UTC Project Information – **Center for Transportation, Environment, and Community Health**	
Project Title	Design autonomous vehicle behaviors in heterogeneous traffic flow
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Brief Description of Research Project	The benefits of autonomous vehicles (AVs) not only depend on the maturity of technologies, but also on how AVs behave and interact with their peers and human-driven vehicles (HVs). Similar to many other systems, individual and collective dynamics of traffic flow are not always aligned with each other (for instance, aggressive driving may benefit an individual driver but disrupts the overall traffic). It is therefore imperative to consider behavior design for AVs such that the benefits of AVs can be realized at both individual and collective levels, especially when centralized control is absent and all involved agents are self-interested. This research explored behavior designs for AVs in mixed autonomy traffic using a game-theoretic approach. In this new framework, we defined agent utilities and casted interactions of heterogeneous agents (i.e., AVs and HVs) as a collective bargaining game. We analytically characterized the equilibria of mixed autonomy traffic, including equilibria types and conditions when each type of equilibria can be reached. We found that in general, mixed autonomy traffic may reach two types of Nash equilibria, namely one-pipe and two-pipe equilibrium. Depending on traffic regimes, mixed autonomy traffic can always reach one of the equilibria that is Pareto-efficient, and this is known as the collective rationality of self-interested agents. Based on the theoretical characterization, we proposed a class of lane use policies that determine the capacity allocation between AVs and HVs. We then developed a computing algorithm to construct the equilibria numerically and conducted simulation experiments to investigate different AV behavior scenarios when they interact with HVs. We showed that with the proposed

	lane use policy, mixed autonomy traffic can always reach collective rationality and attain uniform speed and flow improvements over non-Pareto-efficient equilbria. We also showed a capacity drop phenomenon for HVs in mixed autonomy traffic when exclusive AV lanes are introduced, which pinpointed a potential subtlety of similar lane policies.
Describe Implementation of Research Outcomes (or why not implemented) *Place Any Photos Here*	This research increases the body of knowledge on mixed autonomy traffic in the following regards: • A new game-theoretic model of mixed autonomy traffic consisting of self-interested traffic agents was developed. • A theoretical characterization of equilibria reached in mixed autonomy traffic in different regimes was defined. • An algorithm to compute mixed autonomy traffic equilibrium from agent behaviors was developed.
Impacts/Benefits of Implementation (actual, not anticipated)	The research outcomes bridged the scientific knowledge gap in the connection between agent-level characters and the macroscopic behaviors of mixed autonomy traffic. It also identified a class of theoretically guaranteed lane use policies reaching Pareto-efficient equilibria in mixed autonomy traffic.
Web Links • *Reports* • *Project website*	http://ctech.cee.cornell.edu/final-project-reports