Description

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 2020 (FY20) 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 FY20 solicitation is from January 6, 2020 through January 29, 2020 at 5:00 pm Eastern Time (ET). Full descriptions of U.S. DOT's proposed FY20 Phase I solicitation research topics can be found in **Appendix A: U.S. DOT SBIR Proposed FY20 Phase I Research Topics**.

During the pre-solicitation period, technical questions concerning the proposed research topics must be directed to the U.S. DOT SBIR Program Office via email at DOTSBIR@dot.gov. Questions shall be limited to specific information related to improving the understanding of a particular topic's requirements. Telephone inquiries or meeting requests will not be addressed.

Potential offerors should not seek advice or guidance on its solution to any given topic nor submit any materials other than questions(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. The U.S. DOT SBIR Program Office intends to publish all questions and corresponding answers to the public.

Technical questions regarding the research topics will be accepted only during the pre-solicitation period (January 6, 2020 through January 29, 2020). Technical questions will not be accepted after 5:00 pm ET on January 29, 2020. Only questions received by email to the website cited above prior to the deadline will be compiled by the U.S. DOT SBIR Program Office and sent to the U.S. DOT research topic authors for response. Answers to these questions will be available on the U.S. DOT SBIR Program website (https://www.volpe.dot.gov/sbir) when the U.S. DOT FY20 SBIR Phase I solicitation is released on or about February 6, 2020.

Additionally, potential offerors will have the opportunity to ask questions in person with many of the U.S. DOT research topic authors and U.S. DOT SBIR Program Office personnel at the Transportation Research Board (TRB) Annual Meeting (http://www.trb.org/AnnualMeeting) in Washington, D.C. January 12-14, 2020. U.S. DOT SBIR Program Office personnel will be at booth #835 in the exhibit hall and will be available to answer questions about the program January 12-14. Many of the topic authors will be available at the booth for questions pertaining to their topics January 13-14 during limited times. A schedule and further details are available at https://www.volpe.dot.gov/sbir. Please note that questions asked during the TRB meeting will not be documented, unless the questions are also submitted by email to DOTSBIR@dot.gov. The Government, however, reserves the right to use any information received during the TRB Meeting to clarify or otherwise promote the SBIR solicitation to be issued.

The U.S. DOT anticipates release of its FY20 Phase I solicitation on or about February 6, 2020. An informational webinar about the solicitation and new program changes is tentatively scheduled for February 11, 2020 at 1:00 pm 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 FY20 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 FY20 research topics are listed on the following page.

Full descriptions of each research topic are included in Appendix A.

Federal Aviation Administration (FAA) topic:

20-FA1: Nondestructive Evaluation (NDE) of Critical Nickel Turbine Engine Parts

Federal Highway Administration (FHWA) topics:

20-FH1: Physical Intervention System for Wrong-way Driving on Ramps

20-FH2: Innovative Layered Composite Metal Deck System

20-FH3: Real-time Monitoring and Modeling of Scour

Federal Railroad Administration (FRA) topics:

20-FR1: Autonomous Track Inspection Technology

20-FR2: AI-Aided Machine Vision for Grade Crossing Safety

20-FR3: Platform Edge Proximity Detection to Prevent Inadvertent Passenger Car Door Opening

20-FR4: Crushed Aggregate Gradation Evaluation System

National Highway Traffic Safety Administration (NHTSA) topic:

20-NH1: In-Vehicle Occupant Detection System

Pipeline and Hazardous Materials Safety Administration (PHMSA) topics:

20-PH1: Development and Validation of Inline Inspection (ILI) Technologies for Circumferential Anomalies and Bending Stresses

20-PH2: Internal Repair of Steel Transmission Pipelines

20-PH3: Geohazard Identification and Quantification for Pipeline Risk Models

20-PH4: Scaling up of Composite Metal Foam Manufacturing for HazMat Packaging

Appendix A: U.S. DOT SBIR Proposed FY20 Phase I Research Topics

Pre-Solicitation Material

Agency	#	Titles
FAA	FA1	Nondestructive Evaluation (NDE) of Critical Nickel Turbine Engine Parts
FHWA	FH1	Physical Intervention System for Wrong-way Driving on Ramps
FHWA	FH2	Innovative Layered Composite Metal Deck System
FHWA	FH3	Real-time Monitoring and Modeling of Scour
FRA	FR1	Autonomous Track Inspection Technology
FRA	FR2	AI-Aided Machine Vision for Grade Crossing Safety
FRA	FR3	Platform Edge Proximity Detection to Prevent Inadvertent Passenger Car Door Opening
FRA	FR4	Crushed Aggregate Gradation Evaluation System
NHTSA	NH1	In-Vehicle Occupant Detection System
PHMSA	PH1	Development and Validation of Inline Inspection (ILI) Technologies for Circumferential Anomalies and Bending Stresses
PHMSA	PH2	Internal Repair of Steel Transmission Pipelines
PHMSA	PH3	Geohazard Identification and Quantification for Pipeline Risk Models
PHMSA	PH4	Scaling up of Composite Metal Foam Manufacturing for HazMat Packaging

Below is a list of the U.S. DOT's proposed research topics for the Fiscal Year 2020 Phase I Solicitation. Information on each operating administration participating in this year's solicitation is provided as an introduction to the topics proposed during the pre-solicitation period.

