Improving the User Experience of University of Virginia's UTS Bus System

Challenges in the Implementation of High-Speed Rails in the United States

A Thesis Prospectus

In STS 4500

Presented to

The Faculty of the

School of Engineering and Applied Science

University of Virginia

Bachelor of Science in Computer Engineering

By

Zayda Deese

December 3, 2024

Technical Team Members: Anthony Nosal, Dan Tran, Robel Woldegyorgis, and Kelly Zhou

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

ADVISORS

Karina Rider, Department of Engineering and Society

Adam Barnes, Department of Electrical and Computer Engineering

Todd Delong, Department of Electrical and Computer Engineering

General Research Problem: Accessibility of Public Transportation

Imagine gliding from Washington D.C. to New York in just an hour at a ground speed of 220 miles per hour, effortlessly bypassing airport stress and leaving behind frustrations of highway traffic while enjoying an eco-friendly ride. This is the magic behind high-speed rail, transforming exhausting trips into swift, seamless journeys and redefining how people travel. My interest in high-speed rail began after watching a comedic-action film called *Bullet Train*, where the plot takes place on a fictional bullet train in modern-day Japan. This image of a bullet train lingered in my mind for a while because I found the innovation so fascinating. I thought about how the infrastructure, required to support travel at such a high speed, must involve complex scientific thinking and engineering applications to ensure reliability and safety, which further drew the transportation mode to my attention.

When it came time to select a topic for my STS paper, the bullet train was the first idea that fit into the category relating to my technical project – public transportation. My project attempts to build a visual display of the UVA UTS bus system that provides real-time data of active buses along the academic routes. One of the main goals of the project is to increase the accessibility of the UVA bus system. High-speed rail is just another public transportation example, where accessibility could be improved to spread its positive impacts amongst a wider range of people. The benefits of high-speed rail are well-documented: reduced carbon emissions, economic growth, and decreased traffic congestion. With such clear advantages, it became evident that there must be significant obstacles preventing the adoption of high-speed rail in the United States. This inspired the creation of my research question: what factors are contributing to the delay in the United States' approval and implementation of the high-speed rail system?

My initial hypothesis to this research question centers around the dominance of automobiles in the United States. Starting in the 1950s, the uprising of automobile usage across the country erupted during the construction of the Interstate Highway System under President Eisenhower and the rise of suburbanization. In addition, America's vast size and rural geography contributed to a car-centric culture. As of 2023, approximately one in five Americans live in rural areas (Rogers, 2023). In these less densely populated regions, personal cars offer greater reliability for traveling long distances compared to public transportation. The dispersed spatial geography of the United States made personal transportation more practical and appealing than public transit such as HSR routes (Chester, 2014). As the demand for automobiles and supporting infrastructure increased, the high-speed rail network received less attention and investment. My STS paper is going to dive deeper into the events surrounding the dominance of automobiles, as well as investigate specific factors and events that contribute to the challenges that the United States faces in its implementation of the high-speed rail system.

Improving the User Experience of University of Virginia's UTS Bus System

How can we design a visual display to promote the accessibility and understandability of the UVA UTS bus routes for its users?

University transit services offer solutions to various challenges faced by student bus users. These services can save students time traveling to and from classes, provide a safer way home at night, and offer support for those who may find walking difficult. Additionally, they can help reduce reliance on automobiles and commuter traffic around campus, leading to lower carbon emissions and less traffic congestion. This reduction in vehicle usage can also free up space previously designated for parking, paving the way for more meaningful college

infrastructures. Despite these benefits, university buses are often underutilized due to limited awareness, a lack of interest, and insufficient effort to understand the bus system.

This issue is evident at the University of Virginia, where the transit system's usage is disproportionately low compared to the student population. Currently, the University uses a third-party application, called Transloc, to provide real-time bus location data. Based on personal experience and conversations with peers, the Transloc can be difficult to navigate, and its crowded interface often overwhelms users. My technical project aims to address these issues as well as improve accessibility. It involves creating a visual display of the bus routes, where programmable LED strips are placed along the corresponding streets. The LEDs will turn on and off between bus stops as buses move along their routes in real-time, providing a clear and intuitive way for users to understand bus locations and schedules. Additionally, bus users and visitors won't need to download the app or connect to the UVA UTS server to know where the buses are located. This visual display is to be placed inside a building along the Engineering Way. Installing the display indoors, rather than outside at a bus stop, addresses issues related to power supply and inconsistent wireless connectivity – challenges that our current budget cannot effectively overcome.

The display will feature the four main academic routes – orange, green, silver, and gold – operating during daytime hours. To indicate which buses belong to each route, the LEDs will illuminate in the corresponding bus line colors. The map used for this display, provided by the UVA UTS department, will be enlarged to a size of 24'' by 36''. This map will be affixed to the backside of a clear acrylic sheet of the same dimensions. The structure of the display will have a layered, 'sandwich-style' design. A wooden board of the same size will form the back layer, with the LED strips cut, soldered, and attached to its front. The LED strips and microcontrollers will

be mounted in the space between the wooden board and the acrylic sheet. To ensure the components in the middle are protected and not crushed, the design will incorporate a method to maintain and secure the separation between the boards.

