7th Annual Gateway Arch Engineering Contest

Gateway Arch Riverboat

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ST. LOUIS CENTERS *for* ADVANCED PROFESSIONAL STUDIES

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1. Problem Statement

To accommodate the daily fluctuations in water levels, regular adjustments are necessary to ensure that the ramps remain above water and the docks stay afloat. Presently, these adjustments are carried out manually, a process that is labor-intensive and demands the coordination of a complete team to operate the winch system for moving the docks.

Each year 12 million tourists visit the Mississippi River generating $1.2 billion and supporting 18,000 jobs. As the river rises and falls due to weather, the docks need to be manually adjusted accordingly, which is tedious and time-consuming. To accommodate the daily fluctuations in water levels, regular adjustments are necessary to ensure that the ramps remain above water and the docks stay afloat. Presently, the *Gateway Arch RiverBoat*s docks and ramps adjustments are carried out manually. This labor-intensive process demands the coordination of a complete four-person crew to carry out the process cautiously and precisely.

2. Design Specifications

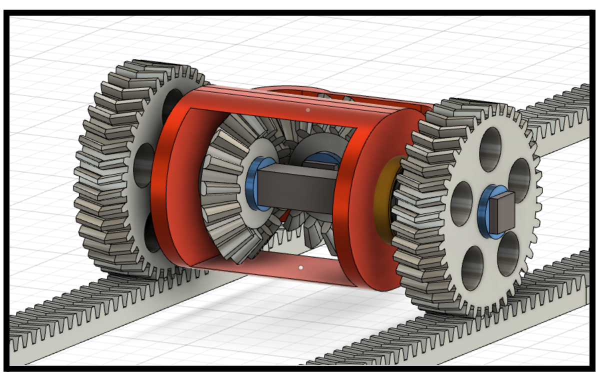
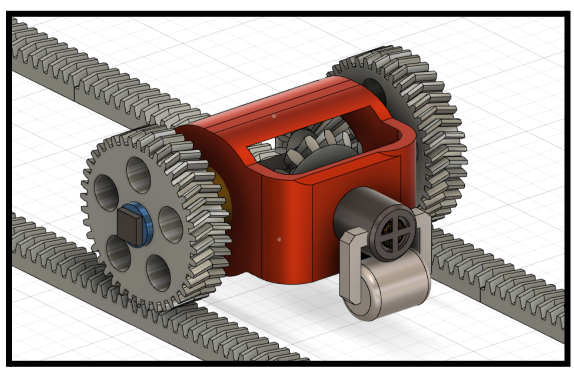
● The system must automatically adjust to the rise and fall of the river.	● The solution must comply with all coast guard requirements.
● Utilities must be out of the way/not interfere of other operating systems	● Must be a functional utility line and supply power to the dock
● Sensors must be able to detect the level of the river.	● Ramps must be automatically adjusting with the anchoring system.
● Ramps must comply with all the different ADA requirements.	● Must be ergonomic.
● Must be able to withstand the elements	● Must be aesthetically pleasing and not take away from the aesthetics of the riverfront and national park.
● Foundations must be able to support the weight of the ramps and plus 500 tons.	● Must be able to withstand the seasons and remain functional during each season.
● Barges must support the shared weight of the bridge and the boat docking system.	

3. Concept Creation

Throughout our design process we have researched and come up with many different components. These components are a mix between concepts that already exist and new designs that we took inspiration from other ideas. We looked into different ways of anchoring, ramp movement, system adjustment, track, and utility line implementation.

3.1 Gear Drive

We first started looking at train tracks and how trains move up steep hills. The gears that pull a train up hills are two simple cog wheels on a track. We took this design and changed it in order to fit our specifications. After finding the design the first thing we did in order to fit our specifications was replace the cog wheels with double helical gears on a double helical track. We made these changes because they have more torque than your standard cog gear which allows us to move ramp without the need of human intervention and they are silent which will make it so it doesn’t take away from the atmosphere of the docks. The next change we made was we embedded the gear track into the levee, this allowed us to have more control over who is able to interact with the track and gears improving safety.The gear drive we are going to use will need regular maintenance which includes lubrication, visual inspection, alignment analysis, noise analysis, gear tooth wear patterns, and bearing inspection. Finally our reasoning for choosing to go with gears instead of wheels is we can know the exact distance we need to move and it isn't able to slide and move when we don't want it to.

