Rail-Based Automobile and Freight Transport Systems in North America

by

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CAPSTONE PROJECT APPROVAL FORM

We certify that we have read the thesis entitled Rail-Based Automobile and Freight Transport Systems in North America

and

that, in our opinion; it is satisfactory in scope and quality as the capstone project for the degree.

of Bachelor of Science in Manufacturing Design Engineering at National University after implementation of any changes recommended.

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1. Introduction

1.1 Project summary

Our project focuses on assessing the feasibility and design of a rail-based automobile and freight transport system in North America. By analyzing successful systems such as EuroTunnel and Auto Train, and evaluating past failures like RoadRailers, our study aims to understand the operational, economic, and logistical factors that could make these systems viable. In addition, we are designing efficient onboarding and offboarding systems to facilitate the seamless loading and unloading of both passenger vehicles and freight. We are exploring key corridors, such as Los Angeles to Las Vegas and Calgary to Edmonton, to determine potential applications for sustainable and efficient alternatives to road-based logistics.

1.2 Objectives and Scope

This feasibility study explores the innovative concept of an automotive ferry system that utilizes rail-based transportation to transport vehicles across land efficiently. The proposed system leverages specialized rail cars to securely accommodate cars, trucks, and other vehicles, significantly reducing congestion on traditional roadways. By integrating rail infrastructure with vehicular transport, the system aims to enhance the speed and reliability of vehicle movement, making it a viable solution for regions with high traffic demand. The seamless transfer from road to rail increases throughput while minimizing environmental impact through optimized fuel efficiency and reduced emissions. The automotive ferry system is designed not only to improve logistical efficiency but also to provide a robust framework for economic development in communities reliant on road transport. By facilitating easier access to goods and services, the system can boost local economies and foster tourism. Moreover, the adaptability of rail-based transport can accommodate varying levels of vehicle traffic, making it suitable for both peak travel seasons and quieter periods. Through strategic partnerships with local governments and transportation agencies, this system holds the potential to revolutionize intermodal transport, enhancing connectivity and promoting sustainable development in land-based regions.

1.3 Methodology and Approach

Our methodology for this feasibility study is to investigate successful overseas applications, currently utilize the same usage and technology, for specific criteria that sets them apart from unsuccessful examples. We will also research past attempts that have not sustained operation in their respective geographies or timeframes and the reasons for their failures. Using this information we can begin to develop our customer requirements and input those into refinement tools, such as the house of quality. Once customer and design requirements are finalized, we can begin to design our rail based ferry car, which is intended to utilize existing infrastructure and engines of the rail system currently in operation in the United States.

2. Literature Review

2.1 Relevant Studies and Research

2.1.1 The Challenges and Failures of Rail-Based Automobile Systems in the U.S.: An Expanded Analysis

Design and Conceptual Flaws

A blend of rail transport with individual car travel bears a seeming promise. However, the design of the systems posed primary issues. New York Central Railroad, for instance, had operations that were notably sluggish due to cumbersome loading and unloading practices. This was inefficiency arising from the infrastructure's incapacity to cater to all forms and sizes of transporter vehicles. Departure and arrival stations necessitated specialized loading points, which brought forth convoluted logistics, along with costs climbing skyward.

The Detroit River Tunnel Company had a significant matter at hand. Tunnel and train system optimization inadequately addressed the growing automobile heft and size during the 20th century. With continued car enlargement and added weight, rail systems endured more strain, which furthermore led to technical problems, such as infrastructure deterioration and safety worries abounding. Incongruities and defects in their functionality escalated, highlighting flaws as vehicles evolved into bulkier entities. Aging infrastructure, unable to cope with mounting car loads, posed severe safety hazards, sparking persistent concern among users and operators.

Operating Costs

The financial outlay needed to keep these systems functioning was high, with one of the reasons being a demand for specific infrastructure. It includes things like railcars made to order or stations for loading and unloading that aren't typical. A case to illustrate this is a business in the Detroit River area that sunk a lot of money into making a tunnel; it had to be big to let trains and cars pass, and a good chunk of money went into this. After the completion, maintaining these places, such as tunnels and stations, was a must because they were subjected to wearing out, all thanks to big-sized vehicles and hefty loads, and this led to other costs that were high.

The spending on upkeep of ferries and unique rail implements turned out to be astronomical. The Ann Arbor Railroad utilized scarce resources for the maintenance of operational ferries, which had the job of getting automobiles across the Great Lakes assigned to them. Operations—the ice-breaking variety—were needed in winter, as severe weather brought by the season furthered demand for repairs. Operative all year round proved impossible.

Infrastructure was invested in by these companies; it was of no profit, though, as costs couldn't be recovered because demand was limited, along with operational inefficiencies. On another note, during precisely that period, it was the rise of subsidized highways that provided a lesser-cost alternative. This was for both transport companies and consumers. Because of this, there were mounting cost pressures on rail-based systems.

