BRIEFING

From the Connecticut Academy of Science and Engineering

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EMERGING ISSUES IN TRANSPORTATION

The Transportation Systems Technical Board (TB) is one of CASE's ten TBs, with all boards aligned to science- and engineering-related policy areas. CASE members select one or two TBs on which to serve. Dr. Kenneth Rosen, Chair of the Transportation Systems Technical Board by election of the CASE Governing Council, met with board members for the purpose of identifying emerging issues in transportation to then share with the Connecticut General Assembly's Transportation Committee for their information. The board placed the issues into one of three timelines: near-, mid-, and long-term. Members are available to discuss these issues at the convenience of the committee, or other issues of importance, as requested by the committee.

1. **Electric Vehicle (EV) ground transport Infrastructure (Energy distribution/production & regional interconnectivity for EV):** Plans are underway in the state for a substantial increase in available quick charging stations, potentially with solar panels to power the stations. EV chargers are rapidly increasing as EV demand rises. Globally, the EV charging infrastructure industry is expected to reach $45.59 billion in revenue by 2025. Falling costs of batteries mean that the total cost of EV ownership will soon hit parity with internal combustion engine models.

   Under the National Electric Vehicle Infrastructure (NEVI) Formula Program, Connecticut is making timely progress in building out fast charging capability along designated Federal Highway Administration Alternate Fuel Corridors. However, it is not yet clear that plans from the NEVI program are adequate for this fast-changing infrastructure.

   Resources:

   - Atlas EV Hub, The State of the Charge: 2017 Report of California's Electric Vehicle Charging Industry, Electric Vehicle Charging Association
   - Connecticut Department of Transportation Infrastructure Program Annual Capital Plan Report FFY2023 - FFY2027
   - Connecticut Department of Transportation, Connecticut's Charging Ahead Plan: A Strategy to Expand Public Electric Vehicle Charging, July 26, 2022
   - National Academies, Navigating an Electric Vehicle Future, Workshop Proceedings, 2022
   - National Electric Vehicle Infrastructure (NEVI) Formula Program
   - Siemens, Transforming electric vehicle development
   - The Economist, An infrastructure for charging electric vehicles takes shape, Sept. 7, 2017
   - UL Solutions, Electric Vehicle Charging Infrastructure

2. **Ground transport safety/environmental issues** (i.e., Lithium-ion Battery (LIB) safety issues, including thermal runaway and crash concerns; vehicle battery disposal and regulations; garage parking safety limitations relative to fire safety). LIBs, a new energy storage medium, are receiving more attention due to the worldwide energy shortage. LIBs are mainly made of electrolyte and active materials (e.g. typically metal oxides) which comprise a very promising energy storage medium for electric and hybrid electric vehicles (EV) compared to other energy storage approaches. Their lightness and high energy density relative to other battery chemistries make LIBs ideal for portable devices, such as laptops. Additionally, LIBs do not use poisonous metals, such as lead, mercury, or cadmium. However, use of LIBs in ground vehicles continues to pose questions relating to safety, cost, and poor performance at low temperatures, which are all challenges related to battery thermal management.

Although upgrading electrical infrastructure and extensive EV charging facilities are a part of the CT DOTs Capital Plan, the related safety and environmental impact of these facilities requires further study. The technical board noted that the CT's legislature has begun to recognize this safety concern with HB05952: An Act Requiring Firefighter Training on Extinguishing Fires Involving Electric Vehicles (2023), SB00568: An Act Requiring a Statewide Protocol and Procedures regarding suppression of Fires in Electric Vehicles (2023) and SB00681: An Act Concerning Battery Storage (2023). These acts are excellent legislative steps; however, a great deal more is required to assure the state benefits from the latest battery thermal management technology.

Resources:

- Big Battery, A Guide to Safely Storing Lithium Batteries, Apr. 28, 2023
- CTDOT Transportation Infrastructure Program Annual Capital Plan Report FFY2023 - FFY2027
- Dragonfly Energy, What is thermal runaway in batteries?, Dec. 14, 2022
- Environmental Protection Agency, Used Lithium-Ion Batteries
- Journal of Power Sources, Thermal runaway caused fire and explosion of lithium-ion battery, June 2012
- UL Research Institutes, Fire Safety Research Institute, YouTube, Test shows explosive power of a lithium-ion battery thermal runaway, 2022
- US Department of Energy, National Renewable Energy Laboratory, Energy Storage Safety for Electric Vehicles

3. **Wide scale introduction of Electric Vertical Takeoff & Landing (eVTOL) aircraft.** EVTOL aircraft are either battery or hybrid electric powered air vehicles, the latter with increased range and operating time. These aircraft, coupled with an increased number of vertiports, will facilitate a growing Urban Air Mobility (UAM) air taxi system for Connecticut, with a potential to link with the northeast region. They can be much quieter than conventional helicopters and can be expected to provide an affordable transport option for Connecticut residents. Is there a need for state specific regulations and infrastructure (i.e., quick charging capability for small aircraft; vertiport specifications; traffic management; safety and noise regulations) to help spur growth and adoption in the state, while at the same time ensuring safety? Is Connecticut ready? Several Federal Aviation Administration certified UAM eVTOL aircraft are expected to be available for sale by 2026 and certainly will be present in the NYC area.

