APPENDIX A:
U.S. DOT SBIR Proposed Fiscal Year 2026
Phase I Research Topics

Contents

Federal Highway Administration (FHWA)

About Us: FHWA's Research, Development, and Technology (RD&T) Program identifies and addresses issues of national significance that other research sponsors cannot or will not address, including areas that require higher complexity, higher risk, longer term research, or specific Federal responsibility. The FHWA RD&T program's activities produce a clear public benefit, support Federal stewardship roles, meet and address current and emerging needs and challenges, and ensure the coordination of highway RD&T activities.

FHWA's RD&T program supports research and development to improve safety; the mobility of people and goods; stimulate growth, productiveness, and competitiveness; reduce congestion; improve durability and extend the life of transportation infrastructure; accelerate project delivery; and provide an approach that serves all road users.

26-FH1: Edge AI-V2X Integrated Practical Solutions for Congestion Prevention and Mitigation

Topic Description

Traffic congestion can be induced by weather, traffic incidents, work zones, planned special events, and other events, and affect traffic efficiency in varying temporal and spatial ranges. While most individual congestion may be local in terms of the scope of their impact, collectively they can significantly impact mobility, safety and economic activity in the United States. Recent advances in artificial intelligence (AI) and communications (such as V2X (Vehicle-to-Everything), fiber, and satellite) make it feasible to combine edge and cloud computing to enable real-time, adaptive and timely localized traffic operations. It can also aid in preventing or mitigating congestion, such as advising lane positioning at ramps, work zones, weaving zones, and detour for lane closures.

For example, AI systems can be engineered to deliver real-time detour recommendations in areas with large sporting events to prevent or reduce traffic congestion or to advise optimal driving maneuvers, such as lane changes, based on each vehicle's position and trip plan. These systems can also be designed to receive traffic signal timing and phasing information and share it as approach-specific travel guidance in the form of a countdown timer. It can also produce speed guidance for individual drivers depending on their positions on respective approaches to the intersection. Together, these outcomes can help to optimize overall traffic flow in a wide area to prevent and mitigate traffic queues.

Although many emerging products and services leverage edge computing for traffic management, most primarily focus on in-vehicle or single intersection edge computing rather than a cloud-server edge computing solution. With cloud-edge computing, the computing power, learning capabilities, and decision-making functions are dedicated to processing diverse traffic data collected within a defined geographic area (such as, a one-mile by one-mile zone; or adaptively scoped by impact zone), with the total region defined as an entire city or even larger geographic area. The technical

approach envisioned for this SBIR topic aligns with this latter category, which is cloud-edge computing.

This SBIR topic seeks to develop an AI system to enhance traffic operations by predicting and detecting real-time congestion in a local or regional area, encompassing multiple intersections and roadways. The system will evaluate the situation and deliver effective operational guidance to target recipients and preemptively prevent or mitigate congestion within the impacted zone, thereby curbing its spread to surrounding areas. It can also, suggest better traffic operation strategies, to a Transportation Management Center (TMC), and function as a complementary component to enhance existing traffic congestion management. Developing these systems requires real-time processing of diverse local traffic data, swift generation of operational responses, and secure delivery of the location-specific advisories to relevant recipients within the impacted area. This requires advanced parallel data processing and decision-making capabilities, efficient system architectural designs that integrate edge, AI, and V2X technologies, to efficiently partition the data ingestion, parallel computing and decision-making workloads, and establish reliable and secure communication channels. To our knowledge, such integrated solutions are not yet available.

To enable such operational innovations, uncertainties and challenges remain regarding:

1. How to quickly predict/detect congestion, dynamically define the impact zone, and then generate efficient location-specific operation guidance to direct traffic or individual vehicles' trips accordingly;
2. How to partition detection, prediction, and decision workloads of the AI system between edge and cloud components;
3. How to efficiently communicate the computing results among edge, cloud, and other local infrastructure;
4. How to reliably and securely deliver location-specific operational advisories to intended recipients within an impacted zone while under low levels of connected-vehicle penetration; and
5. If multiple local-AI agents are involved, how to seamlessly coordinate between them to achieve network-wide benefits.

Key innovations include:

1. Developing an integrative system assembling cloud-edge computing and AI with V2X and other secure communication technologies for real-time location specific traffic congestion mitigation;
2. Demonstrating the product through use cases covering specific temporal-spatial coverages, with estimates in range of communication delays and security risks, and then selecting the best practices of the integration; and
3. Scaling up the application and deployment of edge computing, AI and V2X technologies to network-wide applications in live traffic environment.

The project will develop an innovative system that integrates sensing (e.g., legacy fixed point vehicle detectors and moving connected vehicle data sources), AI, edge and cloud computing, and diverse communication technologies to deliver the following functionalities:

1. Processing real-time traffic data, swiftly ingesting available traffic data and analyzing data to predict or detect congestion within an impact zone, with its scope determined based on specific use cases.
2. Providing optimal operational recommendations to prevent or mitigate congestion within a local impact area (covering multiple intersections and roads prone to recurrent or nonrecurrent traffic congestion), thereby curbing its spread. These recommendations include location-specific advisories, such as general guidance (e.g., detour, merge, continue), precise suggestions (e.g., lane changes, speed adjustments), or traffic control information from roadside infrastructure (e.g., signal phasing countdown timers) relative to the impact area.
3. Delivering human-centric advisories, designed and evaluated through human factors testing to ensure usability and effectiveness.
4. Transmitting secure, location-specific advisories to intended recipients via V2X and other trusted communication technologies, ensuring reliable and targeted delivery.

The workload of the system shall explicitly distinguish between:

- Latency-sensitive tasks (e.g., real-time congestion detection, localized trajectory prediction, immediate advisories speed, lane assignment, detour) to be executed at the edge.
- Data-heavy but non-real-time tasks (e.g., long-horizon prediction, model training, network-wide analysis) to be managed in the cloud.

The system's workload partition and communication technology selection will be designed with privacy, regulatory compliance, resilience to connectivity disruptions, and AI model lifecycle requirements in mind. The integrative system assembling edge, AI, and V2X will complement existing critical infrastructure by leveraging input data from these systems without interference, serving as a complementary solution to existing traffic control infrastructure to mitigate real-time traffic congestion in impacted zones—such as areas near traffic incidents or football stadiums—where traffic advisories are often absent. This approach minimizes direct security risks to existing critical infrastructure.

Proposers are encouraged, but not restricted, to utilize data from legacy sensing sources on accessible networks. They may also incorporate data from emerging technologies or third-party traffic data feeds. For the Phase I proof-of-concept, archived historical data from a selected citywide network can be used to develop and test algorithms and system architecture, provided the system is designed to transition seamlessly to real-time data feeds in Phase II.

Proposers are also encouraged to leverage existing infrastructure such as roadside sensing, roadside units (RSU), cloud computing, and ready-to-implement secure V2X and other communication technologies to avoid major extra infrastructure requirements. Collaboration with state or local agencies is encouraged to support implementation and data integration.

