

<b>UTC Project Information</b>	
Project Title	Formalizing Human-Machine Communication in the context of Autonomous Vehicles
University	Texas A&M University Virginia Tech Transportation Institute (VTTI)
Principal Investigator	Swaminathan Gopalswamy
PI Contact Information	<a href="mailto:sgopalswamy@tamu.edu">sgopalswamy@tamu.edu</a>
Funding Source(s) and Amounts Provided (by each agency or organization)	Safe-D (Federal): \$240,000 Non-Federal: \$-
Total Project Cost	\$240,000
Agency ID or Contract Number	Grant No: Project: 02-014
Start and End Dates	September 2017 – December 2018
Brief Description of Research Project	While driving behavior is generally governed by the nature and driving objectives of the driver, there are many situations (typically in crowded traffic conditions) where tacit communication between the drivers and pedestrians govern the overall driving behavior, significantly enhancing driving safety. We intend to study and formalize the communication pattern between human drivers and pedestrians, as also investigate effective communication mechanisms between an autonomous vehicle and humans. Current autonomous vehicles engage in decision making that is primarily driven by on-board or external sensory information, and do not explicitly consider communication with pedestrians. We will incorporate the formalized communications from this study into decision making algorithms of an autonomous vehicle. Use of the results of this study would lead to improved safety of both autonomous vehicles as well as conventional vehicles.
Describe Implementation of Research Outcomes (or why not implemented)  Place Any Photos Here	<p>Research outcomes from the project would be the specification of the language for communication between (Autonomous) vehicles and pedestrians using a Language Workbench, as well as recommendations for communication mechanisms leveraging this language. There are several companies in the Autonomous Shuttle area that are interested in this technology. While it might not be possible or feasible to interact with all of them, we will engage and discuss our results with at least one of the companies (Auro, EasyMile and Navya would be candidates).</p> <p>As we socialize this concept with multiple automotive industry players (OEMs and Tier-1s) and acceptance grows, there would also be a need to</p>

	<p>make it an official standard (such as an SAE standard). We will actively promote such an activity.</p> <p>In addition to the direct outputs, it is possible for third party products to spawn from this, especially if it is adopted as a standard. For example, specialized communication devices such as embeddable LCD displays that have APIs to accept commands using the Domain Specific Language.</p> <p>We expect publications in conference or journals. We will publish the specification of the autonomous vehicle to pedestrian language, as well as the clinical study of the efficacy of different communication mediums used to express the language.</p> <p>Apart from publications in journals and hosting online courses, we will also publish the results in our website. The data collected and software will be made available to research teams. We will also reach out, publish, and seek guidance from the CAST External Advisory Council which will consist of autonomous vehicle experts from industry and research institutes.</p>
Impacts/Benefits of Implementation (actual, not anticipated)	<p>The expected consumers of the outputs will be:</p> <ul style="list-style-type: none"> <li>Autonomous vehicle researchers: towards enhanced decision making algorithms in crowded traffic scenarios. This should be of particular interest to the last-mile transit solution providers (e.g. Olli Local Motors, Navya, EasyMile), who will be operating in high density pedestrian scenarios.</li> <li>Automotive OEMs and Tier-1s: in addition to the value for autonomous vehicles, the outputs would lead to newer mechanisms for communication with pedestrians in conventional vehicles beyond the turn signals, brake lights, eye-contact and hand gestures.</li> </ul> <p>Currently Decision Making in autonomous vehicles does not explicitly interact with pedestrians. Our approach will be the first in the market to do so. Additionally, we expect our work to facilitate newer communication devices on conventional vehicles to enhance human-driver-pedestrian engagement, and overall safety. Thus we believe our approach will be creating a “new market” space.</p>
Web Links <ul style="list-style-type: none"> <li>Reports</li> <li>Project website</li> </ul>	<a href="http://www.vtti.vt.edu/utc/safe-d/index.php/projects/formalizing-human-machine-communication-in-the-context-of-autonomous-vehicles/">http://www.vtti.vt.edu/utc/safe-d/index.php/projects/formalizing-human-machine-communication-in-the-context-of-autonomous-vehicles/</a>