

Project 5: “Ramp Metering Control for Mitigating Freeway Congestion with Emission Reduction”

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Project Summary

Increased traffic congestion and associated vehicle emissions impact ambient air quality and thus the health of drivers and urban dwellers. A practical solution to freeway congestion is ramp metering, a system that controls vehicles entering into the freeway from an on ramp. One essential question lies in effective measures to mitigate freeway congestion. A practical solution to freeway congestion is the ramp metering system that controls vehicles entering into the freeway from an on ramp. The challenge facing this strategy is how “to ensure the design of ramp metering system effective to mitigating congestion while reducing vehicle emission?” As shown by **Figure 1**, by controlling the entering rate, the traffic flow in the freeway will remain at a moderate level of service and capacity due to the reduction of interrupted traffic from the ramp. At the same time, it is also expected to reduce vehicle emission, crashes and travel time as well, which in reality greatly improve the quality of people’s daily life.

The project goal is to help the teachers to gain hands-on experience in understanding the mechanism about the operational and emission impact of ramp metering by learning related math modeling and simulation-based analysis of a real-world freeway (**Figure 1**). The result will help increase teachers’ awareness of tying math and science knowledge with a real-world problem-solving strategy in addressing a freeway congestion issue. The microscopic traffic simulation tool, VISSIM, and environmental analysis tool, MOVES, will be introduced to the teachers. The microscopic traffic simulation tools stimulate

movements and interactions of road users through car-following and lane-changing algorithms. MOVES estimates on-road vehicle emissions given quantified transportation activities and attributes describing the physical and environmental features of the roadway infrastructures. These tools provide a cost-effective way to test the effect of traffic control measures, including the ramp metering system.

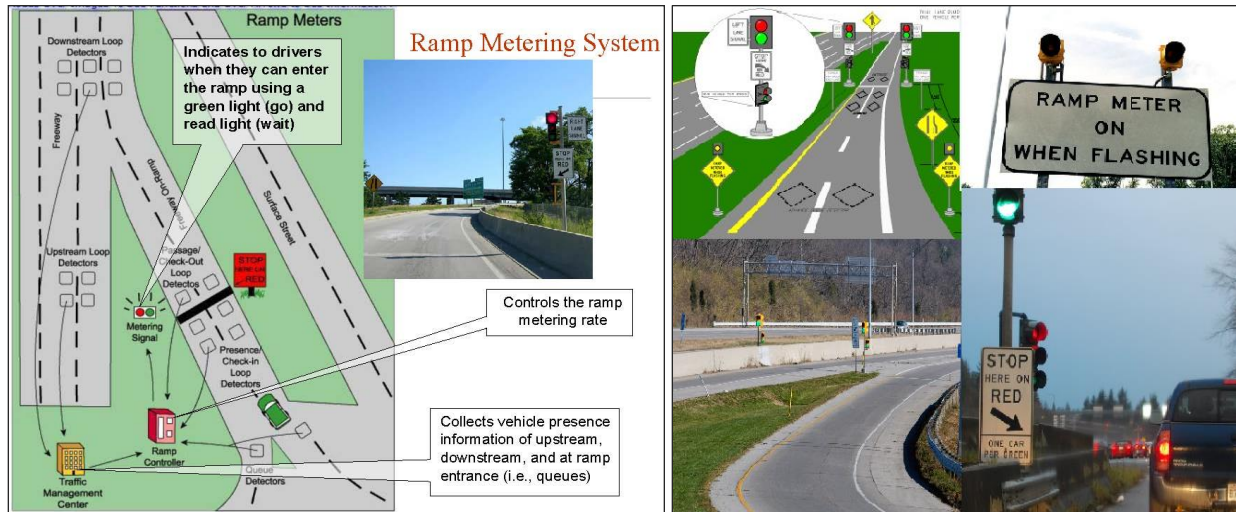


Figure 1: Illustration of Ramp Metering Operation (left) and Simulated System (right)

The research tasks will be completed in 7 weeks, including the following activities that are specifically designated for the 2014 summer project:

- Week 1: The teachers will be taking an *Engineering Foundations* course along with other groups of teachers involved in the summer project.
- Week 2: The teachers will participate in the training course for basics of ramp metering, analysis methods, and development of research framework. A real simulation example with use of VISSIM and MOVES, which will be adopted from an on-going EPA project, will be showcased to the teachers.
- Weeks 3: GPS travel data collection and other data acquisition, and relevant data analysis will be conducted under the supervision of the graduate student mentors.
- Weeks 4-5: The teachers will build a ramp metering system at the case study site in the VISSIM environment and learn how to run the simulation model to evaluate the ramp metering system in terms of operation. Associated math and scientific principles involved in traffic operation and control will be reviewed in conjunction with the case study result.
- Week 6: The teachers will compile the results and knowledge gained from the above tasks to develop their future classroom teaching improvement and implementation plan. Specifically they will develop the engineering design process activity to incorporate in their
- Week 7: The teachers will be preparing final presentation, final report, and summary.

In addition, a field trip will be arranged to visit the statewide traffic management center (TMC) in Ohio Department of Transportation Center Office in Columbus, Ohio (**Figure 2**). This trip is expected to provide an authentic environment for the teachers to perceive the real-world traffic operation and management.

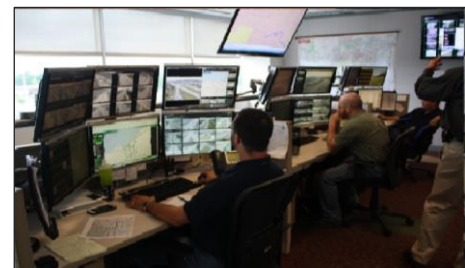


Figure 2: TMC in Columbus, Ohio

Possible Ideas for Classroom Implementation

The teachers could develop a classroom implementation plan around the theme of *“Math: how does it work on real-world problems?”* The course will help students understand the importance of math and science to address a societal problem through a case study of ramp metering impact analysis and assessment. It will use math to: estimate the design parameters using field collected experimental data; make inferences about the relationship between the parameters; conduct further data analysis to better understand the traffic condition of a freeway for ramp metering operation; and finally understand the emission reduction due to control measures. Thus, students will learn the freeway operations through the usage of math and scientific methods.