U.S. DOT SBIR Pre-Solicitation Notice

The U.S. Department of Transportation (U.S. DOT) Small Business Innovation Research (SBIR) Program invites small business concerns to review this pre-solicitation notice for opportunities within its Fiscal Year 2023 (FY23) SBIR Phase I solicitation.

THIS IS A PRE-SOLICITATION NOTICE; NO SUBMISSIONS ARE ACCEPTED AT THIS TIME.

The pre-solicitation period for U.S. DOT's FY23 solicitation is from January 4, 2023, through February 3, 2023, at 5:00 p.m. Eastern Time (ET). Full descriptions of U.S. DOT's proposed FY23 Phase I solicitation research topics can be found in **Appendix A: U.S. DOT SBIR Proposed FY23 Phase I Research Topics**.

During the pre-solicitation period, small businesses must post any technical questions concerning the proposed research topics to the SBIR Pre-solicitation Q&A Forum at https://usdot.uservoice.com/forums/950674 (see instructions below). Questions shall be limited to specific information related to improving the understanding of a particular topic's requirements. Please note that all posted questions will be publicly available. Do not share solution ideas or proprietary information. Only clarifying questions should be submitted. Telephone inquiries or meeting requests will not be accepted or responded to.

Potential offerors should not seek advice or guidance on its solution to any given topic nor submit any materials other than question(s) regarding the topic. The U.S. DOT shall not respond to requests for advice or guidance on any offeror's solution to any SBIR topic, and shall not consider any submitted materials other than questions. Potential offerors shall not include in the question(s) any information that they do not wish to be made public. All questions and corresponding answers will be available to the public.

Technical questions regarding the research topics will be accepted only during the pre-solicitation period (January 4, 2023, through February 3, 2023). Technical questions will not be accepted after 5:00 p.m. ET on February 3, 2023. Only questions received by posting to the forum as cited above prior to the deadline will be answered by the U.S. DOT research topic authors. Answers to all questions from the pre-solicitation period will remain available on the forum when the U.S. DOT FY23 SBIR Phase I solicitation is released on or about February 7, 2023.

How to Use the SBIR Pre-solicitation Q&A Forum (https://usdot.uservoice.com/forums/950674):

Register: Anyone can view questions but registration is required if you wish to post a question and receive a notification when it is responded to.

1. To create a new account or to sign in with an existing account, click on "sign in" located at the top-right of the page.
2. A new pop-up window will open to make a selection. You can use an existing Google or Facebook account to access the site or you may select to create a new account.
3. If you choose to access UserVoice with an existing Google or Facebook account, you will be required to enter your login credentials for Google or Facebook and agree to terms of service.
4. If you create a new account, click "Create an Account" underneath the password box.
5. In the next screen, type in the email and click "Verify Email."

6. Navigate to your inbox and click the link within the email to verify. The link will be generated by noreply@trymagic.com. That link will be live for 20 minutes. Once that time elapses, you will have to request another one.
7. Navigate back to UserVoice, and you will need to provide your name, a password, and agree to terms of service and storage permissions. Click "Create Account."

Search: Browse the existing questions by category to find the topic you are interested in and to see if your question has already been addressed. If you see a question you are also interested in, you can add a vote to the question, or leave a comment.

Post: If your question has not already been posted, use the "Enter your idea" box at the top of the page to enter your question.

1. Select the research topic your question is related to from the drop-down menu that appears when you begin typing.
2. You may add more detail in the Description box (optional). Do NOT attach any files. The U.S. DOT shall not consider any submitted materials other than questions posted on the Q&A Forum.
3. When finished, select "Post idea." If you registered, you will be able to track responses to your post. Please include only one question or comment per post to help keep the forum organized.

The U.S. DOT anticipates release of its FY23 Phase I solicitation on or about February 7, 2023. An informational webinar about the solicitation and any program changes is tentatively scheduled for February 9, 2023, at 1:00 p.m. ET. More information on how to register for this webinar will be available on the U.S. DOT SBIR website and in the solicitation when it is issued.

Upon solicitation release, only small businesses as defined in the Small Business Administration (SBA) SBIR Policy Directive are eligible to submit offers to the U.S. DOT SBIR FY23 Phase I solicitation. Additionally, all small business offerors must be registered in the following databases: SBA's Company Registry Database (https://www.sbir.gov/registration) and the System for Award Management (SAM) (https://sam.gov/SAM/).

The proposed FY23 research topics are listed below. Full descriptions of each research topic are included in Appendix A, which is attached to this notice.