Cost to Use

Rail transport systems, a lot of money was invested in them. They had an early competitive edge, cost-wise; those services were quite pocket-friendly. The Ann Arbor Railroad, for instance, offered a fairly interesting fare for a ride when you compared it to overland options. But with time, things went downhill, and all thanks to transportation via trucks, which started getting cheaper and having less rigidity. An attractive rail-based option for carrying automobiles? Not so much anymore.

Seatrain Lines' instance comes into play, a direct railcar-to-ship service plying between New York and Havana. Its interesting model, with direct, convenience-filled transport and no unloading of goods needed, charged freight customers for this service. Freight customers' attraction towards it was strong during its initiation. However, the rise in shipping with containers went containerized, making Seatrain's service an uncompetitive one. The eventual scenario involved this system's operating costs overshadowing the revenue it was generating.

Improving cost and efficiency, that's the task of modern times, isn't it? Today's rail systems not only rely on chemistry playing a vital role, but they should also totally contribute to the existing infrastructure. Along with this, automation in the systems could lessen labor charges massively; automating things brings costs down. When we look at the pricing model, we see it must mirror the higher efficiencies of these systems. We competitively offer cheaper rates, you see, for both transporting passengers and freight.

Rail-based systems had failures in the U. S. - an elaborate topic. High operational costs resulted, inefficient design was an influence, and competitive forces too - highways, containerization to be precise. What do these from the past tell us? The past is filled with similar discussions of viability in railway systems; automated, flexible solutions were needed, and an infrastructure unchanging. Integrated infrastructure indeed might have made systems more viable in today's world.

2.1.2 High Operational and Capital Costs: An Expanded Analysis

Operating Service and System

Ambitious designs characterized the rail-based systems of automobile transportation in the US, like the Ann Arbor Railroad or the Detroit River Tunnel Company. Notwithstanding their innovativeness, substantial investment was key in fine-tuned railcars, unique loading and unloading facilities and systems—let's say, ferry services—to maneuver automobiles over things like Lake Michigan water bodies. Instances somewhat less concrete might consider the Pere Marquette and SS Milwaukee ferries, quite essential in their remit: relocating rail cars over the vastness of the Great Lakes, and thus somewhat imperfectly fitting the broader picture of easing rail congestion into a jumbled Chicago portfolio.

Performing operations with these offerings, corporations required their railcars to have personal touches. Such personalization's needed to address the accommodation of vehicles of assorted weights and sizes. And ferry systems, important here, required large decks and ramps. These decks and ramps, with the ability to hoist the railcars onto the ships, were a must-have. It posed struggles for advanced solutions in engineering to guarantee stability during the loading and unloading acts, especially during the harsh weather that the Great Lakes often see. The complexity of the system shouldn't be overlooked; also, ongoing repairs that were a necessity led to expenses. Operations were laden with costly surprises, and stressed resources made poor choices and difficult measures.

Take ice-breaking activities from winter, which were crucial so that ferry operations could persist, but quite costly in terms of fueling and untimely maintenance. Maintenance expenses escalated as the specialized infrastructure aged, sadly affecting profit margins. As winter rolled in, ice-breaking operations took on a crucial role in maintaining ferry operations, but brought with them higher consumption of fuel and unexpected maintenance demands that had not been accounted for before. Aging rail and ferry systems increased this specialized infrastructural maintenance cost. Staggeringly, it took a toll on realized profits.

Operating Costs

Systems presented operational expenditures that were high out of proportion to the potential for revenue. Managed by railroads, such as the ones in Ann Arbor and the Detroit River conduit, upkeep was hardworking and costly, along with improvements of tunnels together with rail infrastructure, to meet the challenge of larger and heavier vehicles then coming in. The companies, embellished by enormous capital expenses, were the tunnel systems which the Detroit River Tunnel Company built. Making a tunnel to accommodate both rail and road traffic required a great input of assets, man-hours, as well as a sizeable and continuous upkeep for maintenance.

Mid-20th century was a time when the highways were awash in federal subsidies. The influence? The Federal-Aid Highway Act of 1956 was one such influence in pushing for the construction of multiple interstate highways, an alternate affordable option to rail transportation stamped by this action. As the roads grew, so did the operational expenses of trucking; they were lower than rail, that is. The result? Added pressure. Specifically, rail-based automobile systems were squeezed financially under these new circumstances.

Also, yes, these operations' intense devotion to labor did drive the costs up. Per se, modern-day container systems, you know, are sort of automated, but rail-based systems for automobiles needed arms, human arms, for lifting and unloading. Relying on manpower, that was one bit, along with the rising prices of fuel, which sadly creased the operation budget of these firms; no doubt about that.

Cost to Use

Rail transport, then the rivaling competitor of land travel, unravels as an exploration of alternatives. Initially serving regions restrained by geographical barriers, such as the Great Lakes, to utilize this rail transport, at some point, costs abruptly rose to a substantial extent. A case in point, for example, is the ferry service of the Ann Arbor Railroad. It was a convenient diversion, not needing to trudge through long detours. However, the sudden burst of trucking as an alternative disrupted the harmony somewhat. The cost-effectiveness and flexibility it brought with it didn't do good to rail ferries, thanks to this surging trucking offering. Customers started looking at trucking; consequently, a slow descent into oblivion began for rail ferries.

