Improving Michigan Department of Transportation (MDOT)'s Movable Bridge Reliability and Operations

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16. Abstract The Michigan Department of Transportation owns and operates twelve movable bridges, comprised of eleven bascule bridges and one vertical-lift bridge. These bridges often have electrical and mechanical component failures or malfunctions which can cause unplanned maintenance, traffic disruptions, and navigational disruptions. This research evaluates their existing movable bridge maintenance program, identifies existing movable practices from the industry, and explores practices to reduce closures. While MDOT already performs several tasks informally, it is recommended that formal documentation for Communication Plans, Emergency Action Plans (EAP), preventative maintenance items/checklist (including backup system testing), Movable Bridge Design Guidelines, procedures for updating the as-built drawings, spare equipment data base and malfunction logs (with remedies) are developed. Other recommendations include the use of remote monitoring/troubleshooting which can be paired with advanced diagnostics and alarming. For technological advancements, I/O links provide a great opportunity to improve reliability as the devices can perform self- diagnostic techniques about device health.		

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EXECUTIVE SUMMARY

The Michigan Department of Transportation (MDOT) manages twelve movable bridges, comprised of eleven bascule bridges and one vertical-lift bridge. These bridges are critical for both vehicle and marine traffic. Often, mechanical and electrical component failures and malfunctions cause unscheduled downtime, navigational restrictions, and roadway closures that significantly disrupt both marine and vehicle traffic, and emergency response efforts. MDOT regularly performs preventative maintenance, which prevents most operational inconsistencies. However, there are areas of improvement or strategies that can reduce the frequency of malfunctions and duration of bridge outages. Emergency repairs, which are unplanned maintenance events by their nature, often require maintenance to address component failures as they occur. Unplanned maintenance not only impacts traffic flow, but has additional costs associated with it, such as expedited cost premiums for material and equipment, engineering/contractor support and MDOT staff traveling long distances outside of normal working hours to complete the urgent repairs.

This research aims to evaluate MDOT's existing movable bridge maintenance program, identify best practices from the industry, and explore proactive strategies to minimize unexpected marine and vehicle closures. This research focuses on identifying the main causes of bridge malfunctions for each of MDOT's movable bridges and proposes solutions to reduce delays for users, reduce costs of maintenance/repairs, and ideally, lessen the workload on MDOT staff.

The majority of movable bridge operational inconsistencies are associated with a bridge control system. Limit switches have been shown to be the most common component failure. Bridge operators are at a disadvantage when it comes to troubleshooting these types of issues and may only be able to identify where in the sequence of operation the bridge ceased to function as intended. Applications of various technologies to address failures before they occur, through proactive maintenance, are discussed and recommended as a part of an asset management

plan. The focus of this research is on preventative maintenance, expediting communications such that the right personnel are notified at the right time, and streamlining solutions to more common problems to minimize potential downtimes for repairs. Proper training and site-specific emergency action plans contribute the most to this goal. Findings gleaned from surveys and personnel interviews are discussed throughout this report with some identified as future best practices for maintenance and reliability of MDOT's movable bridges.

In general, MDOT already performs several practices to help prevent and reduce movable bridge malfunctions such as monthly and annual preventative maintenance, but there are additional recommendations. While MDOT already performs several tasks informally, it is recommended that formal documentation for Communication Plans, Emergency Action Plans (EAP), preventative maintenance items/checklist (including backup system testing), Movable Bridge Design Guidelines, procedures for updating the as-built drawings, spare equipment data base and malfunction logs (with remedies) be developed. While these documents likely won't significantly decrease the number of malfunctions, they do have the potential to reduce the duration of these outages. The maintenance checklist, malfunction logs, and spare equipment could be further enhanced by creating an electronic tracking and database that the maintenance staff could utilize.

More advanced recommendations include the use of remote monitoring/troubleshooting, paired with advanced diagnostics and alarming. These recommendations have the ability to significantly decrease the length of outages. Remote monitoring/troubleshooting and advance diagnostics were noted as the items that can considerably reduce outage duration as they can provide MDOT staff with readily accessible information that can be used to diagnose malfunction quickly and efficiently. Another newer technology, IO-Links, could be transformative for future control system reliability due to the ability of the devices (limit switches, solenoid valves, etc.) to perform self-diagnostics about device health.

1. INTRODUCTION AND BACKGROUND

1.1 Statement of Problem

The Michigan Department of Transportation (MDOT) owns, maintains and operates twelve movable bridges (eleven bascule and one vertical-lift) located in six of MDOT's seven regions. Electrical and mechanical components can malfunction or fail, which result in unscheduled downtime for span operation, unanticipated navigation restrictions, and/or roadway closures. Malfunctioning of the control system, electrical distribution, hydraulic, and other machinery components, can trigger disruption to vehicle and marine traffic until the issue can be safely resolved. Additional repair costs are incurred by or from MDOT staff to respond to, troubleshoot, and perform repairs in an urgent manner. Frequently, personnel are required to travel several hours to the site, often outside of normal working hours in addition to expediated premiums for material, equipment, and engineering/contractor support.

This research evaluates MDOT's current movable bridge maintenance program, examines the industry's best practices and investigates proactive strategies that can mitigate unexpected bridge closures. Bridge operating disruptions negatively impact residents' ability to travel through town, emergency vehicles' response time, and marine traffic. For some bridge locations, a significant economic impact can also result due to bridge disruptions, and for other MDOT movable bridges, available detour routes are long (Charlevoix Bridge), or non-existent (Portage Lake Bridge). Maintenance personnel availability, proximity to the bridges, and familiarity with a particular bridge system also impact bridge reliability and outage times. Movable bridges are complex, and when a malfunction occurs it requires experienced personnel who have the knowledge to troubleshoot and resolve the issue.

1.2 Background and Significance of Work

Modern (electrically powered) movable bridges have been in service for over a hundred years. Most research studies on maintenance related approaches to improve movable bridge reliability are based on a specific bridge owner or

consultant's experiences. Several movable bridge owner agencies and consultants have published various related studies which were reviewed and considered as part of this research.

Movable bridges are complex structures, with each one typically qualifying as a 'prototype' to the degree that no two movable bridges are the same. This aspect, coupled with the lack of comprehensive published literature, underscores the importance of this unique and valuable research project.

1.3 Research Objectives

1. Evaluate MDOT's current movable bridge maintenance program to determine opportunities for improvement.
2. Identify best practices used by other bridge owners for maintenance and reliability.
3. Investigate proactive strategies that can mitigate unexpected closures.
4. Determine effective ways to optimize traffic operations during movable bridge roadway closures.

1.4 Report Organization

Section 1 of the report covers the problem statement and research objectives. Section 2 is a comprehensive literature review of articles pertaining to movable bridges, maintenance, and components. Section 3 is the data collection which contains summaries from interviews and surveys pertaining to the research. Section 4 is the vulnerabilities and enhancements to improve MDOT's movable bridge reliability in which vulnerabilities are identified, and enhancements to components are suggested. Section 5 is the validation of the current maintenance, providing a review of MDOT's current procedures for maintenance, communication, standards and training programs. Section 6 analyzes traffic optimization and ways traffic can be improved or reduced. Section 7 contains final conclusions with a summary of the recommendations for MDOT to improve their movable bridges' reliability, maintenance, and operations.

2. LITERATURE REVIEW

2.1 Review of Existing Literature

This section summarizes previous research studies on reliability and maintenance issues for movable bridges. Most studies on maintenance approaches for mechanical and electrical components on movable bridges are based on a specific bridge owner or consultant's experiences. All previous research studies relevant to the current research project are summarized below.

Maintainability of Movable Bridges by Lynn Biwer ()

This research focused on reviewing maintainability issues with Florida's existing bascule bridges to develop a comprehensive design policy for maintainability of bascule bridges by Florida Department of Transportation (FDOT). The research states that, "Maintainability of movable bridges is defined as the adequacy of the design for applying cost-effective maintenance procedures which will minimize bridge malfunctions causing interruptions to marine and vehicular traffic flow." The research discusses maintainability issues with some of Florida's bascule bridges and uses lessons learned to develop a comprehensive design policy that includes maintainability requirements. This guide was created to increase the life of the bridge and reduce maintenance problems. The design guide provides maintenance recommendations for improved maintainability for each of the following bridge components: trunnion bearings, span jacking, trunnion alignment features, lock systems, machinery drive systems, lubrication provisions, drive system bushings, local switching, service accessibility, service lighting, communications, wiring diagrams, diagnostic reference guide, training models, auto lamp changers, and working conditions. The design, maintenance, and training recommendations were developed to minimize the marine and vehicular closures for each bridge while also maintaining reliability in the bridges ability to open and close successfully as needed.

Maintenance Procedures for Electrical Controls on Movable Bridges by Bloom and Bowden (Republished in 2017)

This research provides guidance to minimize downtime when an electrical component fails on a movable bridge. The author's three classifications of preparation can be utilized, as follows:

- Knowing all the components and their application.
- Personnel training for quick, responsive corrections to get the system operational as soon as possible.
- Proper documentation including manufacturers supplied information, component histories, sequence flow charts, and availability and location of parts.

The document elaborates on the preparations and provides preventative maintenance guidelines for various electrical components. A troubleshooting guide pertaining to the problem, cause, and remedy is also provided. Finally, the document contains an example of a routine schedule for electrical component inspections.

A Computerized Predictive Maintenance Program on a Trunnion Type Bascule Bridge by Robert Bloomquist (1987)

This paper outlines the computerized predictive maintenance system that is installed on a bridge operated by the State of Florida. This Predictive Maintenance Program was operational for one year as a prototype system on a trunnion type bascule movable bridge to track trends and determine when components were deteriorated and needed to be replaced. The system was monitored 24 hours/day by the data acquisition computer.

Motion of the lock bars and live load shoes were recorded under traffic loads. Tracking the motion of the lock bars can reflect changes in bridge balance and as well as wear or damage to the lock bar assembly. Live load shoe motion could be indicative of how well gearing wind-up is assuring positive contact on the live load shoes area after bridge closures. Daily traffic counts of the eastbound and westbound traffic were also recorded. Shaft centerline position and peak-to-peak motion of the shaft relative to the bearing were recorded during opening and closing of the bridge to help predict gear misalignment, gear forces, bearing lubrication and

bearing clearance issues. The maximum and average measurements of drive current were also recorded as changes could be indicative of bridge imbalance or friction due to poor lubrication. Trend analysis of drive current was used to identify electrical issues, and maximum and minimum drive shaft torque were recorded to analyze span imbalance. Significant trends in the data were noted as a basis for predictive maintenance to reduce costs associated with unplanned traffic interruption and maintenance.

Considerations for Maintenance for Movable Bridges…. Why Should I Protect my Investment? by Bill Arnold (1987)

This paper provides recommendations to ensure owners are prepared with equipment and parts when a component fails or starts to show signs of deterioration. Renewal or replacement of components can be done on either a routine or emergency basis. Most of the time, performing routine maintenance in a timely manner will eliminate the need for emergency replacement of components. In the writer's experience, keeping critical components that often fail in stock minimizes the need for long term closures of marine and vehicular traffic. Recommendations include creating a list of equipment often replaced by item number which includes a history for that part which can be used to gauge future maintenance needs. There is also a recommendation to create a "reverse index" which includes a list of parts that are often replaced along with their location on the bridge.

Chicago Movable Bridge Maintenance, Operations and Capital Rehabilitation Strategies by S.L. Kaderbek (2002)

The main objective of this research is to summarize Chicago's movable bridges and explain their routine maintenance and operations. Chicago Department of Transportation (CDOT) has a maintenance crew that oversees its movable and fixed bridges.

