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FULLY SCALABLE TRAIN BRAKING SIMULATION ENVIRONMENT

SUMMARY

Through a project funded by the Federal Railroad Administration (FRA), Transportation Technology Center, Inc. (MxV Rail) enhanced the capabilities of an existing simulation environment originally developed to evaluate braking enforcement algorithms (EAs) for Positive Train Control (PTC) applications. The new environment will enable the railroad industry to complete simulations more efficiently and will also provide a concept for on-demand simulations. These simulations will support new software functions and processes with the potential to improve the safety and operational efficiency of train control and other applications such as Interoperable Train Control (ITC), PTC, and Energy Management Systems (EMS). This enhancement was accomplished by developing a Concept of Operations (ConOps), documenting the infrastructure design, and supporting software development for a virtualized, Fully Scalable Train Braking Simulation Environment (FSTBSE).

Figure 1 shows the simulation environment currently used to model train braking performance and evaluate EAs for PTC systems. This technology was designed to improve the safety of railway operations by enforcing a train stop through application of the train air brakes when necessary. Simulation environments have been a key part of updating PTC EAs because the evaluation of their performance through field testing in real world conditions is costly and time prohibitive. However, while evaluating an EA in the simulation environment is more time and cost efficient than real world testing, each new version of an EA requires several weeks to complete. Additionally, the railroad industry has identified the need for a simulation environment capable of supporting on-demand simulations, i.e., the ability to create and run simulations based on each railroad's specific operations. Identifying the limitations of the current simulation environment and the additional needs of the railroad industry led to the development of the FSTBSE concept.

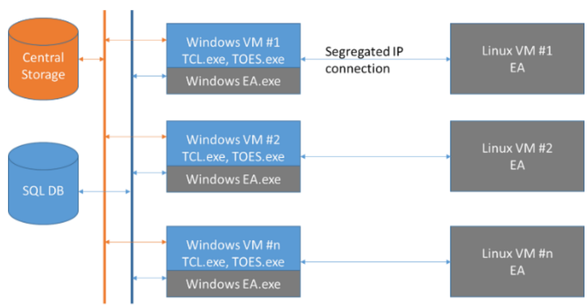

Figure 1. Current Simulation Environment

During this project, the team supported the development of the FSTBSE by:

1) Developing a ConOps for the FSTBSE
2) Documenting the infrastructure design of an environment that can support the capabilities of the current simulation environment as well as the expanded capabilities of the FSTBSE concept
3) Developing a program to convert PTC track data files to Train Operations and Energy Simulator (TOES™) track files
4) Identifying the work necessary to support the implementation and deployment of the FSTBSE in the future

This project was performed in collaboration with Railinc and an advisory group (AG) consisting of Class I and short line railroad personnel. Railinc supported the effort through implementation efforts and will host the new simulation environment.

The ConOps created during this project will be used to guide the implementation of the FSTBSE as the project continues through future phases.

BACKGROUND

PTC technology is designed to improve the safety of railway operations by enforcing a train stop through application of the train air brakes when needed. PTC applications typically use a predictive braking EA to estimate the braking distance of the train and determine when a penalty brake application is required.

PTC EA performance verification can be costly and time-consuming. As part of an FRA-funded effort, MxV Rail developed an efficient and cost-effective process for verifying EAs using the industry tested TOES program and internally developed Test Controller and Logger (TCL) software to virtually model the performance of EAs for freight operations. This process is described in previous reports [1,2].

To facilitate this process, a Monte Carlo simulation methodology was developed to perform a comprehensive evaluation of PTC EAs. The simulations included approximately 3,800 scenarios, with each scenario comprising a train consist, simulation speed, track grade, and a target speed and location. The train consists used in the simulation scenarios included a mix of unit trains (e.g., coal, tank, refrigerated box, grain, and auto-racks), mixed general freight trains, and intermodal freight trains. Each train type consisted of several different configurations for length, locomotive power (i.e., head end only or distributed power), and loading conditions. These trains were operated on grades ranging from a 1.5 percent incline to a 2.8 percent decline and run at the maximum authorized speed, as well as intermediate and slow speeds on certain grades. For each scenario, 100 Monte Carlo simulations, with consist and simulation variables selected from defined ranges and distributions, were generated to represent the real world variation of these variables for each simulation. The simulations were then executed with the results (i.e., scenario details, enforcement locations and speeds, stopping locations, and target speeds and locations) recorded and analyzed.