Proposers are encouraged to make the product function for operation recommended recipients with diverse V2X and other current secure communication capacities, such as mobile users, transit and truck fleets, roadside units, adapting to low connected vehicle penetration scenarios.

Desired Outcomes

Phase I

Phase I shall deliver a proof-of-concept system consisting of AI, edge unit, cloud sever and V2X communication technologies that works on archived or live traffic data and proves that the system can detect local congestion and issue location-specific advisories that would contain the spatial growth of congestion. The proof-of-concept system can be developed using archived or live traffic data and validated within a hardware-in-the-loop testbed.

The product shall include human-centric design to convey the same advisory information in different ways and use a human factor experimental design approach to assess their effectiveness and user comprehension.

Hardware-in-the-loop simulation testing should demonstrate the feasibility of the architecture, critical components, and evaluate the benefits in traffic congestion mitigation under different scenarios. Archived historic data sources, readily substitutable by real-time data feeds, can be used for the test. Specifically, the test shall demonstrate the capability of the system to predict/detect real-time traffic congestion, develop mitigation operations to advise traffic (e.g., detour, merge, continue) tailored to a vehicle's location within the impact zone, and securely deliver the location-specific and human-centric advisories to the intended recipients. The test shall also compare the conditions without a travel advisory to those in which a certain percentage of drivers receive, accept, and follow the travel advisory. This analysis will help quantify the potential system-wide benefits of the proposed advisory messaging approach.

The Phase I final report shall explain the Edge-AI-V2X system prototype in the following aspects:

- Data sources used in Phase I and how the data can be transitioned to live data inputs in Phase II;
- The known, ready-to-implement secure V2X communication (such as C-V2X (5G/4G/LTE), Satellite, etc.) or other communication technologies that may be integrated into the system;
- AI algorithms for processing data, identifying congestion, and approaches used in formulating congestion mitigation strategies;
- The system's architecture design for integrating edge, AI, V2X and other communication, such as workloads distribution and data transfer between edge and cloud platforms and the receiving terminals;
- Hardware-in-the-loop test design and initial simulation results for the technical feasibility of the proposed Edge-AI-V2X system prototype, building upon that framework; and
- Possible candidate regions and potential state/local agencies for field testing the prototype in Phase II and how success of the product will benefit the intended customer(s).

Phase II

The Phase II product is a system integration and implementation of the architecture design acting on live traffic data deployed in region(s) of selected partnering state/local agencies. It will:

- Have at least one state or local agency committed to provide access to their live traffic data for testing the product's performance and scalability and enable the research team and the Government to assess the system's computing and communication latencies, data accuracy, and security risks.
- Further refine the system's architecture design by incorporating feedback from a technical advisory panel, including the AI algorithm, schemes for partitioning the computing loads between edge and cloud, and effective utilization of V2X and other communication technologies.
- Enhance the advisory messaging designs by conducting more human factor tests to improve the user comprehension and regulatory compliance.
- Accumulate knowledge of local traffic congestion patterns, incorporate well-trained edge and cloud AI algorithms to produce real-time congestion mitigation advisories, and securely deliver location-specific advisories via V2X to various receiving terminals (intended recipients, such as cell phones, tablets, roadside units, TMCs and L2 and above vehicles) located in different positions impacted by the detected traffic congestion event.
- Provide a cost-benefit analysis for subscribing to required live traffic data feeds, service-related operating costs and potential revenue streams to sustain the operation of the system, as well as the benefits to road users and traffic operators.

References

- NCHRP Research Report 10180 Using Cooperative Automated Transportation Data for Freeway Operational Strategies

Examples of previously funded work to better understand interest and avoid duplication of effort include:

- An Artificial Intelligence (AI) Based System for Advanced Freeway Data Collection and Analysis, Intelligent Automation, Inc.
- A Wireless Sensor Network with Accurate Time Synchronization and Wide Area Coverage for Traffic Signal Timing Analysis, Intelligent Automation, Inc.
- Simulating Signal Phase and Timing with an Intersection Collision Avoidance Traffic Model, Harmonia Holding Group, LLC
- Edge Server-Based AI Application for Dilemma Zone and Traffic Conflict Events Detection, Aiwaysion Inc.
- Delivering In-Vehicle Messages in Temporary Work Zones, Savari Inc.

26-FH2: Automated Mobile Catch-basin Inspection System

Topic Description

Currently, there is a trend among state and federal regulatory agencies to require that state DOTs perform frequent or regular catch-basin inspections as part of their Nonpoint Discharge Elimination System (NPDES) permits. This is a time-consuming process that includes pulling onto the side of the road, removing the cover grate, and measuring water, sediment, and trash levels. Inspections also are needed to detect catch-basin conditions because failure or clogging can lead to stormwater ponding on the pavement, which can cause hydroplaning accidents and loss of visibility from vehicle splash. Meeting inspection requirements is difficult for state DOTs because they commonly own tens of thousands of catch basins dispersed widely across sprawling road networks. Additionally, the roadside environment can be hazardous with hundreds of fatalities and thousands of injuries every year. Therefore, development of a vehicle with a crash attenuator that carries a multi-sensor boom to collect data by multiple sensors (such as optical, lidar, radar, thermal, and/or radiation) as the vehicle travels past catch basins at slow to moderate speeds could provide preliminary inspections at low cost with little danger. The data collected could be used to help train an artificial intelligence (AI) system that would do image and data processing to infer conditions within each catch basin. The system would need testing and calibration to ensure that meaningful measurements could be collected by a vehicle while on-the move, without removing the cover grate, and that the measurements taken could be reliably interpreted by an AI system to help focus the efforts of inspection and clean-out teams on the subset of catch basins that require near-term maintenance. This research would improve environmental decision-making and improve highway operations.

Desired Outcomes

<u>Phase I</u>

At the conclusion of Phase I, a final report will be developed to summarize efforts in the development of the sensor array and data processing system. Phase I will culminate with a working scale prototype of the sensor array, examples of image and data processing results, and preliminary design details for a full-scale device. In addition, Phase I will be used to identify potential partnerships with testing/research organizations that can provide independent, third-party evaluations of the full-scale device. Interest from potential manufacturing or deployment partners for moving from product to commercialization may also be explored. By the conclusion of Phase I, the developers will have a path towards a clear commercialization plan for Phase II.

<u>Phase II</u>

Phase II will include the development of a full-scale prototype with road testing and evaluation in a controlled road-side setting, preferably with a state or local agency. The research and testing will determine effectiveness of the sensor array and data interpretation system using results of manual catch-basin inspections. Findings from testing would be used to ensure that results from mobile automated inspections would meet the needs of state DOTs and the requirements of regulatory agencies. In addition, results can be used toward marketing the performance of the device to potential buyers. This phase may also include plans for intellectual property protection.

