Center for Transportation Analysis

An Evaluation Framework for ITS Applications: Mobility, Safety and Environmental Sustainability

Emerging applications of Intelligent Transportation Systems (ITS) that utilize vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications, and that are envisioned under the Connected Vehicle Research initiative, are aimed at improving safety, mobility, and environmental sustainability. To determine the real benefits of deployed Connected Vehicle applications, justify the investment of installing sensors into vehicles and the highway infrastructure, and support knowledge transfer from the ITS research program to commercialized innovations, it is desirable to develop an evaluation framework that generates performance metrics in terms of economic, environmental and societal impacts, and supports multi-stage evaluation for gradually deployed new technologies. Given the increasing variety of ITS applications and the fast pace of technological development, a Connected Vehicle evaluation framework is suggested that will encompass existing and anticipated applications and readily adapt to rapid advances in sensing and wireless communications technologies. In addition, since the objectives of congestion mitigation, accident reduction and air quality improvement for a particular application could be consistent or conflicting with each other, it is critical to quantify the benefits that Connected Vehicle applications will provide with regard to multiple performance measures, and to assess tradeoffs among potentially conflicting objectives.

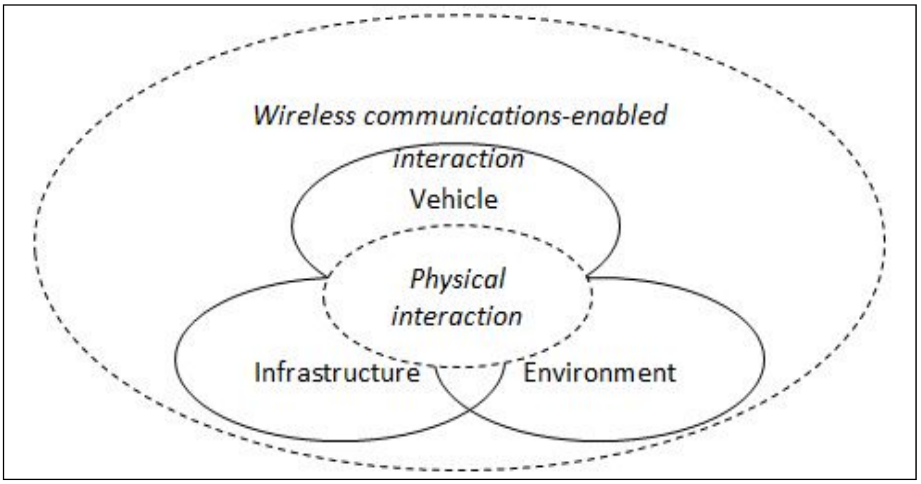

Figure 1. Dynamic interaction among vehicle, infrastructure and environment.

In current traffic networks, the vehicle, infrastructure and environment interact in a limited fashion, with minimal information exchange and in a *reactive* way (i.e., the “physical interaction” in Figure 1). Connected Vehicle sensing and communications systems enable information sharing through wireless connectivity, thus allowing for *proactive* (or

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anticipatory) actions (i.e., the “wireless communications-enabled interaction” in Figure 1) that include considerations over extended distances and time scales, such as vehicles acting in response to downstream traffic conditions, and traffic lights adjusting their signal phase and timing (SPaT) based on approaching vehicles.

A uniformly-applied evaluation framework will facilitate systematic comparison among alternatives (e.g., different traffic control strategies or data transmission mechanisms), will allow for continual performance reassessment when enhanced technologies are introduced and will provide information useful for increased user acceptance. ORNL developed a Connected Vehicle evaluation framework (see Figure 2) applicable to a wide range of emerging ITS applications that take advantage of wireless sensing and communications technologies to improve vehicle control (e.g., adaptive cruise control and collision avoidance systems), traffic operations (e.g., cooperative signal timing), and driver behavior (e.g., traveler information systems).

Given that full deployment of V2V/V2I communications systems and sensors will require a long period of time, the evaluation of Connected Vehicle applications in the early stages of implementation will be conducted using both virtual (simulation models) and controlled test beds. In particular, the evaluation framework includes:

(1) The ability to model traffic, communications, fuel economy and emissions.
(2) Incorporation of traffic and environment data from roadside sensors and in-vehicle devices.
(3) Definition and quantification of tailored performance measures for different audiences.
(4) Assessment of the benefits at different market penetration rates (MPRs).
(5) Trade-off analyses of multiple and conflicting objectives.

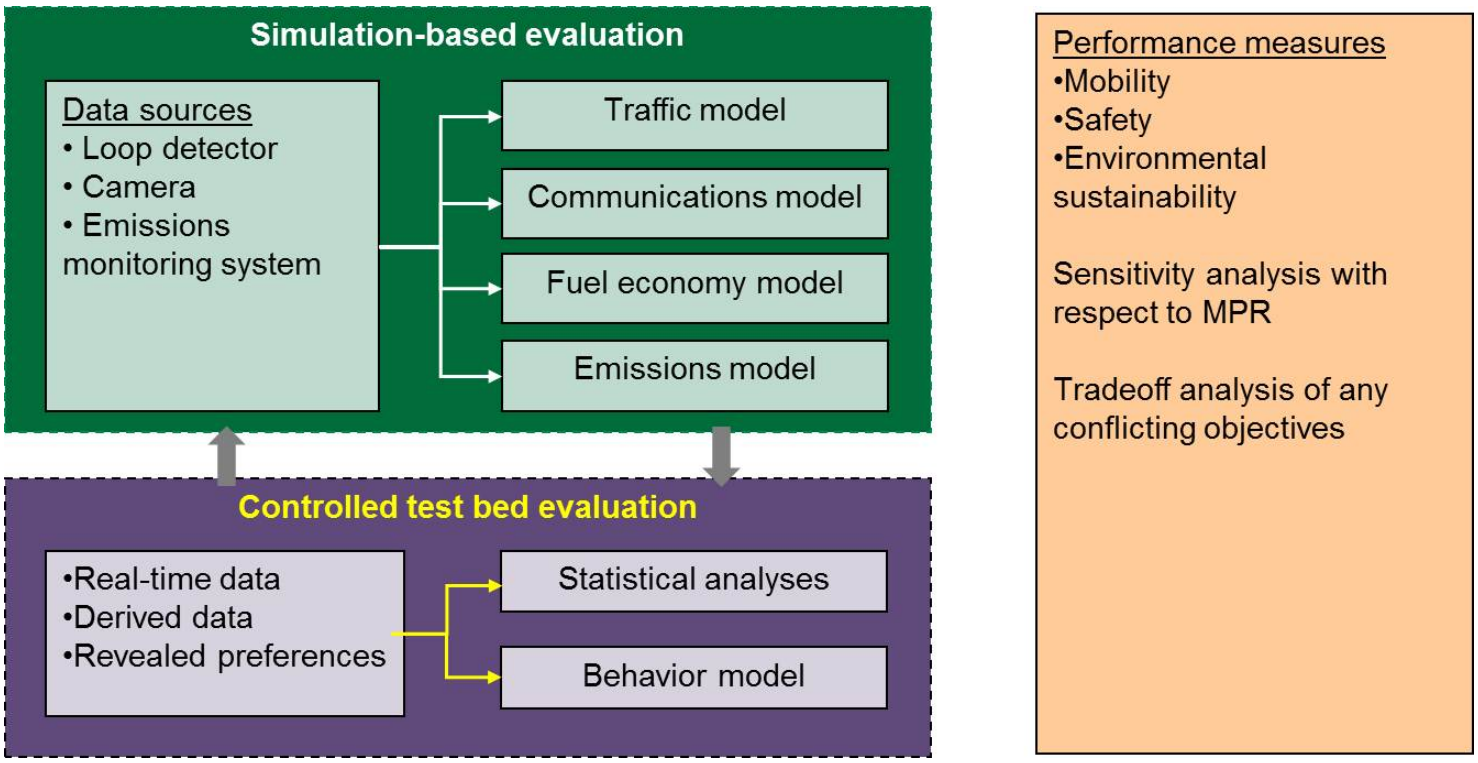

Figure 2. Evaluation framework.

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