Federal Highway Administration (FHWA)

23-FH1: Addressing Stormwater Runoff with a Self-Contained Portable Treatment System
23-FH2: Traffic Monitoring and In Situ Information Processing Using Edge Computing

Federal Railroad Administration (FRA)

23-FR1: Concrete Crosstie Inspection Technology
23-FR2: Novel Design for Passenger Railcar Glazing Securement

National Highway Traffic Safety Administration (NHTSA)

23-NH1: Child Presence Detection CO2 Release Test Device
23-NH2: Immersive Virtual Reality Training on Impaired Driving for Law Enforcement

Pipeline and Hazardous Materials Safety Administration (PHMSA)

23-PH1: Bioremediation for Hazardous Material Spills
23-PH2: Integrated RFID Trackers and Sensors for Hazardous Material Communication in Transportation
23-PH3: Portable State-of-Charge Sensor for Lithium Batteries
23-PH4: Wearable PPE-integrated Sensors for First Responders

APPENDIX A: U.S. DOT SBIR Proposed FY23 Phase I Research Topics

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Federal Highway Administration (FHWA)

About Us: FHWA's Research, Technology, and Evaluation Program strives to generate new solutions, build more effective partnerships, and provide better information and tools for decision making, which will enable the nation to enhance and make the best investments in the U.S. transportation system.

23-FH1: Addressing Stormwater Runoff with a Self-Contained Portable Treatment System
Stormwater runoff emanating from our built environment has direct water quality consequences to our natural environment. Fifty years ago, the Clean Water Act established programs to manage stormwater runoff, however our nation's water resources are in poor condition with over half of our nation's assessed water ways listed as impaired or threatened. Increased urban runoff pollution coupled with aging systems earned stormwater infrastructure a letter grade of "D" on the 2021 American Society of Civil Engineers Infrastructure Report Card. Stormwater quality management is difficult and costly to address as State Departments of Transportation (DOTs) have limited right-of-way (ROW) to construct stormwater treatment controls. Cost and difficulty will only continue to become more challenging as our climate crisis evolves and produces more frequent and intense rain events.

This effort aims to develop an innovative practice within the ROW and support FHWA's Resiliency Research and Technology portfolio. Part of the Resiliency activity requires partnering with State DOTs and others to conduct research and develop demonstration projects to reduce impacts on streams, and other waters; recreation facilities, and habitat by addressing emerging stormwater pollutants.
This proposal seeks to develop a mechanism to remove suspended and dissolved pollutants and other emerging stormwater pollutants from highway construction and urban stormwater runoff sources. Methods may be inspired and modeled after drinking water and wastewater treatment approaches that have been proven to be effective. The proposed technology will be developed for deployment at highway stormwater outfalls to provide treatment of pollutants just prior to discharging stormwater into receiving water bodies. The system will be developed to be safe to use, cost-effective, passive, or semi-passive, portable, easy to deploy and maintain, and self-contained. This tool may address stormwater "hotspots" of highly contaminated runoff or areas that generate pollutants of high concern such as 6ppd quinone, the tire by-product that is killing Coho salmon. The technology sought in this project aligns with the Department's research priority for Sustainable and Resilient Infrastructure. Its goal is to facilitate resilient and sustainable infrastructure development without compromising the beneficial and future uses of our water bodies.

Commercialization could lead to the development of a portable system or unit that could be easily retrofit into existing stormwater infrastructure (e.g., pipes, culverts, detention basins, etc.) to provide water quality benefits. Potential buyers may include state departments of transportations, airports, local municipalities, land developers, homeowner associations, agricultural producers, and other owners of stormwater infrastructure.

Expected Phase I Outcomes

At the conclusion of Phase I, a final report will be developed to summarize efforts in the development of the stormwater treatment technology. Phase I will culminate with a design for and/or a working scaled prototype as well as design details for a full-scale device. In addition, Phase I will be used to identify partnerships with testing/research organizations that can provide independent, third-party evaluations of the full-scale device in Phase II. A detailed SWOT analysis (looking at strengths, weaknesses, opportunities, and threats), marketing strategy, and intellectual property protection plans, where applicable, will be developed. By the conclusion of Phase I, the developers will have a path towards a clear commercialization plan.

Expected Phase II Outcomes

Phase II may include the development of a full-scale prototype and evaluation using simulated runoff events in a controlled laboratory setting. The research and testing will determine effectiveness of the developed device using standard testing methods. Findings from testing may be used to seek inclusion in DOT approved / qualified product lists, which will create opportunities to deploy the device in highway stormwater management applications. In addition, results can be used toward marketing the performance of the device to potential buyers. This phase may also include fillings for intellectual property protection, where applicable.