Routine maintenance for the movable bridges includes:

- Greasing of gear trains, bearings, and other moving parts
- Maintaining the navigation lights and aids
- Life preserver ring maintenance
- Pit pumping and cleaning
- Painting
- Bridge house cleaning

Annual Maintenance for the movable bridges includes:

- Cleaning stringers and floor beams on open deck bridges
- Reliability testing of bridges
- Bridge balancing and shimming
- Heating of bridge houses and machinery areas
- Maintenance of machinery and gear trains
- Snow removal

When choosing between rehabilitation and replacement, rehabilitating more frequently comes in a lower cost. CDOT has rehabilitated 23 movable bridges since 1993. Bridge and sidewalk decks were replaced with steel open deck grating. CDOT's policy is to use concrete filled closed grating rather than open grating for movable decks to reduce accumulation of dirt and salt on the superstructure, when possible. Self-adjusting center locks were developed to reduce the amount of dirt and salt exposure and provide easier access. CDOT continues to face the challenge

of how to best maintain, operate and rehabilitate the largest number of movable bridges, per single government agency, found anywhere in the world.

Inspections, Assessment and Repair of Movable Bridges for Local Authorities Using a System Approach by Steven Shaup (2004)

This paper covers Volusia County Public Works Department approach to determine maintenance needs for the next twenty years for their three bascule bridges. One bridge is located at the north end of the county and the other two in the center of Daytona Beach. Field inspections were completed for all three bridges. Assessment reports were developed that summarized current conditions at each bridge and provided recommendations for repairs. Each discipline (structural, mechanical electrical) prioritized recommended repairs considering when a repair would provide maximum benefit for the owner. Cost estimates for each of the recommended repairs were included.

The three structures were assessed at the same time, which allowed for a system wide approach to developing repair and maintenance recommendations. This prioritized the work and provided the owner with a more cost-effective use of rehabilitation funds.

The Future in Moveable Bridge Control: Fault Tolerant PLC and Remote Operation and Maintenance by Omar Dume (2006)

This study describes in detail many of the features of a Fault Tolerant Programmable Logic Controller (PLC) system and how they can be implemented on a movable bridge to improve reliability of the bridge opening. The PLC system is redundant, which ensures the structure can open repetitively without electrical component failure, and if there is an electrical component failure, the system redundancy kicks in so that the bridge is still able to open and close. Some of the benefits of the system in addition to redundancy are troubleshooting problems, advanced operator interaction, data and alarm logging remote communication, and closed-circuit television cameras (CCTV) use.

A few examples of what can be recorded using data login are listed below:

- Motor speeds and current
- Oil flow, pressure, and temperature (for hydraulic bridges)
- Each bridge opening and duration
- Power failures
- Amount of time generator has been running
- Warnings and alarms

A Maintenance-Centered Approach to Movable Bridge Electrical System Design by Andrew Barthle (2012)

Using case studies, interviews, and other evidence, this paper demonstrates that designing and building a control and drive system tuned to the customer's needs and capabilities result in a finished system that is safer, cheaper, and more reliable. The paper discusses different bridge owners and different scenarios related to electrical systems on various movable bridges. The authors conclude that their goal is to trigger ongoing discussions within the industry to ensure the best maintenance practices are utilized for electrical systems in movable bridges.

Movable Bridge Maintenance Monitoring by F. Catbas, M. Malekzadeh, and T. Khuc (2013)

In this study, the behavior and condition of several critical mechanical, electrical, and structural components on the Sunrise Bridge in Ft. Lauderdale were tracked. Statistical analysis along with machine learning methods were developed to track the behavior and condition of the mechanical components.

Throughout the project, there were two unexpected behaviors for two separate components at separate times. One occurred with the span lock and the other with the gearbox. The research team concluded that the unanticipated behavior was due to the gearbox shaft seal being replaced. This was noted on the maintenance log but not relayed to the research team monitoring the data.

A critical recommendation is that power to the data acquisition system should be a dedicated source of power to ensure there are no interruptions or damage to other systems. For detecting structural issues, implementing vibration sensors at live load shoes, electrical motors, and gearboxes was recommended.

AASHTO Guidelines for the Operation of Movable Bridges from Remote Locations by Rob Moses (2020)

The objective of this research project was to evaluate the risks associated with remote bridge operation and to develop AASHTO guidelines for implementation of reliable remote roadway movable bridge operating systems. Advancements in technology have increased the ability to implement remote operations along with a reduction in cost in the past decade. There is potential cost savings for DOTs, railroads, and local government when implementing a remote system as it reduces the need for multiple operators, ultimately reducing the number of bridge operators needed. The research concluded that safe, reliable, and efficient operation of movable bridges from a remote location is feasible. The proposed AASHTO Guidelines for the Operation of Movable Bridges from Remote locations are included in the appendix of the report. The guidelines provide technical enhancements and programmatic operation and maintenance protocols that can be used to develop remote operation polices.

3. DATA COLLECTION

3.1 Overview

Surveys were sent to owners of movable bridges to capture their best practices on movable bridge operation and maintenance. A summary of the survey responses is provided in the next section of the report. MDOT operators, engineers, software designers, and maintenance contractors were interviewed to gather data related to MDOT's movable bridge operations and maintenance protocols, and reliability issues. Detailed survey responses and interview notes are summarized in Appendix A.

3.2 Agency Survey Response Summaries

3.2.1 *California Department of Transportation (Caltrans)*

The California Department of Transportation has 14 movable bridges: five swing, three lift, and six bascule bridges. Most of the bridges have electrical operation and maintenance (O&M) manuals. Electrical O&M manuals are currently being created for those bridges that don't have them along with mechanical manuals. Caltrans has no specific maintenance crew dedicated to movable bridges because their movable bridges are spread across the state in different districts. Periodic lubrication and various electrical/mechanical maintenance activities are performed on their movable bridges. There is no formal process in place for predicting mechanical and electrical failures nor any Intelligent Transportation Systems (ITS) for maintenance of traffic on or around movable bridges.

Caltrans operational failure protocol requires the operator to contact the district maintenance supervisor first and then coordinate with emergency maintenance staff. Emergency protocol is initiated after traffic has been stopped for a minimum of 20 minutes. If a bridge cannot open, the United States Coast Guard (USCG) is immediately notified, and if a bridge cannot close, the California Highway Patrol is notified to redirect traffic.

3.2.2 *Indiana Department of Transportation (INDOT)*

The Indiana Department of Transportation has one movable bridge in their inventory, a double-leaf bascule bridge in East Chicago, which opens for barges and commercial vessels. The bridge is opened ten or more times per day, and five to seven days a week from April 1st through the end of November. The bridge has an O&M manual on-site that is updated as needed. There is an electronic O&M manual, but it is not regularly updated. As part of the survey response, INDOT suggested adding the plans and maintenance logs with the on-site O&M manuals to assist with troubleshooting, general maintenance, and inspections of the structure. INDOT relies on outside contractors to perform repairs on the bridge.

The bridge averages one to two hours of downtime per month. If there are any issues with opening or closing the bridge, the local authorities are notified after 30 minutes. There is an alternate route approximately one mile from the bridge, which is used to divert traffic when needed.

Various spare parts are stocked on the bridge, and additional parts are purchased on an as-needed basis. A generator termination box and the associated disconnect switch are connected to a portable generator to provide a redundant system.

3.2.3 *Ohio Department of Transportation (ODOT-District 4)*

District 4 of the Ohio Department of Transportation has one movable bridge in their inventory, a single leaf bascule bridge. A physical O&M Manual is located on the bridge. There are no electronic copies of the O&M manual. The bridge does not have a dedicated maintenance crew but there is a team familiar with the bridge and its components. The gears are lubricated and inspected after every 500 lifts. Information and literature pertaining to preventative maintenance is located on-site. Small spare parts are located on-site, but larger parts are stocked in a facility 15 miles away from the bridge.

The bridge has one standby generator that solely operates the traffic control. If needed, a manual lift system can be used to open and close the bridge. Instructions for the manual lift system are located on the bridge. There is no formal training for an operator; typically, the most senior existing operator will train new employees. For emergencies or when the bridge malfunctions, the operators notify the engineering staff. Response time is typically 30 minutes to one hour. There is a 24/7 electrical contractor on call but other discipline responses to emergencies take longer.

3.2.4 *Virginia Department of Transportation (VDOT)*

The Virginia Department of Transportation has a total of eight movable bridges located in three different districts. Within the Hampton Roads District, there are two twin double leaf rolling bascules, a vertical lift, a double leaf trunnion bascule, a swing bridge, and a single leaf trunnion bascule. The Richmond District has a vertical lift bridge. The Fredericksburg District has a double leaf trunnion bascule and a

swing span bridge. Each bridge has an O&M manual on-site as well as a digital remote copy. The O&M manuals are regularly updated as significant repair and maintenance projects are completed. VDOT recommended providing the O&M manuals on a tablet for on-site to make it easier for users to find necessary information.

In addition to VDOT's maintenance crews, each bridge also has a third party contracted maintenance team dedicated to each bridge. VDOT's crews perform both corrective and predictive maintenance following VDOT's schedule for planned maintenance for all electrical and mechanical components (refer to Appendix A for the survey responses which provide details about the maintenance schedule.).

Each bridge has a redundant system, which includes redundant PLCs, redundant main drive motors, backup drive motors, main and emergency drive systems, hand operation, and backup generators. Small replacement parts are kept on the bridge while larger parts, such as gates, motors, etc., are kept in storage facilities no more than 15 miles away from the bridge.

For unplanned downtime of a bridge, Traffic Operation Center's (TOC's) and District managers are notified and if needed, the contractor will be contacted. Downtime is minimal for all bridges due to the predictive/preventative maintenance that is completed at each bridge. When there is emergency or planned work, it is communicated to the Coast Guard, local authorities, and traffic engineering. There are detour routes in place, where possible, that vary in distance per bridge. Two bridges have no alternative route. In terms of ITS, most bridges have security cameras and there is a website, Virginia 511, that provides updates on road conditions including accidents, construction, and more.

VDOT identified limit switches as the component that causes the most problems. VDOT's experiences as well as modifications they have made to various limit switches are summarized on the following page.

- Square D, E-49 switch: fairly "bullet proof"
- GEMCO rotating cam switches: hold up fairly well except if they are located in a wet environment.
- GEMCO sealed cups: maintenance uses grease as a temporary aid to prevent corrosion.
- Brass military type limit switches: installed and tested but did not last a full year.
- Stainless steel screw-in rotary switches: tried but they wouldn't stay securely in place.
- German type switches: tried but their switch heads were popping off, even with added epoxy.
- Berkley Bridges RR switches ("U5"): copper knife switch contacts corrode to pewter green and need to be cleaned off, ensuring the silver tips are not damaged.
- Gear switches on the Coleman Bridge: some failed out of the box and GE discontinued them.
- Smaller relay switches (only an inch long): susceptible to moisture and freezing with temperature drops. Installed pencil heaters to keep enough heat in them to dry out the block.

3.2.5 *Wisconsin Department of Transportation (WisDOT)*

The Wisconsin Department of Transportation has twelve movable bridges in their inventory: eleven rolling bascules and a trunnion bascule. Each bridge has an O&M manual available on-site as well as electronic copies that are regularly updated. An improvement suggested by WisDOT for the O&M manuals is to include all applicable bridge shop drawings.

WisDOT has one full-time movable bridge maintenance employee with four others that assist. WisDOT hires the counties to complete a large portion of the work. Monthly inspections are completed for each bridge and include completing preventative maintenance. Most activities performed are not noted as challenging to

complete and do not involve electrical equipment. WisDOT has contractors on call for addressing cameras, controls, electrical, hydraulic and mechanical issues.

