Federal Railroad Administration
Office of Research, Development, and Technology

Broad Agency Announcement – BAA 2017

Appendix C – Research Topics

Note: Concept papers may be submitted at any time, through the closing date of the research topic.

Track Research		
Topic	**Title**	**Closing Date for Concept Papers**
FRA-TR-001	Innovative Methods for Measuring Longitudinal Rail Stress	May 5, 2017
FRA-TR-002	Autonomous Inspection Technology Demonstration	May 5, 2017
FRA-TR-003	Track Structure Failure Research	May 5, 2017
FRA-TR-004	Predictive Analytics for Track Inspection Optimization	May 5, 2017
FRA-TR-005	Evaluation of Track Inspection Technology Effectiveness	May 5, 2017
FRA-TR-006	Automated Relative Tie Displacement Measurement System	May 5, 2017
FRA-TR-007	Ballast Stability Detection Technology	May 5, 2017

Rolling Stock and Equipment		
Topic	**Title**	**Closing Date for Concept Papers**
FRA-RS-001	Wheel Rolling Contact Fatigue Research	May 5, 2017

Train Control		
Topic	**Title**	**Closing Date for Concept Papers**
FRA-TC-001	Evaluating the Cyber Security Needs of a Connected Railroad Industry	May 5, 2017
FRA-TC-002	Understanding Big Data opportunities in Train Control and Communications to Improve Railroad Safety and Operations	May 5, 2017
FRA-TC-003	Highway-Rail Grade Crossing Requirements for Autonomous Vehicles	May 5, 2017

Human Factors		
Topic	**Title**	**Closing Date for Concept Papers**
FRA-HF-001	Combating Fatigue in the Railroad Industry	May 5, 2017
FRA-HF-002	Human Factors Research in Vehicle and Rail Systems	May 5, 2017
FRA-HF-003	Using Social Media to Promote Railroad Safety	May 5, 2017

Track Research

Topic: FRA-TR-001

Title: Innovative Methods for Measuring Longitudinal Rail Stress

The stress state of rail is a key parameter that drives rail safety. Effective management of thermal stresses in rail is critical to preventing rail buckles and pull-a-parts. The objective of this research is to develop technologies that can accurately determine the in-situ stress state of rail. At minimum, a method to determine if the rail is in compression or tension is desired. Ideally, the technique will be able to quantify the absolute stress state of rail and identify the rail's neutral temperature (stress-free state). The system shall operate without disturbing the track structure and without prior knowledge of the zero stress state of the rail. Offerors shall demonstrate knowledge of the past research in this area and an understanding of the scientific and other technical challenges encountered in these past efforts.

Topic: FRA-TR-002

Title: Autonomous Inspection Technology Demonstration

One strategic research focus of the Track Division is the expansion of autonomous inspection technologies to provide more frequent and cost effective inspection of track condition. FRA has recently deployed Autonomous Track Geometry Measurement (ATGMS) on DOTX225. DOTX225 is a concrete-ballasted, 70 ton boxcar that collects track geometry data while operating in general freight service. FRA recently completed a successful demonstration test of the system covering 9000 miles while surveying approximately 30 different railroads. The ATGMS and its power system (solar panels, batteries, and fuel cell) occupy approximately one half the volume of the boxcar and one half of the available roof area. The remaining space is available for future expansion. This topic seeks research projects to advance autonomous inspection technology through a cooperative demonstration using DOTX225. The ideal project would demonstrate a rail flaw, machine vision, or change detection type of inspection technology in autonomous operation. This research topic is not intended to develop a new inspection technology, but to demonstrate an existing technology operating autonomously. Additional technical information on the design of DOTX225 and the ATGMS will be available to offerors with approved concept papers.

Topic: FRA-TR-003

Title: Track Structure Failure Research

This topic seeks research projects that develop technologies and techniques for predicting the progressive and/or sudden failure of track structures. This is a general research requirement that covers all aspects of track and track support structures. FRA is searching for novel, technology-based, techniques for improving rail safety through improved understanding of system and component failure modes, drivers, and timing.

Topic: FRA-TR-004

Title: Predictive Analytics for Track Inspection Optimization

In the era of "Big Data," the effective utilization of the vast amount of information available can be a significant driver for advancing rail safety in terms of accurate and reliable prediction of track-related issues before they become severely problematic. As such, the FRA is looking to artificial intelligence, combined with advanced predictive methodologies, to provide enhanced safety directed toward a future of zero rail-caused derailments, especially rail breaks. The objective of this research is to provide new knowledge, insights, and implementation tools to assist the FRA and the railroad industry in optimizing track inspection frequencies to prevent rail-caused derailments through predictive analytics, including comprehensive risk analyses and innovative machine learning algorithms for predictive modeling. This research can evolve into a larger, integrated risk management framework for rail transportation providing safety improvement strategies. This research can also result in track safety performance metrics that can be used to assess safety risks and appropriate remedial action timeframes. Offerors must demonstrate an established partnership with a Class I railroad for the acquisition of appropriate data.

