Thesis Project Portfolio

File of Technical Report

Real-Time University of Virginia Bus Routes Display System

File of STS Research Paper

Factors Constraining High-Speed Rail Implementation in the United States

An Undergraduate Thesis

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Zayda Deese

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The technical component of my thesis is a project titled “Real-Time University of Virginia Bus Routes Display System”, which creates a physical, dynamic map of the UVA bus system using real-time data and programmable LEDs. This map is built on an acrylic board that visually outlines UVA weekday daytime bus routes and is designed to simplify route visualization for riders. The system retrieves live location data using longitude and latitude points from TransLoc, the real-time data server used by the University Transit Service (UTS), by connecting and interfacing with its public API. Once the data is received, it is processed and translated into commands that control addressable LED strips embedded in the display. Each LED represents a segment of the route and lights up in a specific color corresponding to each bus line, effectively mimicking the bus locations in real time as they cross Grounds. An additional feature highlights the closest bus to a designated reference stop - programmed for a stop on Whitehead Road - using a 7-segment display and a single LED. This small feature shows how many stops away the nearest bus is, along with its corresponding color-coded route. The system is powered through a custom designed printed circuit board (PCB) that connects to a 120V wall outlet and regulates power to all microcontrollers (a Raspberry Pi 4 and STM32 NUCLEO-G071RB), LEDs, and display components.

The project’s main goal is to improve accessibility and comprehension of the UVA bus system for everyday users. It was inspired by feedback from students who often find the existing mobile app interface that is used to track the buses to be overwhelming due to overlapping routes and a cluttered display. By providing a simple, physical, and visually intuitive representation of the system, the project aims to reduce sensory overload and encourage more people to use campus transit. This aligns with broader efforts in public transportation to enhance user experience and make systems more efficient and inclusive.

The second component of my thesis project is my STS research paper, which investigates public transportation from a broader, national perspective. To keep my research thematically aligned with my technical project, I chose to focus on another form of public transit: high-speed rail (HSR). Specifically, my research analyzes the key factors delaying the implementation of HSR in the United States, despite its proven success in other parts of the world. Using a combination of meta-analysis and content analysis, I identified a complex interplay of economic, legislative, and geographical barriers that have hindered HSR adoption. These include factors such as unstable ridership projections, a limited intercity rail market, political opposition, and low population density in many regions - making rail systems less practical or cost-effective in comparison to other modes of transportation. To contextualize these barriers, my research draws from three major HSR case studies: Amtrak's Acela, California's High-Speed Rail Project, and Japan's Shinkansen. The Acela, operating in the densely populated Northeast Corridor, is often considered the closest example of HSR in the U.S., but it is limited by its reliance on existing conventional rail infrastructure and cannot maintain maximum speed for the entire route. California's HSR project illustrates the bureaucratic and political challenges of building a fully modern HSR system from scratch. Years after its proposal, the project continues to face delays and funding battles. In contrast, Japan's Shinkansen, launched in 1964, set the global precedent for successful HSR implementation by prioritizing dedicated infrastructure, long-term investment, and integrated urban development.

By comparing these examples, I highlight how specific social, political, and infrastructural conditions in the United States differ significantly from Japan, where HSR has succeeded. These differences help explain why HSR is currently not viable on a national scale in the U.S. However, the research also points toward a potential solution forward: urbanization and

transit-oriented development. By investing in denser, more interconnected cities and prioritizing transportation infrastructure in urban planning, the U.S. could create the necessary foundation to support future HSR systems more effectively.

The overarching theme connecting both my STS research topic and technical capstone project is public transportation, with an emphasis on accessibility, usability, and public understanding of transit systems. While my STS research explores the societal and structural barriers to implementing high-speed rail (HSR) in the United States, my technical project addresses a more localized, tangible challenge: helping users more easily navigate existing campus bus infrastructure. Both components aim to make public transit more approachable by either examining the obstacles to large-scale innovation or by offering a practical, user-centered design solution at the local level.