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Data Logging and Monitoring Solutions for Movable Bridges:
As Learned from CSX CMAR Automation Program

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Program Background

Initial Objectives

In 2017, CSX initiated a construction management at risk (CMAR) program with aims of reducing labor and maintenance costs required to operate the movable bridges within their network while also improving their safety performance. These goals would be achieved by building and implementing bridge control systems and remote operation centers that allow CSX bridge operators to control multiple movable bridges from a centralized control center. In order to obtain US Coast Guard (USCG) approval for remote operation as well as ensure costs incurred as a result of incident response, train, or boat delays do not outweigh the savings, the program also laid out guidelines for improving operational reliability through structural, mechanical, and electrical upgrades.

General Approach

The scope of the automation program is to bridge-by-bridge furnish and install new equipment and machinery required to provide an improved complete functioning mechanical, electrical, and controls system capable of simplified operation from a remote-control center. At the program's outset, the current status of bridge operating systems across the network ranged greatly from automated controls systems installed within the past few years and nearly ready for remote operation to extremely basic manual operation systems consisting of HPU's powered by propane-fueled 20th century tractor motors and controlled via levers with very little electronics.

By the program's completion, each selected bridge will have a standardized and multiply redundant programmable logic controller (PLC) based system with touchscreen interface interlocked to ensure the control system cannot perform operation functions out of sequence, without proper feedback from required field devices, or without intentional bypass by the human operator. Each bridge will be operable from a selected centralized control center specially designed and constructed for seamless, reliable, and safe remote operation, achieved by providing the remote operator with adequate information of local information and by ensuring the bridges receive necessary or prioritized reliability improvements to the operating system and structure.

Program Team

Primary Team

The program is led by CSX's Structures Engineering Department with engineering and consulting services provided by HDR. Construction management and general contracting services are provided by PCL, who, with cooperation from CSX's own Brotherhood of Maintenance of Way Employees (BMWE), also perform the majority of structural and mechanical construction. Electrical and controls specialty subcontractors are selected project by project based on best value proposals.

Additional Stakeholders

United States Coast Guard
Requirements regarding the operation of all movable bridges spanning navigable waterways are described in Title 33, Chapter I, Subchapter J, Part 117 of the Code of Federal Regulations. Subpart 5 of the code requires that, "except as otherwise authorized…by this part, drawbridges must open promptly and fully for the passage of vessels when a request or signal to open is given…" Subpart 7 of the code requires that "…drawbridge owners must: (a) Provide the necessary draw tender(s) for the safe and prompt opening of the drawbridge [and] (b) Maintain the working machinery of the drawbridge in good operating condition…" However, Subpart 42 of the code also allows for the local USCG District Commander to authorize a drawbridge to operate under an automated system or from a remote location upon written request by the owner. As of September of 2021, the USCG reported 20 such requests from several state DOT and railroad companies under evaluation, and the numbers are only expected to increase in the foreseeable future.

To obtain this approval, the proposal must convince the USCG that bridge will operate remotely at the same level of safety and reliability as provided by an onsite bridge tender. This is done by comprehensively addressing the following key topics:

- Condition of the Bridge Structure
- Capabilities, Condition, and Reliability of the Bridge Operating System (Local and Remote)
- Contingency Planning for Local Operations
- Emergency/Incident Response
- Maintenance Planning
- Remote Tender Operational Capacity
- Cybersecurity

Since the approval process has not yet been nationally standardized and is unique to each district, early and regular coordination with the USCG throughout preparations for remote operation is necessary for a successful process.

Monitoring Industry Wide

As more technology evolves the easier implementation can be deployed. The challenges in the past were low cost, easily deployable solutions were not available. Limited communications and infrastructure at the bridge were not always available. The lack of smart devices (i.e. PLC's) installed to capture the needed information was very limited. In addition, very few control system vendors with significant experience in other industries where remote communication systems are commonly used, and budget limitations.
Problems gets worse as more sophisticated controls are installed. This increases the amount of time expended by the bridge tender and maintenance contractor in diagnosing and repair complex equipment. Multiple site visits to the bridge required by maintenance contractor to fix a single problem. This will in turn increase maintenance cost, increased staffing, training cost, and requires technology savvy bridge maintenance personnel and bridge tenders. The more frequent and longer duration service interruptions occur to vehicular and marine traffic. The more customers will be frustrated, and few alternative routes are available to customers if the bridge is non-functional.

Benefits of Remote Monitoring

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Users will be able to receive Realtime alerts from the bridge to trigger shortened response time to problems. Districts would have increased visibility to all issues that occur on the bridge including those are precursors to a failure. The districts can provide better technical support to the bridge tenders in solving more complex problems. This will allow the maintenance crew to arrive at the site with the required parts and knowledge to perform the repair.

SCADA Solutions

SCADA (Supervisory Control and Data Acquisition) software is capable of receiving the data collected from machinery, equipment and devices and processes it. The data is then displayed on screens and dashboards often in animated graphs, diagrams, and images, so that operators know in real time what is happening. The operator can analyze this data to determine whether operations are running optimally, or whether they need adjustment or urgent intervention.

SCADA software is the computer program that helps to monitor plant or factory operations. The software processes data sent from microprocessors Programmable Logic Controller (PLC) or Remote Terminal Units (RTU) that communicate with equipment such as valves, pumps, sensors, HMI's, etc.

Data Logging

A major aid when diagnosing, troubleshooting, or investigating issues is having a stored and recoverable record of conditions and events. It's likely that all bridge owners considering remote operation will want some form of data logging. However, the specifics of what information will be logged and how that information will be transmitted, stored, and viewed is a much more complicated subject.

A successful data logging system is capable of enhancing troubleshooting, aiding in incident management, and may even be able to assist with monitoring of system health, early detection of deficiencies, and processes improvement.

Some topics to consider when developing a data logging system include, but are not limited to:

- How much information is needed or wanted?
    - This question relates to the overall functionality of the data logging system. Data logging can be used for analytics, troubleshooting, events logging, or just operation logging.

    - Alarms and messages could occupy a large amount of the PLC's memory. An effective way to reduce the amount of data stored is by developing a system of nomenclature to shorten the messages while still maintaining comprehension and uniformity. This could be done by assigning equipment, conditions, or events a short name or acronym that is readily understandable or easily translatable by the operator yet occupies less memory space.
- How much information should be stored and where?
    - The team must consider whether the data will be fully stored locally, temporarily stored locally then transmitted to a centralized location, or immediately transmitted to a centralized location. PLC memory is very limited and can get expensive. Also, the available bandwidth of the communication path(s) for data transmission must be considered. These decisions may impact the question of what and how much information is able to be collected
- How long can the information be stored?
    - The team must consider the capacity of the final storage location.
- How will the information be organized, viewed, and/or monitored?
    - The team must consider if the owner already has a system that may be used to increase usability, reduce training time, and potentially save software or hardware costs. If not, there are countless options for answering this question.