Federal Aviation Administration (FAA)

About Us: The FAA William J. Hughes Technical Center (Technical Center) is one of the nation's premier aviation research, development, test and evaluation facilities. Its world-class laboratories and top-notch engineering place the Technical Center at the forefront of the FAA's challenge to modernize the U.S. air transportation system. The Technical Center serves as the FAA national scientific test base for research and development, test and evaluation, and verification and validation in air traffic control, communications, navigation, airports, aircraft safety, and security. The Technical Center is the primary facility supporting the nation's Next Generation Air Transportation System, called NextGen.

Topic FA1 - Nondestructive Evaluation (NDE) of Critical Nickel Turbine Engine Parts

A commercial airliner recently suffered an uncontained turbine engine failure which was attributed to the existence of an undetected melt–related anomaly known as a "Dirty White Spot" (DWS). A DWS is an anomaly that can occur during vacuum melting of superalloys. This anomaly is characterized by areas having grains larger than those of the surrounding alloy matrix accompanied by clusters of oxides, nitrides, carbo-nitrides particles and/or other inclusions. If an inclusion cluster is sufficiently large, a crack could initiate and grow under service loading, leading to an uncontained disk failure as in the aforementioned case. In order to prevent further such failures, the Federal Aviation Administration (FAA) is seeking innovative methods to perform nondestructive evaluation (NDE) of nickel alloys during the billet and forging stages to detect and prevent DWS anomalies from entering service in critical life limited parts. Of particular interest is an NDE method that could inspect and detect DWS anomalies as small as approximately 0.005 inches long in nickel billets of 8, 10, and 12- inch diameters.

If proven successful, the NDE method would be a useful technique for nickel billet producers to detect and remove anomalies like DWS. It is also expected that engine manufacturers could benefit from this NDE method as a way to further validate the quality of their nickels materials before the billets are forged and machined.

Expected Phase I Outcomes

The goal of Phase I would be to identify a viable prototype NDE conceptual design to inspect nickel billets and to produce a proof-of-concept report that details the design of the system, including an analysis of the benefits provided over current practices. Prospective small business offerors should establish working relationships with a turbine engine manufacturer (OEM) and a premium nickel melter to ensure that the proposed NDE method is a viable replacement for the current production inspection practice. Offers should include a commitment letter from these entities to document this working relationship or prospective working relationship.

Expected Phase II Outcomes

Building upon a successful Phase I proof-of-concept, the goal of Phase II would be to develop and demonstrate the prototype system on nickel test billets provided by the FAA and transition into a melter's facility for further refinement, validation, and completion of a probability of detection/false call reliability assessment.

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.

Topic FH1 – Physical Intervention System for Wrong-way driving on ramps

Wrong-way driving (WWD) is the act of driving a motor vehicle against the direction of traffic. It may occur due to driver inattention, impairment, purposely, insufficient or confusing road markings or signage. WWD is a serious problem on freeways because of the high speeds involved. In the United States, WWD crashes result in 300 to 400 people killed each year on average, representing approximately 1 percent of the total number of traffic related fatalities that occur annually.[1] While this is a small percentage overall, because WWD crashes involve head-on or opposite direction sideswipe crashes at high speeds, they tend to be relatively more severe than other types of crashes.

To date, mitigation activities have focused on passive enhancements, such as oversized and redundant static signs and pavement markings, and dynamic systems grounded in intelligent transportation systems (ITS) that provide positive detection and activation of flashers, blank-out signs, etc. There are also small geometric changes to ramp terminal intersections that can mitigate the potential for wrong way maneuvers. However, despite all of this, WWD crashes continue to occur. In the past, physical intervention has been dismissed due to myriad concerns, including system durability and reliability, as well as trading off one crash scenario for another. At this time, it would be worth reconsidering whether some type of physical intervention system that could stop a wrong-way vehicle before it enters the mainline is feasible and could function as the "last line of defense".

Such a system would:

- Be directed only at vehicles driving the wrong-way and at a high speed, since most drivers who enter a divided highway or ramp in the wrong direction correct themselves by turning around when they realize their travel direction; however, when there is impairment or drugged driving, drivers may not correct themselves.
- Need to ensure that it won't disable vehicles driving in the proper direction of traffic under any circumstances.
- Be able to be disconnected in case a ramp needs to be used to evacuate a freeway due to other circumstances and traffic would be directed to drive the wrong-way on purpose for evacuation purposes.
- Include some type of final warning system to the driver before deployment.

This topic would benefit safety, operations and law enforcement.

Potential buyers are owners of state and interstate roads. The traveling public would benefit from this system as to avoid facing a wrong-way driving car.

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[1] https://safety.fhwa.dot.gov/intersection/other_topics/wwd/

Expected Phase I Outcomes
The expected outcome for Phase I is a proof-of-concept report that describes a framework of what the system would look like, along with a prototype design or sample to demonstrate technical feasibility.

Expected Phase II Outcomes
The Phase II outcome should feature a system that includes the development of a market ready prototype for testing at a minimum of two different locations. These locations should be jointly agreed upon by the selected offeror and FHWA. Documentation of the system's performance will also be part of Phase II.

