Project Title: Mitigating Cascading Failures for Safety in Transportation Networks in the Era of Autonomous Vehicles

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Project Partners:

- Southwestern Pennsylvania Commission

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Project Description:

Bridge collapses, road closures, disruptions in the public transportation system, and major issues caused by autonomous vehicles (AVs) are everyday realities of our transportation infrastructure that not only cause inconvenience to the public but also constitute a major safety concern. When a particular component of the transportation system fails (e.g., due to an AV blocking a road), the failures and the associated congestion will likely be propagated to other parts of the transportation system, which may lead to further failures, and so on, potentially leading to a cascade of failures and a catastrophe in the whole city. A real-world example of this phenomenon took place on July 21, 2012, when a heavy rain shut down a metro line in Beijing and caused 100 bus routes to detour, skip stops, or cancel operation completely. Similarly, increasing deployment of AVs in the form of robotaxis by companies like Waymo and Cruise have not only led to several accidents but also events where seemingly confused AVs blocked certain roads for several hours. Cities such as Pittsburgh are particularly vulnerable to such cascade of failures and congestion propagation due to harsh weather conditions and existence of many bridges/tunnels creating bottlenecks. Given also the fact that increased congestion levels will likely lead to an increase in traffic incidents, there is a clear need for a better understanding of the impact of these cascading failures on the safety of the transportation system and the role that AVs play, both positive and negative, in them. This project aims to study the cascading effects of transportation network failures with an eye towards developing mitigation policies that maximize overall public safety. We will be particularly interested in accounting for the increased presence of AVs, both to understand their impact on initiating or amplifying these failures, and to reveal how AVs can help mitigate cascading failures. For example, our prior project supported by Mobility 21/Big Ideas fund laid out the initial work demonstrating how AVs can help reduce congestion more effectively by their ability to react in real time to vehicles around them, and their ability to be remotely and centrally controlled by fleet owners. Building on these initial results where the goal was to minimize the overall delay/congestion, this project will seek to reveal the impact of AVs on the safety of the overall transportation system. Our plan is to develop a comprehensive model that quantifies the safety impact of different failure events while taking into account the potential cascading effects. For example, a stalled robotaxi blocking an intersection in San Francisco would initially pose a safety threat to vehicles and pedestrians in its vicinity. In addition, depending on how long it blocks the road, this event may cause congestion which can then cascade to neighboring roads, potentially leading to increased accident rates in the entire city. To the best of our knowledge, this project will be developing the first set of metrics for quantifying the safety impacts of these failures with their cascading effects also included. We would like to add that this project is synergistic with our concurrently submitted proposal entitled “Evaluating Autonomous Vehicles’ Safety Benefits in Mixed Autonomy Scenarios,” where the goal is to evaluate the safety impact of AVs from the perspective of their accident rates with other vehicles and human pedestrians. The current project on other hand focuses on revealing the overall safety impact of AVs including their impact on congestion and cascading road failures.

Outputs:

Our expected deliverables include: i) a comprehensive and realistic data-driven model of how congestion propagates through different parts of the transportation network; ii) a new metric for quantifying the safety impact of cascading road failures which will be customized for autonomous vehicles iii) a comprehensive evaluation of the safety impact of current AV deployments and guidelines for changing existing policy and practices to improve their safety impact.

Outcomes/Impacts:

This work will lead to a new set of metrics for evaluating the overall safety impact of autonomous vehicles that will take into consideration the cascading road failures that AVs might initiate and/or contribute to. These metrics will enable a new perspective on the safety impacts of AVs and can help develop new policy decisions and regulations to control their increased deployment in a manner that puts public safety at the forefront. We will also build on our previous "Big Ideas" Mobility 21 project, which revealed that AVs can help reduce congestion propagation if they can be routed intelligently. Combining these insights with the newly developed safety metrics, we will deliver a comprehensive evaluation of the current safety impacts of the AVs. More importantly, we will deliver guidelines for changes in existing practices and policies that can help improve the safety impact of AVs. As our deployment and equity partner, The Southwestern Pennsylvania Commission (SPC) will aid us in identifying the policy implications of our findings as well as in identifying data sources that lay the foundation of our work. In addition, we will leverage SPC's existing public participation processes to receive community feedback on our work and ensure that the safety metrics we develop take the safety of vulnerable populations particularly into account. We will also leverage SPC's input to help ensure that the policy guidelines we are developing are meaningful from an equity point of view as well.