Impactful Resilient Infrastructure Science and Engineering (IRISE)
-Project Scope of Work-
(FY 2024-25 (IRISE Year 7) Annual Work Program)

SUMMARY PAGE

Project Title: AI Safety Assistant

Person Submitting Proposal: Dr. Lev Khazanovich

Proposed Funding Period: January 1, 2025 - June 30, 2026

Project Duration: 18 months

Project Cost: $126,401.00

Project Title: *AI Safety Assistant*

Problem Statement:

The highway construction industry has made noteworthy advancements in embracing modern technologies to enhance productivity and ensure worker safety. However, it continues to grapple with the ongoing issue of being a prominent contributor to workplace accidents. The unique risks associated with highway maintenance and construction are exacerbated by a perceived lack of directly applicable safety standards, regulations, and programs when compared to the broader construction industry. While established safety practices, such as actively communicating potential hazards during daily work activities, conducting inspections, and analyzing historical incident databases, have demonstrated effectiveness in accident prevention and facilitating swift interventions, there remains considerable potential for further improvement and innovation in their implementation.

The chaotic and dynamic nature of construction, coupled with the multitude of niche activities that occur, increases the risk for personnel in the work zone. Without clear communication and detailed insights, it is challenging to proactively mitigate these potential risks. Many safety management teams have implemented a form of daily huddles between safety officers and laborers. These huddles serve as an interactive platform where all parties involved come together to discuss the day's work plans and their associated hazards. Such huddles enable safety officers to gather firsthand information from field personnel about accidents and near-miss incidents, as well as to provide insight into activities that pose specific risks. However, the information transmitted by safety officers to the field may be limited to their understanding of certain site-specific construction activities and their associated risks, which could be potentially overlooked. This is particularly true for newly contracted, inexperienced workers.

The existing method for reporting incidents relies on field personnel manually crafting textual narratives for critical events, offering valuable insights into the causes of specific accidents and aiding in subsequent analysis and the distribution of vital information. Nevertheless, the quality of these narratives may exhibit considerable variation based on factors such as the personnel's expertise, the level of detail provided, and the consistency of the reporting process. Enhancing the quality of accident and near-miss reports would contribute to a more comprehensive understanding of potential risks, enabling timely adjustments to work processes and the implementation of necessary safety precautions.

Despite the highway industry's exploration of innovative technologies, the utilization of artificial intelligence (AI) in safety management has been constrained. Nevertheless, recent progress in cutting-edge natural language processing (NLP) methodologies, particularly the use of advanced large language models (LLMs), has demonstrated a growing capacity to handle tasks involving extensive textual data. This becomes particularly relevant to the construction sector where NLP approaches can streamline inspection practices, extract pertinent information from unstructured data, and classify textual data (such as project requirement sentences). Leveraging these transformative technologies offers distinct advantages for safety-related tasks within construction, notably in addressing discrepancies in the quality of incident narratives.

Project Objectives:

This project will develop an AI/LLM tool to aid safety personnel in the highway construction industry. The tool will focus on two primary tasks: firstly, it will assist in procuring daily work activity plans with a safety focus, aiding safety management in communicating specific hazards associated with various

activities and inspection practices. Secondly, as an auxiliary feature, the tool will serve as a data entry tool to improve the quality of accident reporting, filling any knowledge gaps that new employees might have, and enhancing future analysis and safety data dissemination. By incorporating innovative NLP techniques, this tool can help ensure more accurate and comprehensive incident reports, overcoming the limitations of manually curated narratives.

The main deliverable of this innovative approach is a prototype of a user-friendly chat-like software interface, the AI Safety Officer Assistant. The software will guide safety personnel in curating daily work plans, inspection checklists, and populating incident reports by gathering inferences and providing follow-up clarification questions. This guidance will ensure the creation of high-quality safety reports, highlighting activity-specific details that might otherwise be overlooked. Integrating AI-powered tools with daily huddles between safety officers and laborers can further improve incident reporting and risk assessment processes, enabling proactive safety measures.

Project Scope:

The proposed investigative approach for this research project seeks to methodically develop, validate, and demonstrate the efficacy of the AI Safety Officer Assistant in improving safety management practices within the highway construction industry. The research will be conducted through the following tasks.

Proposed Work:

The objectives of this project will be realized through the completion of the following tasks:

Task A – Concept Design/Inception and Specification Development

In this task, the research team will engage in comprehensive consultations with stakeholders to discern both functional and non-functional requirements for the assistant. The team will also investigate prevailing methodologies for accident reporting and safety training, drawing insights from practices employed by contractors, PennDOT, and other entities in the highway construction sector. The objective is to ascertain the tool's capabilities and define the specific issues it should address within highway construction safety. This process is designed to ensure a smooth integration into existing workflows and optimize the performance of safety-related tasks.

Task B –AI Assistant Prototype Development

During this phase, the research team will concentrate on the initial development and testing of the AI Safety Officer Assistant, integrating generative AI into highway construction safety workflows. This involves several crucial steps:

- Selecting a suitable Language Model (LLM) that can be fine-tuned to effectively address the safety needs of the highway construction industry.
- Designing natural language processing algorithms for the AI Safety Officer Assistant.
- Conducting in-house testing by the research team, including prompt engineering.

The development process will involve:

- Developing and refining algorithms to enable the AI Safety Officer Assistant to procure incident reports, generate safety insights, and provide hazard communication recommendations.