Topic FH2 – Innovative Layered Composite Metal Deck System

This topic involves the development and verification of an innovative layered composite metal deck system that can be used in the next generation of bridge applications for transportation; including highway, railway, transit, and/or pedestrian. What is envisioned is a modular, prefabricated, manufacturable panel that can be mass-produced within the US, and implemented in bridges supporting any mode of transportation for people, vehicles, trains, wildlife, or multi-mode applications.

Modular construction of bridges with prefabricated decks will improve the resilience of our highway network. If a bridge is lost or damaged due to natural or man-made hazard, it can quickly be returned to service with a prefabricated "off the shelf" deck panel, akin to an "interchangeable part" for automobiles.

Potential advantages of the envisioned deck system include: lightweight, prefab/modular, water-tight surface, minimization of deck joints, girder stiffening, durable/long lasting performance, rapidly constructible, and life cycle economy. In construction, potential advantages include improved safety for both the contractor personnel and the traveling public impacted by the construction, reduced traffic congestion during initial construction and in the future, and improved quality and durability as compared to conventional bridge deck construction techniques. When metal decks are combined with primary girder elements for modular, mechanized construction, further advantages can be realized. The decked girders can be erected quickly and the deck can be paved without the need for any temporary formwork. There are no overhang forms to be erected and no cast-in-place concrete, which always slows construction and introduces quality control issues in current practice. Or, the wearing surface can be shop applied which can reduce duration of field work to the minimum possible. Also, since the bridge deck has a very low dead weight, it is most practical for preassembly of the entire bridge for rolling or sliding into place by automated construction techniques and even futuristic autonomous robotic assembly.

This SBIR topic supports the US. DOT's strategic plan priorities in Infrastructure and Innovation, and the FHWA Modal Research Plan by focusing on new concepts for "Innovative Short Span Bridge Superstructures" and "Automation in Highway Construction." In addition, this research will contribute to achievement of the Department's Innovation goal through development of innovative new design alternatives for highway owners to consider when replacing highway bridges. In the longer term, it will contribute to the Department's Infrastructure goal and State of Good Repair priority through the resulting opportunities for bridge owners to maximize the return on their infrastructure construction investments. The outcome of this work will be applicable to bridges throughout the nation, including those in rural communities.

The specific solution that is being sought is a new variation of a prefabricated modular deck system that has layered design with solid metal plate exterior and bonded wearing course on the top riding surface. The deck design should include metal plates for the outside layers, with separation and composite action provided by concrete or other domestically available, flowable casting material in the core. Additionally, solutions can consider other innovative materials and methods to provide separation between layers, composite behavior, and sufficient thickness. A key requirement is that the deck must by capable to satisfy the American Association of State Highway and Transportation Officials (AASHTO) load-and-resistance factor design (LRFD) Bridge Design Specifications[2] for strength, service, fatigue, constructability, etc.

A key challenge to address is the connection to the primary girder members and joints between panels, which would commonly be needed for bridge applications. These connections must be economical and achievable with U.S. fabrication and erection capability. Also, the deck and its connections must be able to accommodate variations in geometry (profile grade and superelevation) that are commonly encountered in bridges. The target weight of the deck system is less than 75 PSF.

The opportunity for commercialization in the U.S. is very high. This system could potentially create a whole new product market for the steel, aluminum, and/or titanium industries. Further, metals material production and bridge fabrication industries could move toward mass-production and stockpiling of such materials for use on demand. The demand for this type of product could be consistent and sustain the new market since bridges for transportation infrastructure are funded through legislated, government programs. The investment into bridge infrastructure for the future will only increase from current levels. If only a small percentage of all new bridges were built with this deck system it could provide the motivation for these industries to make the commitments and capital investments necessary to mass-produce them at a cost that is competitive with current practice of concrete bridge deck.

Expected Phase I Outcomes
The Phase I project is expected to result in a proof-of-concept report that describes the evaluation of alternatives, the proposed prototype, detailed structural analysis, discussion of critical opportunities and obstacles to implementation, and a tentative plan for verification and demonstration to be done in Phase II.

Expected Phase II Outcomes
Phase II shall perform further refinement of the concept, design and fabrication of the prototype, and conduct analytical and experimental verification. The prototype will be developed in an open-source manner and with non-proprietary materials, resulting in a product that increases the amount of data available to the end users.

<u>Topic FH3 – Real-time Monitoring and Modeling of Scour</u>

Scour at highway structure foundations is a critical problem, often demanding situational assessments that drive decisions on structure resiliency during high water flows induced by extreme rainfall events. Autonomous Underwater Vehicles (AUVs) that can assess scour development during storm events and

[2] https://store.transportation.org/Common/DownloadContentFiles?id=1648

collect real time river bed profile data (i.e., bathymetry) are commercially available. Computational modelling tools can assess scour susceptibility of structures based on the combination of bathymetry, structural geometry, and flow rates. However, the marriage between the AUV and the modelling tools is lacking. Simply, tools to seamlessly convert the AUV bathymetry results into computational model input data are not available. Thus, today it is not possible to produce real time, accurate scour situational assessments.

An analogous situation is commonplace within the meteorological prediction of hurricane attributes. Real time weather data, from airplanes, bouys, satellites, and other sources, is fed into sophisticated atmospheric models. The outcome is a set of probabilistic results that indicate in near real time key attributes of the hurricane. This information is critical to decision makers charged with protecting citizens and property.