Topic: FRA-TR-005

Title: Evaluation of Track Inspection Technology Effectiveness

Effective evaluation metrics for assessing new up-and-coming technologies for track inspection and measurement is of the utmost importance to the FRA and its mission of enabling safe and reliable rail transportation for a strong America. Implementation of new technologies for track inspection and measurement can greatly improve the safety of our nation's railways by providing a means for identifying potential track-related issues in a timely manner. The objective of this research is to develop a practical approach that would allow the FRA to quantify the effectiveness of a broad range of existing and emerging track inspection and measurement technology. The approach should include a process to establish a general performance measure, suitable criteria for acceptance of the technology effectiveness, and a test procedure for gathering the necessary data, including ground truth, that would determine the performance of the technology.

Topic: FRA-TR-006

Title: Automated Relative Tie Displacement Measurement System

FRA sponsored research has identified the Vertical Relative Rail Seat Displacement (VRRSD) as a precursor for the bending failure of concrete crossties. The VRRSD is measured relative to the tie center, and a concrete crosstie can fail and lose its load carrying capacity when the VRRSD reaches a few tenths of an inch. For the more flexible wood and polymer composite ties and the more resilient steel ties, VRRSD can serve as an indicator of the state of ballast deterioration. This topic seeks the adaptation of existing or development of new technologies that can conduct autonomous, real time, in track measurements of the needed data to calculate the VRRSD of all existing crosstie types. The minimal data required to calculate the VRRSD include the three-dimensional coordinates of discrete locations on the top of a tie surface representing the center and the two rail seats, respectively, in both unloaded and loaded conditions. More complete tie surface profiles in both conditions are also desirable if they can be obtained economically. The proposed technology is required to show measures that will ensure data quality and accuracy in an autonomous data acquisition process conducted in a highly dynamic and vibrant environment.

Topic: FRA-TR-007

Title: Ballast Stability Detection Technology

The FRA is interested in technology to support assessment of risks associated with ballast instability. Risks such as track stability and buckling or loss of support at critical areas like rail joints, turnouts, diamonds, and switches are the main focus. Techniques along with failure criteria and possible thresholds are needed to present complete proposals in this area, although these elements could be developed over multiple research phases.

Rolling Stock and Equipment Research

Topic: FRA-RS-001

Title: Wheel Rolling Contact Fatigue Research

Wheel failures in general lead to derailments causing severe equipment and track damage, which is a significant burden to the operating railroads. Therefore, Rolling Contact Fatigue (RCF) on railroad wheels, both in terms of causes and methods of management, is an area that needs a lot of research attention, especially given the trend towards longer and heavier trains. The FRA is interested in research proposals that can study RCF elements in further detail and suggest proper remedies, with due consideration to ongoing railroad industry research on the topic.

Train Control

Topic: FRA-TC-001

Title: Evaluating the Cyber Security Needs of a Connected Railroad Industry

Background: With the rollout of Positive Train Control (PTC) systems, US railroads are now giving consideration to more advanced train control and operation approaches which may utilize railroad-owned or commercial communication networks. These include remote interoperability and configuration management, PTC-based signaling systems, connected distributed power and energy management, and remote operated locomotives. FRA is interested in understanding the security needs of communications systems serving these potential future use cases.

Objectives: Engage with a technical advisory group of relevant railroad experts, produce a detailed communication security picture for current and future railroad operations, develop minimum recommended communication security requirements, estimate implementation cost (bandwidth requirements), and identify areas needing additional research.

Description of Research Need: The US rail system is designated a critical transportation infrastructure and needs to be adequately protected from cyber-attack. The expertise of the cyber-security research community is needed to develop a recommended rail communications security approach.

Technology Focus Areas: Train Control, Communications Systems, Cyber Security

Project Details: Up to 1 awards, $800k available budget, 6-18 month acceptable duration.

Topic: FRA-TC-002

Title: Understanding Big Data opportunities in Train Control and Communications to Improve Railroad Safety and Operations

Background: Advances in Train Control and communication technologies have created opportunities to collect railroad operational data which was not previously accessible. FRA and the railroad industry are interested in understanding the potential benefits of applying proven Big Data analytics techniques to enhance the safety and operational efficiency of the US rail industry. The goal is to understand what data is available and any potential uses for safety and operational enhancements. Examples may include analyzing network-level train movement dynamics and communication data flow for indications of potential problems, opportunities for

capacity improvement, or reduction in false Positive Train Control enforcements. It is envisioned that the data could be used to predict railroad system anomalies so appropriate measures can be taken.