23-FH2: Traffic Monitoring and In Situ Information Processing Using Edge Computing
Gaining real-time traffic monitoring information is critical to improving traffic safety and promoting economic growth through a safe and reliable transportation infrastructure system. Current traffic monitoring practices follow the FHWA Traffic Monitoring Guide and the AASHTO Guidelines for Traffic Data Programs.

Technologies deployed range from traditional pavement embedded sensors such as piezoelectric and electromagnetic loop material to above-ground sensing technologies such as video, radar, and lasers. The extensively deployed Transportation Management Centers rely on video, which is transmitted to the control center, where humans decipher information from the video. While these current technologies have enabled the monitoring of highway traffic flow conditions, additional challenges and opportunities are also revealed. The most significant challenges of the current technologies include two main issues. First, efficiently transmitting information captured by the sensor back to the control center is a significant hurdle, especially in rural areas. This challenge is especially true with video monitoring. Second, deciphering information from the data collected by various sensors with minimum human interference must be overcome. It is challenging for a single person to monitor half a dozen screens with live video feeds. These challenges present a golden opportunity to develop in situ data processing technologies using edge computing chip technologies. In other words, if data gathered by sensors were processed on-site per specifications, transmitting results back would be significantly more straightforward, and human interference would be significantly reduced.

The vision is to integrate the low-power consuming edge computing chip with the traditional traffic data sensors. Instead of sending the raw data back to control, the edge computing device will compute and analyze the raw data in situ. Once the raw data is deciphered, results will be transmitted back to control, significantly reducing the data transmission burden. In addition, it is anticipated that the edge computing chip can be coded/programmed with intelligence where human interference in the control can be significantly reduced.

The eventual deliverables are envisioned to include edge computing integrated traffic monitoring sensors and efficient in-site information extraction computer algorithm for the edge computing devices.
Shall this research endeavor be successful, it would transform the traffic monitoring practices with real commercialization. End users from the transportation industry may include Federal, State, and local highway agencies and any other industry and commerce where monitoring and information extraction are practiced.

Expected Phase I Outcomes

At the conclusion of Phase I, a final report will be developed to summarize efforts in the development of traffic monitoring and information processing. Phase I will culminate with design for and/or a working scaled prototype and as well as design details for a full-scale device. In addition, Phase I will be used to identify partnerships with testing/research organizations that can provide independent, third-party

evaluations of the full-scale device in Phase II. By the conclusion of Phase I, developers should have a clear path towards commercialization.

Expected Phase II Outcomes

Phase II may include the development of a full-scale prototype outlining the highly efficient edge computing codes to decipher information. Such coding shall help to identify vehicle types, speed, crash/collision, roadway conditions such as pavement condition (dry, wet, snow, etc.) and environmental condition (fog, smoke, etc.). Continuous testing and improvements to the protype design hardware with outdoor conditions for its reliability and operability improvements will be completed as well. Such conditions should include time of day lighting differences, temperature differences, humidity differences, humidity (condensation) effects, inclement weather (wind, rain, snow, fog, icing, etc.), and device power consumption and supply needs.

At the conclusion of Phase II, a fully functional and practical integrated edge-computing and traffic sensing device with accompanying software should be ready to be fully commercialized and deployable in DOT approved / qualified product lists, which will create opportunities to deploy the device in highway stormwater management applications. In addition, results can be used toward marketing the performance of the device to potential buyers. This phase may also include fillings for intellectual property protection.

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 innovations and solutions. Safety is U.S. DOT's primary strategic goal and thus, 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 include stakeholder engagement and partnerships with other researchers such as the Association of American Railroads, prioritization of projects, and conducting research through cost-effective procurement.

23-FR1: Concrete Crosstie Inspection Technology
The U.S. railroad system contains approximately 140,000 miles of track. Approximately 10% of all U.S. railroad ties are made from concrete and are used in heavy freight and passenger service tracks. These ties are typically found on higher speed passenger routes and in high tonnage lines in the freight rail industry. Many of these crossties have been in service for decades. Understanding the state of good repair of these essential track components is critical to efficiently maintaining track safety. Concrete ties can fail in many ways, including brittle fracture from overloading, a loss of pre-stressing force due to fatigue or cracks, rail seat deterioration from service, and loss of section due to abrasion from ballast. This topic seeks novel technology research and development to efficiently and effectively inspect concrete crossties installed in track.