3.2.6 *Washington State Department of Transportation (WSDOT)*

The Washington State Department of Transportation has 14 movable bridges: six bascules, four lift, three swing and one floating with retractable pontoons.

Each bridge has one or more hard copies of an operation, inspection, and maintenance manual located on-site. The Operations, Inspection, and Maintenance Manuals (OIM) are not available electronically, but a copy is kept at another location. The manuals provide step-by-step procedures for maintenance tasks including a schedule of tasks. The manuals are made up of eight sections including: Introduction, Operations, Inspection, Maintenance, Emergency Response, Photos, Maintenance Forms and Emergency Telephone List. WSDOT has a dedicated crew for each bridge. The crew performs mostly preventative maintenance that is outlined in the OIM manual.

Besides routine maintenance such as lubrication, WSDOT uses objective measurements taken during scheduled inspections to monitor mechanical component wear and electrical irregularities. They compare the most recent inspection report with the previous, to see if there is significant inconsistency in either component. If there are concerns, then the electrical/mechanical teams will be notified.

There are redundant systems at each bridge. There are hand cranks that can be used, should the mechanical aspect fail, to ensure the bridge can move to the position need. There are spare parts on-site if one is needed for an emergency or routine replacement. There is an inventory list that contains what parts exist.

There is limited unscheduled downtime for the bridges. This is likely due to the consistent preventative maintenance. WSDOT has Transportation Management Centers (TMCs), which monitor all traffic flow. The TMCs determine if traffic is stopped or if there is an issue on a highway/bridge. They are responsible for all traffic

control. However, within the OIM manual there is a contact list with contact information for the operator if there is an emergency. This includes the United States Coast Guard, ecology and more. There is no 24/7 emergency contact point as the issue is assessed by the WSDOT bridge office staff.

3.2.7 *Triborough Bridge and Tunnel Authority (TBTA)*

Triborough Bridge and Tunnel Authority has two vertical lift bridges. Both bridges have physical copies of the O&M manual on-site and electronic copies available. The manuals are updated regularly to include maintenance and repairs that are completed. TBTA suggested making the manuals available via phone so they could be accessed easily.

There is no dedicated maintenance crew for the two bridges. However, preventative maintenance is completed on a regular basis. This includes testing electrical components and testing of machinery components. There are maintenance charts which identify activities that need to be completed along with specifications on them. To help improve reliability on these bridges, plunger switches and proximity switches are implemented and are being tested and evaluated.

For unplanned downtime there are detours in place, dynamic message signs (DMS), and advanced noticed when there is a planned closure. There are no ITS at the bridges. If there is a failure, maintenance staff is on-call for a 4-hour window. A 24/7 contractor is also available to troubleshoot issues.

3.3 MDOT Movable Bridge Affiliated Staff Interview Summaries

HDR assembled interview questions to illicit information from Transportation Service Center (TSC) managers, subject matter experts, and bridge operators. The questions were grouped into several categories to organize the data. The categories included:

- Availability and usage of Operations & Maintenance manuals, as well as suggestions for improvement
- Maintenance practices

- Whether local forces or Statewide crews are utilized
- Schedules, response times, and most common issues
- Proactive and predictive maintenance activities
- Preseason testing
- Access to the latest bridge inspection reports
- Site specific redundant systems and backup drives for bridge operations
- Spare parts locations and inventories
- Average bridge monthly downtimes protocol for detours

The following sections summarize the interview responses from the bridge operators, MDOT personnel and outside vendors which include, Panatrol Corporation, Faith Technologies, and a hydraulic vendor (SunSource).

3.3.1 *Bridge Operators*

MDOT's movable bridge operators throughout the state were interviewed to gather their input on various bridge issues and operations. Notes taken for these interviews can be found in Appendix A. The operators' responses do not necessarily reflect MDOT policy but are used as a testament as they work with the bridges every day. Bridge operators for each of the following bridges were interviewed: Military Street, Portage Lake, Charlevoix, Cheboygan, Fort Street, Veterans Memorial, and Bicentennial Bridges. Each bridge is operated by a bridge tender with a varying experience level, sometimes more than one person, with knowledge levels spanning from a few months to operating a certain bridge for years.

Each bridge has a different procedure for training operators; however, the most common method is for the previous operator to train the new. Each bridge has a unique training process, but it includes practicing opening/closing and becoming familiar with any maintenance and operations manuals. The training duration per bridge can span from a few days to a few weeks. MDOT Movable Bridge Operators generally know if an O&M manual is on site. However, they are instructed to refer any maintenance issues to the MDOT Statewide Crew (Shawn Wigent – Electrical and Michael Wakely - Mechanical) instead of consulting the O&M manual for

possible solutions. For preventive maintenance, the operators witness some monthly maintenance on most bridges. There are smaller maintenance items that occur as well, such as changing light bulbs and basic operator house maintenance.

Many operators say their bridge has some type of emergency action plan (EAP) in place. However, the plans vary from a detailed step by step plan with call lists, to just a call list, and to no plan other than the operator should call local authorities and MDOT. The Grand Haven Bridge has the most thorough emergency action plan because it has a long vehicle detour. The Grand Haven EAP states road/bridge closures should be placed on Mi Drive which is a website developed by MDOT that provides traffic and constructions information. However, the interview does not specify by whom or when it is added to Mi Drive.

The most common failures mentioned by the operators are those pertaining to limit switches. More specifically, the arm/lever becomes jammed and fails to return, or issues occur with the internal circuitry failing to provide the proper indication. There is also a recurring theme of traffic and barrier gate issues, including internal limit switch failures. The ability to quickly obtain spare parts was mentioned by a few operators as an issue. Since many of the bridges are older, parts are becoming less available/obsolete, and according to the operator of the Portage Lake Bridge that is becoming more apparent with time.

3.3.2 *MDOT Personnel*

- **MDOT Design Engineer and Structures Emergency Response Engineer**

  This interview with MDOT Design Engineer, Jeff Triezenberg, and Chris Idusuyi, Structures Emergency Response Engineer, provided perspectives on MDOT's movable bridges and their maintenance and operation.

  MDOT has been discussing implementing remote monitoring and data logging for troubleshooting component issues at the Portage Lake Bridge. However, MDOT Information Technology (IT) has concerns about cyber security issues related to remote data logging. Limit switches serve as a primary failure point,

underscoring the need for longer-lasting switches and strategies to prevent damage primarily coming from moisture.

The importance of overall documentation was emphasized, particularly regarding replacing parts. Manuals can be outdated or incomplete which can hinder maintenance efforts. Routine seasonal maintenance occurs, but recommendations from detailed inspections may be handled by state crews.

Finally, the shift from all state employees to contracted operators for bridge operations has created new communication challenges. Improving the process for reporting issues and coordinating responses with supervisors and MDOT is essential for ensuring timely actions. Overall, the insights gathered point to significant opportunities for enhancing MDOT's bridge maintenance and operational protocols.

- **MDOT Electrical and Mechanical Specialists**

  Shawn Wigent is an electrical specialist with MDOT, and Mike Wakely is a mechanical specialist with MDOT. They provided key testimony on electrical and mechanical issues and direct preventative maintenance for MDOT's movable bridges.

  Monthly maintenance routines are essential, involving lubricating components like bearings and checking limit switches and rubber seals. Logbooks are maintained at each bridge to record maintenance activities, although they do not always capture detailed information like the type of grease used. The need for standardization of parts was a recurring theme, as many components are becoming obsolete, and operators face challenges sourcing replacements. Shawn mentioned the importance of consistent/modern parts to help make repairs and maintenance easier.

  Communication and operator training also emerged as critical factors in minimizing bridge downtime and improving reliability. Inexperienced operators

may contribute to errors, often reacting impulsively in stressful situations when operations don't go perfectly, which can lead to operational mishaps and poor judgement. In-depth structural, mechanical and electrical inspections by a movable bridge engineering firm occur every 5 years and produce a report, but the repairs requested can take 2-3 years to be implemented. Load testing of generators and periodic servicing by contractors was recommended in the hopes to increase reliability. Overall, the interview underscored the need for improved communication, standardized parts, and proactive maintenance strategies to enhance the efficiency and reliability of MDOT's bridge operations.

3.3.3 *Interviews with Local Operations and Maintenance Staff*

TSC members, owners, engineers, and other 3rd parties that perform work on the bridges were interviewed to obtain information about bridge operations and maintenance procedures. Personnel were interviewed for each of the following bridges: Charlevoix, Portage Lake, Grand Haven, Veterans Memorial, Military Street, St. Clair, Fort Street, Bicentennial and Blossomland. The Bay Region information, which includes Veterans, Military, and St. Clair, was combined due to personnel overlap. Similarly, the interview for Bicentennial and Blossomland bridges occurred together, as both are located in close proximity to Benton Harbor and St. Joseph.

The interviews revealed that almost every bridge has different protocols for operation, maintenance, and repairs. A key takeaway is that consistency is needed amongst the bridges and how they are operated. A common denominator for all bridges is statewide crew perform the majority of maintenance and respond to emergencies. The statewide crew can get to every bridge in a reasonably reasonable manner with the exception of Portage Lake due to its location in the Upper Peninsula.

In terms of O&M manuals, few bridges have a copy available electronically or remotely and only some have hard copies located in the operator's house. Grand Haven, Portage Lake, Fort Street, have parts stocked in the house or at a facility

nearby. The parts stored are small and can fit within the bridge house. A common spare part mentioned to be stored at multiple bridges are limit switches, a component that tends to fail in multiple capacities at a variety of bridges.

The Grand Haven Bascule bridge is tied to an ITS and camera signals are transmitted for viewing nautical and vehicular traffic. Grand Haven openings and delays are displayed on DMS on major highways in the surrounding area. The Fort Street Bridge in Detroit has no direct ITS, but the bridge conditions are displayed on a DMS board along I-75 near the bridge. It has been considered at the Charlevoix bridge due to a substantial detour being the only alternative if the bridge is out of service.

3.3.4 *Panatrol Automation and Controls*

This interview was conducted with Brandon Fane and Bruce Krebbers from Panatrol Automation and Controls, which is a control system integrator company, that is utilized by MDOT that has experience on all MDOT's bridges in providing services for construction projects and emergency supports. The accuracy of O&M manuals for bridges is often low, with many not containing all the needed information as they aren't updated regularly or there is no manual at all. Common failure points in bridge systems include limit switches, which are particularly vulnerable, as well as relays and I/O cards. I/O cards are the input and output card for PLC's. They can be vulnerable to failure as they can be connected directly to field devices, such as limit switches, which increases risks of short circuits/faults, power surges, and lightning.

3.3.5 *Faith Technologies*

This interview was conducted with Paul Bauman and Jake Nolan from Faith Technologies, which is an electrical contractor utilized by MDOT through construction projects. In addition to traditional electrical installations, Faith Technologies also performs control system integration. Faith Technologies noted that the O&M manuals have different levels of accuracy and often aren't available. Faith Technologies utilizes the as-builts when responding to emergencies and troubleshooting issues. The as-builts can be out of date because they aren't updated as maintenance/repairs

are completed. After COVID-19, it became more difficult to get spare parts so putting an emphasis on modern parts and keeping an inventory of what is needed for each bridge is essential for maintenance/repairs.

As mentioned by the operators and in many other interviews, the least reliable components are limit switches, which cause the most unplanned bridge downtime. Protecting the limit switches from the elements while still being easily accessible is essential to extend the service life. They suggest the potential of IO-Links, which is explored later in this document, that would have the capability to predict where failures may occur. Faith Technologies emphasized the importance of redundant systems so operation can continue even when an aspect of the bridge fails.

Faith Technologies lists remote monitoring of systems including remote connectivity as a way save time and money when troubleshooting bridge issues. This would have to be done with caution because of potential cyber security threats.