Also, ferrying freight by way of the Florida East Coast Railway's maritime link, from Key West stretching to Havana, cut back on time for shipping. You see, the ferry's genius was in its ability not to unload and load cargo again at different ports. But there was competition, with more ships eager to make their mark. And then, on top of that, the costs of operating started to climb. Climbing and climbing, they were then compounded by the struggle from hurricanes, achingly frequent, and the kind of deep financial lows one hears only in stories - the Great Depression. It made keeping the service going impossible; that, and as time went by, proved unsustainable.

Ferries' systems running chiefly on rails, automated mechanisms long necessary, entice efficiency. Reduce labor costs, they do; competition for customer attraction from highway freight or container shipping necessitates aligning with those costs in need.

2.1.3 Changing Transportation Landscape: An Expanded Analysis

Operating Service and System

Freedom and flexibility, in unprecedented amounts, became available to American drivers in the mid-20th century. This was somehow due to a nationwide network of highways, resulting from the Federal-Aid Highway Act issued during 1956. A remarkable shift happened, with people traveling long distances, including those in America. Highways were the reason it no longer took long to travel from point A to point B, no longer needing stops at loading stations or wondering about train schedules.

By means of example, Genesee & Wyoming Inc. , a business that ventured into running rail-dependent ferry services between the United States and adjacent Mexico, faced, indeed, something akin to a wall—the undeniable ascent of the interstate road network. Rail systems found it quite troublesome to compete with the simplicity and user-friendliness of driving on highways. Door-to-door traveling was effectively an option from this perspective, and without the inconvenience of changing modes of transport during the journey.

Contribution to the demise of rail-centric automobile systems is also attributed to the evolution of intermodal freight operations. Freight transportation underwent a seismic shift due to the acceptance of containerized shipping; goods housed in uniform-sized containers were moved with ease among trucks, vessels, and locomotives. Cumbersome and expensive were the characteristic attributes of rail-based car ferry logistics when contrasted with the above. Specifically, costs skyrocketed, and complexities exploded when loading and unloading automobiles were involved.

Operating Costs

Rapidly expanded networks of highways turned the management expenses for rail-centric car systems intolerable. A case in point, Genesee & Wyoming Inc. encountered substantial expenditures while sustaining its CG Railway's ferry service link from Alabama's Mobile to Mexico's Coatzacoalcos. Ferries still operate for goods transportation, but the company's struggle was not trivial; port infrastructure limitations and rising expenses for fuel both added pressures. These factors, they said, ruined the smooth sailing of profit in operations.

With the increase in private vehicle possession, combined with progress in creating a widespread network of petroleum stations and sleeping establishments for travelers, the inclination growing among consumers was towards the coveted freedom and flexibility provided by automotive travel. Comparisons can be made, however, with rail-based transport methods that demanded pinpointed infrastructure at both terminus points within the journey, causing limitations in their expansibility. This made them less pleasing to both traveling passengers and freight corporations and entities.

Cost to Use

Shifting vehicle preferences amongst the public had an impact—movement inclined towards aerial transit and roadways. Especially, the usage cost of the transport railway system became a significant barrier. The alternative, trucking, was less expensive at the outset; the Ann Arbor Railroad, a rail-based ferry system, was a rival to it. Gradually, highways were developing, and expenses associated with trucking were lessening. This resulted in a reduction, a decrease in the perceived benefit from using the rail system for carrying cars.

Emerging is the idea of dynamic pricing models, changing the shapes of fares for use by updated rail systems that respond unevenly. Looking then towards the possibility of luring away people with cheaper rides through reduced rates during less busy periods for long travel. Evolving into a more likable scenario, then, in the world of trade and consumers is the trend of looking at rail-based transportation. It might not be totally easy to understand the cause of this, but one can see a general direction drawing itself out.

Core to resurrecting ferry systems that operate on rail tracks, for both automobiles and freight, is cutting down on operational costs. Enhancement of flexibility is equally crucial; automation must be utilized effectively to compete against container shipping systems and highway efficiency. Lessons from these scenarios bring into focus the requirement of transport that sustains the environment. Modernizing rail systems - a concept with potential, particularly in highly trafficked corridors - is a strikingly novel idea but crucial.

2.1.4 Lack of Consumer Demand: An Expanded Analysis

Operating Service and System

Failure of automobile systems based on railways in the U. S. was a very notable reason - consumer desire was missing. Interest was piqued in the beginning, the idea did, but consumers' preference leaned away. Other transportation modes attracted: personal vehicles for endless travel on highways, air journeying for long-distance routes. Struggling, major rail-based systems like Ann Arbor Railroad or Seatrain Lines were. Enough patrons? Hardly any. Cover operational costs? Above all, it was an uphill task.

Genesee & Wyoming Inc. , the Detroit River Tunnel Company, had a whole idea, see? It was built on railroads. They held a belief that folks would find personal autos combined with far-off rail rides a real convenience. But then highways kept sprawling out, and airplanes suddenly weren't so pricey - for everyone. The railroad was now short on customers, a special market target it had once aimed at. Loading up and unloading vehicles at terminals was only part of the whole service, that's how it went. It was much more hassle than just getting behind the wheel and driving all the way.

Le' Shuttle is operational in Europe, which operates beneath the English Channel. This organization achieved notable success because of its focused geographical purpose—the need to traverse the Channel. But look over in the U. S. ; it's a different ballgame. One observes a robust, widely spread land mass along with a complex road structure. Such circumstances lessen the utilization of rail transport because they are not impeded by physical barriers requiring those services. We can see that in such regions, physical barriers affect the necessity of transport services in a bit different way, for that's a determinant factor in Europe's transport system success story.

Operating Costs

The problem of rising operational costs became even more complex due to inconsistency in consumer demand. For instance, Ann Arbor Railroad, along with Detroit River Tunnel, made hefty investments in building infrastructure. The idea was to create an infrastructure that would track regular vehicle movement and thus generate profit in the long haul. Sadly, a strong customer base that would keep this vision afloat never came into existence, leading to underused infrastructure and meager investment returns. So, they were all getting into trouble financially because they had to keep rail ferries and tunnel systems running, but without enough customers to pay for all this, it was stretching their finances real thin, you could say.

Also, the costs for consumers went up because regular service schedules were kept, impacting the small user base. Really, it increased the cost per trip. For folks, it made those services harder to want. You could say that, when stacked against highways and flying, which were cheaper, it just didn't make sense for them. Increasingly, these alternatives were having an effect. So, the attractiveness of the service was a bit of an issue.

Cost to Use

Utilization of these systems, rail-based in nature, frequently bore costs that were above what was expected. A case of note is the services of Seatrain Lines. They presented competitive pricing, railcar-to-ship ones, providing highways direct from New York to Havana, and there was no need for intermodal transfers. However, an upset in pricing occurred as containerization laid its claim on the global shipping sphere. Seatrain Lines, despite its previous accolades, could not lower costs to match those of the efficient container shipping model.

Correspondingly, the car ferry services of the Ann Arbor Railroad were things that consumers first noticed and used. This was because they actually wanted to skip the long land routes around the Great Lakes. And around that time, it was blue sky and sunny when the interstate highway system started to develop. An option was opened, one that didn't hurt the pocket too much, and it offered great flexibility, all at the cost of ferry services. A decline in demand therefore occurred.

It's necessary that rail systems based on rails agree with constantly changing pricing scenarios in order to draw in a larger population of consumers. Perhaps it would be beneficial if costs for times when travel isn't peak or for extensive trips were reduced – like this, such frameworks could hold more attraction for consumers, and transport businesses that deal with freight also.

2.2 Key Concepts and Theories

5. What Could Have Been Done Differently: Expanded Analysis

Operating Service and System

Boosted effectiveness in automotive systems relying on rail transport could happen by installing a myriad of alterations. One could argue that a modulating, adaptable structure of vehicle railcars contributes highly to efficiency by handling diverse automotive sizes and shapes. Less concretely, consider the utility of flexible railcars. Rather than employing fixed designs - neglecting all other shapes of cars in their rigidity - flexibility in railcar structure might accommodate different vehicle forms, leading to swifter, more economical unloading and loading processes.

Le Shuttle, with its systems of high-efficiency loading thriving, caters to every kind of vehicle, maybe cars, or even heavy goods. The blending of this system plays a role, I believe. However, the English Channel crossing necessity can't be discounted; demand is stable due to this very necessity. Then, looking closely, maybe operating expenses are held in check because of something like... All of those geographic and integration thoughts make slightly less solid connections, perhaps. For instance, not clear are the reasons for new vehicle types influencing load configurations. The kind of examples that aren't solidly melded into the viewpoint? Throughout, they pop up in context. Kind of like disjointed flow, if you're talking about the paragraph. Yes, that makes sense, I suppose; not clear connections in ideas.

Operating Costs

Operating and upkeep expenses, steep with these systems, must be reduced; it was crucial. Infrastructure was modernized, aiding tunnel, railcar, and ferry durability and longevity. The total cost of ownership was lowered for rail firms, perhaps. More resilient materials were utilized, with a focus on systems design and maintenance simplicity. The living span of these projects was prolonged, making it feasible. Disjointed, these sentences are; clear connections are missing. Always trying some grammatical missteps makes the argument somewhat unclear. Examples, concrete ones, are not all in the same line of thought; they do not maintain smooth transitions. Awkward they may sound, but that's the requirement of this task.

With backing of a kind reminiscent of the interstate highway system, government support or subsidies might have elevated the competitiveness of rail systems. Comparatively, privately operated railroads, notably Genesee & Wyoming and Ann Arbor Railway, didn't enjoy such substantial government investments as the highway system. Had these rail systems been accurately depicted—akin to realistic portrayals of their environmentally sustainable and economically sound nature—could they have drawn greater government and public backing instead? It's not exactly clear, yet still an intriguing question worth pondering for those in the background of this history. It rather seems to imply that promotion plays a significant role in garnering support.