References

- Ballinger, C.A., and Gade, R.H. 1973, Evaluation of the structural behavior of typical highway inlet grates, with recommended structural design criteria: Federal Highway Administration, 81 p. https://rosap.ntl.bts.gov/view/dot/36583
- FHWA, 2024, Urban Drainage Design Fourth Edition: Hydraulic Engineering Circular No. 22, Publication No. FHWA-HIF-24-006, https://rosap.ntl.bts.gov/view/dot/74311/dot_74311_DS1.pdf
- FHWA, 2024, Catch basin, type 1: FHWA Federal Lands Specification Standard 604-1, 2 p. https://highways.dot.gov/federal-lands/std-drawings/Std604-1.pdf
- FHWA, 2024, Catch basin, type 2, with down drain: FHWA Federal Lands Specification Standard 604-4, 2 p. https://highways.dot.gov/federal-lands/std-drawings/Std604-4.pdf
- FHWA, 2024, Inlet, Type 6B: FHWA Federal Lands Specification Standard 604-7, 2 p.
- https://highways.dot.gov/federal-lands/std-drawings/Std604-7.pdf
- Law, S.M., Vaccaro, S.J. 1972, Evaluation of catch basin grates: Louisiana Department of Highways, LA Department of Highways evaluation of catch basin grates

Federal Railroad Administration (FRA)

About Us: FRA's research, development, and technology (RD&T) mission is to ensure the safe, efficient, and reliable movement of people and goods by rail through basic and applied research, and development of innovative solutions. Safety is U.S. DOT's primary strategic goal and the principal driver of FRA's RD&T program. FRA's RD&T program also contributes to other U.S. DOT strategic goals because safety-focused projects typically yield solutions toward state of good repair, economic competitiveness, and environmental sustainability goals. The RD&T program also has an important role to play in workforce development.

FRA's RD&T program is founded on an understanding of safety risks in the industry. Hazard identification and risk analysis allows us to identify opportunities to reduce the likelihood of accidents and incidents, and to limit the consequences of hazardous events, should they occur. Key strategies to these ends include stakeholder engagement, project prioritization, cost-effective research procurement, and partnerships with other researchers such as the Association of American Railroads (AAR), the American Short Line and Regional Railroad Association (ASLRRA), industry, labor, and academia.

26-FR1: Mobile High-Power Emergency BESS De-energizer System for Rail Vehicle Propulsion

Topic Description

Rail rolling stock is increasingly adopting high-voltage lithium-ion battery energy storage systems (BESS) for propulsion. Post-accident or during heavy maintenance, these BESS packs can retain hundreds of kilowatts of stored energy that present electrocution, thermal runaway, and fire hazards during human access. There is a need for a mobile, rugged, safe, and interoperable system that emergency responders and trained railroad maintenance personnel can use to reliably off-load (neutralize) a minimum of 400 kW of stored energy from rail propulsion BESS prior to moving, storing, or performing hands-on maintenance. This topic supports the Federal Railroad Administration's safety priorities by reducing risk to responders and maintenance personnel and enabling safer post-accident vehicle handling and repair.

This topic seeks to develop a concept and subsequent prototype mobile system (skid or trailer mounted) that can: safely connect to a damaged or intact rail propulsion BESS (typical HV DC 600–1000 V); discharge or transfer at least 400 kW of stored energy through controlled, monitored means (resistive dump, regenerative transfer to grid or secondary energy sink, or hybrid approaches); operate remotely (to maintain operator standoff); provide comprehensive safety interlocks and diagnostics; and be operable by trained emergency response teams and railroad employees with defined procedures and use of appropriate personal protection equipment. The system should be designed for field ruggedness, rapid deployment at accident scenes, and for routine use in maintenance shops. The system can have applicability for use in the marine and bus transit sectors as well.

Specifications include:

- Minimum continuous stored energy off-load capacity of 400 kW scalable to 1,000 kW.
- Compatible nominal pack voltages that is configurable/adaptable 600–1,000 V DC.
- Peak continuous current range: up to ~1,500 A; dependent on voltage.
- System deployment via trailer or skid mountable mobile vehicle with capability of operating over road and railroad tracks.
- Rapid connect/disconnect high voltage interfaces with standardized adaptors and insulated connectors.
- Safety features should allow for remote operation capability, high voltage isolation and interlocks, ground fault detection, arc-flash mitigation, emergency stop, safety sensors and indicators.
- Operational modes should include controlled resistive discharge, regenerative transfer to grid or local energy sink, or controlled discharge for degraded or damaged packs.
- Communication: secure telemetry for remote control and data logging; capability to integrate with incident command systems.
- Interoperability: adaptors and procedures to support multiple OEM battery access protocols and connectors or defined adapter kits.
- Standards conformance: adherence to applicable electrical and battery safety standards. A full review of recommended standard compliance should be completed in Phase I.
- Environmental consideration: operable outdoors at accident sites. System must be temperature and precipitation tolerant. Rail vehicle maintenance shops are characterized by high ceilings, narrow clearance between maintenance tracks.
- Human factors: the system must have controls and user interface suitable for use by trained emergency responders and railroad employees; equipped with clear status indicators, sensors, alerts, and checklists.
- Maintenance and training: Digital training manual and user guide must be provided. Maintenance and training: modular design for field repair, documented maintenance procedures.
- To the extent possible, system must use commercially available components for manufacturing and maintenance.

The Phase I proposer should identify and document specific comparable systems, vendors, and fielded approaches and summarize gaps vs. rail-specific needs. Current industry solutions include mobile discharge/load bank systems used in EV test labs and motorsport, but none are commercially available for rail applications.

Partnership with a rail industry stakeholder is required. Rail industry stakeholders can include passenger railroads, such as Amtrak, commuter rail providers/operators (state departments of transportation or contracted operators), freight railroads, rail vehicle manufacturers and battery suppliers providing BESS to rail manufacturers.

Lithium-ion battery chemistries used for rail propulsion are nickel manganese cobalt oxide (NMC), Lithium-ion titanate oxide (LTO), lithium iron phosphate (LFP).

Desired Outcomes

Phase I

The Phase I final report must include:

- A validated concept design and feasible architecture for a mobile BESS off-load system capable of handling a minimum of 400kw of stored energy, including mechanical layout of the system, power electronics approach (resistive, regenerative, hybrid), cooling strategy, and connector/adaptor strategy for rail propulsion BESS interfaces.
- Comprehensive safety standards and regulatory gap analysis identifying all applicable standards and recommended conformance plan.
- Risk assessment and mitigation strategy for accident-scene scenarios such as compromised packs, high impedance faults, thermal runaway risk, and recommended safety features and interlocks.
- Preliminary functional and technical specifications (power, voltage, cooling, interfaces) and high-level cost estimate for a Phase II prototype.
- A commercialization and deployment plan identifying primary customers, use cases, likely procurement paths, and preliminary test/demonstration plan.