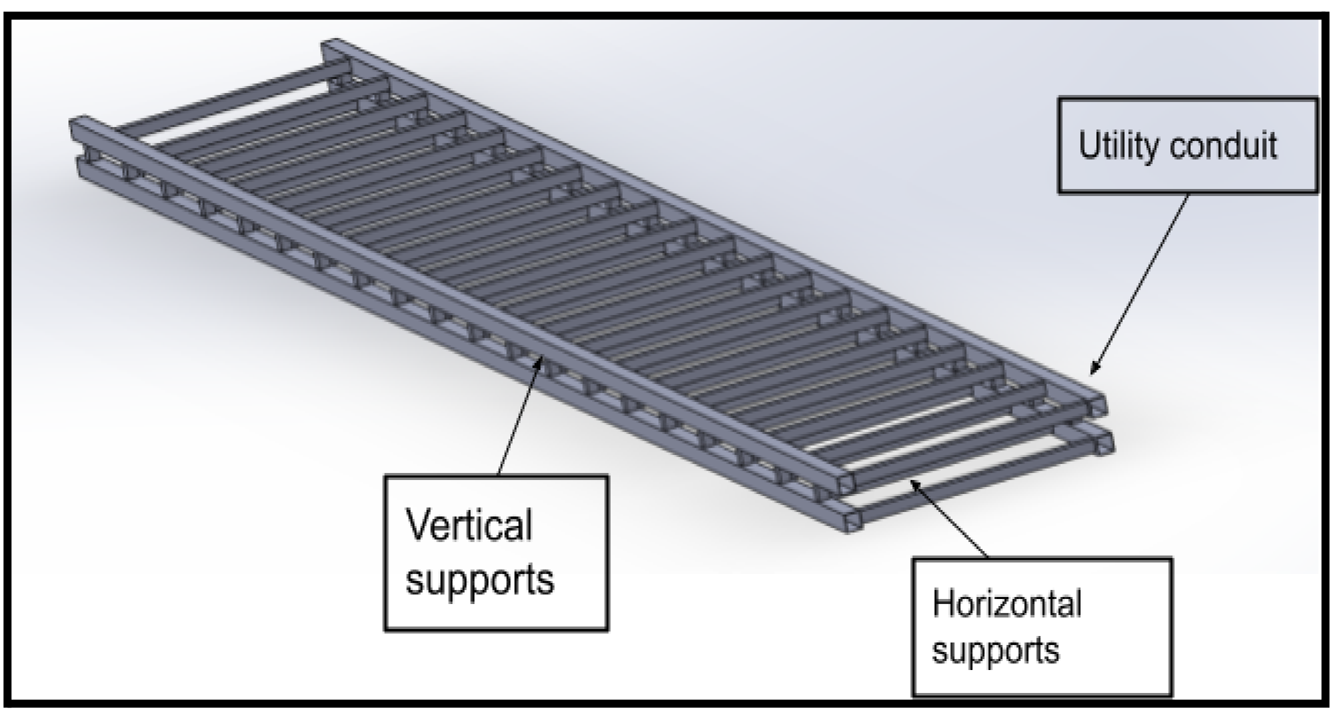



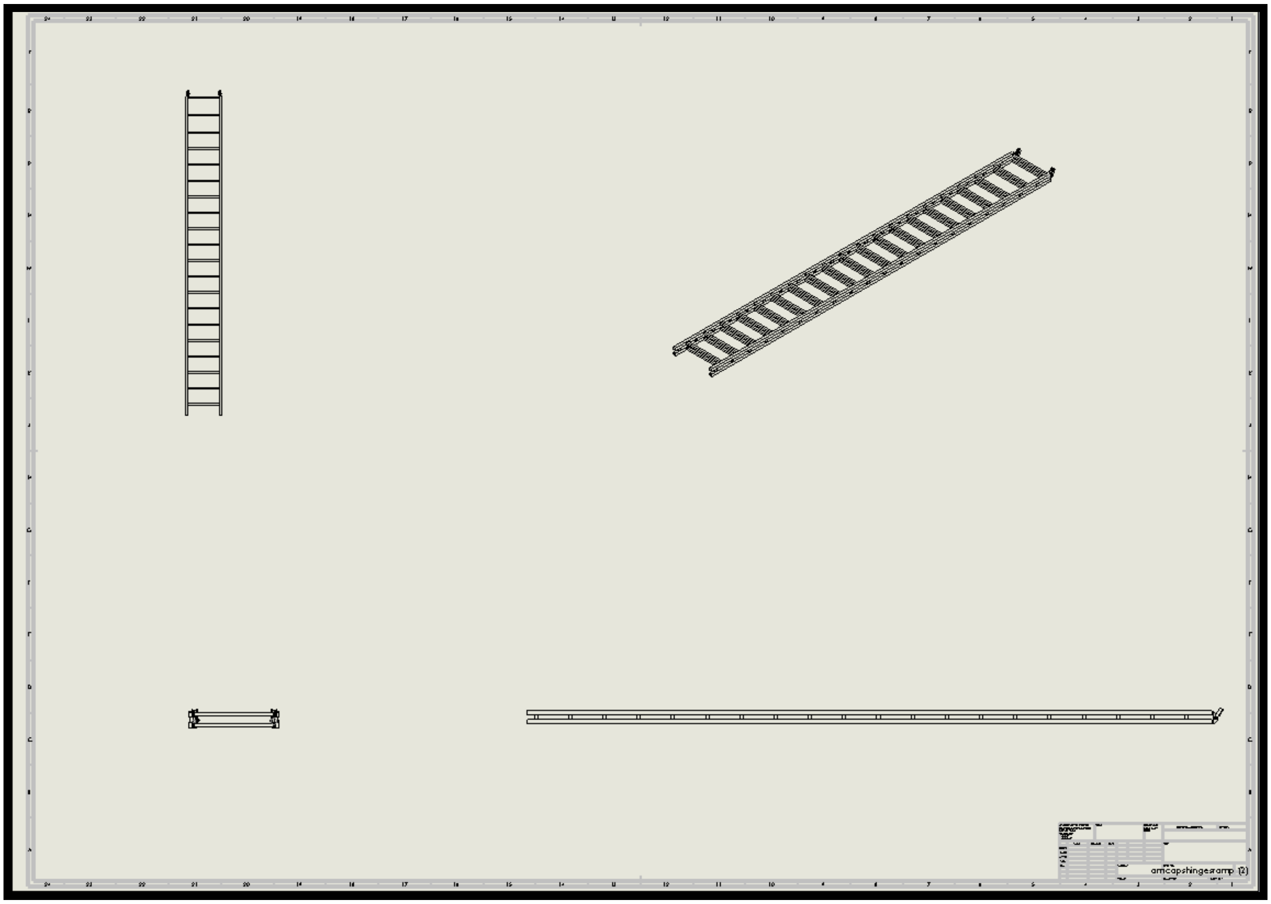
3.2 Anchoring

Our anchoring system is very similar in concept to the current anchoring system but its use is very different. Our systems use will be holding the dock in place and helping raise and lower the dock. The difference between our anchoring system and the current one they have is our dock will not be moving in and out. This will allow us to not have to account for that movement. With the ramps we are using, we will be able to reduce the amount of winches being used down to 3. We will replace the cable and chain with one cable at a much closer point on the levee which allows us to remove a component that had to be manually changed. Between the ramp gear system and the 3 winches we will be able to support the dock and hold it in place. Maintenance will remain the same for what they are doing currently but the amount of winches are lowered.