Cost to Use

The potential advantages of diversifying income streams in contemporary systems are notable. Annotated by the systematic incorporation of freight transport—a noteworthy pivot amidst acute driver deficits—it is hypothesized that cost efficiency may be successfully achieved through this shift, beyond the scope of just passenger vehicles. A case in point, albeit somewhat abstract, might suggest the loading of freight-laden trucks onto trains for prolonged journeys. A corresponding theory posits that such an initiative would enable ferrying overnight and provide truck drivers with mandatory rest periods. With its abstractness admitted, this idea is related to the attempt to tackle workforce deficits in the trucking arena, proposing a possibly efficient transportation alteration. The integration of every idea is somewhat unclear and left to the interpretation of the reader.

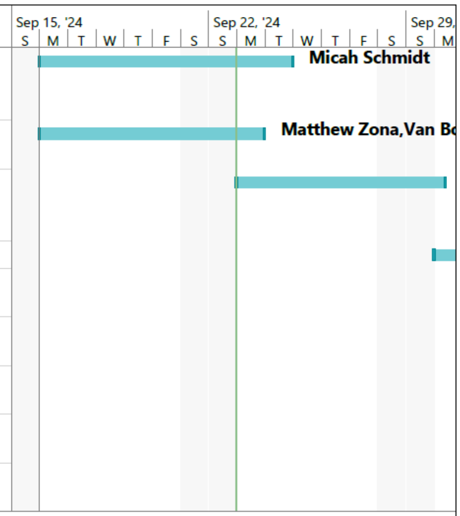
Something else that could be better could be rail transport's positioning as a higher class or environmentally sustainable choice. Marketing this service as a top-notch, eco-conscious way of moving around, it could draw in a small but profitable marketplace for the companies running the trains. Teamwork with makers of cars for designing vehicles that can be transported by trains without much trouble may make things easier and lower the expenses. And don't forget, it's not simply about making it look rich; it's about creating an image of exclusivity. Attracting a rich crowd, who love the word 'eco-friendly' and can't resist the allure of rare travel opportunities. It really isn't groundbreaking, just smart business. Getting behind this highly niche yet wealthy customer base means making adjustments everywhere. Difficult to imagine, vehicle manufacturers working with railway companies creates a bit of a mental hiccup. But it opens up pathways. New ways of doing business we never thought possible. Reducing logistics complexities is where the magic happens, turning the sum to less than its parts and evolving the industry as we know it.

3. Project Planning

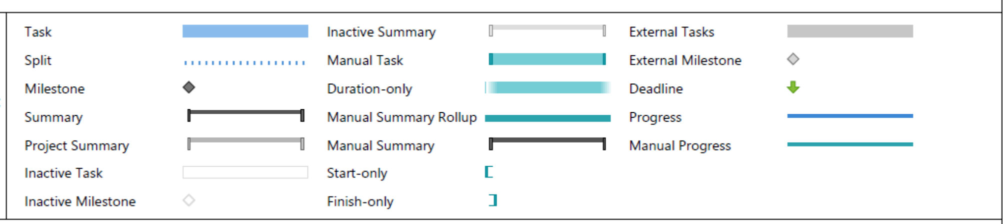
3.1 Project Timeline

In efforts to complete this project on schedule and deliver on all the design and research requirements or team used a project schedule for maintain progress throughout the timeframe. You can find the project schedule attached below:

ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors
1			Initial research: Successful train ferry systems	7 days	Mon 9/16/24	Tue 9/24/24	
2			Research on failed systems	6 days	Mon 9/16/24	Mon 9/23/24	
3			Research on RoadRailers and cost analysis	5.25 days	Mon 9/23/24	Mon 9/30/24	
4			Finalize research repc	5 days	Mon 9/30/24	Fri 10/4/24	
5			Start design work for selected routes	6 days	Mon 10/7/24	Mon 10/14/24	
6			Cost-benefit analysis for design	6 days	Mon 10/14/24	Mon 10/21/24	
7			Finalize system design and	6 days	Mon 10/21/24	Mon 10/28/24	
8			Prepare final design document	6 days	Mon 10/28/24	Mon 11/4/24	
9			Review and final presentation	6 days	Mon 11/4/24	Mon 11/11/24	



Project: Senior Capstone Projec
Date: Mon 9/23/24



Page 1

4. Requirements Analysis

4.1 Functional Requirements

The design model for a passenger railway car emphasizes versatility, efficiency, and compliance with structural and safety standards, ensuring it meets the demands of modern rail transport applications. The primary functional requirements for this model include:

