

# Program Progress Performance Report

Tier 1 University Transportation Center on  
Improving Rail Transportation  
Infrastructure Sustainability and Durability



University of Nevada Las Vegas  
Virginia Polytechnic Institute and State University  
University of Delaware

Submitted to

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## **ACCOMPLISHMENTS**

### **What are the major goals and objectives of the program?**

The goal of the program is to conduct research, education and technology-transfer activities to improve the durability and sustainability of railroad infrastructure in the U.S. It is forecasted that the U.S. economics will continue to grow rapidly, which will cause both intra- and inter-city travels for passenger and freight to increase significantly. Railroad will play a bigger role in carrying this demand, which will in turn expedite the deterioration of the railroad system itself faster. In addition, new railroad infrastructure such as high speed rail will be built to sustain the increasing travel demand.

The first objective of the program is to focus on four areas of research that are critical to the safety and operations of railroad systems:

- Asset Management and Performance Management
- Condition Monitoring, remote sensing, and use of GPS
- Application of new materials and technologies
- High Speed Rail Construction Methodologies and Management

The consortium universities will emphasize their research on the area they are specialized in.

The second objective of the program is to develop railroad degree granting courses, certificate programs, and short courses that can be made available to the workforce. These educational programs will be needed in the future.

The third objective of this program is to develop and conduct professional activities such as seminars and conferences through which research results can be disseminated to railroad industries effectively. Through these transfers of knowledge and technology, the railroad industry will be able to improve its productivity correspondingly.

### **What was accomplished under these goals?**

During the first six-month period, our UTC has embarked on every aspect of the UTC program: research, education/workforce development, and technology transfers. At the current time, there are nine research projects (VT and UD) ongoing, and four more projects (at UNLV) slated to start in June 2017. Each project has at least one graduate student involved. Each of the three universities offers at least one degree-granting course on railroad, covering track, vehicle and high speed rail. They also offer short courses for training and workforce development. All three universities attended major railroad meetings and conferences, leading the development of technology in railroad. They have prepared for presenting their current ongoing research work at conferences in the near-future, and have been meeting and visiting consortium universities regularly in order to monitor their programs' progress and prepare for future plans. Their accomplishments are reported university by university below.

VT:

Five research projects have started since the beginning of the UTC program:

1. Top of rail (ToR) lubricity assessment using laser optic reflective sensors
2. Detecting the on-set of track rolling contact fatigue (RCF) with ultrasonic emissions
3. Determination of Lateral Resistance of Tie Fasteners on Steel Bridge Girders
4. A Machine Learning Approach to Modeling the Dynamics of Rolling Stock [active]
5. Dynamic Analysis and Process Improvement for Tamping Practice

They are offering the course: Rail Vehicle Dynamics, to their graduate students. In addition, they are preparing to offer a course on Machine Learning applications in rail data analysis.

So far, they have attended the following conferences:

1. AAR Annual Review, 7 posters by VT, March 21-22, 2017
2. Joint Rail Conference, April 4-7, 2017, VT

They plan to attend the AREMA annual meeting on Sept. 17-20, 2017.

UD:

In this first six months, the University of Delaware (UD) has initiated two new research projects:

- Development of new generation rail wear model, which is in the data collection stage.
- Development of new generation rail fatigue model

Both projects are in the data collection stage in which they actively work with US Class 1 railroads.

It also funded final analysis in the area of track geometry degradation using the first hitting time (FHT) analysis approach (Big Data).

In addition, they are also working with the Federal Railroad Administration on two research projects:

1. Relationship Between Subsurface Track Conditions and Development of Track Geometry Defects where they employ Big Data Analysis looking at relationship between geometry defects, GPR, data, M-Rail data, etc. This project is in the data collection stage in which they are actively working with FRA and two US Class 1 railroads
2. Relationship between track geometry defects and tie condition where they are working with Georgetown Rail. This project is in the data collection stage. They are actively working with Georgetown Rail and one US Class 1 railroad

So far, UD has hired a new senior scientist who is starting on September 1, 2017. Two new graduate students under UTC fellowship will start in Fall 2017.