The goal of this research is to develop a working system that transfers real-time river bed (scour) and streamflow data during storm events to a computer model that can then predict critical scour development at bridge foundations. AUVs have the capability to monitor scour development during storm events and collect real time bathymetric data. Computational Fluid Dynamics (CFD) models offer the capability to model scour and predict "final" bathymetries. The challenge is to link the real-time field bathymetric data obtained by AUVs with high speed CFD models to compute erosion forces and determine probable final scour bathymetries during the storm event to inform decisions concerning infrastructure safety.

This topic is within the scope of FHWA's Geotechnical and Hydraulics Research and Technology Program. It is specifically aligned with the Scour functional area of the program.

Expected Phase I Outcomes

The Phase I project is expected to result in a proof-of-concept report that describes how bridge scour bathymetric and streamflow data during storm events collected from AUVs can be processed and used by a CFD scour model in real time. For example, the data may be sent to a national cluster computing center that operates a CFD scour model to predict river bed deformation (scour) at bridge foundations. The algorithms developed must demonstrate how large amounts of AUV bathymetric and streamflow data can be processed in real time. The data processing algorithms of the sonar data must be compatible for CFD scour modeling. The offeror must also identify which bridge owner or bridge sites will be studied for this project, including detailed knowledge of their foundation elements, USGS gage data (via https://waterdata.usgs.gov/nwis/rt), and river bathymetric data that will be used for this research.

Expected Phase II Outcomes

Phase II requires further development and refinement of the concept described in Phase I. This will include creating algorithms to convert UAV sonar data to a format that can be meshed by a CFD scour model in real time. It is projected that UAV data will also include streamflow data such as velocities and flow depths needed for the CFD scour model. Additionally, processes will be developed where multiple sequential UAV sonar scans will be used to update a CFD scour model to continuously refine the bed deformation (scour) prediction.

Another outcome of Phase II would be the development of a working system where post-processed UAV data are processed by CFD scour models in real time and provide data to inform decisions concerning infrastructure safety. The prototype system should be further demonstrated and validated either in a laboratory setting or under controlled field conditions and then finally tested at the bridge sites identified in Phase I. The final product would be a validated working system that can be used to inform bridge owners when critical scour develops during storm events. It is anticipated that the validated working system will require the collaboration with a cluster computer that operates the CFD scour model.

In summary, the final deliverable should be a validated working system that facilitates interpretation and transfer of scour bathymetries and streamflow data from an UAV during storm events to enable real time to run CFD scour predictions. The development of this system will move the state-of-the-practice toward real-time scour assessments in potentially life critical situations.

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.

Topic FR1 - Autonomous Track Inspection Technology

FRA's strategic objectives include the expansion of autonomous inspection methods to provide more frequent and cost-effective measurements and quality assessments of track condition. This Phase I SBIR topic seeks innovative railroad track inspection technologies suitable for deployment on autonomous inspection rail vehicles.

FRA has recently developed and deployed Autonomous Track Geometry Measurement (ATGMS) technology on FRA inspection vehicles DOTX225 and DOTX226, and variations of ATGMS technology are now available from commercial vendors. Additional information describing FRA ATGMS technology development and demonstration is available in the FRA e-library at:

https://railroads.dot.gov/elibrary/autonomous-track-geometry-measurement-system-technical-development-short-line
https://railroads.dot.gov/elibrary/autonomous-track-geometry-measurement-technology-design-development-and-testing

Autonomous inspection technologies offer greatly improved operational efficiency compared to traditional, manned inspection vehicles, but there are significant challenges that must be overcome to effectively deploy inspection technologies on an autonomous freight-service rail platform. These challenges include limited power availability, extended maintenance intervals, and data transfer bandwidth restrictions. As detailed in the documents referenced above, the FRA's ATGMS requires less than 200 watts of electrical power, can run for weeks without human intervention for maintenance, and uses the commercial cellular network for data transfer. The ATGMS and its power system (solar panels, batteries, and fuel cell) occupy approximately one half the volume of the boxcars (DOTX225/226) and one half of the available roof area. The remaining space is available for additional systems.

This SBIR topic seeks additional, service-proven, track safety inspection technologies for deployment on the DOTX 225/226 platform. FRA is particularly interested in non-contact technologies that will provide data to enhance the value of the track geometry data currently collected on these railcars.

Examples include, but are not limited to:

- Optical imagery or LiDAR data documenting the in-situ track condition that is suitable for post processing
- Rail Fastener detection and inspection
- Rail rolling contact fatigue (RCF) detection and severity quantification (scaling)
- Rail defect detection
- Joint bar and/or weld integrity assessment
- Ballast and/or subgrade condition assessment, including ballast height, fouling condition, mud spot detection, and track moisture content

Successful offeror(s) will demonstrate a clear understanding of the limitations and challenges associated with autonomous technology deployment in the railroad environment and will have identified a single, high value technology for integration into the autonomous platform.

Expected Phase I Outcomes

Phase I of this research will complete preliminary engineering activities necessary to assess the viability of the new technology for autonomous operation on DOTX 225/226 platforms. The proof-of-concept report will include a feasibility analysis, including risk assessment, a conceptual system design and integration plan, and a refined plan for continued development.