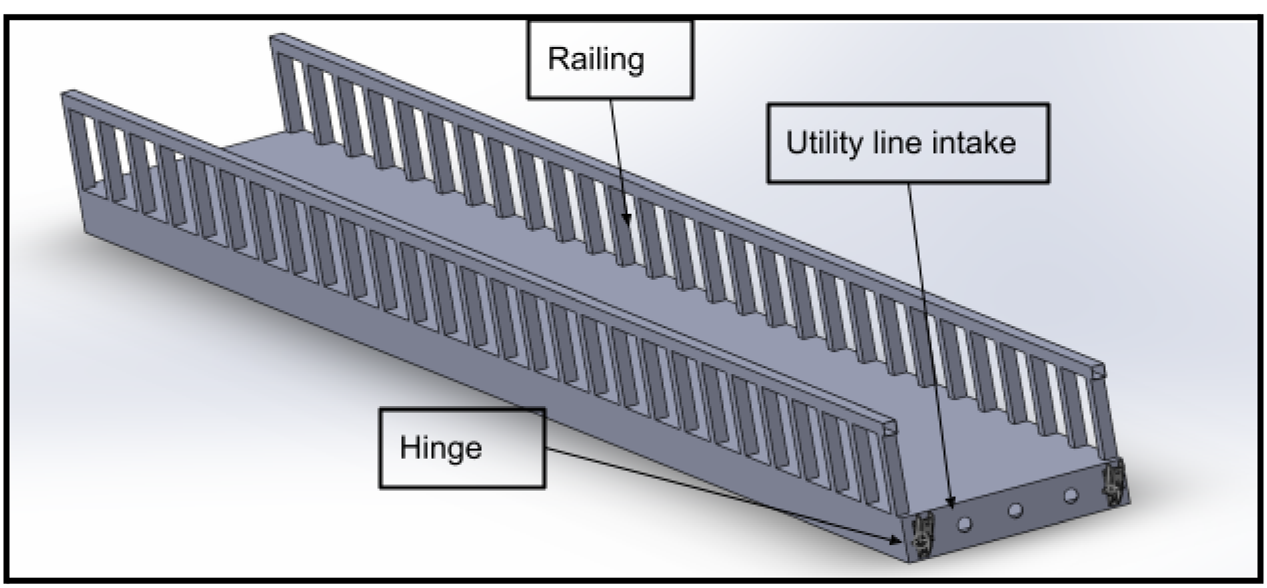
3.3 Ramp Structure

We will be completely remaking the ramps in order to more effectively fit our design requirements.We will reduce the amount of bridges down to 2 from 3. Our Ramps main difference would be the actual structure of the bridge itself. We will have horizontal and vertical support beams in order to ensure the secureness of the bridge. We will make the four long horizontal beams that run the length of the bridge utility conduits.(seen below)

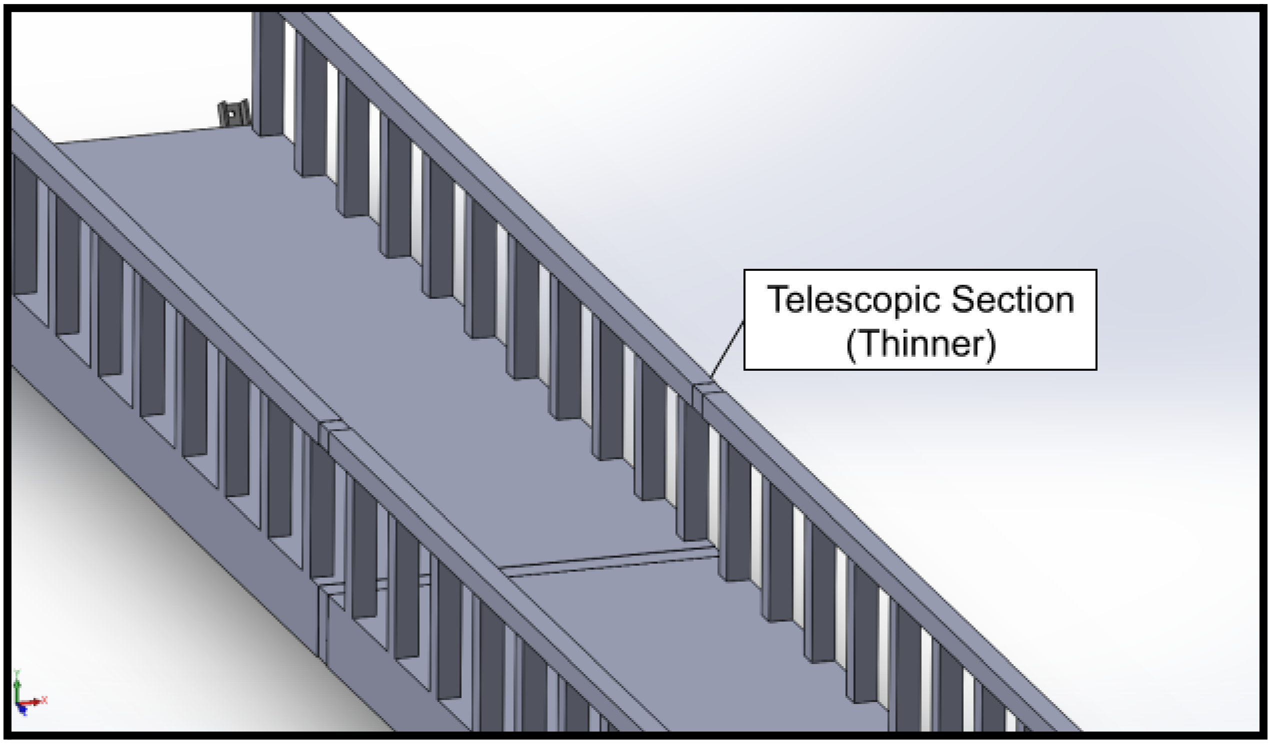




The actual look of the bridge won't be that different from what they have currently but there will be some smaller changes that will make the bridge more modern and ergonomic. Our railing will be a more aesthetically pleasing design which will try to match the railing on the bridge with the railing on the dock. This will not only improve the aesthetics of the bridge but improve the cohesion of the bridge and dock.



