## 1.INTRODUCTION

TPF-5(504) member agencies invite qualified and experienced teams or organizations to submit proposals for the development of analysis methods and/or software tools aimed at automating the detection of pavement subsurface defects, with a primary focus on stripping in bituminous and composite pavements, utilizing 3D-GPR (Three-Dimensional Ground-Penetrating Radar) data. The developed analysis methods and/or software tools are expected to be used by the member states and their partners for the enhancement of pavement scoping, maintenance, and management by accurately identifying, mapping, and quantifying critical subsurface issues. The initiative is one of the task activities (Task 5) of the pool fund study.

The organization recognizes that starting a GPR data analysis process from scratch may be unnecessary and resource intensive. Therefore, TPF-5(504) encourages interested teams to leverage existing analysis methods and software tools developed in the past, including algorithms developed in a previous study sponsored by AASHTO and FHWA (R06D). The data collection of GPR and the supporting data will be provided at no cost to the team. Furthermore, TPF-5(504) members and friends are committed to collaborating closely with the selected team and will actively share knowledge and the needs of users in the member states. This collaborative effort is expected to enhance the productivity of the project.

## 2. DATA SOURCE

**2.1 Primary data source:** The primary data source for this project will be 3DGPR data collected by the TPF-5 (504) and the member states using air-launched and/or ground coupled 3DGPR step-frequency antenna array units manufactured by Kontur. The data will be collected in actual roads identified by the pool fund study and in test sections built to mimic asphalt stripping conditions at Minnesota Road Research Facility (MnROAD). The 3DGPR data generated by the Kontur unit is collected and stored in a frequency domain in 3dra file format. The selected team will receive access to this data under a mutually agreed-upon data-sharing agreement. As of now, no other 3DGPR antennas are intended to be included in the project. However, flexibility for future data integration from different sources is desirable. Prospective teams must specify whether the proposed analysis tool can directly process the native files obtained from the 3DGPR units (i.e., 3dra) or if it necessitates basic filtering and conversion to the time domain using other platforms such as Kontur's licensed software (Examine). In cases where the required data has not been collected, TPF-5(504) welcomes recommendations from the selected team regarding data collection procedures and parameters. The team may propose suitable methodologies, equipment specifications, and data acquisition strategies to ensure the acquisition of high-quality 3DGPR data for effective software development and validation. However, if the data has already been collected or if TPF-5(504) has initiated data collection based on its current understanding of the 3D-GPR system and pavement issues, the team should still be prepared to work with the available data.

**2.2 Supplementary data source**: In addition to the primary 3DGPR data, TPF-5(504) will provide limited spot and continuous testing data collected including coring, Falling Weight Deflectometer (FWD), Traffic Speed Deflection Device (TSDD), and Impact Echo/Seismic Analysis of Surface Waves (IE/SASW) data, will be made available to the selected team. These datasets will serve to validate the results obtained from the analysis methods and software tools.

## 3. GENERAL REQUIREMENTS

**3.1 Format of the developed analysis methods and software tools**: The selected team is required to clearly describe the format of the developed analysis method and software tool. Please specify whether it will be embedded in existing commercially available 3DGPR software or if it will be a stand-alone application.

Stand-Alone Application: If the analysis method and software tool is intended to be a stand-alone application, please address the following:

1. Specify whether the stand-alone application will include other basic 3D-GPR filtering and analysis algorithms, such as automated or semi-automated layer interface detection that are offered in existing software applications and are indispensable for pavement evaluation.
2. Describe if the stand-alone application will offer functionalities for mapping 3DGPR data on geographical maps or other visual representations.
3. Explain if the software tool will feature a user-friendly interface. Please indicate the programming language and technology stack that will be used for the user interface.
4. Provide details on how the stand-alone application will be used, maintained, and updated by the TPF-5 (504) member agencies and partners.

Embedded in existing 3DGPR Software: If the analysis tool will be embedded in existing commercially available 3DGPR software, outline how this integration will be achieved and specify the software platform(s) that will support the tool.

Usage of the Developed Tools Regardless of the software delivery method (stand-alone or embedded), the selected team should indicate how the TPF-5(504) members and their partners will use the developed tools. Please discuss any plans for deploying the pavement subsurface defect detection and analysis methods and software tools.