Expected Phase II Outcomes

Phase II will progress the technology development through design and prototype development, including laboratory and early field testing. Component and systems level testing will be completed using contractor-supplied resources. It is expected that Phase II efforts will include system integration on the DOTX 225/226 platform along with some field testing on railroad track. FRA will provide access to vehicles and rail track facilities for integration and field testing.

<u>Topic FR2 – Artificial Intelligence (AI)-Aided Machine Vision for Grade Crossing Safety</u>

A vehicle or person is struck by a train every three hours.[3] Highway-rail grade crossing safety is of the utmost importance to both the Federal Railroad Administration (FRA) as well as the Federal Highway Administration (FHWA). Additionally, strategic objectives of the FRA include the expansion of autonomous inspection methods to provide more frequent and cost-effective assessments of railroad infrastructure, including highway-rail grade crossings. This Phase I SBIR topic seeks an innovative artificial intelligence (AI) aided approach for autonomous highway-rail grade crossing inspections using locomotive forward-facing cameras.

Locomotives are equipped with forward-facing cameras that provide a clear view of what is in front of the locomotive as it is in operation. The video obtained from these cameras can provide an opportunistic source of information regarding the current condition of infrastructure as it relates to highway-rail grade crossings, including crossing gates and pavement markings as well as other safety-related characteristics, such as unhindered line of sight in either direction. It is critical for pedestrian and driver safety that warning devices are properly functioning and in a state of good repair. This topic seeks to develop an advanced machine-vision approach using commercially available AI-based technologies for inspecting these crossings to ensure compliance with regulations under 49 CFR Part 234 – Grade

[3] https://www.fra.dot.gov/Media/File/1179

Crossing Safety. The objective is to apply such an approach to video footage from the locomotive forward-facing cameras to observe and report on the current state of infrastructure at highway-rail grade crossings. Various characteristics of the grade crossings should be detected and assessed, including, but not limited to: presence and condition of crossing gates, other warning devices, required signage, pavement markings, adequate sight distance for pedestrians and drivers alike, etc. It is expected that the technology will accurately and precisely geolocate the crossing and will reference information (e.g., DOT crossing inventory number) in the Grade Crossing Inventory System[4] as necessary. This technology development project aligns with the U.S. Department of Transportation's strategic goals[5] for Safety and Innovation by advancing technology that improves the efficiency of safety inspections on our nation's highways and railways.

Successful offeror(s) will demonstrate a clear understanding of not only the regulations associated with highway-rail grade crossings but also the limitations and challenges associated with autonomous technology deployment in the railroad environment. The selected offeror(s) will have identified a single, high-value technology for development and will be expected to partner with an operating railroad for access to relevant data and resources necessary for the successful completion of this project.

Expected Phase I Outcomes

Phase I of this research will complete preliminary engineering activities necessary to assess the viability of the new technology for autonomous operation on locomotive-based platforms. The proof-of-concept report will include a feasibility analysis, including risk assessment, a conceptual system design and integration plan, and a refined plan for continued development.

Expected Phase II Outcomes

Phase II will focus on the design and development of a market-ready prototype for laboratory and early field testing (to establish operational capabilities and limitations) and possible commercialization. It is expected that the laboratory and early field testing will be undertaken by the selected offeror in partnership with an operating railroad, which can potentially provide access to equipment and an appropriate field location for testing purposes. Alternatively, the FRA maintains the Transportation Technology Center in Pueblo, Colorado, which houses grade crossing equipment adjacent to non-revenue railroad track allowing for safe, controlled testing of new technology.

Topic FR3 – Platform Edge Proximity Detection to Prevent Inadvertent Passenger Car Door Opening

FRA and passenger railroad operators share concern for the safety of the travelling public. Recent incidents have occurred in which a passenger train is stopped at a station with high-level platforms and the side doors have opened on the incorrect side, resulting in at least one passenger falling out of a train onto a live track. Other similar circumstances can occur when long trains stop at stations with short platforms. In this case, side doors may open where no platform exists. Since 2014, one of the more frequent reports received by one passenger railroad operator via the Confidential Close Call Reporting

[4] The Grade Crossing Inventory System data can be accessed via https://safetydata.fra.dot.gov/OfficeofSafety/publicsite/crossing/xingqryloc.aspx

[5] U.S. DOT Strategic Plan for FY2018-2022: https://www.transportation.gov/sites/dot.gov/files/docs/mission/administrations/office-policy/304866/dot-strategic-planfy2018-2022508.pdf

System (C3RS)[6] has been related to side doors opening in cars positioned beyond the platform limits. These situations clearly pose safety risks, the mitigation of which is the subject of the proposed research.

FRA seeks technology (low-cost and possibly off-the-shelf) which could be adapted to permit detection of a platform edge and interface with door control circuitry and/or trainline to permit doors to open only when a platform or temporary “bridge plate” is present. The hardware will be required to be sufficiently robust to function properly under the adverse conditions (snow/ice/dirt/cold/heat) present in the railroad environment. Since the door control function is safety-critical, the proposed system will be required to be fault-tolerant, experience low rates of false detections and be able to be overridden should the need exist. The proximity detection system should be conceived with the goal of eventually interfacing with modern rolling stock with digital trainlines, although FRA expects that the detection features of the system will also be compatible with legacy equipment that uses discrete (analog) trainlines.