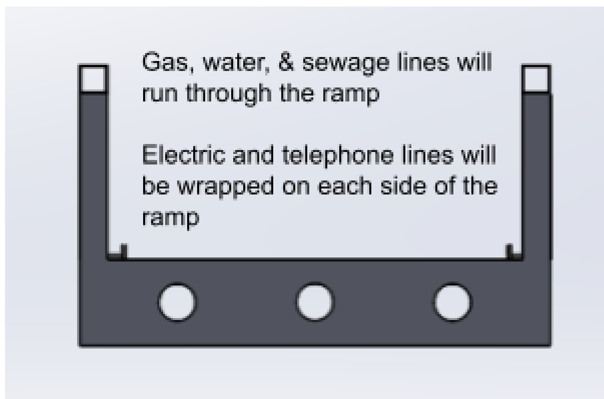
The last major change we will be making with the bridge is we are making the bridge telescopic allowing it to extend without having the dock move. The section of the railing that will be telescopic will just be a little bit that accordions. The section of the bridge that is telescopic will have a skinner part inside it that is able to move in and out.



As the angle changes, the slope will adjust but retain an ADA-compliant slope of 1:12. The changes made to the ramp do not add barriers or add any difficulty for people with disabilities. The ramp is easily accessible and does not interfere with their ability to get to the riverboat.

3.4 Utility Line Implementation

The utility lines originate from an external source and need to be directed into the dock area. To achieve this, we plan to place these utility lines in a trench that starts outside the ramp. From the trench, the lines will emerge and run into the ramp, ensuring a smooth transition. Once inside the dock, the utility lines will be carefully guided upward and turned at a 180-degree angle to optimize their placement and organization. They will be securely fixed in place within the dock area. Importantly, when the ramp extends, the 180-degree loop will naturally unravel the line while keeping a constant tension and maintaining the lines' integrity and functionality. This structured approach ensures that the utility lines are properly organized and can adapt to the changing position of the ramp.



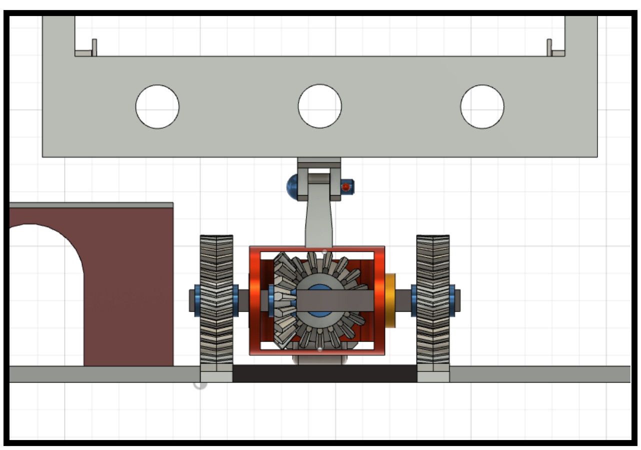
The electric and telephone lines will be looped around the telescopic section of the ramp so if the ramp expands, the utility lines will be able to unravel and maintain their constant tension.

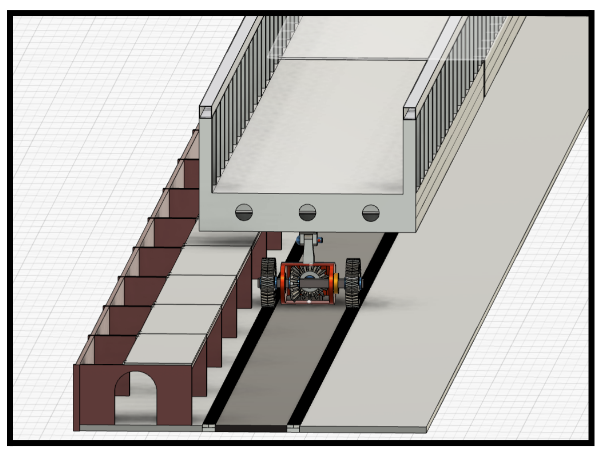
3.5 System Adjustment

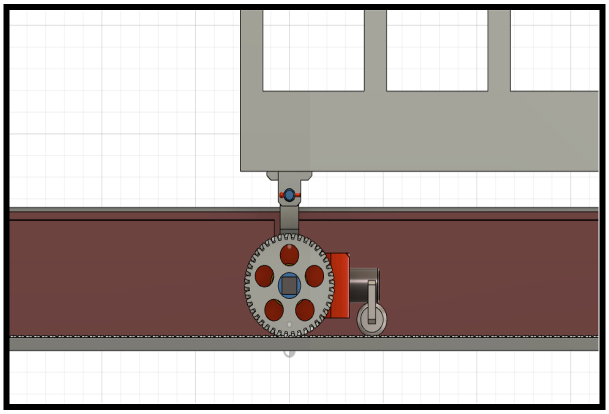
We knew that the previous water level data was sourced from the National Oceanic and Atmospheric Administration (NOAA), we strategically opted to fortify our system by directly integrating their data creating our very own data integration system. This decision granted us the advantage of relying on NOAA's well-established and dependable network of sensors and data collection infrastructure, eliminating the need for the development and maintenance of our own sensor system. Through our seamless integration with NOAA's app, we gained access to real-time, precise, and authoritative information on water levels. When our data integration system detects an increase in water levels, it triggers a comprehensive safety protocol. This protocol involves comparing the current water level to predefined thresholds and promptly generating alerts when necessary, ensuring that relevant personnel are notified of changing conditions. In response to these alerts, the system takes charge of our gear track system, expertly relocating the ramp to a predetermined secure position. Throughout this process, constant monitoring of water levels ensures the ramp's safety during its relocation. Once the water level stabilizes at a safe point, the system expertly halts the ramp's movement and verifies its security. Subsequently, a notification is promptly dispatched to inform personnel that the safety protocol has been executed successfully, reinforcing the assurance of the ramp's safety in response to rising water levels.