3.3.6 *Hydraulics Vendor*

An interview with Chris Drago, a hydraulics specialist from SunSource, was conducted to get perspectives about the MDOT movable bridge inventory and his thoughts on operations and maintenance. SunSource has intimate knowledge of MDOT's hydraulically operated bridges. Chris mentioned the bridges are not standard and many contain completely different parts and systems making it difficult to perform consistent maintenance.

As previously mentioned, spare parts have become more and more difficult to find, reiterating that equipment consistency across bridges would make part inventory, both for procurement and spare inventory, more convenient. He also mentioned it will be easier to build power units horizontal as it leaves less room for potential contamination and other resulting issues.

Chris also stated that most of the equipment he sells for Original Equipment Manufacturer (OEM)'s are IO-Link compatible. The OEM's in other industries are relying on IO-Link equipment to minimize downtime and enhance troubleshooting.

3.3.7 *Strain Electric*

This interview was conducted with Bob Strain, licensed electrician and owner, who is utilized as a private contractor. Bob emphasized the importance of having accurate O&M manuals and drawings. Having them accessible on paper is good, but according to him, thumb drives are more convenient.

3.4 Review of Existing Bridge Information

The information that was reviewed include the existing O&M Manuals, Preventative Maintenance Programs/Schedules, Bridge "Malfunction" and "Operations" Logs, Inspection Reports and As-Built Plans. The summary of the information is below:

3.4.1 *O&M Manuals, As-builts, and Inspection Report (availability/access – MiBRIDGE)*

The O&M Manuals and as-built drawings were reviewed for completeness, usefulness and access for MDOT staff.

The review found that the O&M Manuals did contain the anticipated information for the electrical equipment located on each bridge for the initial/original O&M Manuals. In addition, it was found that when smaller targeted rehabilitations were performed, the O&M Manuals were not typically updated to match the new conditions.

The O&M Manuals for the mechanical equipment were reported to be located at the bridges themselves, but electronic versions were not available for most of the bridges. The only electronic mechanical O&M Manuals provided were found for Fort Street and Portage Lake Bridges. It should be noted that the mechanical O&M Manual for Portage Lake only includes the equipment installed in the 2016 project.

The Operations part of the O&M Manual for the step-by-step bridge operations is also included in the manuals. During MDOT interviews it was discovered that bridge operators rarely reference this information after they have been trained, nor do they typically refer to them in the event of bridge malfunctions. Bridge operators typically call maintenance staff relatively quickly after a malfunction occurs instead of referring to the manuals due to the speed of finding potential solutions. While the bridge

operators don't often refer to the Operating Manual, maintenance staff does utilize the information to help diagnose issues and operate bypasses.

The as-built drawings for the control schematics were found within the O&M Manuals. There were several instances that the control schematics were also separated from the rest of the O&M Manual, likely for convenience purposes. While convenient, the information is then in more than one (1) location, which complicates updates when smaller targeted rehabilitations are performed. Similar to the O&M Manuals, the as-builts drawings for smaller or targeted rehabilitations that did not include complete system replacements also did not include updates to the existing drawings. The as-builts for the smaller projects were treated as a separate project with their own O&M Manuals/Drawings resulting in disjointed and sometimes conflicting information.

In all locations, the initial/original O&M Manuals were located at each bridge per MDOT interviews. Most of the bridges also had the information available electronically. The following summarizes the electronic O&M Manual availability for each bridge:

- Veterans Memorial
  - None Available
- Bicentennial
  - Operations Manual
  - Control Drawings
- Blossomland
  - Control Drawings with limited electrical drawings included
- Charlevoix
  - None Available
- Cheboygan
  - Control Drawings with limited electrical drawings included
- Portage Lake
  - Hose Real Manual
  - Electrical O&M
  - Mechanical O&M
- Manistee
  - Control Drawings
- Grand Haven

        - Electrical Maintenance Manual
        - Operations Manual
        - Control Drawings
    - Military Street
        - None Available
    - St. Clair
        - Control Drawings with limited electrical drawings included
    - Fort Street
        - Electrical and Mechanical O&M

Inspection Reports were reviewed for completeness and to identify common issues between bridges. The reports have routinely been uploaded to MiBRIDGE for access to interested parties with proper credentials. The latest report recommendations can be accessed to identify immediate repair needs and potential trouble spots. During the MDOT interviews, the maintenance staff also utilized the reports to identify repairs and maintenance items that could be completed internally.

3.4.2 *Scheduled/Preventative Maintenance & Asset Management*

No formal preventative maintenance program at the bridges was found. There is, however, an informal regularly scheduled and implemented monthly preventive maintenance plan for each bridge as indicated during the MDOT interviews. The preventative maintenance activities are tailored to each specific bridge based on previous experience and previous operational inconsistencies. This includes greasing and lubrication of machinery, limit switch adjustments as needed, and pre-season bridge washing.

3.4.3 *Redundant Systems on Bridges*

Each bridge location has some type of redundant means of operation, however, not all operators are aware of backup capabilities. Some examples of these are a redundant main span drive motor, redundant HPU motor/pump, auxiliary motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc. Backup power is consistently provided for all bridges including either standby generators or an alternate utility feed: The following includes a list of redundant systems for each bridge:

Table 1: Redundant Electrical Systems

Bridge	Primary Span Operations	Auxiliary Span Operations	Primary Control System	Auxiliary Control System	Back-Up Power
Veterans Memorial	Redundant Main Drive Motor	Auxiliary Motor	PLC - Redundant Processors	Relay	Generator
Bicentennial	Redundant HPU Motors/Pumps	None	PLC - Redundant Processors	Relay	Generator
Blossomland	Redundant Main Drive Motor	Auxiliary Motor	Relay	Relay	Generator
Charlevoix	Redundant Main Drive Motor	None	Relay	None	Generator
Cheboygan	Main Drive Motor	Auxiliary Motor	Relay	Relay	Generator
Portage Lake	Main Drive Motor	Auxiliary Motor	Relay & PLC	Relay	Generator
Manistee	Redundant Main Drive Motor	None	Relay	None	Generator
Grand Haven	Redundant Main Drive Motor	Auxiliary Motor	PLC - Redundant Processors	Relay	Generator
Military Street	Redundant HPU Motors/Pumps	None	PLC - Redundant Processors	Relay	Second Utility
St. Clair	Redundant HPU Motors/Pumps	None	Relay	Relay	Generator
Fort Street	Redundant Main Drive Motor	None	Relay	None	Second Utility
Lafayette (Proposed System)	Redundant Main Drive Motor	Auxiliary Motor	PLC – Redundant Processors	Relay	Generator

Notes:

1. Military Street is planned to have the hydraulics removed and operated with an electro-mechanical system.
2. See Appendix G for additional bridge control equipment information.

3.4.4 *Spare Parts Access and Availability*

In reviewing the existing bridge information, spare equipment protocols and recommendations are not formally documented. Due to the lack of documentation, spares are sporadically located at each bridge for frequently replaceable items, including limit switches, lever arms, coupling seals/gaskets, and some spare valves for the hydraulically equipped bridges. Spare parts are generally stocked on MDOT maintenance vehicles. Some spares are regionally located at an outside facility. A record of a spare parts inventory was not documented or available.

3.4.5 *"Malfunction" and "Operation" Logs*

Malfunction logs were reviewed to determine typical issues that occur at each bridge and to identify correlation between bridge equipment.

Some "malfunctions" reported, while important, are not an actual bridge malfunction, such as when utility power is lost but the backup power source was brought online to power the bridge. This is not a malfunction as the bridge has no control over utility power availability and the availability of backup power keeps the bridge operational. Additional ancillary maintenance items, such as window leaks were reported, but are unlikely to affect operations.

Several malfunctions provided only indicate the action to operate the bridge and do not provide a potential root cause. Without documenting potential root causes for malfunctions, it is unknown what steps, if any, had been taken to mitigate future malfunctions.

The malfunction logs between bridges are not consistent or include a formal way to document them. For example, the logs at Bicentennial and Blossomland utilize a standard monthly form, but at the Portage Lake Bridge malfunctions are in a running list recorded in a notebook.

Based on interviews with MDOT Maintenance Staff and Bridge Operators, malfunctions have occurred at every bridge. However, malfunction logs or other malfunction documentation were only provided for the following bridges:

- Bicentennial
- Blossomland
- Charlevoix
    - Only a single malfunction was reported in email form
- Portage Lake
- Grand Haven
    - Only a single malfunction was reported in email form
- Military Street
    - Only a single malfunction was reported in email form
- St. Clair
    - Two (2) malfunctions were reported in email form
- Fort Street

In reviewing the malfunction documentation and MDOT interviews, the most consistent malfunctions were in relation to gates, limit switches, and hydraulic equipment.

The operator logs include each bridge operation throughout a particular month. The operations activity provides some insight into how often a bridge operates and was utilized to correlate malfunctions with the number of operations. In general, no definitive correlation was found between the number of operations and malfunctions other than bridges that have higher rates of operation should be expected to have more malfunctions than bridges that don't operate as much.

4. VULNERABILITIES AND ENHANCEMENTS TO IMPROVE MDOT'S MOVABLE BRIDGE RELIABILITY

4.1 Equipment Reliability vs Operational Reliability

Equipment reliability refers to the bridge's ability to consistently operate with all components in service or operation, such as the main drive motors and all limit switches. Operational reliability refers to the bridge's ability to still operate after a component has failed but the operation will likely take longer than normal operations,

such as when utilizing auxiliary motors or utilizing bypasses. The operational reliability on any bridge needs to be as high as possible to minimize unanticipated navigation and traffic closures.

The primary method of increasing operational reliability is eliminating single points of failure. While there are many single points of failure within a movable bridge control system, these can be managed by the operator through the use of an auxiliary operating system and/or the use of bypass switches. Most identified single points of failure with no recourse within the electrical switches are related to power distribution equipment, such as panelboards and transfer switches. These items are robust and only fail in extremely rare occasions. There are several single points of failure for the mechanical systems, such as shaft, pinion, or bearings, but due to the robustness and higher safety factors used in the design of the mechanical systems, there are typically few failures within these systems.

Most failures for MDOT movable bridges are contained within the control system, which then prevents a bridge from operating under its normal conditions. The typical control system failures are with the main span drive motor control equipment and field devices. Due to this, the control systems are equipped with auxiliary systems for span operation and bypasses for workaround.

4.2 Identify vulnerabilities to movable bridge operational reliability

4.2.1 Control System Capabilities

Control system component failures are inevitable because they are more sensitive to power surges, overcurrent, vibration, and environmental conditions on a movable bridge and operate more, when compared to other electrical components. Power distribution electrical components are designed to better withstand these conditions. Effective and safe bypasses are in place for the major equipment issues, such as having auxiliary motors in the event of a main drive motor/variable frequency drive (VFD) failure or utilizing relays when a PLC component was to fail. Each bridge is equipped with some type of second system for operating the movable spans, such as a redundant span drive motor and/or auxiliary motor.

Auxiliary controls and bypasses need to be in locations where a bridge operator can easily access them. Having auxiliary controls and bypasses in locations where the bridge operator does not have visibility of the roadway and access significantly affects their confidence in making the decisions on which bypasses should be used and if the correct equipment is being operated. Nomenclature for bypasses can be confusing and needs to be better defined within the O&M Manuals. For example, a "tail lock" bypass may be used to bypass tail lock position interlocks on one bridge, but it then refers to a bypass that will allow the tail locks to operate on a different bridge.

