Executive Summary: 7th Annual Gateway Arch Engineering Challenge

Proposal for Automatic Dock Adjustment System for the Gateway Arch Riverboats and the Gateway Arch National Monument.

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1. Problem

The Gateway Arch Riverboats dock rests on the bank of the Mississippi River below the Gateway Arch. As a result of the Mississippi River being natural and free-flowing, it doesn't maintain a constant height and constantly fluctuates up and down. This fluctuation creates a problem for the Gateway Arch Riverboats company, which must manually adjust a series of winches to keep the dock at an acceptable water depth. Therefore, the Gateway Arch Riverboats Company, in conjunction with the Gateway Arch National Monument, is requesting a proposal for a system that automatically adjusts the dock to keep it in a suitable depth of water.

1.1 Constraints and Criteria

1. The budget is approximately 2 million dollars.
2. It shall be able to move the 482-ton combined weight of the four barges (the dock) and two riverboats.
3. It shall have a system to contain/adjust the position of the utility lines connected to the dock.
4. It shall be weatherproof.

2. Solution

After much research and consideration, we are proposing the following solution. Our solution can be divided into three sections: the winches, the automation system, and the utility lines' controller.

2.1 The Winches

Electric winches are ideal for maritime applications, especially for the Gateway Arch Riverboat Company. Hydraulic winches present several risks, most critically being the potential of leaking hydraulic fluid into the river, which can be mitigated by installing an electric winch. Therefore, we recommend replacing the last 40-ton hydraulic winch with a 40-ton electric winch. This will also create uniformity in the winch style installed on the barge, simplifying maintenance requirements.

Lastly, by replacing the current 40-ton hydraulic winch with a 40-ton electric winch, the capabilities of the winch system will be maintained.

2.2 The Automation System

For the automation system, we recommend installing three sonar transducers at the three proposed locations on the dock (see Figure 1). The function of the sonar transducers will be to find the depth of the water under the pier. The data from these three sonar transducers will be routed to a microcontroller, which will see the two data values closest together and average them. The averaged data point will become the depth reading used to determine whether to move the dock in or out. To resolve this, the water depth under the pier will be compared to a preprogrammed, optimal water depth under the port. If the measured depth is less than optimal, the microcontroller sends a signal to a relay, which sends a signal to a solenoid, activating a winch to let out the cable for two seconds. This process is repeated until the optimal depth is reached, and all the winches have been adjusted the same amount. The process is the same if the depth is higher than optimal, except the winches pull the cable in. Finally, the current system will remain in place, with a switch being installed to switch between the automatic and manual systems.

2.3 Utility Line Control System

In the current set-up of the dock, the utility lines are attached to the side of the middle ramp. However, due to the genuine possibility that the movement of the ramp could negatively impact the utility lines, we recommend that a system to protect the utility lines be installed. Foremost, we recommend replacing the utility lines because the current ones are dirty and some are spliced together. This increases their points of fail and chances of damage. As a result, the installation of new ones will greatly increase the resilience of the lines. Secondly, we recommend installing a guard around the wheels nearest to the utility lines to prevent them from being run over. The guard (pictured in Figure 2) is composed of a vertical corral around the wheel, with the bottom 1.25” of the guard flaring out. Additionally, there is a minimal gap between the bottom of the guard and the ground, which is significantly less than the diameter of the utility lines. Therefore, inhibiting the utility lines from being able to get near the wheel, and significantly lessening their chance of being damaged by the wheels of the ramp. We recommend that the guard be composed of 18 gauge 304 stainless steel in order to combine strength, rust resistance, and durability. Lastly, the guard will be mounted using L brackets and bolts to the side of the ramp (an L bracket for mounting is also shown in Figure 2).

3. Expenses

The following table is our estimated expenses for our proposed changes:

Corresponding Section of Proposal	Item	Cost		Quantity		Cost Estimate
2.1	40-Ton Winch	$22,643.00	per unit	1	unit	$22,643.00
2.2	Sonar Transducer	$481.82	per unit	3	units	$1,445.46
2.2	Microcontroller	$5.00	per unit	1	unit	$5.00
2.2	Solenoid	$135.80	per unit	5	units	$679.30
2.1 and 2.2	Wiring	$268.00	per unit	2	units	$536.00
2.2	Relay	$50.00	per unit	5	units	$250.00
2.3	Metal for Wheel Guard (8’ x 3’ 304 Stainless Steel, 18 Gauge)	$350	per unit	1	unit	$350.00
2.3	Wheel Guard Fabrication	$1,000	per unit	1	unit	$1,000.00
2.3	Gas Line	$2.34	per foot	400	ft	$944.41
2.3	Electric Line	$0.70	per foot	200	ft	$140.40
2.3	Water	$0.70	per foot	400	ft	$280.00
All	Electrician	$75.00	per hour	60	hours	$4,500.00
All	Plumber	$150.00	per hour	16	hours	$2,400.00
All	Code to Convert Data	$40.00	per hour	20	hours	$800.00
All	General Contractor	$75.00	per hour	40	hours	$3,000.00
					Total Cost Estimate	$39,260.42

4. Timeline

Upon consultation with various industries and companies, we are estimating that the project will take approximately two weeks to complete once the installation begins. We are estimating that it will take about a day for a team of four general contractors to uninstall the old hydraulic winch system and install the new electric winch system. This will be done in tandem with an electrician installing the appropriate electrical wiring for the new winch, as well as the wiring for all the components for the

automation system. Additionally, the electrician will have to help with the replacement of electric utility lines running to the dock. In all, we are estimating about seven and a half days for the electrician to complete their work. We are also estimating that it will take the master plumber about two days to replace the water line, waste water line, and the gas lines. For the metal wheel guard, we are estimating it will take about two days to fabricate it, and about half a day for a team of two general contractors to install it to the side of the ramp. For the code, we are estimating about 2–3 weeks to complete and install on the microcontroller. Ultimately, we are estimating a lead time of one month to get all the materials before installation can even start. Therefore, for an overall timeline, we are estimating about 40 days for the implementation of our solution.

5. Figures

Figure 1:

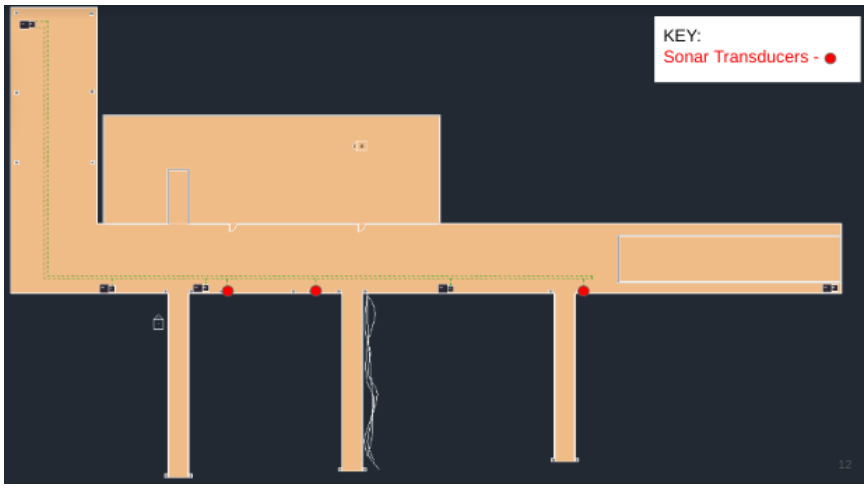

Figure 2: