the State of Oklahoma. This project can help underserved communities in rural Oklahoma through the assessment of infrastructure conditions.

Outputs: The outputs include a reliable solution for surface structure inspection and potentially sub-surface testing in a non-destructive manner. Remote assessment of infrastructure conditions under all-weather conditions, such as snow and dust coverage, enhances safety. Several innovations are expected from this project. Firstly, the project will produce a new radar sensor payload hardware design and associated software that DOT can use immediately in field operations. Secondly, it will generate an important sensor database for analyzing and detecting structural faults from lab emulations or field tests. The results will be published in conference and journal papers and filed as an invention disclosure, which will be a basis for collaboration with an industry partner (for example, Essential Aero, which is dedicated to the UAS infrastructure inspection business) on technology transfer.

Outcomes/Impacts: Unmanned, automated, and airborne sensor deployment will reduce ground transportation inspection crews' workload, time, cost, and safety risks. Using automatic drone-based inspections also provides support to rural roads and remote locations. The system will enable the inspection of critical structure areas that the current ground penetrating radar or other sensors cannot reach or operate due to weather conditions. The sensor payload would be scalable to fit in platforms from small UAS to large UAS with a more extended range. Images with different resolutions (cm to m) for various penetration depths (surface structure to meters) can contribute significantly to overall surface transportation maintenance. This project will also promote a new technology and practice that boosts the performance and capability of air vehicles under challenging weather conditions. The proposed application can be extended to non-destructive testing of runway and airport pavements, weather-related damage surveys, and analysis of weather/climate impacts. The proposed technology will provide real-time information for transportation information fusion centers.

Final Research Report: