CENTER FOR CONNECTED AND AUTOMATED TRANSPORTATION

Project Title	**Motion Sickness Alleviation via Anticipatory Control of Active Seats in Autonomous Vehicles**	
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Industry or Government Principal, organization, and contact information	**Industry Champion 1:** Srinivas Bidare, Founder and CEO, Intent Design, sribid@intent-design.com, 248-866-1929	
Most relevant CCAT research thrusts (choose all applicable)	_____ Enabling Technology _____ Planning and Policy __X__ Human Factors _____ Infrastructure Design and Management _____ Control and Operations _____ Models and Implementation	
Funding (CCAT)	$250,000	
Matching Funds and Source		
Total Project Cost	$250,000	
Contract Number	69A3551747105	
Project start/end dates	October 1, 2020 – December 31, 2021	

Project Abstract	The goal of this integrative research project is to develop and demonstrate a passenger motion sickness mitigation solution that employs preemptive or anticipatory control of Active Seats in autonomous vehicles. The resulting proof of concept will enable implementation and deployment of the proposed technology. Motion sickness when traveling in a vehicle is a common condition that afflicts one in three adults in the US. Moreover, passengers who are not driving the vehicle experience such motion sickness more acutely compared to the driver of the vehicle. This is due to the driver's ability to make anticipatory corrections when initiating a driving action that involves acceleration (e.g. speeding up, breaking, or taking turns). These anticipatory corrections by the driver (such as tightening their abdominal core muscles when braking or leaning their body/head into the direction of the turn when turning) help prepare the driver for the accelerations associated with the driving actions slightly ahead of time, whereas the passenger ends up passively reacting to these driving actions. With the impending transformation in ground transportation due to autonomous vehicles, where every occupant is a passive passenger, the deleterious effects of motion sickness on the passenger comfort and productivity during their commute is expected to be significant. The proposed solution strategy leverages the existing science on the causes of motion sickness (including the sensory conflict, neural mismatch, and postural instability theories), and the well-known benefits of anticipatory corrective action in mitigating the same. In this project, we will develop a test vehicle equipped with Active Seats capable of roll, pitch, and yaw motions that can be controlled preemptively based on apriori knowledge of the driving conditions in a closed-track testing facility (M-City). These driving conditions include vehicle path/route (including turns and stop and go events), vehicle speed and acceleration profiles, and vehicle parameters and dynamics. Based on this apriori knowledge of driving conditions, we will develop algorithms that preemptively control the Active Seat, for example starting to tilt the seat towards the direction of a turn slightly before the turn happens. Our hypothesis is that such preemptive correction will provide anticipation and reduce body movement, thereby lowering the incidence of passenger motion sickness. Thus, the passenger of an autonomous vehicle equipped with the proposed technology will no longer

	be entirely passive and instead be more like the driver of a traditional vehicle.
High-level implementation plan	The project will be led by a strong cross-functional team comprising faculty and researchers from Mechanical Engineering and UMTRI that together have expertise in motion sickness theory, user-centric design, mechatronic systems, controls and systems theory, hardware development and testing, additive manufacturing, and design of experiments. Furthermore, the R&D team will be supported by a diverse Advisory Panel with deep technical and commercialization expertise as well as broad network across the automotive industry. This panel comprises representation from Intent Design, an innovation, engineering, product development and commercialization firm based in Farmington Hills, MI will serve as the Industry Champion. Intent has decades experience in advanced seating systems for the automotive industry. The panel also includes Tech Transfer specialists from the University of Michigan Office of Tech Transfer who will help create an implementation and deployment roadmap for the technology outcomes of this project. Additional oversight will come from a CCAT administrator as well as a CCAT partnering institution representative on the Advisory Panel.
Project Metrics	The outcome objective of this project is to demonstrate a functional proof of concept of the proposed technology and deliver a thoroughly vetted translation roadmap. This will ensure that the technical risk is sufficiently mitigated, and industry adoption challenges are sufficiently understood, thereby facilitating subsequent implementation and deployment in the automotive industry.
Web Links:	ccat.umtri.umich.edu