Education wise, UD has offered new professional education courses in summer 2017. Planning has begun for the Big Data conference scheduled for December 14-15, 2017.

UNLV:

The Call for Proposals was sent out on February 26, 2017, and 12 proposals were received on March 25. These proposals were reviewed and four research projects will be announced on June 2, 2016. These four projects are:

1. Mobile 3D Printing of Rail Track Surface for Rapid Repairment
2. High speed rail access charge for the XpressWest of Nevada
3. Developing Acoustic Technology to Detect Transverse Defects in Rail at High Speed (220 mph)
4. Development of a Platform to Enable Real time, Non-Disruptive Testing and Early Fault Detection of Critical High Voltage Transformers and Switchgears in High Speed Rail

These proposals were developed in collaboration with the California High Speed Rail Authority and the XpressWest, the high speed rail agency in Nevada. The consortium universities VT and UD have provided inputs to these four projects for their development as well.

A degree granting course on High Speed Rail was taught in Spring 2017. An outstanding seminar by Prof. Sam Labi from Purdue University on railroad infrastructure modeling was held.

The UNLV staff attended several conferences like TRB in January and the TTCI Annual Review in March. They also visited research institutes in China to develop joint research programs.

## **What opportunities for training and professional development has the program provided?**

VT:

Nothing to Report.

UD:

Working with University of Delaware Professional Engineering Outreach, the UTC at UD has provided professional courses for working railroad and transit professionals. One professional development course was offered in March 2017 and two new professional development courses to be offered this summer:

- Management Essentials for Railroad Industry

- Steve Ditmeyer, Robert Gallamore, AMZ
- March 2017 (12 attendees)
- Planning and Designing Rail Transit for Operational Performance
  - August 2017
- Rail, Rail Problems and Rail Maintenance
  - August 2017

UNLV

A 3-days seminar on Public Transportation System has been prepared for August 2017, which has been delayed to December 2017.

### **How have the results been disseminated? If so, in what way/s?**

VT:

Nothing to Report.

UD:

Result results have been submitted to two conferences for presentation:

1. Poster session at UTC Spotlight conference in Washington DC in September 2017
2. University of Delaware Big Data in Railroad Engineering December 13-14, 2017

UNLV

Nothing to Report.

### **What do you plan to do during the next reporting period to accomplish the goals and objectives?**

VT:

In the next six months, VT will continue their five research projects. They will prepare to offer a new course on railroad in 2018. Dr. Mehdi Ahmadian will give a seminar on railroad education at UNLV, and students and faculty from VT will attend the AREMA annual meeting.

UD:

In the next reporting period, UD will continue to work on the four research projects they have funded. The degree granting and training courses they are preparing will be offered in next six months. Their papers will be presented at two conferences for which their research results have

been submitted. In addition, a new research scientist will begin to work on September 1, 2017, and 2 new graduate students to begin in September 2017.

UNLV:

UNLV will conduct the four research projects they supported. In addition, it will offer the railroad course: Introduction to Railway Transportation, to ECE, ME and CEE as well. They will hold the 3-day seminar on Public Transportation Systems and the seminar by Anthony Perl, previous Chair of Rail program at TRB. UNLV will also prepare and hold a 4-day workshop on high speed rail that is open to the States. Our UTC consortium will meet in June at UNLV where Dr. Allan Zarembski will give a seminar and the researchers from UNLV will present their projects. Dr. Mehdi Ahmadian will give his seminar at UNLV in September, 2017. In addition, UNLV will give seminars on railroad at 10 high schools in Las Vegas.

All these three universities will select research projects and plan for the second year funds in the next six months.

## PRODUCTS

### Publications, conference papers, and presentations

*Journal publications:*

UD:

- S. Galvan-Nunez and N. Attoh-Okine. "A Threshold-Regression Model for Track Geometry Degradation," Submitted to Journal of Rail and Rapid Transit, 2017

*Books or other non-periodical, one-time publications:*

Nothing to Report.