4.2.2 Spare parts and availability/obsolescence

Having control component spare parts on hand is important as these items are the most likely to fail. Changing code requirements and obsolescence of components may result in significant lead times for components that were previously readily available. One example is the use of 120V control power that MDOT utilizes on all bridges. Control systems outside of the movable bridge industry are starting to utilize 24V for control power to address safety concerns around higher voltage equipment, specifically as it relates to shock hazards and arc flash concerns. Utilizing 24V control voltage reduces shock and arc flash hazards per National Fire Protection Agency 70E – Standard for Electrical Safety in the Workplace (NFPA 70E). 120V control equipment is not going away anytime soon due to the vast amount of equipment that is currently under operation, but as control systems get replaced or new systems are installed the likelihood of returning to 120V control equipment is low. Another historical example is 240V control was common before the 1970's, but no longer in use today.

Due to the projected significant decrease in 120V control equipment installations, the 120V equipment is starting to have longer lead times and at higher costs. This has already been seen with PLCs and VFDs. The 24V equipment is typically readily available, while 120V input and output (IO) cards can have a few weeks or months of

lead times. As a workaround, interposing relays can be used, but this only increases the amount of equipment required and thus, the potential for single point failures..

With the increased use of electronic equipment such as PLCs and VFDs, obsolescence of existing equipment is only going to get worse. Direct replacements are typically unavailable a few years after the equipment has been manufactured. While the exact part number may be obsolete, most manufacturers have comparable replacements that don't require a substantial rehabilitation. For example, the Allen-Bradley ControlLogix Product line of PLC equipment that MDOT utilizes was released in 1999. The first ControlLogix controller was the 1756-L1, which has the same physical size and connections as the 1756-L8X series that was released in 2022 resulting in upgrades that are easier and less costly to implement as long as the existing IO cards and chassis are compatible with the new processors.

Communication capable equipment such as controllers and ethernet communication cards require preventative maintenance to help ensure they operate as intended, especially if the equipment is remotely connected. Preventative maintenance for this equipment is firmware patching. As the equipment ages and no longer supported by the manufacturer, new firmware patches may no longer be applied, resulting in equipment that will either be at-risk to cybersecurity concerns or is not compatible with new equipment that may need to be installed.

The "standard" relay type for movable bridges found on all of MDOT's bridges is the "Machine Tool" relay. This type of relay is robust, flexible due to convertible contacts, stackable contact blocks (max of 12 contacts), high contact ratings, and has been available for decades. The primary drawbacks of machine tool relays are cost, replacement time, and size. The size of these relays also increases costs as the enclosures required are larger. Due to the increased costs, the availability of machine tool relays is decreasing. Per the interview with Faith Technologies, vendors have reported that these relays are no longer going to be stock items. This information has not been confirmed with manufacturers, but it does represent a

growing shift to plug-in style relays (commonly referred to as "ice cube" relays), if relays are used at all, which are still very common in the movable bridge industry .

4.2.3 Backup Equipment

Each bridge in MDOT's inventory has some type of redundant power source. At most bridges, the redundant power source is a backup generator with an automatic transfer switch (ATS) that provides power in the event of a power outage. At the remining bridges, a second electric utility feed provides the redundant power source. See Table 1 for a list of bridges and their backup power source. In both instances, the ATS is a single point of failure, which is the only single point of failure in MDOTs inventory that requires a control board to function properly. Equipment that utilizes control boards or electronics are much more susceptible to power surges and/or failures due to short circuits. Electronic equipment is also more likely to become obsolete with no spare parts available. While an ATS can be operated manually if needed, waiting for maintenance staff to arrive could result in a significant outage. MDOT also does not utilize ATS's that includes a bypass option, which allows the ATS to be serviced without removing normal utility power to the bridge.

MDOT's bridges are not equipped with surge protection, typically installed in upstream locations to protect the ATS from a power surge. Portage Lake and Lafayette bridges have experienced a damaged ATS from a utility power surge.

Each bridge within MDOT's inventory is equipped with redundant span drive motors, auxiliary motors, and at some bridges both. See Table 1, which lists span operations and control system redundancy. At locations with hydraulics, each HPU is equipped with a redundant pump motor. In addition to having redundant span drive motor, a secondary or auxiliary type of control system is also in place. A secondary means of operating a span is only effective if the redundant equipment is operational and the bridge operators know how to operate the auxiliary systems.

At the more troublesome bridges, (Military Street, Bicentennial), and high-profile bridges (Charlevoix, Portage Lake, Grand Haven), the redundant modes of operation are well tested, and the bridge operators know exactly what steps are required for

the next mode of operation. At the remaining bridges, the redundant operations are not tested regularly nor are the bridge operators familiar with the operations. Bridge operators that are not familiar with redundant operations take longer to operate the bridge when the primary operating system experiences a failure.

4.2.4 Hydraulicly Operated Bridges

Hydraulicly operated bridges (Military Steet, and Bicentennial) within MDOT's inventory have been the most troublesome bridges and are perceived to have the most issues per maintenance personnel. Hydraulicly operated bridges require more maintenance than electro-mechanically operated bridges as the hydraulic systems incorporate a higher number of components. The typical service life of hydraulic machinery is about 25 years, at which point major rehabilitation is required. In comparison, "geared" electro-mechanical systems have approximately a 75-year service life.

A few issues identified with hydraulic bridges include a lack of up to date as-built drawings/manuals, a lack of standardization between bridges, and overly complicated systems. As an example, the Military Street bridge employs servo valves in its operating system. The servo valve has electronics within the valve to provide flow feedback to the control card, providing precision flow values based on the feedback. For the operation of a movable bridge this feedback and precision are not required and just provides more electronics to fail in the future. Proportional valves also require control cards, but there is no feedback from the valve on a simple proportional valve. It has set functions and timing for acceleration, deceleration and full speed values that are set on the card. There is also a dearth of up-to-date information that can be cross-referenced with the electrical system when troubleshooting. As an interim measure to support future troubleshooting efforts, "Canfield" lighted wafer indicators can be incorporated with the existing valve manifolds to identify which individual valves in a manifold are energized during operation.

4.2.5 Limit Switches

MDOT utilizes several different types of limit switches such as lever arm, plunger, proximity, and rotary cam types. The primary types of limit switches on MDOT movable bridges are lever arm and rotary cam type switches. The type of limit switch utilized depends on the location and the intention of the original design. Limit switch failure is typically the most common failure on any movable bridge because the number of limit switches that are utilized on each bridge is significantly more than any other component. Each movable bridge within MDOT's inventory incorporates well over 20 switches, which is significantly more than any other component.

Limit switches located outdoors or subjected to harsh environmental conditions and vibrations are the most prone to failure. Examples of limit switch failures on MDOT bridges include:

- Limit switches mounted to the operating rack that use the pinion for bridge position have the highest limit switch failure experienced by MDOT. It should also be noted that these are the locations with the predominant quantity of limit switches on a typical bridge. The limit switches are also installed below the joint between the movable and approach spans and are marginally protected from the weather. The location below the joint is subjected to corrosive runoff from salting operations in the winter.
- Tail lock limit switches are typically installed below the movable joint subjecting them to harsh environmental conditions similar to switches mounted to the operating rack.
- Fully closed limit switches have been problematic, because they get stuck in the actuated position. This typically happens during the winter when ice builds up on the operating mechanisms which doesn't allow the switch to change positions. An example of this can be found at the Fort Street Bridge where the bridge could not be lowered due to ice on the fully closed limit switches.
- For the majority of limit switches subjected to harsh environmental conditions, MDOT has utilized potted switches, which feature manufacturer-installed

cable seals at the cable entry point, which provide an enhanced degree of protection from water and dust infiltration to help extend limit switch life. While switch life has likely increased due to the potted cables, switch life is still less than switches in locations that do not experience the same environmental impacts. Limit switches failures in other locations do happen, but the frequency is significantly less. For example, each thrustor brake incorporates three (3) lever arm or plunger type switches that do not have potted, or manufacturer installed cables, yet they rarely fail. These thrustor brake switches are simply located in areas that don't experience the same harsh environmental conditions.

4.2.6 Maintaining Current Schematics

The majority of movable bridge operational inconsistencies are related to a movable bridge control system issue or failure. When troubleshooting activities are required, the most important tool to help identify and correct issues is having a current set of electrical schematics at the bridge. A readily available electronic (PDF) version of the schematics is also highly valuable if remote troubleshooting assistance is required. Inaccurate schematics create confusion and can significantly delay progress. Attempting to understand how a control system functions "on the fly" and without the aid of schematics can lead to prolonged delays to bridge users and potential temporary solutions resulting in unsafe operations.

4.2.7 Lubrication of Mechanical Systems

The majority of issues associated with the span drive machinery or ancillary systems, such as span locks or tail locks, are due to poor lubrication. Continued lubrication of bearings and sliding surfaces need to happen on a regular basis as part of routine maintenance. Plain bearings, such as sheave trunnion or shaft bearings, need more frequent lubrication than roller type bearings. When plain bearings are not lubricated regularly, or improper grease that is not compatible is used, the grease can harden in the grease grooves and the bearing will either stop accepting grease or the grease will not flow through the entire width of the bearing.

Grease extruding from both sides of the bearing can easily be checked on smaller bearings, but on larger bearings, such as sheave trunnion bearings, this task is more difficult. Typically, on larger bearings, the grease grooves extend through the entire width of the bearing with a plug at the opposite side of the grease fitting. Purging the grease through on a bi-annual basis to ensure the grease passages are clear is rarely done, resulting in poor lubrication, increased friction over time, possible scoring of the bushing and shaft, and in some cases the shaft freezing in the bearing. This is also true for the bushings and guides on span locks and tail locks.

4.2.8 Shimming of Mechanical Systems

Although less of an issue with short term reliability, not shimming the wear parts of the machinery over the long term can cause operational issues. This is particularly evident at the span locks, live load shoes and tail locks. Excessive movement, impact loads, or vibration of the movable span due to live load can lead to some major long-term issues. Over time the welds connecting the deck to the stingers can start to fail, as well as the welds or bolted connections at the armored joints at the rear and center breaks. Excessive movement can cause issues with safe passage of pedestrian and bicycle traffic. Using the wrong shim material or improper shimming can also cause operational issues. For example, using a malleable material such as lead to shim a live loads or using slotted shims which allow moisture and lead to pack rust. Annual or bi-annual inspections involving checking clearances on bearings can be done to determine when shimming is required. Unfortunately, there is no set rule on when to shim an assembly as wear is a factor of initial alignment, loads and the robustness of the initial design.

4.2.9 Hydraulic Systems

Hydraulic systems on movable bridges are primarily used for the operation of the span locks and tail locks, and in a few cases as the primary mover for the movable span. Actuators consist of either hydraulic motors or, more commonly, hydraulic cylinders. Except for hydraulic fluid leaks, typical reliability issues occur within the hydraulic power unit (HPU). For the HPU's used as the primary mover, the

movement of the span is typically controlled by a proportional directional valve. The valve not only controls which direction the span moves, but the speed and acceleration/deceleration of the span through a control card.

Over the 25-year life cycle of an HPU, valves and control cards become obsolete. When a control card fails, replacement control cards need to be obtained, which can sometimes be previously used, or the existing cards need to be sent out to be refurbished. Both replacement options are time-consuming and may cause shutdowns if spare cards are not readily available. Another hydraulic system issue is a specialist is required for hydraulics troubleshooting. The more complicated the system, the more issues the system typically has as it ages and internal valves start to stick or fail. Hydraulic systems also need periodic maintenance, such as changing the filter and hydraulic fluid on a regular basis. Due to the low operating time of movable span hydraulic systems the fluid is typically not filtered as much as if the system were running all day. Due to this low duty cycle, hydraulic fluid typically becomes contaminated, causing valves to stick and seals to fail.