FRA has identified one passenger railroad operator who will provide controlled access to stations, platforms and rolling stock to permit familiarization of a successful offeror with the typical layout and arrangement of trains, track and platforms to facilitate understanding of the operating environment and existing physical constraints.

Expected Phase I Outcomes
Phase I of this research will complete preliminary engineering activities necessary to identify, assemble, configure and assess the viability of the new technology to detect the presence of platform edges and temporary “bridge plates”. Outcomes will include a bench prototype of the hardware and a proof-of-concept report which provides an analysis of the feasibility for installation on in-service rolling stock, including a risk assessment, a conceptual system design and integration plan, and a refined plan for continued product development.

Expected Phase II Outcomes
Phase II will advance the prototype to a state in which it could be mounted on hi-rail equipment for the purposes of demonstrating the detection capability and identifying any environmental or physical barriers which might impede detection performance. Once successful, the prototype will be installed on an actual railcar and subjected to field testing on an out of service segment of track. FRA will facilitate access to an appropriate site and rail vehicles for these demonstrations. The site will be located in the New York/New England geographical area.

Topic FR4 – Crushed Aggregate Gradation Evaluation System

Crushed aggregate is used as railroad ballast, road base, drainage layers, and embankment stabilization material. The gradation affects the performance of the aggregate in each of these applications. From fouled ballast to contaminated and plugged drainage systems it is often necessary to assess the gradation and level of contamination during inspections. Contamination of uniformly graded crushed stone is often detrimental to the material’s performance and is the focus of this SBIR topic.

[6] https://railroads.dot.gov/elibrary/confidential-close-call-reporting-system-c3rs-lessons-learned-evaluation-final-report

Once uniformly graded aggregates are contaminated with finer material, the ability to drain water is inhibited leading to reduced shear strength when saturated. An optical system or other rapid, hand-held imaging, photographic or other sensing technology is sought to quantify the level of contamination or percent of void space filled to help estimate the degree of gradation change. The technology sought is the development of a combined sensor and smart phone application that can analyze the data and develop an estimate of change in void space or other parameters that can be associated with change in gradation. Ideally, but not limited to, this technology would utilize the camera in the smart phone to make an initial assessment using the application developed. Other measurements or alternative measurements may also be utilized as needed.

Expected Phase I Outcomes
During Phase I, the outcomes expected from this topic would be the proof-of-concept and design for the (1) development of the application and (2) linking the application to the smartphone camera for initial testing. The logic to associate various levels of contamination to change in void space or gradation must also be defined. At the end of Phase I, it is expected that the application would be developed and the recommendation for any other measurements in addition to the camera would be made.

A report and presentation describing the technology, the correlation of the system response to aggregate performance, and a description of the envisioned field unit and applications will be required.

Expected Phase II Outcomes
The expected Phase II outcomes include finalizing the measurement technology and logic linking the measurements to the gradation changes. In the final system, the application will locate the measurement using GPS technology and store the location with the test data and results. The final system will be demonstrated on several unknown aggregate conditions in a blind evaluation and the system will be demonstrated in the field at appropriate test sites. The awardee will be encouraged to have a railroad participate in the testing.

A report and presentation at FRA is expected during Phase II along with two (2) technical papers documenting the test results.

National Highway Traffic Safety Administration (NHTSA)

About Us: NHTSA research efforts are primarily comprised of programs within the Office of Vehicle Safety Research and Office of Behavioral Research and support U.S. DOT's and NHTSA's safety goals by conducting research and safety testing of motor vehicles and motor vehicle equipment as well as research supporting behavioral countermeasures to reduce the occurrence of traffic crashes.

The Office of Vehicle Safety Research (VSR) performs testing and research related to vehicle electronics and emerging technologies, advanced driver assistance systems for crash avoidance, human factors, and crashworthiness/human injury research. Research efforts include technologies that aim to address common crash problems on U.S. roadways as well as research addressing unsafe driver behavior including distracted and impaired driving. In addition, VSR conducts testing and research on the reliability of complex safety-critical electronic control systems, vehicle cybersecurity, and develops new test tools and countermeasures to improve vehicle crashworthiness. The Office of Behavioral Safety Research directly supports the Department and Agency goals of reducing traffic crashes, fatalities, and injuries by providing the scientific basis for the development of effective behavioral countermeasures to reduce the occurrence of traffic crashes. The Office focuses on unsafe driving behaviors that contribute significantly to death and injury from crashes on the Nation's highways, evaluates the relative effectiveness of programs to reduce highway fatalities and injuries, and assesses existing and emerging highway safety problems.

Topic NH1 - In-Vehicle Occupant Detection System

There are isolated systems that currently provide incomplete information about vehicle occupants. For example, load cells in the seats, belt use sensors, and seat position sensors can estimate the occupant size and position to a limited degree. A single high-resolution camera could address much of what is unknown about occupant size, position, and safety belt use or misuse. This information could be used in automated driving systems (ADS) to customize the passive safety systems (re-position seats, deploy custom inflatable restraints). In the transition to full ADS systems, when some driver input is required, the video analysis can detect driver distraction.

This effort will focus on technical feasibility and developing capabilities towards understanding the vehicle interior environment, leading to short- and long-term benefits described below.

Approximately 40 children die each year as a result of being left unattended in vehicles, especially in summer. A vision-based system (or alternative systems proposed by the vendor) that detects occupancy and movement at all seating locations is an example of a technology that could be implemented in the short-term to address this critical safety need.

In the longer-term, the technology developed for road vehicles can be used to monitor the environment in all modes of transportation, like aircraft, surface transport, control centers for key infrastructure like building security, powerplant control room, etc. Wide applicability of image processing, refined by machine learning using diverse data collected from naturalistic driving studies, will open this to the possibility of commercialization once societal concerns on data privacy and security have been addressed.

Using high resolution in-vehicle camera views (or alternative systems proposed by the vendor), this topic seeks the development of a comprehensive in-vehicle system capable of addressing a variety of functions beyond the single factor (e.g., weight sensors) detection of unattended children. Possible functions may include:

- Detect occupant(s) presence: prevent lockout (don't lock the doors with engine running and no occupancy), lock-in of children (don't lock the door with engine running and only children in the vehicle)
- Detect and warn for unattended children
- Recognize occupants: adjust personalized interior settings
- Detect seat belt (non)-use, misuse
- Detect out-of-position occupants (leg on dash!)
- Detect drowsy driver
- Detect distraction: eyes/hands
- Detect medical condition: cardiac (cameras can detect heart rhythm).

Prior experience in image analysis or other occupant detection systems will be considered in selecting the vendor.

Expected Phase I Outcomes
The Phase I proof-of-concept report should include market research and a feasibility study of available technologies that can be integrated for development of a comprehensive in-vehicle occupant detection system including features of: data/image/video collection, real-time analysis, storage, and verification. Data/image/video quality, CPU requirements, data sources, and software capabilities should be examined with the proof of concept report presenting the recommended approach.

Expected Phase II Outcomes
Phase II will fund the development of the in-vehicle systems. The hardware will be installed on a government provided vehicle. The awardee will collect the video data for training and machine learning. The performance of the hardware and software will then be evaluated by the awardee in some limited controlled environments.

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 Office of Pipeline Safety regulates products going through the nation's pipeline infrastructure. The U.S. pipeline infrastructure is the oldest and largest in the world, spanning over 2.8 million miles, and is the primary means of transporting natural gas and liquid petroleum products in the U.S. Because of the significant economic importance and safety consequences of energy pipelines, research projects to improve safety and performance are necessary. Engaging stakeholders- including the public, academia, and industry- is imperative to ensuring such research is effective. The Office of Pipeline Safety funds research improving safety, supply reliability, productivity, and security and mitigate environmental impact. The Office of Pipeline Safety is seeking to support these efforts through topics PH1, PH2, and PH3.

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, support 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 through topic PH4.

Topic PH1 - Development and Validation of Inline Inspection (ILI) Technologies for Circumferential Anomalies and Bending Stresses

Collectively, PHMSA and industry have invested heavily in improvements to inline inspection (ILI) technology in order to identify accidents or incidents before they occur. However, preliminary research funding was limited for circumferential cracking detection and characterization cracking in dents (particularly bottom side), creating a gap for additional R&D, due to the costs to bring circumferential crack technology to market. PHMSA is preparing regulatory requirement for pipeline operators to be able to detect several features, including circumferential cracking. This technology will help support that requirement.

This project should develop and validate advanced ILI technology in compliance with American Society of Mechanical Engineers B31G[7] and RSTRENG[8] to fill this gap. The project should also quantify bending stresses, including those contributions from geotechnical and environmental conditions. To ensure proper application of a solution, the analysis of government and industry data to benchmark current practice should factor into ILI pull tests with non-destructive testing and destructive testing. The effects

[7] https://www.asme.org/codes-standards/find-codes-standards/b31g-manual-determining-remaining-strength-corroded-pipelines
[8] https://www.technicaltoolboxes.com/products/rstreng/

of temperature changes and thermal variability on pipelines with regard to stress added should also be evaluated.

Expected Phase I Outcomes

The Phase I proof-of-concept report is expected to describe the feasibility of and methodology for development of an instrument/tool deployable for field testing solutions that can obtain circumferential anomaly and bending stresses. A methodology to validate results is expected.

Expected Phase II Outcomes

The Phase II outcomes will result in a prototype and validation that is expected to lead to full scale initial field tests of a commercially feasibly solution in terms of manufacturing and implementation. This should include the completion of a field deployable prototype.

Topic PH2 - Internal Repair of Steel Transmission Pipelines

External repairs are made today by excavating around a damaged or leak site, preparing the pipe surface, and mechanically installing a repair product such as a clamp or wrap on the outside of the pipe. Welding is also a common form of repair which requires shutting off the gas to customers. Currently, repairs are performed by shutting off the gas, cutting open the pipe, and manually replacing the pipe. Some companies perform a repair using a motorized system driven through the open end of the pipe for installing an internal repair sleeve or liner. Most repairs are costly in terms of time and resources and disruptive to customers. For example, the Centreville, Virginia pipeline failure resulted in accident related expenses over $16 million.