- Creating an architecture that prioritizes high-priority requirements, considers both functional and non-functional aspects, and ensures alignment with the objectives and user experience established in the previous phase.
  Additionally, the team will focus on:
- Designing specialized prompts that guide the assistant's responses toward the safety domain.
- Developing prompts that elicit clarifications or explanations from the assistant in cases of uncertain responses.

Task C – In-House Testing

This task will involve the following activities:

- Evaluation of Natural Language Processing (NLP) Algorithms: We will conduct a detailed evaluation of the accuracy and effectiveness of the natural language processing algorithms used by the AI assistant. This will include assessing the AI's ability to understand and interpret complex construction safety terminology and jargon. Continuous improvements will be made based on the evaluation results to enhance the NLP algorithms' precision and reliability.
- Development of Comprehensive Test Cases, Test Suites, and Scenarios: We will create a collection of test cases, test suites, and scenarios to evaluate the tool's functionality. This development process will incorporate detailed feedback from safety officers affiliated with various partners, including the Department of Transportation (DOT), contractors, and relevant associations. We will ensure that the test cases reflect real-world construction site conditions and challenges, facilitating a realistic assessment of the AI assistant's capabilities.
- Implementation and Execution of Test Suites: The developed test suites will be systematically implemented to identify any gaps and areas for improvement in the tool's performance. This step will involve rigorous testing under controlled conditions, simulating various construction site environments and safety scenarios. We will evaluate the AI assistant's responses and actions to ensure they align with industry standards and best practices. Feedback from these tests will be used to iteratively refine and enhance the AI assistant's performance.
- Assessment of Safety Insights and Hazard Communication: The assistant's capability to offer pertinent safety insights and hazard communication recommendations will be thoroughly assessed. We will examine the relevance and timeliness of the safety recommendations provided by the AI assistant in various construction scenarios. The assessment will include the AI's ability to identify potential hazards and suggest preventive measures effectively.
- Incorporation of Partner Feedback and Continuous Improvement: Throughout the testing process, continuous feedback will be gathered from all participating partners to ensure the AI assistant meets their specific needs and expectations. We will establish a feedback loop to incorporate insights and suggestions from safety officers, ensuring the tool evolves and adapts to emerging safety standards and practices. Regular updates and improvements will be made to the AI assistant based on the feedback and testing outcomes to enhance its overall effectiveness and reliability.

Task D: Field Deployment and Evaluation

In this phase, the research team will execute field deployment and conduct a real-world evaluation of the AI Safety Officer Assistant. The tool's functionality will undergo iterative implementation and refinement, aligning with specified requirements and the designed user experience (UX). The following activities will be carried out:

- Deploying the AI Safety Officers to the field on selected projects, including the training of safety officers in operating the tool for safety training and accident reporting.
- Iteratively refining the AI assistant based on feedback received from early users and experts, addressing concerns, and incorporating valuable suggestions.
- Optimizing the architecture and deployment setup of the Language Model (LLM) to ensure rapid and efficient inference.
- Documenting the newly implemented functionalities and UX enhancements, providing clear and accessible documentation.
- Developing training materials, resources, or sessions to ensure that safety specialists can effectively utilize the AI Safety Officer Assistant

Task E: Draft Compile a final report summarizing the research findings.

Results and observations from all previous tasks will be compiled in a final report summarizing the process of developing the AI Safety Assistant and the results of its evaluation. In addition, the User Guide and recommendations for the best use of the tool, as well as suggestions for future improvements, will be provided.

Task F: Final report

A Final Report taking into consideration comments that were received on the Draft Final Report will be prepared and electronically submitted to the technical panel for the final approval.

Deliverables:

- *Deliverable #1* – Task A: A memo report summarizing AI assistant's functional requirements (specific tasks the assistant must perform) and non-functional requirements (performance criteria such as reliability, usability, scalability)., due 5 months from the Notice to Proceed date.
- *Deliverable #2* – Task B: A memo report detailing the results of the AI Assistant development. due 12 months from the Notice to Proceed date.
- *Deliverable #3* – Task C: A memo report detailing the AI Assistant testing, due 14 months from the Notice to Proceed date.
- *Deliverable #4* – Task D: A memo report documenting the results of the AI Assistant field deployment and evaluation, due 17 months from the Notice to Proceed date.
- *Deliverable #5* – Task E: A draft final report, due 17 months from the Notice to Proceed date.
- *Deliverable #6* – Task F: Final report, due 18 months from the Notice to Proceed date.

In addition to the deliverables listed above, it is also anticipated that the findings of this research will be published and presented at key technical conferences and in journal publications with a prior approval from the Technical Panel.

Key Personnel:

Principal Investigator: Dr. Lev Khazanovich is to provide the technical expertise, project management, and oversight on all project activities.

Schedule:

	2025				2026					
	Q1	Q2	Q3	Q4	Q1			Q2		
Task A. Task A – Concept Design and Specification Development										
Task B. AI Assistant Prototype Development										
Task C. In-House Testing										
Task D. Field Deployment and Evaluation										
Task E. Prepare draft final report										
Task F. Prepare final report										

Proposed Person-Hours by Task:

Project Role	Name	Task A	Task B	Task C	Task D	Task E	Task F	Total
PI	Lev Khazanovich	24	60	48	40	40	20	262
Grad Student 1	TBN	240	460	240	300	120	40	1508
Hourly Student 1	TBN	10	50	100	100	20	10	290

Budget: The total project cost is $126,401.00.

Acknowledged By:

Lev Khazanovich

Dr. Lev Khazanovich
Principal Investigator