*Other publications, conference papers and presentations:*

UD:

- Conference presentation: Nii Attoh-Okine "Critical Analysis of Factors Contributing to Rail Safety and Derailments in the Era of Big Data" presentation at the Big Data Risk Analysis Symposium, The Institute of Railway Research and RSSB, UK, June 14, 2017

*Website(s) or other Internet site(s)*

The website for the railroad UTC was created: <https://www.unlv.edu/railteam>

- Technologies or techniques

Nothing to Report.

- Inventions, patent applications, and/or licenses

Nothing to Report.

- Other products

Nothing to Report.

## **PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS**

### **What organizations have been involved as partners?**

VT:

Class I railroads have provided matching funds to research projects at VT.

UD:

- Organization Name: CSX Transportation
- Location of Organization: Jacksonville FL
- Partner's contribution to the project (identify one or more):
  - Extensive data for Big Data analyses activities
- Organization Name: GREX (Georgetown Rail Equipment Company)
- Location of Organization: Georgetown Texas
- Partner's contribution to the project:
  - Financial support \$50,000
  - In-kind support : Extensive Data

UNLV:

Nothing to Report.



## Have other collaborators or contacts been involved?

VT:

Class I Railroads provided inputs to the research projects at VT.

UD

- Amtrak has provided limited data
- Federal Railroad Administration has provided support and data

UNLV

- Frank Vacca, California High Speed Rail Authority, California
  - Tony Marnell, XpressWest, Las Vegas, Nevada
- Providing research topics on high speed rail.

## IMPACT

### What is the impact on the development of the principal discipline(s) of the program?

VT:

Nothing to Report

UD:

- Development of new applications in the area of Big Data. Specifically, application of the first hitting time (FHT) analysis approach to track geometry degradation as reported in the paper S. Galvan-Nunez and N. Attoh-Okine. "A Threshold-Regression Model for Track Geometry Degradation," Submitted to Journal of Rail and Rapid Transit, 2017. This approach is a probability distribution of the time at which the degradation path first reaches the safety threshold limit. The paper presents the formulation and implementation of the FHT in railway track geometry degradation using track geometry inspection data. The underlying degradation path is modeled as a Wiener process with drift and the FHT follows an inverse Gaussian distribution. The results provide a more robust representation of track geometry failure time using degradation data.

UNLV:

Nothing to Report

### What is the impact on other disciplines?

VT:  
Nothing to Report

UD:  
Potential large impact in application of Data Sciences

UNLV:  
Nothing to Report

### **What is the impact on the development of transportation workforce development?**

VT:  
Nothing to Report.

UD:  

- Opportunities for research in area of data Sciences application to railway degradation analysis and maintenance planning. (State of Good Repair) Both undergraduate and graduate students are being brought into this area under the UTC program.

UNLV:  
Nothing to Report.

### **What is the impact on physical, institutional, and information resources at the university or other partner institutions?**

VT:  
Nothing to Report.

UD:  
The program is allowing for the expansion of the Railroad Engineering and Safety Program by allowing the program to hire a Senior Scientist level person, effective September 1, 2017.

UNLV:  
Nothing to Report

### **What is the impact on technology transfer?**

VT:  
Nothing to Report

UD:  
○ First papers and international presentation based on early results of UTC program.

UNLV:  
Nothing to Report

## **What is the impact on society beyond science and technology?**

Nothing to Report

## **CHANGES/PROBLEMS**

Nothing to Report

## **ADDITIONAL INFORMATION REGARDING PRODUCTS AND IMPACTS**

**Outputs are the direct, tangible products of your research, education/workforce development, and technology transfer activities**

VT:  
Nothing to Report.

UD:

- Publication: S. Galvan-Nunez and N. Attoh-Okine. "A Threshold-Regression Model for Track Geometry Degradation," Submitted to Journal of Rail and Rapid Transit, 2017
- Conference presentation: Nii Attoh-Okine "Critical Analysis of Factors Contributing to Rail Safety and Derailments in the Era of Big Data" presentation at the Big Data Risk Analysis Symposium, The Institute of Railway Research and RSSB, UK, June 14, 2017

UNLV

Nothing to Report

**Outcomes are broader changes that are expected to result from the products**

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