   The CT Department of Economic and Community Development is assessing the benefits and opportunity costs for the City of Hartford and the state of the current and alternative uses of the Hartford-Brainard Airport property. Perhaps an eVTOL vertiport at the property might be something to consider. Statewide, in addition to Bradley, five general aviation airports are owned and operated by the CT Airport Authority, providing additional opportunities.

Resources:

- Aviation Week Network, FAA Releases First eVTOL Certification Basis for Comment, Nov. 8, 2022
- Avionics International, Concerns Raised Over the Ability of the FAA to Efficiently Certify eVTOLs, Feb. 10, 2023
- Avionics International, Vertiports, Air Traffic Management, and Infrastructure Requirements for eVTOL Aircraft, Nov./Dec. 2022
- Federal Aviation Administration, Advanced Air Mobility | Air Taxis
- Joby Aviation, Joby completes the second stage of eVTOL Certification, Feb. 9, 2023
- National Academies, Advancing Aerial Mobility: A National Blueprint, Consensus Study, 2020
- New Atlas, NASA acoustic testing puts real numbers on Joby's eVTOL noise signature, May 10, 2022
- Connecticut Department of Economic and Community Development under CT DECD RFP No. 2022-3 Regulatory Analysis of Hartford Brainard Airport
    - Hartford Brainard Airport Property Study, Executive Summary, 2022/2023
    - Hartford Brainard Airport Study Website
    - Review of Existing Studies, Dec. 30, 2022
    - Community Engagement Study, Jan. 9, 2022
    - Hartford Brainard Airport Property Study, Appendix J: Valuation Analysis, Oct. 25, 2023
- The Vertical Flight Society, Vertical Flight Society Electric VTOL Directory Hits 700 Concepts (Press Release), Aug. 16, 2022

4. **Hydrogen fuel Infrastructure (distribution/production), safety issues and regional interconnectivity for Hydrogen powered ground and air vehicles (fuel cells and engines)**: Does hydrogen fuel as a new energy source provide a significant source of energy, and economic benefit to Connecticut and the region? Is an infrastructure plan needed to capitalize on this new energy source? Affordable hydrogen may result from the widespread use of solar energy or offshore wind turbines where excess power available during non-peak load periods could be used to cost-effectively produce hydrogen from water through electrolysis. Hydrogen is potentially the lowest-cost option to significantly reduce emissions in heavy duty transportation.

   The Biden Administration recently announced plans to award $7B to create seven regional hubs around the country. Connecticut, along with several states in the region, did not secure one of these awards but should the state continue planning and seeking supplemental support to establish a regional hub? CT/MA/RI have formed a partnership to develop wind energy for the region. Is it possible that potential excess in wind energy from non-peak periods will support affordable hydrogen as green fuel source?

   Resources:

   - BMW AG, Hydrogen fuel cell cars: what you need to know
   - Exxon Mobile, Hydrogen | Low Carbon Solutions
   - US Department of Energy, Office of Energy Efficiency & Renewable Energy, Hydrogen Fuel Basics | US Department of Energy
   - US Department of Energy, Office of Energy Efficiency & Renewable Energy, Alternative Fuels Data Center: Developing Infrastructure
   - CASE Studies/Technical Reviews:
     - A Study of Fuel Cell Systems, on behalf of DECD and CERC, 2002
     - Energy Alternatives and Conservation, on behalf of the CGA- Commerce, Energy & Technology and Environment Committees, 2006
     - Preparing for a Hydrogen Economy, on behalf of the CTDOT, 2006
     - Feasibility of Utilizing Fuel Cells to Generate Power for the New Haven Rail Line, on behalf of the CTDOT, 2007
     - Preparing for Connecticut's Energy Future, on behalf of the CGA-Energy & Technology Committee, 2008
     - Energy Efficiency & Reliability Solutions for Rail Operations and Facilities, conducted on behalf of the CTDOT, 2014

5. **Autonomous personal and commercial ground vehicles:** This area is rapidly emerging with the introduction of autonomous trucks and cars. Autonomous ground vehicles (AGVs) are robotic vehicles that can perform some or all aspects of their operations without the need for direct input from a human. Self-driving cars and trucks use a range of sensors to perceive and navigate through their environment, including cameras, light detection and ranging (LiDAR) for autonomous vehicles, global navigation satellite system (GNSS) receivers, odometers, and inertial measurement units (IMUs). Data is combined using sensor fusion algorithms and processed using onboard embedded computing systems.