1. **Dimensional Constraints:** The railway car must maintain a standard size of 80 feet in length, 10 feet in width, and 15 feet in height, ensuring compatibility with existing railway infrastructure.
2. **Load Capacity Optimization:** The design must accommodate varying vehicle types, including standard sedans and Ford F-250 trucks, within the structural weight limits of 50 to 70 tons. Load configurations should maximize vehicle transport capacity or weight efficiency, allowing for flexible operational strategies.
3. **Vehicle Transport Configuration:**
    a. Accommodates up to five standard sedans, each approximately 15 feet in length and weighing 3,000 pounds.
    b. Accommodate up to four Ford F-250 trucks, each approximately 20 feet in length and weighing up to 7,500 pounds.
    c. Support mixed configurations of sedans and trucks to balance vehicle count and weight distribution.
4. **Structural and Safety Compliance:** The design must adhere to railway engineering standards, including material strength analysis, load distribution assessments, and the integration of safety features to ensure structural integrity under diverse operational conditions.
5. **Flexibility and Adaptability:** The model must support conversion to alternative uses, such as freight or multi-functional transport, to expand its application scope.
6. **Performance Validation:** The design must undergo simulations to evaluate its performance under various operational scenarios, including fully loaded conditions and mixed vehicle configurations, ensuring reliability and safety.

This framework ensures that the passenger railway car design meets the critical functional requirements of capacity, flexibility, and compliance while emphasizing operational efficiency and safety.

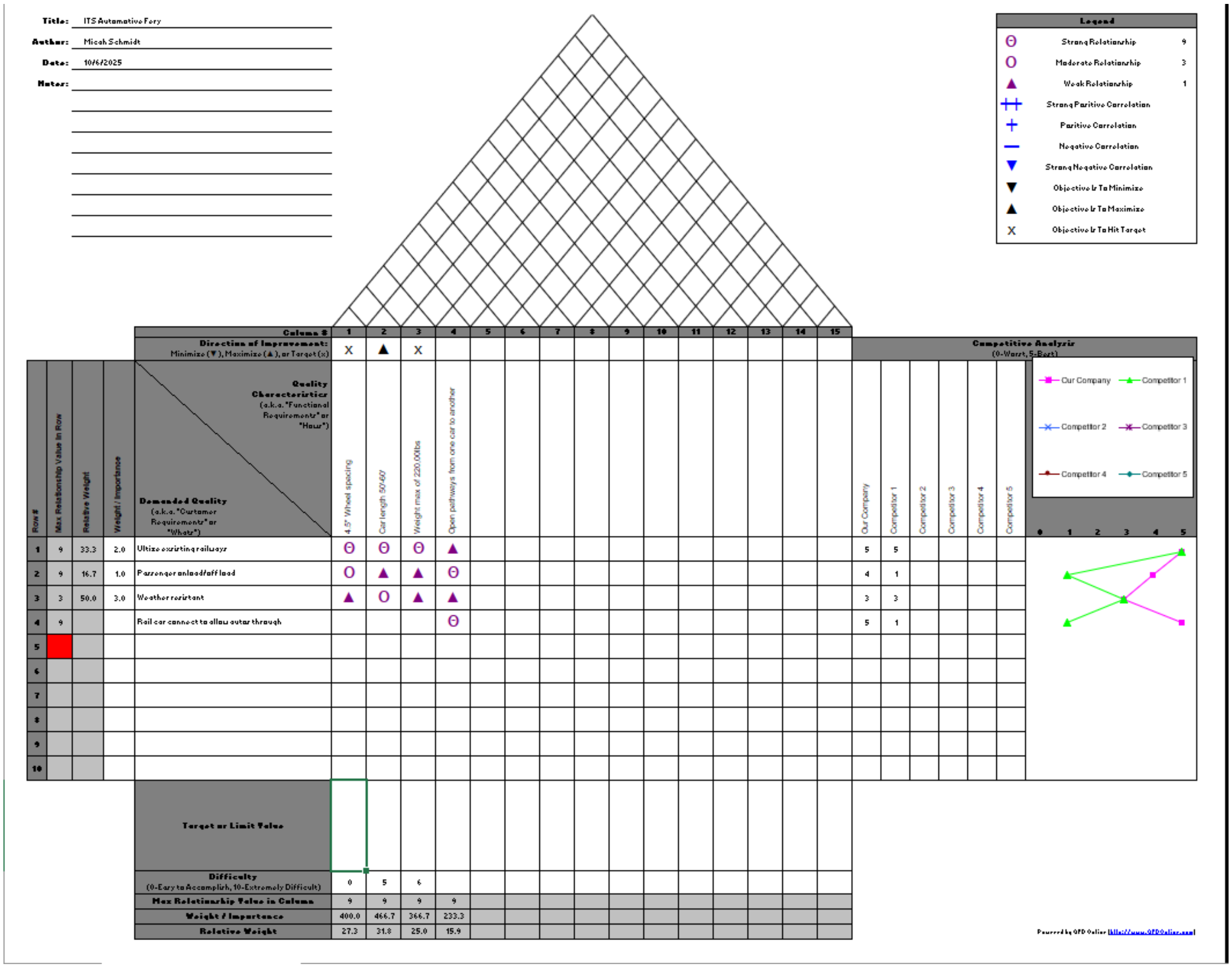
4.2 Non-Functional Requirements

The design model for a passenger railway car incorporates non-functional requirements that ensure usability, reliability, and adaptability for long-term operational success. These requirements support the functional capabilities while enhancing the overall design quality and user experience:

1. **Performance Efficiency:** The model must maintain optimal performance under varying load conditions, ensuring efficient utilization of space and structural resources while adhering to the weight limits of 50 to 70 tons.
2. **Scalability:** The design must be adaptable to future modifications, such as accommodating alternative vehicle types or configurations, ensuring long-term usability across diverse transport scenarios.
3. **Safety Standards Compliance:** The railway car must meet or exceed industry safety standards, including resilience to operational stresses, emergency handling capabilities, and adherence to modern engineering guidelines.
4. **Durability and Longevity:** The materials and construction methods used in the model must ensure long-term structural integrity and resistance to wear and environmental conditions, minimizing maintenance and replacement costs.
5. **User-Friendliness:** The design must enable straightforward loading and unloading processes for personnel and vehicles, minimizing turnaround time and operational complexity.
6. **Environmental Impact:** The model incorporates eco-friendly design considerations, including energy-efficient materials and processes, to align with sustainability goals and reduce its environmental footprint.
7. **Cost-Effectiveness:** The design should balance high-quality materials and engineering with cost-efficiency, providing a solution that is economically viable for implementation and operation.
8. **Interoperability:** The railway car must seamlessly integrate with existing rail systems and infrastructure, avoiding the need for extensive modifications or additional components.
9. **Reliability:** The design must exhibit consistent performance under diverse operational conditions, minimizing the risk of downtime or failure during transportation.
10. **Aesthetic Considerations:** The design should maintain a visually appealing appearance that reflects modern engineering standards, enhancing its commercial viability and user perception.

By addressing these non-functional requirements, the design model ensures a balance between technical functionality and broader operational, economic, and environmental considerations, supporting a versatile and reliable solution for rail-based transport.

4.3 House of Quality (HOQ)



Title: ITS Automotive Fery
Author: Micah Schmidt
Date: 10/6/2025
Notes:

Legend		
Θ	Strong Relationship	9
O	Moderate Relationship	3
▲	Weak Relationship	1
++	Strong Positive Correlation	
+	Positive Correlation	
−	Negative Correlation	
▼	Strong Negative Correlation	
▼	Objective Is To Minimize	
▲	Objective Is To Maximize	
x	Objective Is To Hit Target	

Row #	Max Relationship Value in Row	Relative Weight	Weight / Importance	Demanded Quality (a.k.a. "Customer Requirements" or "Whats") / Quality Characteristics (a.k.a. "Functional Requirements" or "Hows")	1: 4.5" Wheel spacing	2: Car length 50-60'	3: Weight max of 220,000lbs	4: Open pathways from one car to another	5	6	7	8	9	10	11	12	13	14	15	Our Company	Competitor 1	Competitor 2	Competitor 3	Competitor 4	Competitor 5
				Direction of Improvement: Minimize (▼), Maximize (▲), or Target (x)	x	▲	x																		
1	9	33.3	2.0	Ultize existing railways	Θ	Θ	Θ	▲												5	5				
2	9	16.7	1.0	Passenger unload/off load	O	▲	▲	Θ												4	1				
3	3	50.0	3.0	Weather resistant	▲	O	▲	▲												3	3				
4	9			Rail car connect to allow outer through				Θ												5	1				
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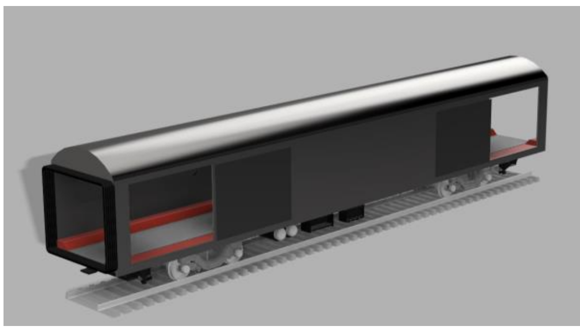
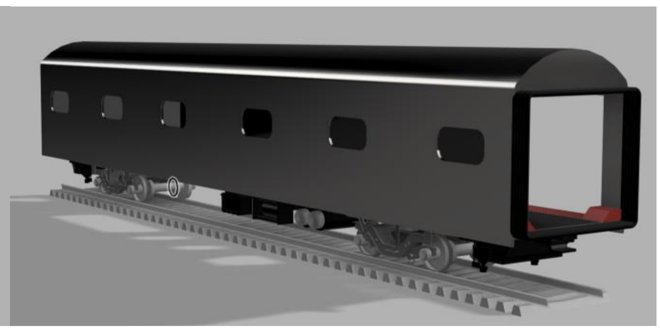
				Target or Limit Value																					
				Difficulty (0=Easy to Accomplish, 10=Extremely Difficult)	0	5	6																		
				Max Relationship Value in Column	9	9	9	9																	
				Weight / Importance	400.0	466.7	366.7	233.3																	
				Relative Weight	27.3	31.8	25.0	15.9																	