4.3 Recommended Enhancements or Modifications to Improve Reliability

4.3.1 Backup Equipment Testing

Performing regular testing and maintenance on each ATS will ensure that it will transfer to the redundant power source and in the locations with generator backup, start the generator. Preventative maintenance of an ATS needs to include identifying potential obsolete equipment that can affect its automatic operation if failed.

Generators need to be tested on a regular basis and per the manufacturer's recommendation. Generators within MDOT's inventory are tested on a weekly basis to ensure they operate as intended, as the ATS includes preprogrammed scheduled tests for test operating the generators. Additional annual third-party servicing and preventative maintenance activities include identifying potential generator and ATS controller obsolescence that can no longer be procured which could prevent the ATS from automatically starting a generator and transferring to generator power.

MDOT has only reported an issue with a generator or ATS not providing the necessary backup functionality for the Portage Lake and Lafayette Bridges. It should be noted that other bridge owners have proactively replaced vintage generators and ATS's when obsolete controllers or other components were identified. Proactive replacement is due to the substantial lead times for replacement generators and ATS's, which can take several weeks to repair or even several months for a replacement.

Regular redundant equipment operational testing including the auxiliary control system and span drive motors, should be conducted by all bridge operators to increase their ability to resolve operational inconsistencies when they arise. This testing should also include operating and understanding how the various bypasses are to be used and function.

When maintenance activities are performed, including emergency troubleshooting, or when taking equipment, such as a tail lock, out of service, the bridge should be operated in the primary and redundant modes to ensure all operations are functioning. MDOT has experienced some operational inconsistencies that have created bridge outages due to lack of testing the redundant modes of operations after statewide crews have been on-site. Developing a standard procedure for what needs to be done before leaving a bridge after maintenance work has been completed will minimize unintended consequences and operational issues.

4.3.2 Enhanced PLC and Human-Machine Interface (HMI) Diagnostics

While not all of MDOT's movable bridges utilize a PLC and HMI, most of them do. MDOT primarily utilizes PLCs for automatic and some manual operations. The secondary function of a PLC and HMI configuration is to provide diagnostic information (bridge and limit switch positions, span drive motor speed, etc.) and alarms that can be displayed on an HMI screen. While diagnostic information can be useful, most of the information is also displayed on the control desk with indicating lights and meters. Most of the system alarm messages are generic and do not

provide the bridge operator or maintenance personnel with adequate information on where to begin troubleshooting.

The PLC and HMI programming can be further developed to include advanced diagnostics and warnings to help identify potential issues or direct bridge operators and maintenance staff on where to begin troubleshooting activities. A short list of items that can be added to PLC control systems for consideration are:

- Utilize limit switches with two (2) Form C Contacts (single-pole, double-throw).
  - In instances where the limit switch is only utilized by the PLC or goes directly to a relay, both contacts can provide indication to the PLC for monitoring purposes. Based on the switch configuration the PLC will be able to monitor when they provide conflicting information.
  - In instances where a limit switch is hardwired within a circuit, the PLC can monitor those locations, plus the additional contacts to provide indication if the switch changes states.
- Monitor each selector switch and pushbutton.
  - Warnings for out of sequence commands
    - In addition, the warnings could help inform bridge operators as to the proper operating sequence on the next bridge operation.
  - When an operation is desired, that cannot be commenced due to a failed limit switch, failed relay, loose termination, etc., a warning could be provided to the operator indicating what information is missing to allow the next operation.
  - Adding I/O screens to the HMI that show input and output statuses. Each input and output point on the HMI could also include text to illustrate what each point is used for and provide references to the as-built control schematics.

The concern with adding too much additional diagnostic information, specifically warnings and alarms is that it will create "Alarm Flooding". Alarm flooding is when there are so many alarms and warnings that don't provide any useful information or are considered nuisance alarms. Bridge operators and statewide crews eventually become complacent with the various alarms and warnings. If alarm flooding occurs bridge operators and statewide crews will start to ignore them and not know when a real warning or alarm occurs.

4.3.3 Remote Troubleshooting, Monitoring, and Datalogging

The various components on a bridge are susceptible to adverse conditions that can lead to failure over time. Continuous monitoring and analysis can be utilized to prevent equipment failures. By integrating structural health, vibration, and displacement sensors with smart motor controls, operational data can be captured. When analyzed and correlated, this data can provide valuable insights that enable predictive maintenance, reducing downtime and preventing prolonged outages.

In contrast, bridge tenders and onsite staff primarily rely on physical observations to assess bridge functionality. However, their ability to diagnose issues is limited, as human observation alone cannot reliably probe electrical components and sensors. This can lead to the loss of crucial information that could have been used for preventive maintenance, potentially averting major bridge failures.

Movable bridge equipment will degrade over time, potentially affecting operations. To effectively monitor the equipment an optimal baseline needs to be established, such as shortly after maintenance has been performed. Depending on how the monitoring is set up, information such as trending information to show span drive motor current and voltage could be reviewed. Once a baseline has been established, monitoring can be used to detect abnormalities early, resulting in quicker response times and minimizing operational disruptions. In addition, information on bridge stability and stress can be captured for informed decisions.

Any bridge that is equipped with a PLC can be utilized for remote access and monitoring. While MDOT has several PLC based control systems, none of the bridges have remote access.

In addition to monitoring, the frequency of events can be logged which can help statewide crews pinpoint trouble areas. Depending on the equipment used, emails can also be sent for predetermined warnings and alarms, which can alert maintenance staff of potential issues before an operational outage.

While HMI screens and PLCs can be used to store historical information locally at a bridge, they do have limited data storage capacity which prohibits retaining data over a long period of time. To provide longer-term data storage, an offsite server dedicated to data logging could be implemented.

The local PLC facilitates remote monitoring of all critical bridge components by collecting the operational data which can then be relayed to a remote server for retention and further analysis. A Supervisory Control and Data Acquisition (SCADA) system will be created by collecting data from various bridges to create security and maintenance alerts based on remote events detected. The SCADA system logs historical sensor data and provides real-time insights into bridge operations and essential equipment performance. SCADA servers with extensive storage capacity enable long-term data retention for informed decision-making.

Another powerful benefit to remote monitoring is the ability to remotely troubleshoot an issue. Bridge operators and other staff do their best to relay as much vital information as they can over the phone, but there are items lost in translation as the remote troubleshooter must decipher what information is being passed. Having the ability to physically see what the issue is gives them a better handle on a potential remedy. MDOT already does some remote troubleshooting on a smaller and disjointed level, such as:

- FaceTime
  - Bridge operators routinely utilize video phone calls (iPhone FaceTime) to provide information to maintenance staff to help address and issue, by showing maintenance staff what is being displayed on the control desk or HMI screens. This has proven to be relatively effective when it is a small issue, but it does require both bridge operators and maintenance to utilize their personal cell phones.
- Remote Desktop
  - When additional assistance is needed from a third-party control system integrator, maintenance staff have utilized the on-site local laptop that has the PLC programming software with a wireless internet hotspot to access the internet. An example of this is to use the Microsoft Teams Screen Share function. Once on the internet, the integrator gains access to the laptop and can then access the PLC program. While this has also proven to be effective, it takes a significant amount of time.

Remote access will require a virtual private network (VPN). A VPN enables remote centralized monitoring of all bridge electronic and electrical infrastructure, offering a single-pane-of-glass view of operation status, enabling quicker action to security events. Figure 1 illustrates a typical network architecture for remote bridge monitoring requiring third party network communication infrastructure with private IP address range that isn't routable over the internet. This setup minimizes cybersecurity risks by preventing direct internet access to bridge sites.

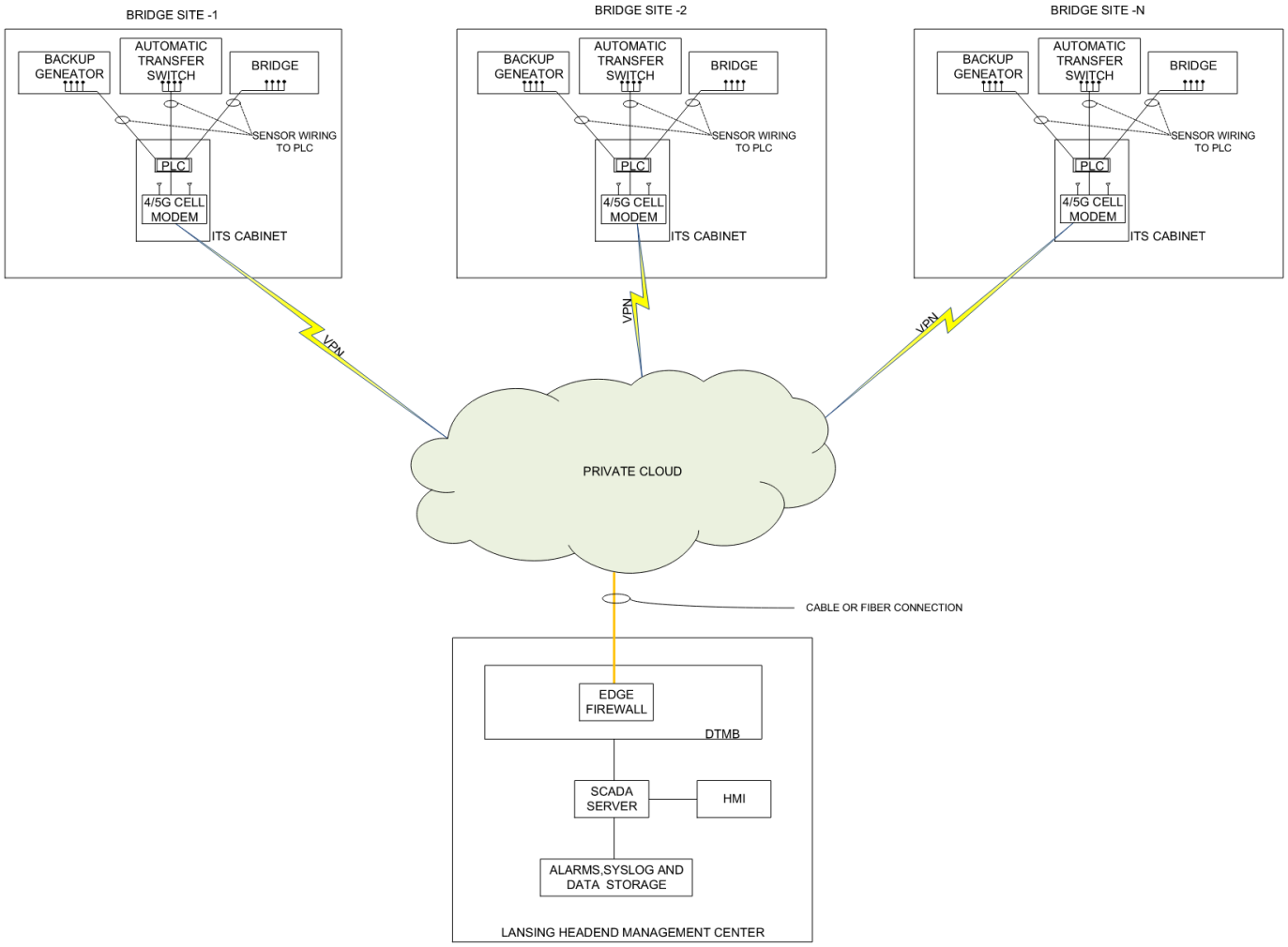

Figure 1: Remote Monitoring Through Private Cloud VPN

Over the past two years, MDOT has successfully implemented Verizon Private VPN technology to remotely manage and monitor statewide traffic signals from a centralized location in Lansing. This same network infrastructure can be extended for bridge monitoring by deploying 4G/5G cellular modems at bridge sites, creating secure VPN tunnels.