Phase II

Phase II will include prototype design refinement and build of one mobile demonstration unit and associated adapter kits, including:

- Full system hardware prototype capable of offloading a minimum of 400 kW with documented performance such as test reports and safety verification.
- Remote operation and monitoring software with logging, incident reporting, and secure communications.
- Detailed operator and maintenance training materials, standard operating procedures, emergency procedures, and a training guide for emergency responders and railroad employees.
- Field demonstration and validation at one or more rail maintenance facilities or controlled accident simulation site(s), with measured performance data and after-action safety assessment.
- A commercialization package: manufacturing plan, unit cost estimates, and pilot agreements or letters of interest from potential customers.

References

No additional references for rail applications.

Federal Transit Administration (FTA)

About Us: The Federal Transit Administration's (FTA) mission is to improve America's communities through public transportation. We envision a better quality of life for all built on public transportation excellence. The Office of Research, Demonstration and Innovation, which directs FTA's research program, provides industry and policy makers with the information and skills to make good business decisions about transit technology, operational, and capital investments. The program uses research results to identify best practices and shares this information with others who can benefit from it. Through its research, FTA shows a range of outcomes that help direct where future transit investments should be made.

26-FT1: Person-Centered, Carefree, Complete Trip Planning - Powered by AI

Topic Description

Travelling by public transportation can be challenging. This is especially true if the trip 1) may involve more than one mode, 2) is not completed within the traditional 9 am – 5 pm commuting pattern, 3) crosses multiple jurisdictions, 4) is in a rural or frontier area, or 5) changes day to day. Luckily, technology holds great promise in efforts to address the full range of challenges that can stymy even the most seasoned transit user, and which certainly stand in the way of a broader slice of the American population choosing public transportation to meet their needs.

The thoughtful examination of the challenges facing (potential) transit riders is referred to as the Complete Trip. This begins with the conception of the possibility of using transit and includes learning how to: 1) plan for and pay for a trip; 2) travel across the streets as a pedestrian; and 3) know where to go, when to go, and how to adapt to changes. Removing barriers at each step of the Complete Trip can open the potential of transit as a useful choice to many more travelers, with all the attendant benefits to their own wellbeing, and the additional societal benefits.

Current trip planning apps provide today's travelers with a great deal of information; however, they do little to resolve key elements of the Complete Trip, starting with conceiving of transit as an option. Today, a user must choose to investigate the transit option. They then must delve further to learn all the small details that can help complete their trip such as payment, accessibility, and timing.

We believe that a thoughtfully developed, AI-powered system can resolve the challenges of the Complete Trip. By learning a person's preferences and travel needs, an AI tool can provide the user with all the information they need to travel confidently, while also responding to challenges as they arise in a way that meets that person's needs. A smart system can make transit an easy, logical choice for many more people. This SBIR topic seeks to investigate the idea that an AI system can be developed that would place comprehensive, comprehensible, and actionable information addressing the myriad challenges of the Complete Trip in the hands of travelers.

The tool to be developed must empower travelers across each segment of the Complete Trip, including trip planning and payment, as well as enroute navigation support across the streetscapes, transit stations and vehicles. A successful prototype will empower the traveler to know when to choose transit. It will also use its capacity to learn to recommend a trip plan that best meets the needs of each person, for each trip. This can provide comparable options for the traveler to make an informed decision on whether to choose transit or another mode of travel.

To do so, the system must be able to collect and bring together data from a range of transportation-adjacent sources (e.g., traffic, transit arrival/departure, mode change, pedestrian path condition, cycle path options, etc.). This is a task that requires adherence to existing data standards and necessitates the creation of others. It is also imperative that data be presented in a clear, easy to understand, and actionable way to travelers, whoever they are. Universal Design is essential to ensuring the tool provides independent travel for all users, including those with diverse physical or cognitive needs. Beyond usability, however, this tool must proactively understand and address travel challenges facing people with disabilities as easily as it would for other travelers.

Desired Outcomes

Phase I

A Phase I project will result in a proof-of concept report that describes a prototype AI-powered traveler support system. Desired deliverables for this technology would include research to demonstrate technical feasibility during Phase I and show a path toward Phase II software development culminating in delivery of a software package at the completion of the Phase II contract.

Phase II

Phase II will result in the development of a minimally viable product (MVP) version of the tool. This MVP must demonstrate the following:

Understanding of Requirements

- The broad potential sources of data available to support Complete Trips.
- Diverse user needs and applied principles of multimodality and universal design to ensure the AI system can support a wide range of travelers.

System Design

- An AI system that can address the user needs, create a novel experience, and respond to changes in both user behavior and the mobility data ecosystem.

Prototype and Technical Implementation

- Developed the technical architecture and initial algorithms necessary to integrate the data and user requirements identified in Phase I.
- Produced an interactive demonstration prototype that demonstrates real-time trip planning and personalized updates.

Testing & Validation

- Conducted early usability and performance testing to validate the core functionality and documented how the system performs across sample scenarios.
- Gathered and properly assessed user feedback from sample scenarios to provide support for future improvements.

Documentation

- A Phase II report summarizing the design, prototype capabilities, testing results, and recommendations for next steps beyond Phase II.
- Written software documentation listing dependencies and user instructions that demonstrate well-maintained code.

References

- Mobility Data – Standards and Specifications for Interoperability (FTA/CUTR Project) https://www.transit.dot.gov/sites/fta.dot.gov/files/2024-08/FTA-Report-No-267.pdf
- Mobility Standards and Guidelines Resource (MSGR) Tool https://maasresources.com/
- Mobility Data Interoperability Principles (MDIP) https://www.interoperablemobility.org/
- Mobility Data (Data Standards) https://mobilitydata.org/
- Routing Algorithms – Established Literature
    - Non-Preference
        - (PDF) Optimization of cold chain multimodal transportation routes considering carbon emissions under hybrid uncertainties
        - Robust Optimization of Multimodal Transportation Route Selection Based on Multiple Uncertainties from the Perspective of Sustainable Transportation
        - Optimal routing and request selection for multiple service routes in a demand-adaptive transit system | Frontiers of Engineering Management
    - Preference based
        - [1906.04832] UnLimited TRAnsfers for Multi-Modal Route Planning: An Efficient Solution
        - [2502.14528] Dynamic Preference-based Multi-modal Trip Planning of Public Transport and Shared Mobility
        - A data-driven preference learning approach for multi-objective vehicle routing problems in last-mile delivery - ScienceDirect
- Predicting transit crowdedness (Literature and a source)
    - TransitCrowd: Estimating Subway Stations Demand with Mobile Crowdsensing Data | Data Science for Transportation
    - Crowdsourced Transit predictions - Transit Partners Help

Office of the Secretary (OST)

About Us: The Office of the Assistant Secretary for Research and Technology (OST-R), works at the dynamic intersection of new and emerging technologies, transportation data, policy, research and all modes of transportation across the Department. Our mission is to facilitate the transformation of our transportation system–making it safer, more efficient, competitive, and accessible. To do this, we:

- Advance innovation, technology development, and breakthrough knowledge
- Facilitate research and multimodal research collaboration
- Foster technology transfer through partnerships both within the Department and with other Federal agencies, academia and private entities
- Provide decision makers with useful statistics and information of the highest quality and integrity
- Develop a skilled interdisciplinary transportation workforce for the nation

OST-R coordinates the Department's research investment, oversees the development of Annual Modal Research Plans, and provides opportunities for research collaboration with public and private sector partners.

26-OS1: Predictive Safety Analytics for Commercial Transport Modernization

Topic Description

The U.S. DOT seeks to partner with the commercial transportation sector to modernize safety and operational efficiency through advanced research and development. This initiative aims to foster a collaborative environment where government and industry work together to apply cutting-edge technology for mutual benefit. The technology portion of this effort will explore AI-driven predictive analytics to assist the industry in moving toward a proactive, prevention-based safety culture.

Current safety methodologies primarily utilize historical data to understand past events. This R&D effort aims to explore how diverse data streams can be leveraged to identify potential safety needs before incidents occur. By identifying patterns early, a data-driven approach can support proactive interventions that enhance safety for all road users while maximizing fleet uptime and supply chain reliability.

A central component of this research is the exploration of "Trusted Intermediary" architectures. Recognizing the importance of data privacy and commercial sensitivity, this approach seeks to design secure frameworks where voluntary industry data (such as telematics) can be fused with public safety records. This system would prioritize data protection, ensuring that safety insights are generated without compromising proprietary information.

The proposed solution will focus on analyzing these combined data streams to provide actionable insights that optimize safety resource allocation. By leveraging cloud-based computing and advanced modeling, the system aims to create a safety ecosystem that reduces preventable incidents. Furthermore, the system will adhere to "explainability" principles, providing clear reasoning for its safety assessments to ensure transparency and build trust among all transportation stakeholders.

This topic seeks tools that optimize the use of predictive analytics in support of the integration, safety, and efficiency of motor carriers. Areas of interest include, but are not limited to, those below.

- **Secure Collaborative Data Frameworks:** Research into "Trusted Intermediary" systems that securely aggregate and anonymize diverse data sets to generate safety insights while maintaining strict privacy and commercial confidentiality.
- **Proactive Safety Indicators:** The use of historical data and real-time external feeds (such as weather and infrastructure conditions) to identify "leading indicators" of safety anomalies, enabling preventative measures that save lives and reduce costs.
- **Resource & Efficiency Optimization:** Tools that allow safety partners to realize significant efficiency gains by focusing educational and support resources on operations with the highest projected need, minimizing disruptions to safe operators.
- **Transparent & Explainable AI:** Development of models that provide understandable, transparent reasons for their assessments, fostering confidence and collaboration between technology providers, carriers, and safety officials.
- **Comprehensive Health Modeling:** Exploration of diverse factors—including maintenance trends and environmental conditions—to create a holistic view of fleet safety health.

Desired Outcomes

Phase I

Phase I shall demonstrate the technical feasibility and deliver a proof-of-concept system design. This includes a high-level architecture for a Trusted Intermediary and a predictive modeling strategy. The design should demonstrate how disparate data elements can be securely harmonized to generate proactive safety insights. Key outcomes will include a validated framework, an initial prototype design, and supporting analyses showing the system's potential to improve safety outcomes and operational efficiency using AI-driven analytics.

Phase II

Phase II will focus on developing, validating, and demonstrating a fully functional prototype of the predictive safety platform. The effort will transition the Phase I concept into an operational decision-support tool for pilot testing. The model will be built using standardized formats ensuring interoperability to enable broader deployment. Field demonstrations will be conducted to evaluate performance, usability, and the ability to reduce risk. A commercialization and transition plan identifying market pathways, partnerships, and strategies for Phase III scaling will be developed.

The final report will consolidate technical results and lessons learned, summarizing the system's potential for modernizing industry safety.

References

ISO 21448 - Safety of the Intended Functionality (SOTIF): Applies to systems where proper situational awareness is critical for safety, particularly Advanced Driver Assistance Systems (ADAS) and high-level autonomous driving.
(Proposed) SELF DRIVE Act of 2026: House discussion draft focused on updating federal motor vehicle safety law for vehicles equipped with automated driving systems.
ISO/PAS 8800: Covers safety-related systems that include one or more electrical and/or electronic (E/E) systems that use AI technology.
USDOT Strategic Plan (FY 2022-2026): Federal roadmap emphasizing the shift toward digitally intelligent infrastructure and connected corridors.

26-OS2: Freight Corridor Predictive Intelligence

Topic Description

This topic is funded by the Federal Highway Administration (FHWA) and managed by the Office of the Secretary's Intelligent Transportation Systems Joint Program Office (ITS JPO). Freight congestion along national corridors in the United States costs billions annually and weakens supply chain reliability. Existing analytical tools generally rely on historical or static data, offering limited predictive capability. This topic is seeking a Freight Corridor Predictive Intelligence tool. Such a tool would investigate the blending of real-time edge analytics, generative artificial intelligence (AI), and federated learning to enhance both public and private freight operational decision-making and to gain system-wide freight efficiencies. This is a multimodal project that would rely on partnering with other DOT modes (e.g., FHWA, FMSCA, MARAD) and supports the Administration's priorities in AI and freight simultaneously.

Two overarching objectives are desired: 1) develop an AI-enabled predictive system that fuses multimodal data sources to forecast freight bottlenecks and supply chain disruptions along critical U.S. freight corridors; and 2) leverage edge AI processing, synthetic data generation, and federated learning to deliver proactive corridor management tools for state and local DOTs and private sector freight operators.

Across SBIR phases, the solution will incrementally meet the following high-level specifications:

- Phase I: Demonstrate a functional predictive AI architecture capable of integrating and analyzing combined real-world and synthetic freight datasets, achieving baseline corridor-level prediction accuracy of at least 80% for short-term (30–60 minute) congestion and delay forecasts.
- Phase II: Conduct field pilots along 2–3 representative freight corridors (urban, rural, and intermodal) featuring real-time data ingestion from sensors, GPS, and connected vehicle feeds, and deliver a decision dashboard with automated alerting and visualization capabilities.
- Phase III: Implement and validate system scalability and interoperability with commercial telematics platforms, freight carrier systems, and state and local DOT operations platforms, achieving near-real-time predictive updates (<5 minutes latency) and readiness for larger scale deployment and commercialization.

The proposed solution will meet the following high-level technical parameters:

1) Deploy low-power edge AI devices at strategic freight bottlenecks (e.g., interchanges, bridges) to enable real-time monitoring and analytics with minimal connectivity requirements;
2) Create the ability to integrate multimodal public and private data sources—including GPS, weigh-in-motion (WIM), weather, work zones truck parking availability (based on historic parking data and predictive algorithms to forecast parking availability by time of day and day of week), and connected vehicle (CV) feeds—into an integrated predictive intelligence framework;

3) Generate synthetic "digital twin" logistics data to model freight flows, corridor performance, and system disruptions for scenario testing;
4) Apply federated learning methods to enhance model accuracy across multiple jurisdictions while preserving data privacy and proprietary logistics information; and
5) Provide a cloud-hosted, web and mobile accessible decision-support dashboard compatible with common enterprise platforms (e.g., ArcGIS, Power BI, Tableau) for visualizing corridor performance analysis.

Desired Outcomes

Phase I

By the end of Phase I, the project will have demonstrated the technical feasibility and proof of concept for the proposed freight corridor predictive intelligence initiative. Key outcomes will include a validated framework, an initial prototype design, and supporting analyses showing the system's ability to forecast freight corridor performance using AI-driven predictive analytics.

- Conceptual Architecture and System Design: Develop a high-level system architecture outlining data elements (traffic, freight, work zones, weather, incidents), predictive modeling, and user dashboard components. The design will show how real-time and historical data streams can be integrated to generate corridor-level insights.
- Prototype Predictive Model (Proof of Concept): Build a preliminary model for a selected freight corridor or segment to demonstrate how machine learning and data fusion can predict short-term corridor performance metrics such as travel time reliability, congestion probability, and truck delay.
- Data Inventory and Integration Plan: Compile and assess freight, supply chain, and traffic data from public and private sources (e.g., NPMRDS, Freight Analysis Framework, ATRI and system infrastructure data including authorized truck routes, bridge clearance, and weight limits). Develop a data integration strategy defining access methods, availability, and preprocessing steps for Phase II implementation.
- Performance Metrics and Validation Approach: Define measurable evaluation criteria (e.g., accuracy, timeliness, completeness) and identify candidate corridors for Phase II validation. Conduct preliminary benchmarking to assess model scalability and sensitivity.
- Commercial and Implementation Readiness Assessment: Evaluate Phase II commercialization pathways, partnerships, and integration opportunities with state DOTs, MPOs, and logistics data providers to support transition to a deployable prototype.
- The final report should summarize findings, prototype performance, data gaps, and recommended next steps for Phase II, in accordance with SBIR requirements.

Phase II

Phase II will focus on developing, validating, and demonstrating a fully functional prototype of the Freight Corridor Predictive Intelligence (FCPI) system. The effort will transition the Phase I concept into an operational decision-support platform capable of real-time freight corridor prediction and performance analytics for transportation agencies, freight carries, and logistics partners.

- Develop and integrate an operational prototype that combines multimodal freight datasets (traffic, WIM, GPS, weather, truck parking, and connected vehicle feeds) through a unified predictive analytics framework compatible with DOT and commercial systems.
- Refine and validate predictive models using large-scale, real-world data from 2–3 pilot corridors, targeting defined accuracy for short-term (30–60 minute) forecasts.
- Implement federated and edge AI capabilities to enable distributed model learning and real-time processing while preserving data privacy.
- Deliver a cloud-based, web-accessible dashboard (compatible with ArcGIS, Power BI, etc.) to visualize corridor conditions, predictive trends, and recommended responses.
- Conduct field demonstrations with at least two significant freight corridors that are represented by state DOTs, one regional freight partner, and potentially two private sector freight carriers and logistics providers to evaluate performance, usability, and scalability.
- Develop a commercialization and transition plan identifying market pathways, partnerships, and licensing strategies for Phase III.

Anticipated Phase II Deliverables

- Fully integrated prototype with real-time analytics and dashboard functionality.
- Pilot test reports and validation results from selected corridors.
- Technical documentation and system design materials.
- Performance and evaluation report summarizing model accuracy and system scalability.
- Commercialization and transition plan outlining Phase III market readiness.
- Final Phase II report consolidating technical results and lessons learned.

References:

- Shaping the Future of Freight Logistics: Use Cases of AI in Freight Logistics (2025): Systematic academic review identifying over 70 unique AI use cases across freight logistics and supply chain management.
- Application of Artificial Intelligence in Prediction of Road Freight Transportation (2017): Demonstrates AI and ML applications for forecasting road freight transport trends using Bayesian networks and smoothing methods.
- FHWA Freight Demand Modeling & Data Improvement (SHRP2 C20 Project Results): Outlines ongoing USDOT efforts to enhance freight data and modeling practices for decision-making.
- Freight Corridor Digital Twin Optimization Market Outlook (2024): Market analysis describing trends and technologies in freight corridor optimization and digital twin markets.
- Automated Freight Corridor Assessment (ATRI/INRIX) (2018): Data-driven approach to identify corridors best suited for autonomous freight operations based on volume, congestion, and incident data.
- TRB / NCFRP Freight Research Collection: Series of reports providing guidance on freight data collection, modeling, and sharing; multiple resources that are foundational to corridor predictive modeling and analytics.

- CSCMP State of Logistics Report (2024): Annual report summarizing freight and logistics trends, technology adoption, cost pressures, and resiliency factors shaping freight corridor operations.
- CSCMP White Paper--The Threat of Resiliency and Sustainability in Global Supply Chain Management: Expectations for 2025: Discusses emerging risks and strategies in global supply chains, highlighting the growing need for predictive intelligence and resilient freight operations.
- TRB / NCFRP Report 38 — Guide for Conducting Benefit-Cost Analyses of Multimodal, Multijurisdictional Freight Corridor Investments (2017): Comprehensive guide for evaluating freight corridor investments using benefit-cost frameworks; relevant to quantifying predictive intelligence benefits.

Pipeline and Hazardous Materials Safety Administration (PHMSA)

About Us: The Pipeline and Hazardous Materials Safety Administration (PHMSA) operates in a dynamic and challenging environment where advances in technology, manufacturing, and energy production impact transportation safety. PHMSA's mission is to protect people and the environment by advancing the safe transportation of energy and other hazardous materials that are essential to our daily lives.

PHMSA's Pipeline Safety Research Program sponsors research and development projects focused on providing near-term solutions for the U.S.'s pipeline transportation system that will improve safety, reduce environmental impact, and enhance reliability. Recent R&D projects are focused on leak detection; detection of mechanical damage; damage prevention; improved pipeline system controls, monitoring, and operations; and improvements in pipeline materials. These projects are addressing technological solutions that can quickly be implemented to improve pipeline safety.

PHMSA's Office of Hazardous Materials Safety carries out a national safety program, including security matters, to protect against the risks to life and property inherent in the transportation of hazardous materials in commerce by all transportation modes. The office regulates the transportation of hazardous materials by air, rail, highway, and water. Over 1.3 million hazardous material products are transported daily over the various transportation modes. The Office of Hazardous Material Safety seeks to improve the safety and reliability of hazardous material transportation.

26-PH1: Increase End-of-Life Battery Safety and Recovery of Rare Earth Minerals

Topic Description

Shipping end-of-life lithium-ion batteries presents significant safety and cost challenges. These batteries often retain residual, or "stranded," energy that can lead to fires or explosions during transport. This risk drives up shipping costs and, in turn, the cost of recapturing rare earth minerals. Rare earth minerals, such as lithium, are essential to support national security and the economy as stated in E.O. 14272. *Ensuring National Security and Economic Resilience Through Section 232 Actions on Processed Critical Minerals and Derivative Products*[1].

To address this issue, PHMSA is seeking a small business to develop a safe, fast, and cost-effective method for removing residual energy, eliminating the primary hazard and potentially paving the way for regulatory relief and market expansion. PHMSA previously collaborated with the Naval Research Laboratory on the development of a conductive gel designed to neutralize stranded energy and is

[1] https://www.federalregister.gov/documents/2025/04/18/2025-06836/ensuring-national-security-and-economic-resilience-through-section-232-actions-on-processed-critical

now exploring additional strategies or alternative technologies that can be commercialized for broader use.

Desired Outcomes

Phase I

By the end of Phase I, the awardee will produce a proof-of concept or working prototype that clearly demonstrates an effective method for safely removing residual energy from end-of-life lithium-ion batteries. While the solution does not need to be fully optimized, it should show strong technical feasibility and a clear path toward refinement in Phase II. In addition to technical progress, PHMSA also seeks to see growth in strategic relationships with early adopters, industry stakeholders, and a potential pilot partner, that will support future testing, validation, and commercialization. These outcomes will help accelerate the development of practical, scalable solutions that enhance safety, reduce costs, and support regulatory innovation.

Phase II

In Phase II, PHMSA expects the small business to refine and optimize the proposed product or method with a focus on cost-effectiveness, ease of use, and operational speed. The goal is to move beyond proof-of-concept and develop a solution that is practical for real-world application. In addition to technical advancement, the business should be prepared to initiate pilot testing with early adopters and have established relationships that support the transition to commercialization. These efforts will help ensure the solution is scalable, market-ready, and capable of improving safety and efficiency across the lithium-ion battery supply chain.

References

Example of accident involving end-of-life lithium-ion batteries:

- https://abc3340.com/newsletter-daily/truck-carrying-batteries-explodes-in-birmingham-lithium-explosion-fire-daniel-payne-hazmat-hazardous-smoke
- Report on the cost to recycle end of life batteries: https://www.sciencedirect.com/science/article/pii/S2405829725000364
- Conductive Gel report from Naval Research Lab: https://www.mdpi.com/2313-0105/11/5/201

26-PH2: Thermal Indicator Coatings for Hazardous Materials Packaging Safety

Topic Description

Effective, easy to understand, hazard communication is fundamental to PHMSA's safety mission. Yet, in high-risk transportation events such as fires or thermal events, operators and first responders lack simple, visible failure indicators that signal when hazardous materials packaging is approaching dangerous internal temperatures. While certain hazmat markings are familiar to seasoned HAZMAT professionals, non-HAZMAT-trained responders, such as law enforcement who are frequently the first to arrive on scene, are often less familiar with these markings. This gap, combined with the absence of visual cues about evolving hazards, increases the risk of responder injuries, which are already common among police officers arriving at hazardous materials incidents. An intuitive thermal stress indicator would provide critical early warning of rising internal temperatures, allowing operators and first responders to act well before packaging failure.

PHMSA is seeking the development of a thermochromic coating system that can be applied to the external sides of hazardous materials packaging. The proposed coating would change color in response to defined temperature thresholds, offering a visual indicator of internal thermal stress progression during emergencies. While the solution should not prescribe a specific material class or technology preference, it may consider ceramic-based coatings, polymer composites, or nano-enhanced paints that would integrate temperature-sensitive pigments. The system should be low-cost, lightweight, durable under transport and weathering, and scalable to industrial applications. The solution should not interfere with the outer packaging nor be incompatible with any hazardous material commodities.

The proposed coating must visibly change color at pre-determined temperature thresholds. Color change must be irreversible or long-lasting enough to provide meaningful information to transportation operators and first responders during and immediately after an incident. It must maintain coating adhesion, visibility, and durability under routine operational exposure; and it must be visible under low-light and smoke conditions. The proposed coating must be compatible with certain hazmat packaging substrates such as steel, aluminum, or other composites. Prototypes should undergo bench-scale torch fire thermal testing.

Desired Outcomes

Phase I

At the end of Phase I, the small business will demonstrate a proof-of-concept thermochromic coating based on laboratory results. The coating should be able to demonstrate distinct temperature threshold color changes, providing visible indicators when a material is exposed to rising internal heat levels. The initial testing should demonstrate the coating's adhesion to common substrate materials, its durability under repeated use, and the repeatability of its color-change response under controlled thermal exposure conditions.

Additionally, the small business will include feasibility and initial test data reports that document the different coating formulations tested, their compatibility with potential substrate materials, and a structured plan for scaling the application of the coating to larger surfaces.

Phase II

Phase II will focus on advancing the technology from laboratory proof-of-concept toward full-scale testing. The small business is expected to develop pilot-scale formulations and produce larger area coating samples suitable for evaluation. The coating will be validated through testing under simulated fire conditions, including radiant panel exposure and pool fire scenarios, to determine its performance in realistic emergency incidents. Additionally, the coatings must demonstrate durability under long-term operational stressors such as ultraviolet radiation, weathering, impact, and abrasion. The small business will also engage with transportation end-users such as tank car operators, trucking companies, and emergency response organizations. These end users should be involved in pilot demonstrations to ensure that the coatings meet operational needs and integrate into existing safety practices.

References

- Behavior of Thermochromic Coatings under Thermal Exposure; Z. Tatíčková et al., 2023 - https://www.mdpi.com/2079-6412/13/3/642
- Chameleon inspired high temperature thermochromic traffic light type photonic crystal sensors toward early fire detection and visual sensing Q. Shi et al., 2024 - https://www.sciencedirect.com/science/article/abs/pii/S1385894724014529

26-PH3: Self-repairing Hazardous Materials Packaging

Topic Description

Self-repairing materials are used in construction, automotive, and other industries to repair cracks and other minor flaws. This technology has not been approved or used yet in HAZMAT transportation despite the importance of packaging integrity on HAZMAT safety. While performance packaging standards help ensure packages meet a certain level of robustness, incidents can still occur during transportation when packaging integrity is compromised. Metals can crack/corrode, external forces can cause damage (crushing, punctures, or dents), excessive heat can cause deformation, and materials can simply wear over time. Being able to save on packaging damage could not only increase safety but also save direct costs in the HAZMAT transportation industry.