OBJECTIVES

The primary purpose of this project was to develop a concept, infrastructure design, and initial development tasks for a FSTBSE by:

- Identifying the use cases for running simulations in a scalable, virtualized simulation environment
- Creating a ConOps for the FSTBSE based on the use cases
- Documenting the infrastructure design to allow the FSTBSE to mimic the functionality of the current simulation environment and support the expanded capabilities of the FSTBSE identified in the ConOps (Figure 2)
- Supporting Railinc during the initial development and implementation tasks for the FSTBSE
- Developing a program to create TOES track files from existing PTC track files to support on-demand simulations
- Recording the changes needed to the TCL-EA interface specification document to support capabilities identified in the use cases and ConOps

METHODS

MxV Rail collaborated with a railroad AG to define the FSTBSE use cases to support the capabilities of the current simulation environment and identify additional capabilities. The team collaborated with Railinc to review and document the infrastructure design needed to support the FSTBSE and identify the elements of the FSTBSE infrastructure design that would be supported by Railinc. The team then developed the ConOps, which was reviewed by the AG and Railinc. Finally, the

TOES Track File Generator (TOES TFG) program was developed to convert PTC track files to TOES using sample files provided by the AG.

RESULTS

During the identification and documentation of the infrastructure design, the team identified the elements of the infrastructure and software functions required to support the concept. During this process, a cloud-based solution running in a Linux environment was determined to be the desired approach for the simulation environment. The cloud-based structure will allow Railinc to develop the infrastructure necessary to provide a scalable environment. Figure 2 depicts the proposed user interface.

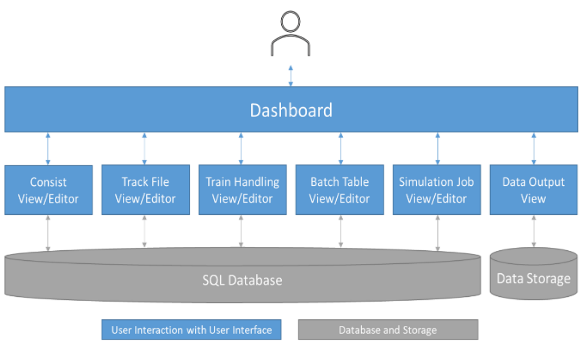

Figure 2. Overview of FSTBSE User Interface

A program to create TOES track files from existing PTC track files to support on-demand simulations (i.e., the TOES TFG program) was developed based on the existing TOES track file creation program. This expands on the program's ability to support the automated conversion of PTC track data files to a format useable in the TOES simulation environment.

CONCLUSIONS

The FSTBSE will retain the core functionality of the current simulation environment while improving efficiency and allowing users to create on-demand simulations that will allow railroads to create and run simulations based on specific operational conditions. Initially, the FSTBSE will allow users to create the desired simulation by accessing the FSTBSE through a web interface, but future phases will allow users to directly create and execute simulations in a more automated fashion through an application programming interface (API).

The TOES TFG program is a vital component of the FSTBSE, and it enables users to efficiently model routes for simulations in the system. These simulations may improve consist building, route planning, and the ability to examine in-train forces and other factors that affect operations.

FUTURE ACTION

The ConOps created in this project will be used to guide the implementation of the FSTBSE as the project continues through the next phases. Ongoing collaboration with Railinc will be required for future phases of this work to implement and deploy the FSTBSE. Phase II of the project is envisioned to provide continued support of Railinc during the initial implementation and deployment of the system, including testing of the FSTBSE functionality. Phase III of the project is envisioned to support implementation of an API that will allow users to directly import data to the FSTBSE from external sources, such as railroad back-office systems.

REFERENCES

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