The research challenge is to develop a non-destructive technology to assess the internal and external condition of concrete railroad crossties in track. This research supports DOT goals for improving the state of good repair, safety, and efficiency. When developed and tested, this technology will allow for quantitative assessment of the condition of these critical track components ensuring the safety of rail infrastructure and preventing the premature replacement of components.

Proposed solutions shall be non-destructive and shall provide quantitative inspection data to allow for informed decisions regarding tie condition replacement. Inspection of external tie features includes: identification of surface cracks located in the rail seat area, in the center of the tie, and at the tie ends; rail seat abrasion; identification of exposed reinforcements; presence and orientation of the rail seat pad; presence and orientation of rail insulators, rail clips, and fasteners; and, tie section depth (detection of the effects of tie abrasion in the ballast). Inspection of internal tie condition includes: assessment of the amount and location of internal cracking or voids and identification of other defects related to the bond condition between reinforcements and the concrete.

A complete solution will report external and internal crosstie feature conditions in an automated manner. FRA will consider partial solutions provided the offeror presents an approach to obtaining a more complete inspection. FRA envisions the inspection system(s) will be suitable for deployment track hy-rail vehicle operating at speeds up to 30 mph. Proposed systems must include referencing capabilities to geo-locate individual ties. Technical approaches may employ more than one technology, and FRA expects the system to complete an inspection in a single pass over each tie. These technical parameters are important to ensure the inspection technology is compatible with typical rail industry inspection methods.

The FRA e-library system contains many technical reports documenting research into concrete crosstie design, manufacturing, testing, and failure modes. A few of these reports are linked here for reference:

- International Concrete Crosstie and Fastening System Survey | FRA (dot.gov)
- Improved Concrete Crosstie and Fastening Systems for US High Speed Passenger Rail and Joint Corridors: Volume 1 – Project Summary Report | FRA (dot.gov)
- Understanding the Splitting and Bursting Failure of Concrete Crossties | FRA (dot.gov)
- A Study of Environmental and Track Factors that Contribute to Abrasion Damage of Concrete Ties | FRA (dot.gov)

Expected Phase I Outcomes

Phase I efforts shall include technology investigation, selection, and initial laboratory-level proof-of concept testing. The output from Phase 1 should be a technology development plan to progress the inspection system to a more mature level. The development plan shall include a scientifically determined rationale for the technical approach, supported by laboratory test results.

Expected Phase II Outcomes

Phase II shall progress the system development in alignment with the technology development plan. FRA expects Phase II to include field testing of a prototype system in a real or simulated environment to establish technical and operational efficacy. Phase II will produce detailed test reports and an updated technology development plan.

23-FR2: Novel Design for Passenger Railcar Glazing Securement

Glazing systems on passenger railcars serve several critical functions beyond offering passengers a view outside the car. They also serve certain safety functions: impact resistance, emergency egress, emergency access, fire resistance, and occupant containment. Rail passenger car glazing systems must perform satisfactorily under competing expectations. They must allow passengers to escape in an emergency scenario. They also must allow emergency personnel to enter the car if necessary. However, trying to boost performance for one aspect often reduces the effectiveness in another, making this a difficult engineering problem to solve.

Failures of glazing retention mechanisms on passenger trains have led to multiple injuries and fatalities due to train occupant ejection in rollover-type accidents over the last several decades. A review of recent accidents has underscored the key failure mode that contributed to passenger injuries and fatalities: the failure of the outer gaskets during rollover derailments after the cars have been dragged along the ground. Once the gasket has failed, the window is pushed into the car, leaving an opening through which occupants may be ejected.

FRA is seeking design concepts which do not rely on traditional glazing securement methods and which are compliant with FRA's safety regulations related to passenger equipment glazing (specifically, 49CFR238.113 (for emergency exit windows) and 49CFR238.114 (for emergency access windows). Emergency egress/access windows and "conventional" (non-emergency egress/access) are equally challenged in a rollover derailment during which a passenger car slides on its side. Therefore, alternative solutions may be proposed for securing emergency egress/access windows and "conventional" windows.

Expected Phase I Outcomes

Phase I efforts shall include conception of technology alternative(s), selection, and initial effectiveness assessment (though analysis or other means) of one or more alternatives. The output from Phase I should be a technology development plan to progress the proposed design solution(s) to a more mature level,

including manufacturability. The development plan shall include a rationale for the technical approach, supported by preliminary analysis results.

Expected Phase II Outcomes

Phase II shall progress the design development in alignment with the technology development plan. FRA expects Phase II to include development of a prototype(s) which can be physically tested in accordance with methods acceptable to the Government and described in the research report to establish technical and operational efficacy.

National Highway Traffic Safety Administration (NHTSA)

About us: The National Highway Traffic Safety Administration's (NHSTA) mission is to save lives, prevent injuries and reduce economic costs due to road traffic crashes, through education, research, safety standards and enforcement activity.

23-NH1: Child Presence Detection CO2 Release Test Device
Leaving an unattended child in a parked automobile can lead to heat stroke and death, even if only left for a few minutes. Child deaths from automobile-related heat stroke occur with lower frequency than those that occur in traffic crashes, but the nature of these completely preventable deaths warrants special attention. A young child's inability to exit the vehicle on his/her own combined with a low tolerance for elevated temperatures requires that children never be left unattended in an automobile.
NHTSA supports a variety of research efforts aimed at the detection of children in vehicles to prevent heat stroke. This project aligns with NHTSA's Fiscal Year 2022 – 2026 (FY22 – FY26) Research, Development and Technology Strategic Plan (RD&T Strategic Plan) and the Fiscal Year 2022 (FY22) Annual Modal Research Plan (AMRP) priorities by directly addressing child presence detection system testing with the intent of reducing child heat stroke deaths and injuries.

In particular, the research will support the RD&T Strategic Plan's Vison Zero grand challenge by working to "eliminate all fatalities and serious injuries on the U.S. transportation system." In addition, the FY22 AMRP stated, "Sensor systems will be evaluated for the ability to detect unattended children and prevent heat stroke occurrence." Some Child Presence Detection Systems measure chest movement and/or generation of Carbon Dioxide (CO_2) to determine if a child is present in the vehicle cabin. In order for NHTSA to test and evaluate Child Presence Detection Systems that measure CO_2 levels, NHTSA needs test equipment that simulates a child breathing through the realistic and repeatable release of CO_2.
The Office of Vehicle Safety Research (VSR) is interested in understanding the amount of CO_2 humans generate in an enclosed or predominantly enclosed vehicle, with a particular emphasis on children. This project will aim to develop test equipment that simulates a human child breathing by releasing CO_2 inside a vehicle cabin. The awardee will have to develop the test equipment to release CO_2 and record various test parameters, like the amount of CO_2 released and the overall amount of CO_2 in the vehicle cabin.

Expected Phase I Outcomes

The Phase I outcome will include a working prototype that meets the technical and interface specifications paired with a final report. The report shall include comparisons between the CO_2 release test device and human CO_2 production in exemplar vehicles, in addition to a repeatability analysis, showing repeated test device performance against a separate NIST-traceable CO_2 ground-truth sensor.

Expected Phase II Outcomes

Phase II is expected to result in a final version of the CO_2 release test equipment that is ready for commercialization and includes a portable storage container. In addition, the Phase II final report shall include all the measurement and analysis required, including CO_2 release comparisons against human data and repeatability analysis against NIST-traceable ground-truth sensor.

23-NH2: Immersive Virtual Reality Training on Impaired Driving for Law Enforcement
NHTSA is interested in the development of new training tools that can support the agency's continuing efforts to provide law enforcement professionals the necessary training resources to identify and remove impaired drivers from our nations' roadways. Preliminary estimates show roadway deaths climbing to 42,915 in 2021, a 16 year high. Every day, about 32 people in the United States die in drunk-driving

crashes — that's one person every 45 minutes. In 2020, 11,654 people died in alcohol-impaired driving traffic deaths — a 14% increase from 2019 (NHTSA Media, 2022).

The ability of law enforcement to identify impaired drivers is a critical component to reducing fatalities involving alcohol and/or drug impairment. Impaired driving is a human factor that must be addressed to overcome the vision zero challenge to eliminate all fatalities and serious injuries on our nations' roadways. This aligns with DOT's Strategic Goal of Safety. The effects of alcohol on an individual have been researched extensively and law enforcement are trained to identify signs and symptoms associated with alcohol impairment through the basic Standardized Field Sobriety Testing curriculum, often included in the basic police academy/certification course. Law enforcement officials may later receive advanced training in the identification of impairment through the 16-hour Advanced Roadside Impaired Driving Enforcement (ARIDE) curriculum provided through the Drug Evaluation and Classification Program (DECP). Due to the complexity that comes with drug use and impairment, ARIDE is designed to introduce law enforcement officers to the identification of signs and symptoms associated with impairment from drugs other than (or in addition to) alcohol. The ARIDE curriculum also identifies the practical use of a Drug Recognition Expert, post-arrest, in Driving Under the Influence of Drugs (DUID) cases.