The project uses a Raspberry Pi 3B+ to retrieve live bus data, wirelessly, by accessing the Transloc Open API using a private API key. A Python program continuously sends GET requests to the API fetching critical bus information such as bus line color, bus ID, and GPS coordinates. This data is parsed and processed to map the location of the bus to the corresponding LED on the display, which is contained in a CSV file. Each LED defines boundary ranges, where if a bus's location falls within the boundary, the appropriate LED is controlled and turned on using the Adafruit NeoPixel Library. The project incorporates a 7-segment display showing the number of stops from the nearest bus, which is controlled by a STM32-NUCLEO G071RB microcontroller. Each segment of the display is connected to a GPIO pin on the STM32 and controlled using the HAL library by sending RESET or SET signals, where a combination of RESET segments forms a digit. Communication between the two microcontrollers is established using the UART serial protocol. The transmitted bus data, from the Pi, is processed on the STM32 to display the correct number on the 7-segment display.

If this project is expanded in the future, solutions could be developed to address any limitations. For instance, the display could be powered by a solar panel, with a backup battery charged by the panel for cloudy days. In addition, the entire setup would need to be weatherproofed with protective casing to prevent component damage. Solving the connectivity problem would be more complex, likely requiring an extension of the university's wireless network. Despite these current constraints, the display still has the potential to fulfill its purpose:

increasing the understandability and accessibility of the UVA UTS bus service through a visually appealing and user-friendly interface.

Challenges in the Implementation of High-Speed Rails in the United States

What factors are contributing to the delay in the United States' approval and implementation of the high-speed rail system?

One of the most well-known high-speed rail initiatives in the United States is the California High-Speed Rail project. It attempts to connect San Francisco to Los Angeles, eventually linking together other big California cities. Once completed, the rail network will span 800 miles and serve 24 stations ("Project Sections", 2024). The project has encountered numerous setbacks from the start. The California High-Speed Rail Authority submitted its first business plan in 2008, but since then, the initiative has struggled to secure the necessary funding. The total estimated cost to complete the project is $128 billion, yet it remains only partially funded (Buchholz, 2024). The Biden administration allocated $3.07 billion in federal funds to the project in hopes to push the modernization of transportation and tackle global emissions (House, 2023). However, this contribution is still not enough to fund the entire system.

In contrast, Japan was able to successfully develop as one of the world's leading countries in high-speed rail network, overcoming many of the challenges that have delayed California's efforts (Jones, 2024). Since the start of its first bullet train, Shinkansen, in 1964, Japan has managed to address funding and opposition, but also consistently expand its high-speed rail network, which now covers over 1700 miles and connects nearly all major cities. Japan greatly benefited from its dense urban geography and already existing rail system as a strong foundation for advancing high-speed rail technology. Despite the United States also

having an already existing rail network, this is not enough to convince lawmakers and the opposition to follow in Japan's lead. Instead, Japan can be seen as a cautionary lesson for the United States as the infrastructure of the high-speed rails would require massive deficit spending and long-term financial commitments. Japan's government accumulated nearly $400 billion in debt, contributing to what became known as Japan's "lost decades", a period of economic stagnation (O'Toole, 2021). In addition, its impact on the labor market was constrained as the overall employment rate showed a slight decline from its initial job boost it brought (Rungskunroch, 2021). These financial challenges can be a concern for California as the state could experience similar economic consequences, leading to the pushback and skepticism.

While it is widely understood that the United States faces financial, political, and social obstacles when it comes to high-speed rail implementation, what remains less clear are the specific events, policies, and legislative actions that have directly delayed progress. My STS report aims to uncover and analyze these critical factors. By gathering and examining real-world news articles, reports, and case studies through meta-review and content analysis, I will map these sources to the root causes that continue to challenge and impede the development of high-speed rail in the country. To expand upon this, I will use comparative analysis to examine data from both the U.S. and Japan, a country with a well-established high-speed rail system. This investigation will go beyond the surface-level understanding of resistance and provide a detailed exploration of the legislative, financial, and cultural roadblocks that have shaped the current landscape. In doing so, I hope to bring clarity to the complexities behind America's struggle to adopt this transformative mode of transportation.

Conclusion

The STS research project aims to highlight the complex and interconnected barriers preventing high-speed rail implementation in the United States, from legislative and financial obstacles to social and political resistance. By comparing the U.S. experience to Japan, where high-speed rail has flourished, we gain critical insights into what policies and practices have led to success abroad and why similar efforts have struggled domestically. Together, the STS research paper and my technical project emphasize the importance of addressing transportation challenges. High-speed rail and improved transit solutions have the potential to transform American infrastructure, reduce environmental impact, ease traffic congestion, and make travel more efficient. By understanding the underlying causes of public transportation challenges and developing innovative solutions, we can pave the way for a more sustainable and connected future.

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