Grant Deliverables and Reporting Requirements for UTC Grants

UTC Project Information	
Project Title	Aerodynamic Equilibrium and Stability in Ventilation and Air Quality Control of Complex Urban Tunnels
University	Cornell University
Principal Investigator	H. Oliver Gao
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Funding Source(s) and Amounts Provided (by each agency or organization)	USDOT: $39,433 Cornell: $18,168
Total Project Cost	$57,601
Agency ID or Contract Number	Sponsor Source: Federal Government CFDA #: 20.701 Agreement ID: 69A3551747119
Start and End Dates	Start date: 11/01/2017 End date: 12/31/2018
Brief Description of Research Project	Urban vehicular tunnels generally have a branched structure and complex nonlinear aerodynamics, the study of which is crucial for tunnel ventilation design and air quality control. In this study we aim to establish the aerodynamic equations describing the 1-D airflow distribution in such bifurcate tunnel systems. A novel piecewise-affine (PWA) approximation is proposed for the flow-dependent local pressure-loss coefficients at tunnel junctions. This enables us to model the system via first-order ODEs with piecewise-quadratic polynomials. Based on this model, we derive the sufficient condition for the uniqueness and stability of the steady-state solution of each ODE piece. This condition is easily verifiable given the tunnel parameters. We will also show via numerical examples that there may exist multiple stable steady-state solutions for the entire system. Our model provides a theoretical foundation for ventilation design and air quality control in complex tunnels as well as for analysis of other hydraulic network systems with similar structures.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	This work focuses on formulating an optimal ventilation control model for bifurcate vehicular tunnels with distributed pollutant discharge points and deriving theoretical properties of the model. It is not implemented. A paper “Ventilation Control in Bifurcate Tunnels with Distributed Vents” out of this research was

	published in 2018 Annual American Control Conference (ACC) June 27–29, 2018. Wisconsin Center, Milwaukee, USA. (https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8431467&tag=1)
Impacts/Benefits of Implementation (actual, not anticipated)	Results from this study provide theoretical foundation and guidelines for the design of tunnel ventilation in transportation systems.
Web Links • Reports • Project website	http://ctech.cee.cornell.edu/final-project-reports/