Objectives: Engage with a technical advisory group of relevant railroad experts, produce a detailed feasibility analysis, operational concept, cost/benefit analysis, and identify potential areas for future research.

Description of Research Need: Data mining and Big Data analytics are relatively new sciences which have not yet been implemented in a railroad environment. Research is needed to determine if these techniques possess potential safety or operational benefits.

Technology Focus Areas: Train Control, Communications systems, Data analysis

Project Details: Up to 2 awards, $500k available budget, 6-18 month acceptable duration.

Topic: FRA-TC-003

Title: Highway-Rail Grade Crossing Requirements for Autonomous Vehicles

Background: One of FRA's key missions is improving highway-rail grade crossing safety. FRA is currently engaged with railroads and transportation agencies to develop Connected Vehicles (CV) technologies for highway-rail grade crossings. However, autonomous vehicle technology advancement is accelerating and may have different infrastructure requirements for safe and reliable negotiation of highway-rail grade crossings. FRA wishes to stay abreast of these quick-moving technologies and identify where there may be opportunities for complimentary connected/autonomous vehicle strategies.

Objectives: Engage with railroad, connected vehicle, and autonomous vehicle experts to document technical requirements of grade crossing systems to support autonomous vehicle operation. Identify complimentary requirements of connected and autonomous vehicle operation.

Description of Research Need: Grade crossing safety one of FRA's primary responsibilities. The expertise of the autonomous vehicle development community is needed to inform targeted efforts to advance grade crossing infrastructure technology.

Technology Focus Areas: Grade Crossing Safety, Connected Vehicles, Autonomous Vehicles

Project Details: Up to 1 awards, $250k available budget, 6-12 month acceptable duration.

Human Factors

Topic: FRA-HF-001

Title: Combating Fatigue in the Railroad Industry

The FRA is interested in research and pilot projects that address the railroad industry's susceptibility to the risk of injury and property damage caused by human fatigue and loss of attentiveness. This susceptibility is the result of several inevitable factors surrounding the around-the-clock operations faced by railroaders. Unfortunately, this inevitably results in irregular hours of work, long shifts, and an unpredictability of on-duty times. FRA seeks to develop interventions or solutions to mitigate the effect of these factors.

Research may address:

- Scheduling/calling systems
- Shiftwork
- Calling assignments
- Lodging conditions
- Commute times
- Sleep disorder screening and treatment
- Fatigue education
- Fail-safe technologies

Topic: FRA-HF-002

Title: Human Factors Research in Vehicle and Rail Systems

FRA seeks to improve system designs and integration of advanced technology equipment in locomotive cabs by including human capabilities and limitations in the design space for new solutions. The goal is to reduce risk of human error with the introduction of new control and display technologies in the locomotive cab and in rail operations. Research interests in the following areas include addressing rail systems design specifications for the human-machine interface, system design methodologies that include human factors, impacts of technology on human performance, and generally the impact of technology on safe and efficient vehicle and rail system operations where humans are involved:

- The increasing technological complexity and system automation and the need for improved operational procedures to ensure safe and efficient human performance
- The value of the use of simulators in a multi-simulator, integrated way that depicts the operational environment

- The role of operational full-scale vehicle simulators in system design, forensics, and operational procedures development
- Systems, processes and tools to improve rail operational decision-making
- Defining human information requirements, communications methodologies and systems to ensure effective communication within the train and between the train and external interfaces, e.g. dispatching centers
- Integration and interoperability of cab equipment and the effect of such system designs on human performance, operational efficiency and system safety
- Assessment of the effects of operating cab automation, display integration, and information flows on human performance
- Risk assessment and prediction of the unintended consequences of advanced technologies and automated technologies on human train control
- Positive Train Control (PTC) technologies and their effect on in-cab human factors, including automated train control information requirements, display designs, real-time (and latent) and information flows, and the effect of operator experience on performance
- Applicability of integrated, multi-function, synthetic, moving map, and heads-up displays to the locomotive cab and the effect of these systems on human performance, including the identification of critical system design requirements
- Impact of train and rail system technology on training and selection of personnel-skill set and aptitude determination
- Conduct research into the feasibility of improving crew communication with each other and with those that they interact (i.e. dispatchers, employees-in-charge, etc.) by using the techniques of crew resource management.

Topic: FRA-HF-003

Title: Using Social Media to Promote Railroad Safety

FRA is interested in using social media to spread its safety messages. The overall purpose is to develop a unique safety message or campaign that will grab the attention of 18 to 25-year-old drivers to alert them of the dangers associated with violating grade crossing traffic laws. Additionally, FRA would like to look at a long range plan to conduct outreach using social media

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