   What infrastructure, safety and legal concerns can result for the state of Connecticut? The Connecticut Department of Transportation has created some positive documents relating to Connected and Automated Vehicles (CAVs). However, much more detailed plans are required to address this revolutionary change in transportation and the potential impact on CT transportation infrastructure.

   Resources:

   - Connecticut Department of Transportation, Preparing for Connected and Automated Vehicles, CTDOT Strategic Plan, Feb. 2021
   - CSIRO Robotics, Autonomous Ground Vehicles
   - Library of Congress: Research Guides, Autonomous Trucking, Sept. 20, 2017
   - National Academy of Engineering, Driverless Motor Vehicles: Not Yet Ready for Prime Time, NAE Perspectives, Sept. 30, 2021
   - Siemens, Develop Autonomous Vehicles | Siemens Software

6. **Lack of rail interconnectivity to Connecticut's airports:** The lack of interconnectivity remains a big issue for our state. An airport rail link is a service that provides passenger rail transport from an airport to a nearby city by mainline or commuter trains, rapid transit, people movers, or light rail. Examples of services include direct links that operate straight to an airport terminal and other systems that require an intermediate use of people movers or shuttle buses. Although airport rail links have been popular solutions in Europe and Japan for decades, only recently have links been constructed in North America. The CT State Rail Plan (2022-2026) delineates, as one of its Mobility Goals, the expansion of non-automotive access to Bradly International Airport. Furthermore, the plan states that "highway congestion, to which airport passenger traffic contributes, may be relieved by expanding passenger rail connectivity to Bradley." This capability is also supported by the CT Statewide Airport Systems Plan (2016) which recommends enhancing in-state intermodal connectivity at airports.

   Advantages for the rider include faster travel time and easy interconnection with other public transport, while local and state authorities have benefited from less highway and parking

congestion, less pollution, and additional business opportunities. Amtrak studies show that rail transport is 46% more efficient than auto transport. Additionally, the suggested links benefit served airports by drawing in more passengers via easy access. Although the Connecticut Department of Transportation's Capital Plan describes how the department continues to work with the Federal Railroad Administration on projects supported through the Consolidated Rail Infrastructure and Safety Improvements (CRISI) Program, it is unclear whether rail interconnectivity to the state's airports is considered appropriate for an award based on the discretionary grant application process through the Federal State Partnership for Intercity Passenger Rail Grant Program. Connecticut's comprehensive future rail program (TIME For CT) could include improving rail interconnectivity to Tweed and Bradley airports, with both facilities near existing rail lines. This capability might be supported by grant funding for projects located on the Northeast Corridor under the Federal-State Partnership for Intercity Passenger Rail Program.

Resources:

- Railway Technology, Sky tracks: airport rail links - Railway Technology, Sept. 29, 2011
- Wikipedia, List of airport rail link systems
- Denver, Denver Airport Train & Light Rail
- Connecticut Department of Transportation, Connecticut State Rail Plan (2022-2026), Nov. 2022
- Connecticut Airport Authority, CT Statewide Airport Systems Plan, 2016
- Connecticut Department of Transportation Infrastructure Program Annual Capital Plan Report FFY2023 - FFY2027

7. **Autonomous air vehicles:** Starting with the Electric Vertical Takeoff & Landing (eVTOL) Urban Air Mobility (UAM) vehicles, plans are under study to create an environment for the widespread introduction of autonomous air taxis. Connecticut must be prepared with adequate regulation including state specific safety, environmental and acoustic rules. Although significant research has been accomplished in this area over the past decade, it is not yet clear that wide scale use of autonomous UAM taxi's is appropriate.

   Connecticut General Statues 7-149b-Regulation of commercial unmanned aircraft is current law; and in this section "commercial unmanned aircraft" means an aircraft operated remotely by a pilot in command holding a valid remote pilot certificate with a small, unmanned aircraft systems rating issued by the Federal Aviation Administration." Fully Autonomous eVTOL UAM vehicles will not be operated by pilots certified by the FAA, so some clarification and potential regulation is required in the state as the FAA eventually addresses this form of air transport. Flight rules, insurance and liability concerns should be addressed early.

   Resources:

   - Science Direct, Urban air mobility (UAM): A comprehensive review and comparative analysis with autonomous and electric ground transportation for informing future research, Nov. 2021
   - Wisk Aero LLC, Wisk | Autonomous Urban Air Mobility
   - ABC 7 News (Los Angeles, CA), Autonomous flying taxis being developed in Bay Area, Sept. 20, 2023
   - The Verge, Boeing-backed Wisk Aero reveals a four-seater autonomous air taxi, Oct. 23, 2022
   - National Research Council, National Academies, Autonomy Research for Civil Aviation, 2014