Verizon and AT&T offer private VPN services that route traffic within their core networks, minimizing exposure to internet-based threats. Alternatively, MDOT could establish a self-managed VPN, leveraging DTMB support to secure tunnel endpoints while maintaining full control over network security without involving third parties, as shown in Figure 2.

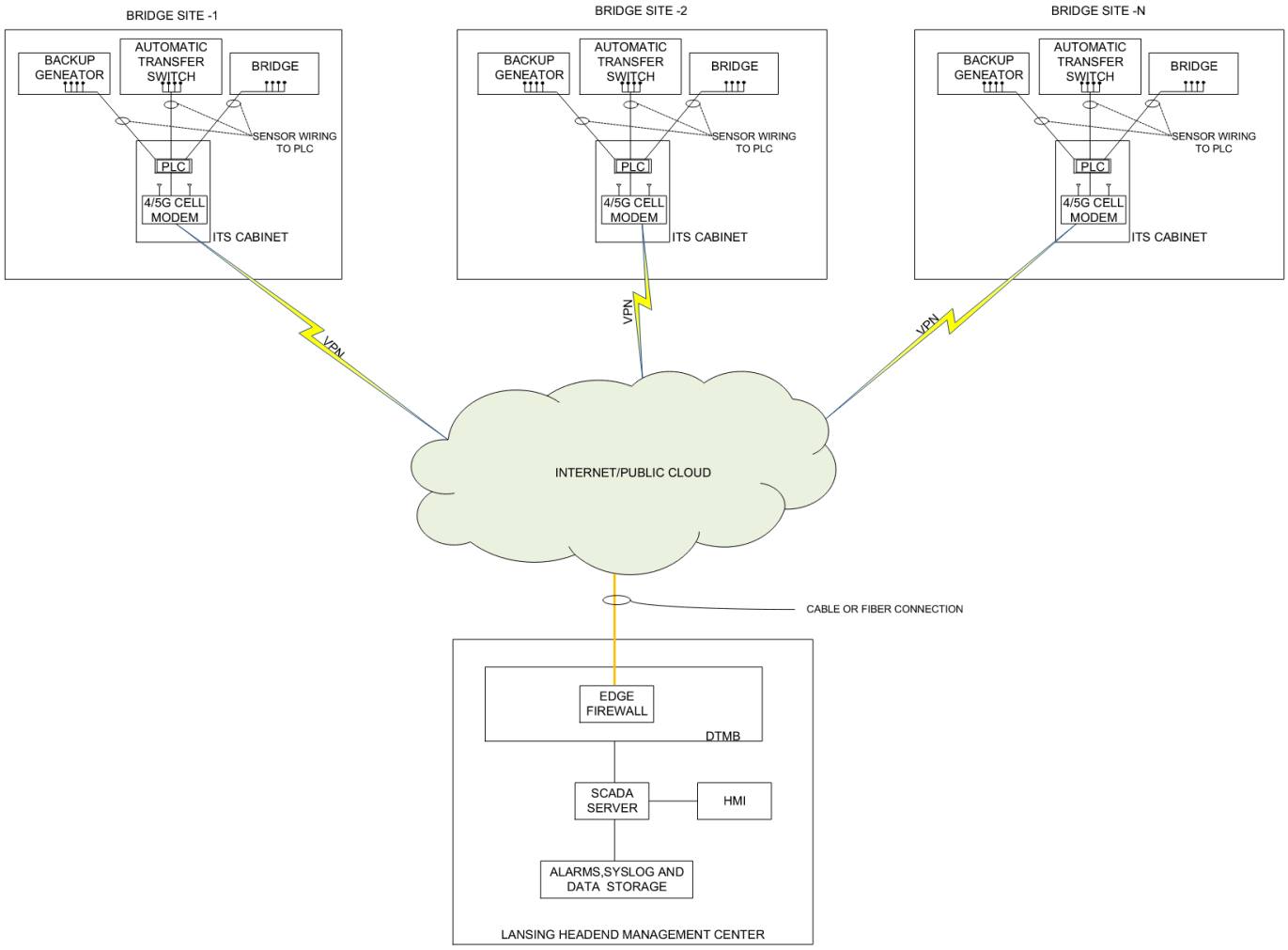

Figure 2: Remote Monitoring Through Internet VPN

Remote access to a movable bridge can be a powerful tool for both data logging and remote troubleshooting, but it does include risks that need to be considered, most notably cybersecurity. As more and more operational technology (OT) equipment gets added to networks that can be accessed from the internet the more likely that bad actors might attempt to infiltrate and exploit them if proper security controls are not implemented.

Physical and cybersecurity threats against remote bridge monitoring operations can be greatly mitigated through the implementation of administrative, physical and technical controls. This involves updates to operation security policies, site video

surveillance, secure access to ITS cabinet and backup generator, and configuration hardening of the ITS cabinet 4/5G modem, Ethernet switch and firewall.

Further risk mitigation against any unknown threats can be achieved by aligning security controls with cybersecurity standards for industrial control systems IEC 62443-3, ISA 95 standard for integrating enterprise with operation technology, and the TSA cybersecurity directive (SD 1582-21-01) for enhancing public transportation and passenger rail.

The Department of Technology Management and Budget (DTMB) will need to be consulted before remote monitoring can be started as there are several items that need to be implemented, such as:

- Firewalls and Network Segmentation
  - How will the local network be configured?
- Access and Source Control
  - How is access granted or limited?
  - How are program changes logged and documented?
- Disaster Recovery
  - How are back up programs stored and updated when changes do occur?
- Patching
  - How and when are manufacturer patches implemented?

4.3.4 IO-Link

IO-Link is a newer technology that has been under development since 2006, which initially resulted in the 2013 publication of the IEC 61131-9 standard for "Single-drop digital communication interface for small sensors and actuators (SDCI)". IO-Link is an open communication protocol and networking standard that is used for connecting sensors (limit switches) and actuators (hydraulic valves). Because IO-Link is an open protocol, and an international standard, any manufacturer can make equipment that adheres to the standard. The equipment is then compatible with an automation system such as a PLC on a movable bridge.

The IO-Link system offers advantages as a digital interface for connecting sensors and actuators:

- IO-Link is an open standard, therefore devices can be integrated in the same way in all commonly used automation (PLC) systems.
- Tool-supported parameter assignment and central data management allowing for:
    - Fast configuring and commissioning
    - Easy creation of up-to-date documentation
- Simple, standardized wiring
    - Standard uniform interface for sensors and actuators regardless of their complexity.
    - Reduced variations and inventory of spare parts.
    - Reduced control system space.
    - Sensors and actuators without IO-Link can still be utilized
- Communication between sensors between actuators and the controller allows access to process data, diagnostic data, and device information
- Diagnostic information down to the sensor and actuator level allows for:
    - Reduced effort for troubleshooting as the exact device experiencing issues is directly identified
    - Minimized failure risks
    - Preventive maintenance and maintenance scheduling
    - Diagnostic data can be utilized to determine device health allowing for early indications of potential issues.
- Automatic parameter reassignment for device replacement during operation allows for minimized downtimes and replacement by untrained personnel without additional tools.

While IO-Link has significant upsides to help reduce or eliminate potential movable bridge outages it does have some drawbacks that should be considered:

- IO-Link is still relatively new technology that appears to have primarily been used within manufacturing that typically have consistent environmental settings which devices are tailored.
- Movable bridges require some devices to be installed in high vibration areas. Based on the maximum distance (20ft) between an IO-Link device and an IO-Link master, it is highly likely that some IO-Link masters will also be installed in high vibration areas. It is unclear what vibration limitations there are for IO-Link equipment.

IO-Link devices can be used without an IO-Link master, but advantages such as the communication and diagnostic information will not be available. Likewise, a non-IO-Link device can be used with an IO-Link master, but the same advantages are also lost. Based on these limitations, it is currently not possible for a system to utilize both IO-Link devices and master's with relay-based control systems unless additional redundant equipment (limit switches) is installed.

It is also unknown if IO-Link has been utilized on a movable bridge, therefore a pilot program should be implemented to help determine viability.

4.3.5 Limit Switches

As previously stated, the primary cause of limit switch failure appears to be related to its physical location with most of the failures or operational inconsistencies occurring where limit switches are mounted to the operating rack, tail locks and fully closed switches at the end of the movable spans. The primary failures and operational inconsistencies appear to be related to environmental issues. If possible, covers should be installed over limit switches to limit the impact the environment has on them. Another potential option to increase limit switch life expectancy in these areas is to change to a different limit switch type or potentially remove the switches all together and implement an alternate means to sense device travel.

The type of limit switch utilized can also play a role in life expectancy. Proximity type limit switches generally have longer life spans than a lever arm limit switch as they don't have any external mechanical components, which further allows them to better

withstand environmental conditions and vibration. Lever arm type limit switches require the switch to physically encounter the target or object that it is sensing. This results in internal and external mechanical components that must move to change the electrical contacts resulting in mechanical wear. MDOT typically utilizes lever arm type limit switches and has not historically utilized proximity type limit switches in most locations. The primary location a proximity switch is found on an MDOT owned movable bridge is for the mating position for the double leaf bascule bridges. It should be noted, that the new Lafayette Movable Bridge will have proximity type limit switches, in lieu of lever arm limit switches at most locations.

In locations where ice can build up on the operating mechanisms, which doesn't allow the switch to change positions, when mounted properly a proximity type limit switch may be recommended as they have the potential to eliminate the effects of ice buildup.

While proximity type limit switches tend to last longer than their lever arm counterparts, they do have some disadvantages:

- Limited sensing ranges.
  - Ranges may be able to be extended with the use of magnets depending on the manufacturer.
- Initial installation may require adjustment due to thermal expansion/retraction.

Rotary cam type limit switches are very robust as they are contained with a water-tight and corrosion resistant enclosure. Many of MDOTs movable bridges incorporate a rotary cam type limit switch for span position, such as fully open, nearly open, and nearly closed. Fully closed and overtravel limit switches should not be utilized within the rotary cam. Many times, the rotary cam limit switches are in addition to the limit switches located on the operating racks that also provide span position or checks. This essentially equates to redundant limit switches that perform a similar function, but in different locations, creating the opportunity for more switches to fail. In locations where the limit switches are redundant, the switches on the operating rack could be removed. Depending on the type of mechanical equipment utilized to operate the tail locks, a rotary cam could also be used for tail

lock position. The biggest disadvantage to utilizing a rotary cam is if there is a mechanical failure with the operating machinery that prevents the rotary cam from turning.

4.3.6 Scanning in all bridge files to MiBRIDGE and Maintaining Up-to-Date Information

Most movable bridge outages are primarily due to control system failures or inconsistencies and to a lesser extent mechanical equipment causes. While on-site as-built information relating to the mechanical and electrical systems should be updated after each rehabilitation, project, modification or troubleshooting task, and additional copy also should be retained on MiBRDIGE. This will help ensure that an up-to-date copy can be easily found. MiBRIDGE is also a beneficial location to find information that can be sent to remote troubleshooters should they be needed.

4.3.7 Ethernet Connected Motor Starter Overloads

Similar to IO-Link or VFDs diagnostic capabilities, ethernet connected motor starter overloads can be utilized to monitor loading for the additional electric motors, such as the auxiliary span drive motors, lock motors, gate motors and hydraulic pump motors. The motor loads can then be logged and trended by the PLC to allow for access to historical data or allow for triggering warnings and alarms. For example, if the load of a tail lock motor increases above its historical operating load a warning can be sent to the bridge operator indicating that high than normal load was recorded. The higher load could be an indication of temperature changes, preventative maintenance needs (lubrication), equipment interference or others. Without some type of load monitoring the motor load could get worse until it causes an overload trip resulting in a bridge outage. Based on the warning preventative maintenance can be performed to help reduce a potential motor overload and prevent an outage.