**3.2 Approaches and methodologies:** The selected team is expected to include a comprehensive discussion on the approaches considered in the development of the algorithm for the detection and quantification of pavement defects. This discussion should explain the methodologies and techniques contemplated during the algorithm's design phase. Specifically, the team should discuss whether they are considering, but not limited to, the following approaches:

1. Traditional Signal Analysis: Describe if traditional signal analysis techniques are being employed in the algorithm development process, and if so, provide insights into how they are utilized.
2. Numerical Simulations: Explain whether numerical simulations are part of the algorithm development process, including details on their role and significance.
3. Artificial Intelligence (AI) and/or Deep Learning Techniques: if these techniques are considered, discuss the integration of these techniques and their potential impact on the algorithm's effectiveness.
4. Algorithms and concept developed in the past: outline how you plan to utilize these existing resources.
5. Other Approaches: Highlight any additional approaches or innovative methods that the team is exploring in the pursuit of robust and accurate pavement defect detection and quantification. For example, the team should consider utilizing TSD or FWD data to aid or validate the GPR based analyses

The discussion on these approaches should provide TPF-5 (504) with a clear understanding of the research and development strategies, helping to evaluate the suitability and feasibility of the proposed algorithm.

**3.3 Integration of data sources:** It is expected that the software developed shall incorporate features for integration and linking of coring, FWD, TSDD, and IE/SASW data with the 3DGPR analysis. This integration will facilitate a comprehensive understanding of pavement conditions, contributing to more accurate detection, assessment, and quantification of stripping issues.

**3.4 Training, verification, and validation:** The selected team shall collaborate closely with TPF-5 (504) to train, verify, and validate the analysis tools. These efforts will be conducted using data collected from the MnROAD test sections and roads in states participating in the pool fund study.

1. The MnROAD test sections are designed and constructed to replicate various asphalt stripping conditions in full depth asphaltic concrete (AC) and AC overlaid Portland Cement (PC) concrete pavements.
2. Roads in participating states GA, IL, MN, MO, MS,TN, TX, FL. Currently, seven states are participating in the pool fund study, and each state has identified two roads known to exhibit stripping conditions. If other states are added to the pool fund study before the beginning of the proposed project, TPT-5 (504) will work with the select team to ensure the new data is included in the analysis. Collaborating with different regions will enable the exploration of diverse stripping mechanisms and levels of stripping. This geographic diversity will enrich the validation process, ensuring the robustness and applicability of the analysis tools across various real-world scenarios.

**3.5 Reporting functionalities:** The developed software is expected to include comprehensive reporting functions that facilitate the analysis and presentation of pavement subsurface defects. These reporting functions should encompass but are not limited to the following features:

1. Heatmaps that provide a quick and intuitive way to identify areas with a higher concentration of defects.
2. Geographic Maps allowing users to correlate pavement conditions with other geographic information.
3. Users should have the capability to analyze and visualize data from the 3DGPR, coring, FWD, TSDD, IE/SASW sources concurrently.
4. Database with Coordinates: The software should maintain a database of detected defects, each associated with precise geographical coordinates.
5. Quantitative measure of stripping defect Level

**4. EXPECTED DELIVERABLES**

The selected team is expected to provide the following deliverables:

**4.1 Developed analysis methods and software tools**: A fully functional digital tool capable of automated detection and quantification of pavement subsurface defects, with a primary focus on stripping in bituminous and composite pavements using 3DGPR data.

**4.2 Reports**: Detailed reports summarizing the development process, algorithmic approaches, validation results, and any recommendations for usage.

**4.3 Manuals**: A comprehensive documentation accompanying the developed analysis methods and software tools. This documentation should include user guides, technical specifications, and necessary training materials to facilitate the efficient use of the analysis tools by the TPF5 (504).

**4.4 Training Materials**: Training materials for TPF-5(504) personnel to effectively use the analysis methods software tools for pavement defect detection and analysis.

**5. COST ESTIMATES**

The pool fund study has set aside a maximum of $150,000 for the team that successfully fulfills the objectives outlined in this RFP. Additionally, the study will finance the expenses associated with constructing artificially stripped section in MnROAD, along with data collection. Additional data collection, if needed, will be arranged. The pool fund study members will collaborate closely with the selected team and validate the project's outcomes at no cost to the team.

The proposals should include a detailed cost estimate outlining the budget required for the entire project. Please provide a comprehensive breakdown of costs, including a justification for each expense category. and proposed milestones for payment schedule.

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