**RES2016 -28: CYBER-PHYSICAL APPLICATIONS FOR FREIGHT TRANSPORTATION SYSTEMS**

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## PROBLEM STATEMENT

Freight transportation systems constitute key factors in the productivity, the environment, and the energy consumption in Tennessee, as well as beyond the state's borders. To achieve more efficient, safe, secure and sustainable transportation, the freight transportation industry is relying heavily on the use of cyberphysical (CP) applications. This involves deploying computing software/hardware to control or monitor physical components in real-time (e.g., automation, sensors, mobile technologies, GPS). CP technologies present opportunities for freight management and operations in both the public (e.g., ports, traffic operations, incident management) and private (e.g., shippers, carriers, warehouse/distribution operators) sectors. Concerns have been expressed, however, as to potential limitations to CP adoption due to issues involving information fidelity, application scalability, and acquisition/operating costs. Moreover, excessive dependency on CP systems can introduce vulnerability to accidental and intentional security breaches, a growing concern as many freight operators are shying away from investing in backup systems.

## OBJECTIVES

The objective of this research is to perform a comprehensive review of existing and anticipated CP technologies and applications, with a critical eye on their role in improving freight transportation management and operations. These technologies will be evaluated according to their performance in achieving system efficiency, safety, security, and sustainability. Communication with CP providers and users (in both the public and private sectors) will be utilized as additional sources of information. The deliverable from this effort will be a synthesis report summarizing the opportunities and challenges of implementing cyber-physical applications for freight transportation systems management and operations, including recommendations for how TDOT and the freight transportation industry in Tennessee can make the most appropriate use of this growing technology trend.

## SCOPE

Successful completion of this project will involve performing the following tasks:

**Task 1. Review of existing CP systems technologies**: We will perform an extensive and comprehensive review of the current CP systems technologies deployed in various applications of freight transportation systems. The review will consist of two phases. In the first phase, we will review the current literature to identify the state of the art of CP systems technologies in freight transportation that are deployed and

that are under development. In a second phase, we will focus our effort on communicating with CP systems technologies providers and users in the public and private sectors through interviews and surveys. In addition to learning about the current and anticipated CP systems technologies, we expect to collect information on the impact of such technologies on freight systems operations as well as their reliability and any associated risks, which will constitute a significant input for tasks 2 and 3. The second phase of this review will help identify the needs of stakeholders and as a result, opportunities where CP systems could play a role.

**Task 2. Performance metrics assessment:** We will address the effectiveness of CP system technologies in improving freight transportation systems management and operations through an analysis of freight performance objectives. We will consider both qualitative and quantitative metrics to measure the effect of such technologies. Using results from 3 the survey conducted in task 1, we will study specific examples of public and private sectors (shippers, carriers, operators) employing CP systems technologies to assess their systems performance.

**Task 3. Comparative analysis**: opportunities and challenges. We will simulate potential disruption scenarios to perform a comparative analysis of the behavior of freight transportation systems under uncertainty given CP systems technologies. Such analysis will highlight the opportunities and challenges of deploying such technologies in various applications such as real time monitoring, automated communication, and remote sensing, among others. The analysis is aimed at identifying the trade-off between the effectiveness of such technologies and their limitations. This task will be specific to a selected number of freight transportation systems and will be used to provide more generalized insights.

**Task 4. Synthesis of finding and preparation of final report**: The findings from the literature review, the assessment, and the recommendations will be synthesized into one final report to be delivered to TDOT. The report will include (1) a summary of the current state of the art in the applications, research and development of CP systems technologies, (2) an analysis of freight transportation systems performance given such technologies, (3) a comparative analysis highlighting the opportunities and challenges of deploying CP systems technologies, and (4) recommendations and suggestions for TDOT when considering such technologies for Tennessee's freight transportation system. A draft will be submitted to TDOT for comments and review before a final report is produced.

In addition to these activities, an ongoing task throughout the entire project will be coordination with TDOT to discuss study results and planned activities, report preparation, and other engagement, as appropriate. For this reason, such coordination is not listed as an independent task, but rather embedded in the performance of each of the aforementioned tasks.

**TIME PERIOD**

The proposed period for this research project will be 12 months, with an anticipated start date of August 15, 2016