There is a need to make impaired driving training as realistic as practical so law enforcement can ensure they are identifying and apprehending impaired drivers' roadside. There are limitations and legitimate concerns (such as liability and harm) with dosing live individuals with impairing substances for the purpose of curriculum development. This project aims to reduce unnecessary risks of harm to individuals. Additionally, we aim to reduce monetary costs and time involved in dosing individuals for the purpose of training.

This topic aims to develop a course structure and technological approach for the purposes of training law enforcement on the behaviors associated with impaired driving. To achieve this, it is expected that subject matter expertise in the areas of drug-impaired driving enforcement will inform the training approach and material. Ideally, these subject matter experts (SMEs) should be drug recognition experts (DRE); drug recognition expert instructors; or drug recognition expert state coordinators who are familiar with the content and application of the DECP. The proposal should explain when this expertise will be introduced into the project and, when possible, by whom.

Expected Phase I Outcomes

Expected outcomes for the conclusion of Phase I are a "Proof of Concept" Final Report which presents a course design for the interactive training technology and describes the technological approach and software and hardware requirements. The project should also produce a detailed plan for the development of the software files for a wide variety of virtual drivers (varying by age, gender, race, ethnicity) that can be displayed as under the influence of various impairing drugs, combinations of drugs, and control subjects. Finally, the project outcomes must include the identification of qualifications required (i.e., DRE Instructor) to proctor the use of the interactive training technology. A proctoring instructor should be well versed in the field of DUID and current DUID curricula used to train law enforcement nationwide.

Expected Phase II Outcomes

Conditional on the outcomes of Phase I, Phase II will begin development of a market ready device for use by law enforcement officers. This device will be tested using the development plan developed in Phase I for ensuring the input responses corroborate with current DUID curricula and determining how well the device works in conjunction with user inputs. The device will be a pilot. The device must be affordable for most public safety agencies and, allow for selected proctors to use with a minimal amount of training.

The expected outcome is a demonstration of the market-ready device as well as a report that documents the testing results and contains a marketing plan.

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. This includes ensuring that PHMSA's R&D program implements the Administration's priorities through R&D investments that promote safety and environmental protection, climate change, economic recovery and rebuilding, and transportation as an engine for equity.

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 and limit environmental impact of PHMSA-regulated infrastructure. PHMSA's Office of Hazardous Material Safety 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. Because of the ubiquity of hazardous material movements, supporting the safe transport of these products will have a positive impact on safety and performance. The Office of Hazardous Material Safety seeks to improve the safety and reliability of hazardous material transportation.

23-PH1: Bioremediation for Hazardous Material Spills

Over the past 10 years, there have been close to 200,000 hazardous material (HAZMAT) incidents. Such incidents can result in human injuries, fatalities, economic losses, and environmental damage. Environmental damage and human exposure risk are of particular concern after HAZMAT spills, where spilled HAZMAT can enter soils, groundwater, surface water, or volatilize into air. Existing emergency response protocols call for containment and cleanup from the environment. Nonetheless, current cleanup methods typically focus on immediate containment and physical removal (e.g., berms, soil caps, dispersants, etc.). Though containment and physical removal are critical responses, there is less focus on short- or long-term treatment and remediation once the HAZMAT spill is contained or removed. After removal, HAZMAT may be disposed, incinerated, or recycled. Alternative and novel containment, removal, and treatment methods could reduce the environmental and safety risks of HAZMAT and further DOT's strategic goals of safety and climate change and sustainability, notably advancing DOT's Vision Zero initiative

To satisfy this need, we invite the small business to develop bioremediation solutions and applications for first response and ongoing treatment of HAZMAT spills. Bioremediation is a technique that uses living organisms such as plants, algae, bacteria, or fungi to treat contaminants. Bioremediation can also include applications of enzymes or engineered enzymes. These remediation techniques can be effective removal methods for a multitude of hazardous materials, especially when the organism can break down contaminants into less harmful substances. There is strong evidence in the academic literature for efficacy of bioremediation for different contaminants, including polychlorinated biphenyls, petroleum products (e.g., benzene, toluene, ethylene, and xylene) and even explosives. Recent studies have also demonstrated novel bioremediation delivery mechanisms such as enzyme immobilization or bio amended carbon materials.

The solution must consider containment and treatment of spills of different sizes, short-term and long-term treatment of the contaminant, environmental impact of the solution, and cost. For environmental

impact, solutions must not introduce invasive species into the environment. The solution should consider possibilities of regeneration/reuse of the remediation method or environmentally sustainable disposal or attenuation. The solution should also consider different possible spill locations (i.e., a spill in water, soil, or within a transport vessel or container). Parameters to consider would include sorption capacity of materials, time required for contaminant removal and treatment, and applicability to different contaminants.