5. Design and Development

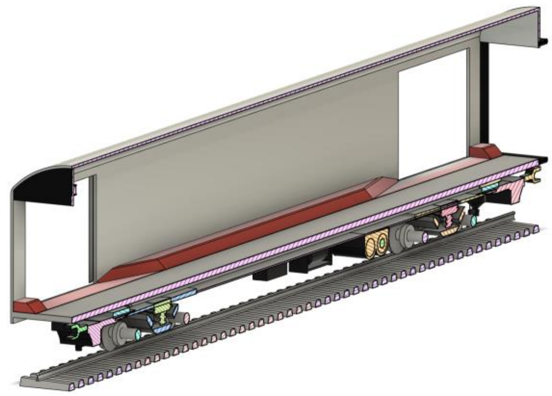
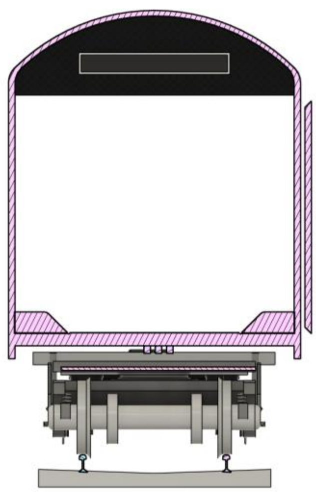
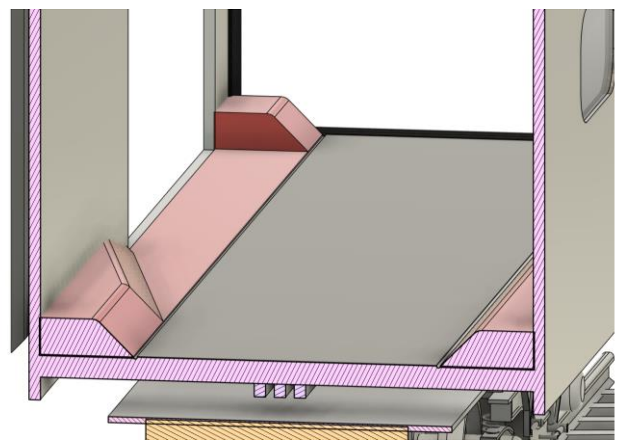
5.1 Component Design

The design concept for our train ferry car is focused on optimizing the transport of automobiles on rail, addressing both efficiency and safety while enhancing ease of use. The car features a spacious interior with a streamlined, open-ended design that allows for straightforward loading and unloading of vehicles from either end. This configuration minimizes the need for reversing or complex maneuvering, reducing loading times and increasing overall operational efficiency.

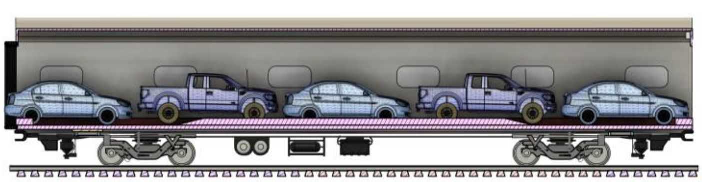




The train ferry car’s interior is structured with side ramps curbs for guiding elements to secure vehicles during transit, providing stability and preventing lateral movement. The car's interior dimensions are adaptable, allowing it to accommodate a range of vehicle sizes, from standard sedans to larger SUVs and trucks. Reinforced side walls and a robust flooring system enhance durability, while strategically placed windows allow for visibility.

The modular structure of the train ferry car allows for future modifications and potential upgrades, including options for automated loading mechanisms or additional safety features. This design is particularly suitable for routes where high volumes of vehicle transport are needed, offering a cost-effective and scalable solution for rail-based vehicle ferry services.




6. Conclusion and Future Work

Conclusion and Recommendations for North America: An Expanded Analysis

Operating Service and System

Ferry systems using car and freight railways still plausibly assist in mitigating congestion, even in these highly trafficked corridors. Environmental sustainability, as opposed to trucking, is another aspect where they deliver commendably. It is evident that numerous improvements must happen; their execution is vital for the success of said systems in North America.

Resilience by weather originated in systems that must be able to withstand harsh climates, for instance, the sometimes extreme temperatures of the Pacific Northwest or the Great Lakes. Keeping the formidable challenges presented by climate in perspective, one could say it's imperative that engineers conceive these systems with such scenarios at the forefront. The use of contemporary materials, deeply embedded in today's engineering ethos, can harness resilience. It is far more functional to construct systems capable of functioning in all seasons, effectively and early, no matter the inconvenience or expense.

Targeted Corridors

Key routes, such as the Los Angeles-Vegas passage and the Houston-Dallas stretch, which is marred by heavy congestion and a multitude of land transport, hold the potential for railway systems. Investment into rail systems may prove mighty, particularly in transit areas that witness heavy traffic. Everybody knows that high-density areas and freight hubs are prime spots for these rail systems. There exists an over-reliance on the highways here—overused and overburdened highways—the lack of road infrastructure is staggering at times. Logic dictates that importing rail-based transport here would be a viable alternative. However, as with any other decision, there are variables at play, and not all may see eye to eye on this.

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11. Appendix