This topic seeks solutions to perform internal inline repair of pipeline anomalies. Proposal activities should include investigation of internal repair methods for cracks: stress corrosion cracks, fatigue cracks, and weld cracks.

Expected Phase I Outcomes

The proof-of-concept report should include a study of the following:

- pipeline types (hazardous liquid or gas) that would be appropriate for the internal repair solution,
- the state of the internal pipeline wall,
- the flow conditions the tool could operate in,
- the diameters of the pipe,
- the timeframe the repair would be valid,
- the feasibility of such a tool, and
- how internal pipeline anomalies are identified and ranked for urgency of repair.

Expected Phase II Outcomes

In Phase II, a prototype tool should be developed that can be tested and validated, informed by the anomaly ranking and identification. The demonstration should include pipe with different anomalies to be repaired, different wall conditions, and different positions on the pipeline wall. Ideally, a pressure test to benchmark the quality of the internal repair would be performed.

Topic PH3 - Geohazard identification and quantification for pipeline risk models

Pipelines operate in a variety of conditions, and are subject to many risks which can be mitigated. The routes into which these pipelines are placed is a result of the operating needs, resource locations, and point of delivery, making geological hazards unavoidable. For example, there have been at least seven pipeline failures since 2016 due to geological related conditions, tens of thousands of barrels of hazardous liquids have been spilled and over 200,000 Million Cubic Feet (MCF) of natural gas released.

This research topic seeks to holistically account for the geological hazards (geohazards) facing operating pipelines and result in actionable information from threat identification. The method by which these threats are identified and the contributing risk profile to the pipeline must be considered and include leading indicators of pipeline failure, location, and contributing factors, with industry standards such as ASME B31.8S Managing System Integrity of Gas Pipelines[9] for threat identification as a reasonable basis.

Expected Phase I Outcomes

The proof-of-concept report should describe methods of data acquisition and frequency, factors identified, and their interaction to create a risk model. The report should also include a data supported framework for how the solutions would be utilized, discussion of a commercialized product, and a qualitative hazard identification by location.

Expected Phase II Outcomes

The Phase II outcomes will result in a prototype and validation that is expected to lead to a packaged risk identification system, including the model and data acquisition services to inform end users of threats and threat ranking. A field demonstration to validate the risk identification and ranking system is also expected.

Topic PH4 - Scaling up of Composite Metal Foam Manufacturing for Hazardous Materials (HazMat) Packaging

Several derailments have occurred with DOT-111 railcars transporting various hazardous materials (hazmat) that resulted in casualties or destruction. When pipeline capacity is insufficient, railcars are often used to transport flammable liquids in bulk quantities. If an incident such as a collision occurs this can lead to the destruction of people, property and the environment. While reducing derailments and collisions is certainly one half of the issue, there remains a need to improve the puncture and thermal performance of railcars and other hazmat packaging.

Tank car designs are currently constructed of traditional steels. While thicker steel tank car designs can increase puncture resistance, increased thicknesses would be heavy and cost prohibitive for rail lines.

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[9] https://www.asme.org/codes-standards/find-codes-standards/b31-8s-managing-system-integrity-gas-pipelines

Composite metal foams (CMFs) have shown incredible promise as a potential material for railcars that transport hazmat as they exhibit excellent impact and thermal resistance at a light weight when compared to traditional steel. However, this material has only begun to be developed and further development requires more resources for it to be manufactured on a larger scale. The technology requires manufacturing scale up before it can be produced on a mass scale for railcars. Additionally, railcars may not be the only application for CMFs. The offeror can propose other hazmat packaging that may be suitable for CMFs. Since CMFs exhibit excellent impact and thermal resistance while being lightweight, their use in other packaging types may be of value.

Expected Phase I Outcomes

The Phase I proof-of-concept report is expected to describe the methodology, feasibility and commercial potential of a manufacturing line that can produce 3'x3' CMF specimens that can obtain thermal performance as described in:

- Appendix B to 49 CFR Part 179 – Procedures for Simulated Pool and Torch-Fire Testing;
- the impact resistance outlined in 49 CFR 179.200 and Appendix A to Part 179 – Procedures for Tank-Head Puncture-Resistance Test; and
- other general requirements as specified in the Association of American Railroads' Manual of Standards and Recommended Practices, Section C Part III Specifications for Tank Cars, M-1002.

If the offeror proposes to use CMFs to design another packaging type, then the report shall describe how specimens/panels will be manufactured to meet the performance requirements for that packaging type as outlined in 49 CFR Part 178 or 179. The report should include a feasibility analysis of the material's acceptance by the rail industry (or other applicable industry), to include an economic analysis of current tank car material and manufacturing costs to that of possible CMF designs. This report shall also specify on which part of the railcars (or other packaging type) the CMFs would be applied to for maximum prevention of puncture and heat transfer.

Expected Phase II Outcomes

Phase II outcomes seek a manufacturing process that can produce CMFs at a large scale, making 3'x3' panels that meet the thermal performance as described in Appendix B to Part 179- Procedures for Simulated Pool and Torch-Fire Testing; the impact resistance as outlined in 49 CFR 179.200 and Appendix A to Part 179 – Procedures for Tank-Head Puncture-Resistance Test; and other general requirements as specified in AAR M-1002 Manufacturing, Standards, Recommended, Practices for Tank Cars.