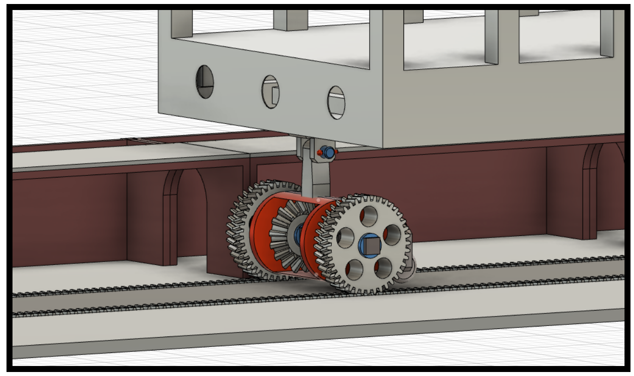
3.6 Assembled Systems

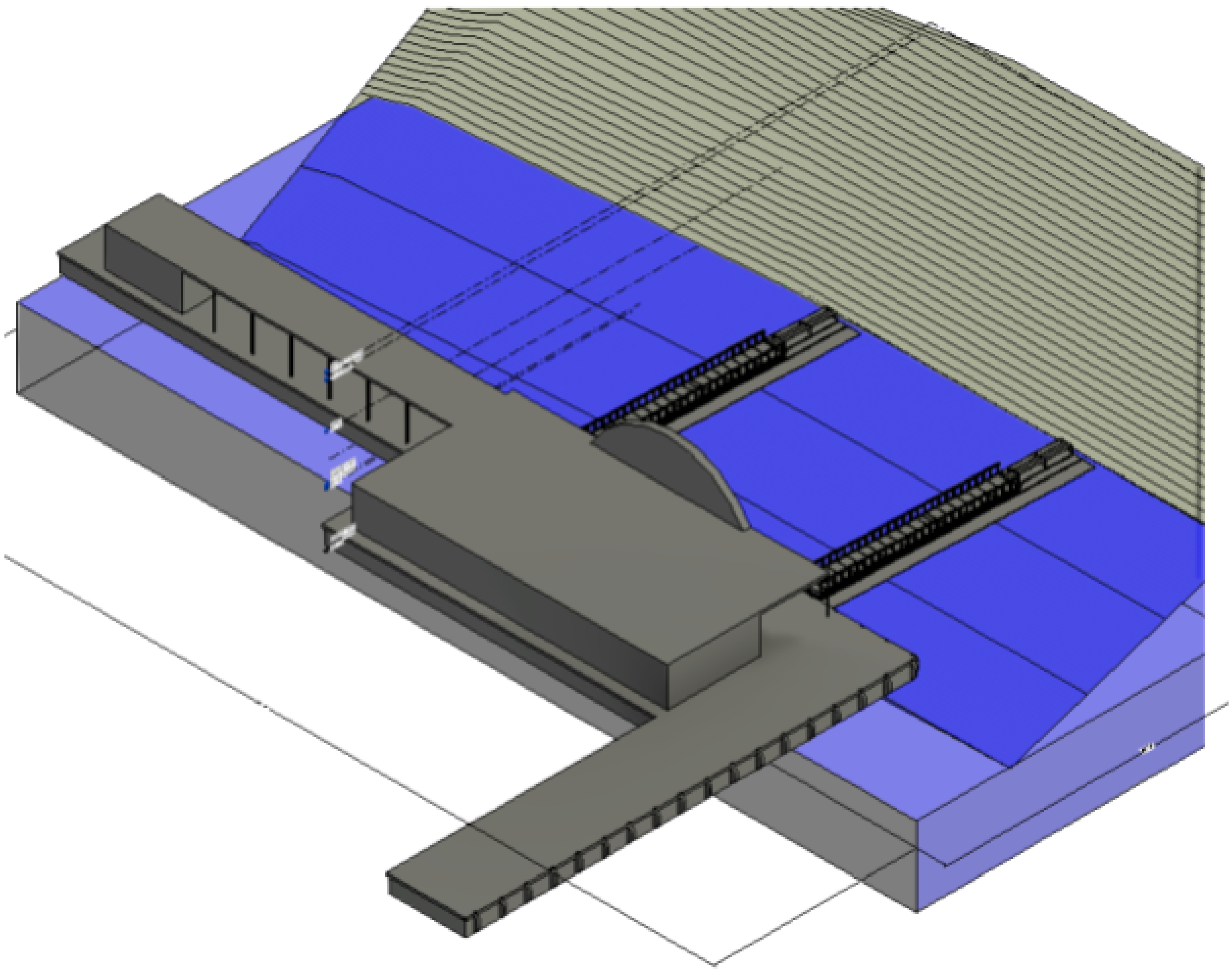
Together our systems combine to efficiently work on their own. The automated system that is connected to NOAA is connected to our gears motor which will, depending on water level, pull the ramp in or out. With the exception of whenever the ramp needs to be pulled up to the top of the levy in extreme circumstances. The winches are used to add extra support for the dock to stay in place connected to cables that anchor it to the land. Otherwise the dock is secured by the double helix gears and the gear track. These gears were specifically chosen due to the fact that they are quieter than any other gear and have a high level of torque. Within the ramp we have our utilities which moves them out of the way of potential damage and visitors. Providing a more aesthetic look to the riverfront and aiding the experience of the river boats.











4. Cost & Timeline

BUDGET PROJECTION

2023/24

PROJECT EXPENSES	AMOUNT
EXPENSES	
1. 4 Double Helix Gears	$13,000
2. Bridge Supports	$10,000
3. Tracks	$24,346
4. Stainless Steel Panels	$427.32
5. Gear Motor	$6,050
6. Concrete+Labor	$24,330
7. Industrial Cable	$2,836
8. Computer Systems	$6,020
9. Labor	$40,494.60
TOTAL EXPENSES PRICE	**$127,503.98**
GRAND TOTAL	$127,503.98

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The majority of our prices came from contacting various industrial supply companies and getting quotes on their products. For example, in order to get accurate prices for the four industrial double helix gears, we contacted “Circle Gear” to get an industry accurate quote of $13,000. For other materials such as the Bridge Supports and Industrial Cable where direct quotes were not needed, we found online companies that sold the materials we needed. We set the material parameters to what we needed on the online storefront and took the prices that were given as a result. There are numerous things that we had in our budget that we could not find solid prices for. Such as the costs of Labor, and developing a computer system to interpret NOAA data that adjusts the bridge accordingly. For these problems we looked at industry standards. We found that on average, the total labor costs of a commercial project is about 40% of the cost of supplies. Knowing this, we calculated that the labor costs for this particular project would be approximately $40,494.60. On top of finding labor costs, we had to find the costs of integrating a system that would control the bridge based on data obtained from NOAA. To do this we used online tools to find that the cost for a basic data Integration program to be around $5,000. On top of the $5,000 for the program, a NOAA yearly subscription would cost $20. We also factored in an extra $1,000 for any electronics or computers to effectively implement this system, bringing the total price for “Computer Systems” to be $6,020.

