UTC Project Information	
Project Title	Safety of Lithium Nickel Cobalt Oxide Battery Packs in Transit Bus Applications
University	The Pennsylvania State University Mineta National Transit Research Consortium
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Funding Source(s) and Amounts Provided (by each agency or organization)	Research and Innovative Technology Administration University Transportation Centers Program ($84,416) Larson Institute/Penn State ($84,416)
Total Project Cost	$168,832
Agency ID or Contract Number	DTRT12-G-UTC21
Start and End Dates	December 2013 – December 2016
Brief Description of Research Project	High energy density and specific power are vital in achieving maximum electrified vehicle performance. These specifications are some of the most sensitive parameters affecting vehicle range, effective fuel economy and performance. NCA is a leading chemistry in regard to energy density. Because of this, it is an attractive technical solution for high-capacity applications; however, similar to other advanced battery chemistries, safety is a concern. Ensuring safe nominal operation as well as keeping passengers and first responders safe during any vehicle crash event should be addressed in detail for the transit industry. Before this chemistry can be used on a large scale in passenger buses, a study of the risks and available mitigations should be completed to cover potential concerns and proper responses. This study will investigate the potential risks of integrating an advanced chemistry battery into a transit bus. An emphasis will be placed on covering battery management systems and their ability to effectively prevent and anticipate failures resulting in thermal events during nominal operation. The research team will also investigate and validate structural solutions to protect large-format NCA battery packs in crashing events of transit buses. This research will include the analysis, simulation, and real-world

	validation of traction/SLI battery systems. Through this analysis, protective design concepts will be proposed to ensure the safety of passengers and pedestrians during and after a crash event. Compatibility of system shock and vibration fatigue requirements will be considered. The team will also evaluate available fire suppression system performance during these crash events. This process will also be presented as potential standard for battery integration into transit vehicles.
Describe Implementation of Research Outcomes (or why not implemented)	Currently a report to MNTRC and a student's master's thesis are in draft form and will be submitted for publication shortly.
Place Any Photos Here	
Impacts/Benefits of Implementation (actual, not anticipated)	Penn State ME 597 Advanced Vehicle Hardware-in-the-Loop class lectures and group work on both data acquisition system setup and data analysis. Penn College of Technology ABM355, shared testing results and lectured on battery safety. Assisted a group of students to design a battery system using the same cells tested as part of this research.

Web Links • Reports • Project Website	Single cell overcharge test: https://www.youtube.com/watch?v=nMV7pdT1zmU Final report (MNTRC Website): Final report (TRB Website):