Expected Phase I Outcomes

The expected Phase I outcome would be a proof-of-concept report that demonstrates technical feasibility of the solution (including preliminary data) and how the solution will address the specifications for this topic. Proof-of-concept could include a model for a prototype or a design report including a testing plan and mock-up for the technology.

Expected Phase II Outcomes

The expected Phase II outcomes should result in a demonstration of a working prototype of the bioremediation technology showing efficacy in HAZMAT spill test scenarios. The prototype should be developed to be close to market-ready and the deliverables would include any test data or modeling work.

23-PH2: Integrated RFID Trackers and Sensors for Hazardous Material Communication in Transportation

To transport hazardous materials (HAZMAT), packages must be appropriately labeled and marked as specified by the Hazardous Materials Regulations (HMR; 49 CFR 172.300 and 172.400). The safe transportation of hazardous materials hinges in part on the visibility of hazardous communication (HAZCOM) labels and markings. Physical labels and markings can be torn or destroyed during transit, hard to see on the package, or even obscured due to the addition of external packaging after the package is dispatched (e.g., wrapping added onto a labeled package.) Additionally, labels and markings can be inaccurate. One such example of the impact of incorrect marking is an incident where lithium batteries inaccurately labeled as "computer parts" caught on fire during shipment.[1] Visibility and accuracy issues increase risk of unknown hazards to HAZMAT transporters and incident response teams. One possible solution to visibility and accuracy issues in HAZCOM is radio frequency identification (RFID) tagging. RFIDs have unique identification and work by sending a radio frequency signal from a reader. RFID tags then respond with the identification information. RFIDs are highly popular in the retail sector for inventory management and theft prevention and have wide applicability to multiple industries. RFID is a well-developed technology, and emerging technology such as integrated sensors with RFID tagging further improves utility. Within the HAZMAT field, the Department of Energy collaborated with Argonne National Lab to develop ARG-US, an integrated RFID and sensor system that can be used to monitor radioactive waste drums in transit or at facilities.[2] ARG-US is an award-winning technology, but HAZMAT transporters have yet to widely adopt RFID technologies.

Given the success and commercialization of ARG-US for radioactive waste, we invite small business to further innovation to improve upon RFID and sensor technology for HAZMAT transportation outside of radioactive waste. Particularly, pairing RFID tagging with a sensor for packaging failure would allow for communication of otherwise unknown incidents during transport. The overall solution being sought is an integrated RFID and sensor system for HAZMAT packages in transportation that allows for secure real

[1] https://homeport.uscg.mil/Lists/Content/Attachments/77040/USCGSA_0122.pdf
[2] Argonne/DOE ARG-US Radio Frequency Identification (RFID) Technology for Tracking Nuclear Materials in Storage, Transportation (anl.gov)

time transport monitoring, clear communication of HAZMAT contents, package failure and alert, and an easy-to-use user interface.

The overall system must be modular and adaptable to the major types of HAZMAT packaging including but not limited to metal drums, plastic tanks, cargo tanks, and other bulk or non-bulk packaging. The RFID tag must be able to convey pertinent hazardous material information such as UN number, hazard class, proper shipping name, quantity, and packaging type. Size of the system should be scalable to different packages. The system must be durable to human abuse, weather (I.e., rain and heat), potential fire, and impact. The system should include an active RFID (powered system that can continually transmit data) while maintaining a low cost.

This topic supports two of the OST-R Grand Challenges: Resilient Supply Chains and Transportation System-of-Systems of the Future. This technology has the potential to enhance resiliency in supply chains by improving timely and accurate data on goods location and movement. It also targets the Transportation System-of-Systems of the Future Grand Challenge by developing integrated sensor and communication systems.

Expected Phase I Outcomes

The desired Phase I deliverable for the RFID trackers and sensors technology would include a research report to demonstrate technical feasibility of the RFID tracker and sensor system on HAZMAT packaging and show a path toward a prototype in Phase II.

Expected Phase II Outcomes

The expected Phase II outcomes would be a hardware/software demonstration, test results from different types of packaging and packaging failure, with delivery of a technology and/software package at the completion of the Phase II contract.

23-PH3: Portable State-of-Charge Sensor for Lithium Batteries

The use of lithium batteries continues to rise over recent years, especially as demand grows for electronic devices, vehicles, and scooters/bikes. As usage grows, so do concerns of lithium battery safety due to incidences of battery fires. To minimize or prevent occurrence of battery fires, there is a great need to monitor battery health and state-of-charge (SOC). Lithium batteries at lower SOC are less likely to enter thermal runaway and cause fires. However, current methods of measuring battery health and SOC are either proprietary (e.g., battery management systems produced by manufacturers), require destruction of the battery, or are not easy to implement. Thus, there is a need for a non-destructive sensor capability to effectively monitor SOC for lithium batteries during shipment.

There have been recent advances in non-destructive magnetic imaging techniques to measure SOC.[3] Such techniques can measure damage due to mechanical impact or overcharging in addition to SOC. Further advancement of such methods to reduce form factor of the sensor, scale up sensing capabilities to larger batteries, and maintain low costs would allow for effective SOC monitoring.

The goal should be to create a handheld device that allows the user to quickly test the state of charge or amount of energy within any size of lithium-ion battery.

[3] Sensitive magnetometry reveals inhomogeneities in charge storage and weak transient internal currents in Li-ion cells | PNAS

This device will promote the use of Lithium Ion Batteries while reducing the likelihood of an accident, advancing the RD & T Grand Challenges of Vision Zero and Net Zero Emissions.

Expected Phase I Outcomes

The expected Phase I outcomes for the proposed technology would include a report detailing the research of the technology and describing the technical feasibility. The report would also have to show a path toward Phase II which would include a technology demonstration with delivery of a workable prototype of the technology at the completion of the Phase II contract.

Expected Phase II Outcomes

Phase II outcomes will include taking the research and knowledge from Phase I and to further research the technology resulting in the development of a prototype for user testing that would lead to a possible commercialization.

23-PH4: Wearable PPE-integrated Sensors for First Responders

First responders to hazardous material (HAZMAT) incidents face many safety risks daily. Some risks, such as exposure to hazardous chemicals and toxic gasses, can be difficult to detect. Without information on real-time exposures, first responders are at a higher risk of injury or harmful exposure. Current detection methods (e.g., portable photo-ionization detectors for gases) for hazardous material exposure can be costly, difficult to transport, and not effective at detecting multiple hazards. One promising research area is wearable sensors, including small form-factor badge sensors or clothing-integrated sensors. Wearable sensors have been developed for measuring physical exertion, heart rate, stress, and other variables. [4]

Though we have seen some advancements in wearable badge-type sensors for hazardous gases, sensor technology for HAZMAT incident response lags behind sensor technology advancement in biomedical and other fields. Though badge-type sensors and watch-type sensors can be easy to wear, they also have the risk of accidental removal or detachment from the user. The frontier of wearable sensors now includes studies on clothing-integrated sensors. Clothing-integrated wearable sensors could eliminate possibility of sensor detachment during incident response.

We are looking for a small business to develop novel sensor technologies for first responders that are wearable and integrated into clothing or personal protective equipment (PPE). The sensor should be able to monitor exposure to hazardous materials (environmental, contact with PPE, or breach in PPE) and provide notifications to the first responder in advance of dangerous exposure.

The sensor technology must be integrated into first responder PPE. Sensor reading outputs or actuators must be in real-time or close to real-time. The sensor should be able to detect multiple kinds of hazardous materials (e.g., different flammable gases or liquid hazardous chemicals). Sensitivity of the sensor should be high enough to notify the first responder prior to reaching OSHA exposure limit thresholds.[5] The clothing/PPE-integrated sensor should also be durable, reusable, and low cost. This topic fits into two Grand Challenges from the Office of the Assistant Secretary for Research and Technology. The first relevant Grand Challenge is "Vision Zero"; this topic targets the desired outcome of "work zones operate safely, and the safety of our transportation workers and first responders is assured. "The second relevant

[4] Wearable Sensing Technology Applications in Construction Safety and Health | Journal of Construction Engineering and Management | Vol 145, No 11 (ascelibrary.org)

[5] Permissible Exposure Limits – OSHA Annotated Table Z-1 | Occupational Safety and Health Administration

Grand Challenge is “the Future Transportation System-of-Systems"; this transformative research topic touches on advanced materials and sensor technology to help inform rapid decision-making and first responder safety.

Expected Phase I Outcomes

The expected Phase I outcome would be a detailed proof-of-concept report detailing technical feasibility, description of proposed prototype design and functionalities, and how it can be integrated into first responder PPE. Technical parameters and specifications above should be fully addressed in the report.

Expected Phase II Outcomes

The expected Phase II outcomes include a demonstration of a working prototype, report including stakeholder input on prototype, technology results, and a marketing plan.