

Penn State Bus Research and Testing Program

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David Klinikowski

Director, Bus Research and Testing

Assistant Research Professor

Larson Transportation Institute

College of Engineering

Penn State University

University Park, Pa



PennState
College of Engineering

Presentation Objective

- Overview of Penn State Program
- Overview of Facilities
- Penn State Low-No Testing Capabilities
- Future Needs



The Penn State “Altoona” Bus Testing Program

- Independently owned and operated, non-profit
- Established in 1989 by STURRA legislation
- Penn State developed testing procedures and protocols for Diesel, CNG, LNG, propane, methanol, hybrid-electric, battery electric and hydrogen fuel cell buses
- Penn State developed the Pass/Fail protocol
- 30 years of Penn State bus testing experience at one facility provides consistent, repeatable test results



Penn State is a certified and accredited laboratory under ISO-17025 for bus testing

Mandated Tests

Eight evaluation categories

1. Maintainability
2. Reliability
3. Safety-Braking
4. Performance
5. Structural Integrity
and Durability
6. Fuel Economy
7. Noise
8. Emissions

Penn State's Extensive Experience

486 Bus Models Tested

Number of Buses	Service –Life Category
197	12-Year, 500,000 Mile
78	10-Year, 300,000 Mile
130	7-Year, 250,000 Mile
26	5-Year, 150,000 Mile
55	4-Year, 100,000 Mile

38 Low-No buses tested since 1998



9700+ Failures Encountered

Battery and electric drive components

Chassis/structure

Suspension

Engine/drive train

Exhaust/emissions

Electrical wiring

Air conditioning/heating

Brakes

Steering

Fuel Systems

Seats/Lifts/Doors/Windows

Quantity and Class of Failure

CLASS 1:	Potential for serious injury or crash	46
CLASS 2:	Bus inoperable, interrupting service 184	215
CLASS 3:	Bus operational but must be removed from service	5,175
CLASS 4:	Degrades operation, may be repaired during next scheduled service	<u>4,338</u>
TOTAL:		9,774

Based on data from 486 buses completing structural durability test as of June 2019.



Body Cracking



Frame Rail Crack



Altoona Facility

- 7,000 Square ft. facility
- Bus maintenance and repair
- 4 testing and maintenance bays
- Administrative Offices



Penn State Test Track Facilities

SlopeBrake

Dynamometer

Rail-Guided Crash Test Facility

Vehicle Handling Area

Vehicle Durability Track

Vehicle Testing Laboratory

Lab and Office

Research Laboratory and Office

Entrance
(Test Track Road)



Test Capacity

- Over the past 10 years, the average number of buses submitted for testing was **15 buses per year**
- Approximately 1/3 third were partial tests
- Penn State facility can test 14 buses simultaneously
- Penn State has two structural durability test tracks (unused capacity)
- Capacity can be increased by adding additional staff
- Delays in total testing time are largely caused by the FTA approval process and from failures, parts deliveries, etc. during testing
- **Track currently operates 24 hours/day, 6 days/week**



Pennsylvania Safety Transportation and Research Track

PennSTART



- Testing and hands-on training for new ITS, tolling, and signal equipment;
- Safe, simulated training for higher-speed and mobile work-zone operations;
- Safety certification training opportunities;
- Simulated environments for temporary traffic control device testing and evaluation;
- Smart truck-parking applications and other opportunities for commercial vehicle technology partnerships; and
- Controlled environments to test various connected and automated vehicle technologies for infrastructure equipment, fleets, and other applications.

PennStart Facility Concept



Low-No Testing Capability

Vehicle Testing Laboratory

10,000 ft² maintenance/testing
Large-roll (72-in diameter)
dynamometer

Horiba Automotive Test Systems
Electronic simulation

Battery/electric drive test area

Aerovironment AV-900, ABC-150
250kW power processing
Large environmental chamber for
EV component testing (-65 to 85
C)

Full-Scale Emissions Laboratory

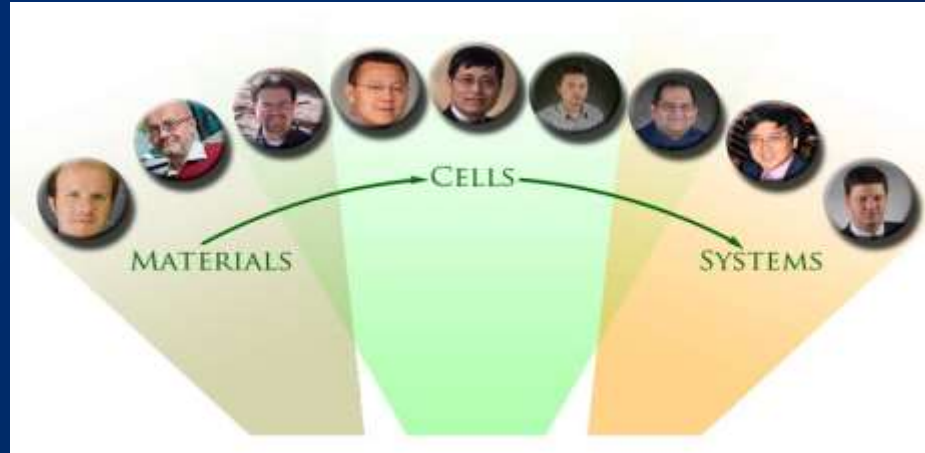


Low-No Facilities

- Facilities Include:
 - Battery Charging
 - Hydrogen fueling station
 - LNG, CNG, Propane, gasoline, diesel
 - Hardware-in-the-loop test and simulation



Penn State Advanced Vehicle Technology



- Battery & Energy Storage Technology (BEST Center)
 - Electrochemical Laboratory
 - Materials Chemistry and Polymer Synthesis Lab
 - Energy Nanostructure Lab
 - Electrochemistry Engine Center
 - Battery manufacturing Lab
 - Mechatronics Research lab
 - Battery Testing Lab

Penn State Advanced Vehicle Team



EV Education and Training:

The interdisciplinary group of students that make up Penn State's Advanced Vehicle Team are doing more than working on cars. Their projects will impact the hybrid-electric vehicle industry, furthering the pursuit of better, more sustainable transportation.

Penn State Hydrogen Research (H₂E Center)



Future Needs

- From 1998 through 2018, funding was flat at \$3 Million per year (20 years with no increase)
- Supplemental funding was recently provided to cover salaries
- Funding shortage resulted in deferred repair and replacement of equipment
- Continued operation beyond 2021 will require a level of funding at \$5 Million/year