CENTER FOR CONNECTED AND AUTOMATED TRANSPORTATION

Project Title	Leveraging Control Theory to Facilitate UAV Application for CAV Deployment	
PIs	Shaoshuai Mou	Sikai Chen
Telephone #	(765) 494-2546	(213) 806-0141
E-mail:	mous@purdue.edu	chen1670@purdue.edu
Institution:	Purdue University	Purdue University
Department:	School of Aeronautical Engineering	School of Civil Engineering
Industry or Government Principal, organization, and contact information	Dr. Barry Partridge Director, Joint Research Transportation Program Indiana Department of Transportation 1205 Montgomery Street, West Lafayette, Indiana 47906 (765)463-1521 ext. 250, bpartridge@indot.in.gov	
Most relevant CCAT research thrusts (choose all applicable)	__X__ Control & Operations __X__ Enabling Technology _____ Human Factors _____ Infrastructure Design & Management __X__ Modeling & Implementation _____ Policy & Planning	
CCAT Research Theme	Models and Implementation (primary theme)	
Funding Request	$100,000	
Matching Funds/Source	$100,000	
Total Project Cost	$200,000	
Contract Number	69A3551747105	
Project start/end dates	April 1, 2022 – March 31, 2023	
Project Abstract	Recent studies have espoused the benefits of connectivity among ground vehicles, which include proactive safety management, savings in fuel consumption, efficiency of traffic mobility, and reduction in emissions. Connectivity makes it possible to acquire data on the traffic streams (and any disruptions thereto), as well as threats and opportunities associated with the weather conditions, pedestrians, and the non-roadway environment. With such data, the ground vehicles can make more informed decisions that reduce delay and yield the attendant benefits associated with safety, mobility, emissions, and energy use. In quests to identify additional potential sources of data, researchers have identified the opportunity offered by Unmanned Aerial Vehicles (UAVs) in this regard. It has been found that UAVs can acquire and transit aerial data to ground vehicles and other end users quickly and cost-effectively. First, camera-equipped UAVs acquire visual information about the terrain they are monitoring. Secondly, UAVs provide greater efficiency and convenience compared to surveillance cameras with fixed camera	

M | UMTRI — The University of Akron — Illinois Center for Transportation — Purdue University — Washtenaw Community College — Central State University 1887

	angle, scale and view. Thirdly, if UAVs are equipped with Vehicle-to-Everything (V2X) communication technologies, they can lend another dimension of communication in the Connected and Autonomous vehicle (CAV) data environment. Previous studies have used microscopic traffic simulation to investigate and exploit the potential benefits and use cases of a CAV-UAV connected networks. In the proposed study, we intend to use real life (but, smaller scale) simulation of both UAV and CAVs. We intend to show how the traffic and roadway environment information can be collected by the connected UAVs and disseminated to the CAVs below. We will then assess the performance of the CAVs in fuel economy and traffic mobility vis-à-vis the baseline case of no UAV communication and the case where only connected UAVs were present. We shall do this for a number of scenarios involving traffic and roadway conditions, and we shall identify the conditions under which the UAV application is most beneficial to CAV deployment. In addition, recognizing that the benefits of UAVs are not just for information delivery to the ground CAVs, we shall show how control theory can be used by the UAV to help provide prescriptions for safe and efficient movement of the CAVSs. The proposed study will also demonstrate the efficacy of a DSRC based communication architecture between the connected UAV and the ground CAVs, and examine the issues related to package loss in the data transfer, reliability of the DSRC communication, and communication ranges, latency, and scalability to real life deployment. The practical benefits of the proposed products are numerous. A reliable UAV-CAV data domain can help the road agency carry out traffic safety risk assessment and vehicle trajectory monitoring. From the control perspective, it can also help establish optimal operational maneuvers for CAVs (including weaving and lane-change) and trajectory planning.
High-level implementation plan	CCAT research projects are intended to yield products that will be applied in practice. In view of this, the research team should devise a plan for effectively translating the results of the proposed research into practice and promoting the application of the study products. The product of the research should be designed in such a manner that the product will be readily applicable to practice with minimal implementation barriers. Therefore, we intend to undertake the following activities in order to enhance the likelihood of successful implementation: • Close cooperation, throughout the study, with stakeholders and the audience associated with the research product.

	These may include individuals from the tech companies and car manufacturers, transportation agencies (federal, state, cities), and other organizations involved in highway management and operations including AASHTO and AAA. • Learning from the experiences of others who had succeeded (or faced challenges) in implementing CAV research or other related research. • A well-designed modular implementation plan using appropriate technology transfer tools and techniques to ensure clear understanding of the use and benefits of the study product • Use of communication tools for effective technology transfer to make the stakeholders aware of the possible benefits from the research products. • Offer training of personnel at the implementing organization, as part of the implementation plan. • Pilot applications of the tools to enable full-scale evaluation and improvement.
Project Metrics	Number of papers presented at nationally and internationally renowned conferences; Number of papers published; Number of graduate student theses; Media stories and website hits
Web Links:	ccat.umtri.umich.edu; engineering.purdue.edu/ccat purdue.edu/discoverypark/cav/nextrans/index.php