Research on self-repairing materials explores applications in electronics, polymers, corrosion control, and more.[2] Scientists have even observed nano-scale crack self-repairing in metals under a vacuum.[3] The food packaging industry has advanced research towards implementation of self-repairing packaging, investigating films and coatings for the purpose of food preservation.[4] Research conducted by the National Institutes of Health has shown promising results, specifically with self-repairing polymers.[5] Overall, the foundational research shows promise for self-repairing materials in a variety of applications. By integrating self-repairing polymers into hazardous material packaging, shippers could see a reduction in costs due to extended packaging life, reduced downtime if a package is damaged in transit, and enhanced safety to the public and HAZMAT transportation professionals.

PHMSA seeks a solution that can be used as an application on existing packaging types (e.g., self-repairing coating or other application) or a novel self-repairing packaging material. Proposals may consider both bulk and non-bulk packaging types. The solution must meet existing packaging specifications in section 49 CFR 178, "Specifications for Packaging" and any referenced sections. The offeror should consider existing testing requirements for packaging; the solution must be able to pass existing testing requirements for that packaging type. Packaging for Class 7 (radioactive materials) is excluded from consideration for this topic.

The solution should be cost-competitive with existing commercially available packaging types. The solution must specify whether the material can be used for bulk, non-bulk, or both packaging types. The solution must also specify types of material applicable (i.e., plastic, metal, composite, etc.) and what types of damage can be reduced or mitigated. The solution should consider stakeholder involvement from packaging manufacturers. The material must be able to withstand typical HAZMAT transportation conditions; the offeror should consider which mode(s) may be used for the packaging and the relevant forces the packaging may encounter, including any potential damage due to the HAZMAT being transported.

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[2] https://pubs.acs.org/doi/10.1021/acs.chemrev.2c00839
[3] https://www.nature.com/articles/s41586-023-06223-0
[4] https://www.sciencedirect.com/science/article/abs/pii/S000186862500034X
[5] Kim S, Jeon H, Koo JM, Oh DX, Park J. Practical Applications of Self-Healing Polymers Beyond Mechanical and Electrical Recovery. Adv Sci (Weinh). 2024 Apr;11(16):e2302463. doi: 10.1002/advs.202302463. Epub 2024 Feb 15. PMID: 38361378; PMCID: PMC11040355.

Desired Outcomes

Phase I

The anticipated Phase I outcome is, at a minimum, a proof-of-concept final report demonstrating the feasibility of the proposed self-repairing packaging solution. The outcome may also be a working prototype design or sample of self-repairing packaging solutions along with initial data demonstrating self-repairing ability capable of withstanding HAZMAT transportation conditions.

Phase II

The anticipated Phase II outcome would be a further-developed prototype from the proof-of-concept (at minimum). In Phase II, the small business would further identify potential pilot partners and develop a plan to advance the prototype towards commercialization. Considerations include how to scale production and cost-effectiveness. Deliverables would include a final report documenting the development of the prototype and path to commercialization.

References

- Introduction: Self-Healing in Chemical Systems | Chemical Reviews
- Autonomous healing of fatigue cracks via cold welding | Nature
- Self-healing packaging films/coatings for food applications; an emerging strategy - ScienceDirect
- Kim S, Jeon H, Koo JM, Oh DX, Park J. Practical Applications of Self-Healing Polymers Beyond Mechanical and Electrical Recovery. Adv Sci (Weinh). 2024 Apr;11(16):e2302463. doi: 10.1002/advs.202302463. Epub 2024 Feb 15. PMID: 38361378; PMCID: PMC11040355.
- https://pmc.ncbi.nlm.nih.gov/articles/PMC11040355/
- eCFR :: 49 CFR Part 178 -- Specifications for Packagings

26-PH4: Improved Response to Lithium-ion Battery Fires

Topic Description

Lithium-ion battery fires present a growing safety challenge across multiple transportation modes, particularly as electric vehicles, consumer electronics, and energy storage systems become more prevalent. These fires are notoriously difficult to extinguish, as the fires can propagate and be self-sustaining for hours at high temperatures. Accessing where the fire is located can be difficult, making traditional extinguishing techniques ineffective. After ignition of the battery, it has a higher risk of thermal runaway and reigniting, which can pose serious threats to first responders, the public, and supply chain infrastructure. This research aligns with the U.S. Department of Transportation's innovation priorities and PHMSA's Safety Mission.

The goal of this topic is to support the development of a low-cost, easy-to-deploy solution that can rapidly and reliably suppress lithium-ion battery fires across all modes of transportation. The solution should be effective across a range of battery chemistries and form factors, and ideally scalable for use in field settings by emergency personnel, shippers, and battery recyclers. Specifications of this solution may include rapid extinguishment capability, prevention of reignition, and compatibility with existing safety protocols. Technical parameters should support integration with emergency response workflows, allow for piloting with key stakeholders such as fire departments and battery manufacturers, and demonstrate feasibility for commercialization and widespread deployment.

Desired Outcomes

Phase I

By the end of Phase I, the small business should demonstrate a clear proof of concept for a low-cost, safe, and effective method or tool to suppress lithium-ion battery fires. The solution should demonstrate technical feasibility in extinguishing fires quickly and preventing reignition, even if the concept is not fully optimized at this stage. In parallel, the business is expected to initiate relationships with potential early adopters, such as fire departments, emergency response teams, battery manufacturers, and recyclers, to support future pilot testing and commercialization. These outcomes will lay the groundwork to advance fire mitigation strategies, improve public safety, and enable broader deployment in Phase II.

Phase II

During Phase II, the small business is expected to refine and optimize the fire suppression product or method, focusing on performance, cost efficiency, ease of deployment, and reliability across various lithium-ion battery fire scenarios. The solution should be ready for real-world application and demonstrate consistent effectiveness in extinguishing fires and preventing reignition. In addition to technical refinement, the business should complete or have concrete plans to complete pilot testing in collaboration with fire departments or emergency response units. These pilot efforts will validate the tool's usability in field conditions and help build momentum toward commercialization, broader adoption, and enhanced public safety.

References

There are many current strategies and methods for extinguishing a lithium-ion battery fire. You can find current PHMSA guidance in the Emergency Response Guidebook (ERG). https://www.phmsa.dot.gov/sites/phmsa.dot.gov/files/2024-04/ERG2024-Eng-Web-a.pdf

There are also a variety of ideas on best methods/practices, with some demonstrating a clear need for more advanced response techniques:

- NY Division of Homeland Security and Emergency Services Li-ion battery fire guidance
- FEMA Li-ion battery guidance
- FDNY Li-ion guidance: https://www.fdnysmart.org/be-fdnysmart-when-using-any-devices-powered-by-lithium-ion-batteries/
- OSHA Li-ion guidance: https://www.osha.gov/sites/default/files/publications/OSHA4480.pdf