Task	Nov. 1-7	Nov. 8-15	Nov. 16-23	Nov. 24-31	December 1-7	December 8-15	December 16-23
Cable Install	■						
Dig Trench	■	■					
Concrete Trench			■	■			
Gear Track Install			■	■			
Bridge Install					■	■	
Feed Utilities					■	■	
Adjustment System Installation							■
Adjustment System Testing							■

Commencing construction in November is a strategically sound decision driven by several key considerations. One primary factor is the seasonal fluctuation in attraction to riverboats. As we have meticulously analyzed, the post-summer period witnessed a decline in the number of visitors and riverboat enthusiasts. Initiating construction during this off-peak season minimizes disruptions to the daily operations of riverboats and ensures that our project does not interfere with the enjoyment of our potential patrons. This, in turn, upholds our commitment to providing a seamless and pleasurable experience for all visitors.

Our comprehensive research has also unveiled another compelling reason for November's commencement - the drop in water levels during the winter season. Lower water levels offer practical advantages for construction by providing easier access to the construction site and a more favorable environment for the deployment of infrastructure. This insight not only streamlines the construction process but also contributes to cost-efficiency and safety, a core aspect of our project management philosophy. Moreover, targeting completion by the beginning of January aligns perfectly with the commencement of a new year. This symbolic timing presents an opportunity to introduce our upgraded system to the public, symbolizing a fresh start and a rejuvenated river boat experience. A January launch positions our project as a beacon of newness and innovation, potentially attracting heightened interest and engagement as individuals seek novel experiences at the onset of the year. It ensures that our system is fully operational when the peak season reemerges, thus capitalizing on its profitability and impact.

In summary, our choice of a November construction commencement demonstrates a calculated approach, harnessing the benefits of an offseason lull and favorable weather conditions. This strategy will ultimately enhance the success and longevity of our project, aligning it with the dynamics of the riverboat industry and the preferences of our target audience.

5. Conclusion

The Gateway Arch Riverboat Docks are an iconic attraction for the people of St. Louis and tourists. The riverboats allow you to get one of the best views of the Arch, but the docks are outdated and need changes in order to fit in more with the surrounding architecture. The docks are not only outdated but the current system for adjusting the position of the dock is impractical and needs to be manually moved, can't automatically adjust to the water level of the river, and this can be unsafe for the workers. Our system not only improves the docks aesthetically but they also majorly improve the system of dock movement that is in place. One of the major components of our new system is the ramps, with our new ramp system the dock is able to remain in place and only have to adjust to the rise and fall of the river because it is able to telescope and not have to account for moving in towards the bank and away from it. The ramp system also is directly connected to the gear drive system. This is the system that moves the ramps with the help of the programming system adjustment to automatically change the position of the ramp on the levee to match where it needs to be in relation to the river level. The gear drive system, and ramp system are a part of the anchoring system taking load off of the winches which are mainly there just for insurance in case something happens with the other 2 systems in the anchoring system the winches and cables are able to make sure nothing happens to the dock. The last system we changed was the utility line implementation system, this system allows for the dock to automatically adjust and not have to account for the utility lines because they are self adjusting and will never interfere with other systems. For these reasons we believe that our solution accounts and exceeds all of the requirements that Gateway Riverboat's problem presented.

Cited Sources

National Oceanic and Atmospheric Administration (NOAA). (n.d.). NOAA's Official Website. https://www.noaa.gov/

U.S. Environmental Protection Agency (EPA). (n.d.). EPA's Water Data and Tools. https://www.epa.gov/waterdata

ResearchGate. (n.d.). ResearchGate. https://www.researchgate.net/

IEEE Xplore. (n.d.). IEEE Xplore Digital Library. https://ieeexplore.ieee.org/

Venn Technology. (2023, February 15). How Much Do Integrations Cost, and Is It Worth It? [Webpage]. https://venntechnology.com/blog/how-much-do-integrations-cost-and-is-it-worth-it