The addition of ethernet connected overloads does increase the complexity of a control system and more reliance on communication type equipment.

4.3.8 Strain Gage Balancing, Torque (Strain) Monitoring and Pressure Transducers

Similar to IO-Link or VFDs diagnostic capabilities, another means of data collection and monitoring can be obtained through the use of strain gages and pressure transducers incorporated at strategic locations within the drive system. The resultant data could then be used in comparison to a baseline to identify abnormalities. This would allow for preventative maintenance to be scheduled to address problems before they could result in potential downtime. Strain gages may be permanently affixed to output shafting to provide real time wireless remote monitoring of shaft strain that can be translated into span balance. This would also be able to provide imbalance data due to excessive resistances such as wind, snow and ice loading on the movable span, especially if the electric motors are showing an overloaded condition. In the case of a rolling lift bridge, of which MDOT has several in their inventory, strain gages on opposite pinion shafts (or transducers in opposite hydraulic cylinders) would corroborate if the movable leaf tended to "walk" between its respective segmental girders and flat tracks, due to uneven loading. Note that for the hydraulic bridges, pressure transducers would serve a similar function to that of the strain gages. Another advantage of strain gages or pressure transducers would be to identify locations of unusually high friction. If there is indication of higher loading in machinery components such as tail locks or mechanical span locks, this may suggest a lack of grease or component misalignment. The remedy would then be for maintenance to grease or adjust the locks preemptively, before they end up jammed or damaged, putting the bridge out of service.

4.3.9 Lubrication

Adding grease to a grease fitting on a bearing should be completed as part of regular maintenance. In conjunction with adding fresh grease to a bearing, personnel should look where the grease is exiting the bearing because this is a good indication if the grease is being distributed properly within the bearing. Grease should be exiting both sides of the bearing and around the entire circumference of the shaft. On some bearings, such as where there are thrust surfaces, this is not always possible, but at

least there should be grease exiting between the thrust faces. To determine this, old grease needs to be removed from the bearing with each new greasing cycle. On larger bearings, such as trunnion bearings, it was noted above that the grease grooves typically run all the way through the bearing and out the opposite side where the port is typically plugged. To ensure the grease is traveling through the bushing and to the other side the plug should be removed and grease pumped through the grease port until fresh grease comes out the other side. This should be done bi-annually. Plugged ports should be cleaned as soon as practical to minimize damage to the bearing contact surfaces. Purging should take place about every 5 years, with shorter intervals if issues are found.

4.3.10 Shimming

Shimming is typically only done on span locks or tail locks. Shimming a bearing is only feasible when the gap due to wear is at the 12:00 or 6:00 position. If the gap is anywhere else and liners are removed from the bearing binding between the bushing and shaft will occur. In some instances, shimming at the span lock or tail lock can be cumbersome and, in some cases, requires disassembly beyond what maintenance is capable of doing in a reasonable amount of time. In these cases, the shimming is put off until a maintenance contract can be put out for construction. This is typically when the movement, or impact to the span starts to become detrimental to the life of the deck and/or structure. The movement can also result in wearing at the live load shoes, resulting in nuisance problems such as detecting a fully seated limit switch. Newer span lock systems should be designed such that adding or removing shims is easy. Florida and South Carolina have used a system that utilizes a wedge system to adjust the span locks. A lot of new tail lock systems use a two strut design with a pivot between the two struts that pushes up on the girder to "lock" the back of the span in place. This system is good because it does not require periodic shimming. See sketch below for a current tail lock design showing the two struts with the upper strut pivoting about two-thirds of the way up on the main strut and pivoting over-center to lock into place.

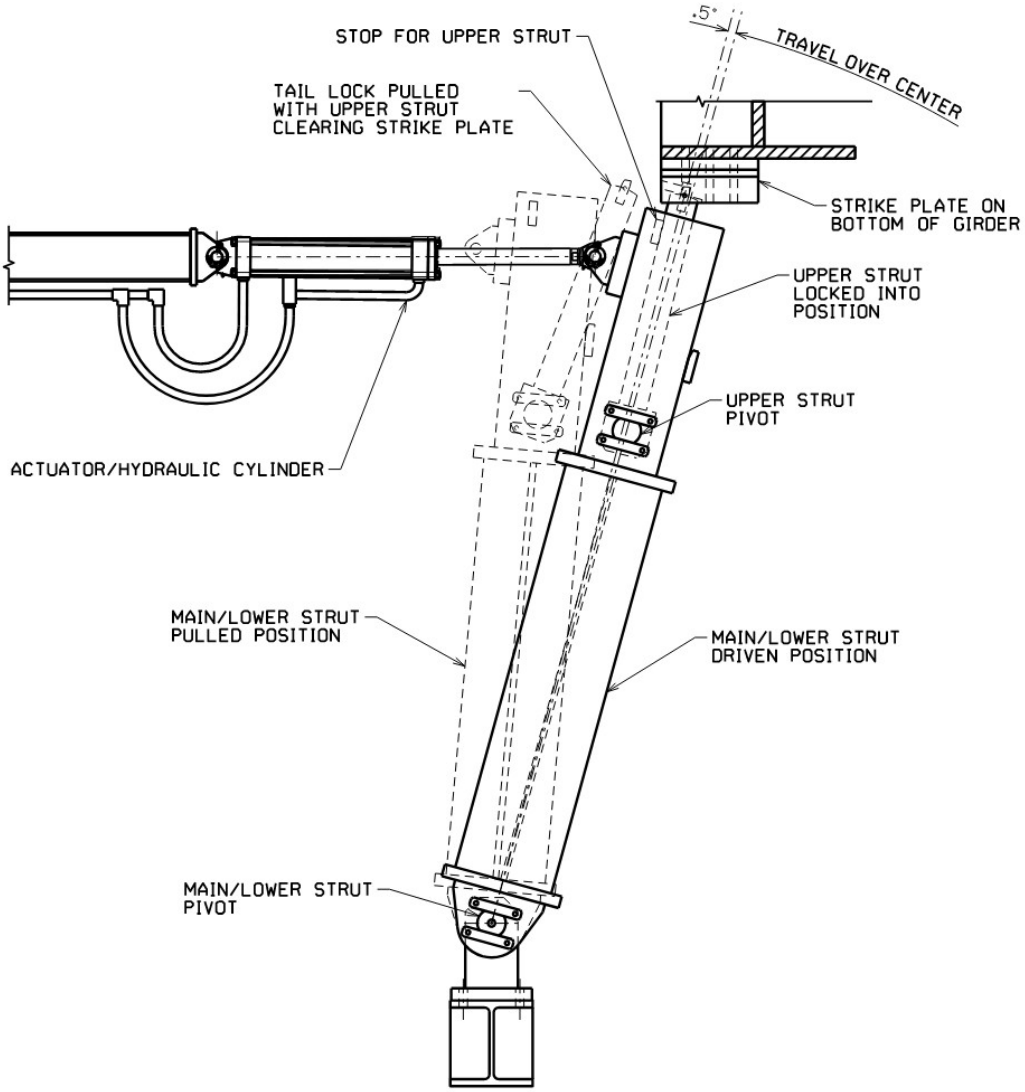

Figure 3: Sketch showing new tail lock system

4.3.11 Hydraulic Systems

Hydraulic systems should be designed as simply as possible with as few moving parts as possible. Newer hydraulic systems for moving the span are starting to use drives to control the pump motors, similar to drives operating the motors on mechanical span drive machinery. The proportional directional control valves with control cards for controlling the speed are swapped out for simple bang-bang directional valves that open when the drive starts and closes when the drive stops. The drives are easier to program than the hydraulic directional proportional valves,

typically last longer, are typically off the shelf and are interchangeable. Similar to mechanical drive systems, the hydraulic drives can be redundant, or multiple hydraulic pumps can be used in the HPU for redundancy, with slower operating speeds occurring if there is a drive issue. The drives are also more easily integrated into the control system for monitoring. The only drawback to using drives and controlling the speed of the span with the speed of the pump motor is the pumps must be able to be operated at slower speeds. This issue can be managed through specifications during design and ensuring the pumps are below reservoir to provide head pressure to the pumps, so they don't "starve" during low-speed operation.

Due to the low runtime of the HPU it is desirable to add a conditioning circuit with filters and heaters, or kidney loop filtration, that has a set runtime for a few hours a day. Even when not operational in the winter running a conditioning circuit will help to keep moisture out of the system and increase the likelihood that the fluid is clean when spring startup occurs. It is also better to have the heating element in the conditioning circuit rather than an immersion heater in the HPU reservoir. With fluid traveling over the heating element, it is less likely to burn the fluid if the heating element is set toward the high end of the temperature range.

With an HPU it is easy to communicate system information back into the control system for monitoring. The hydraulic oil temperature, oil level, operating pressures of the system and cylinders, and even the cleanliness of the oil can be monitored. Parameters can be set up such that when something falls out specification a warning alarm can come on, or even a shutdown of the system, which is currently typically done with temperature and fluid level only.

4.4 Design Guidelines

MDOT currently does not have design guidelines to provide information to the designers on how MDOT would prefer to have the control system designed. While mechanical guidelines would also be beneficial, control systems are typically customized resulting in numerous variations that can be implemented. Throughout MDOTs inventory, there are control systems that are only relay-based system, relay-

based system with a PLC for limited control functions, PLC based with a relay backup system, and a PLC and relay intermingled system. Within each control system type, there are further variations on how the control system was designed. The different variations result in each bridge control system differing vastly from the next and maintenance staff need to know how each one operates.

The variety is most likely due to the preferences of different design firms and different lead designers within those firms that have designed the control systems throughout the years. The variety is further complicated as MDOT executes smaller targeted projects that require modifications to the control system, resulting in a design preference modification.

By creating control system design guidelines, system design would reflect MDOT preferences and not the preference of multiple designers.

Having design guidelines for some of the mechanical systems would be beneficial as well. Common designs for assemblies such as span locks, tail locks and HPUs which currently have very basic design criteria under AASHTO would be beneficial for MDOT. The designs would ensure each system is robust, easily maintainable, and, since they would be common to MDOT, all maintenance personnel would be familiar with them and be able to troubleshoot them if issues were to arise. HPU's would be designed with the same communication requirements to integrate seamlessly into the control system.

5. VALIDATION OF CURRENT MAINTENANCE

5.1 Communication Plan

During the interview process with MDOT Staff (Bridge Operators, Statewide Maintenance, TSC) communication was discussed at length. The primary discussion points included: communications plans, bridge projects/timelines, emergency action plans, and maintenance activities. During the interviews, it was apparent that a formal communication plan is not in place, which does affect responsiveness of staff and effectiveness of maintenance and future projects/rehabilitations.

Each TSC Region interviewed noted that they have little insight into future projects or maintenance. Information is sometime shared in passing, but there is little to no formal communications to the TSC Staff for their visibility. Many times, the statewide priorities don't line up with the local priorities. Some of the TSC's have noted that many of the projects appear to be repetitive and continually affect traffic management and the local communities. There is a preference by the TSC's to have one (1) large project instead of several small projects, if the budget allows. The TSC's also suggested that there be regularly scheduled coordination meetings to discuss upcoming projects and long-range planning.

The TSC's for each region noted that the communication between the various stakeholders (TSCs, Statewide Maintenance, bridge tenders, local public, etc.) was minimal.

There is no formal timeframe for when bridge outages for when issues are to be elevated. The lines of demarcation between who is responsible for tasks or who to contact isn't clear. Only the Portage Lake and Grand Haven Bridges had a documented emergency action plan, with Grand Haven Bridge the only asset with a formalized communication plan. It is recommended that communication and emergency action plan specific for each bridge be created. The plans should be reviewed on an annual basis to help ensure the information is up-to-date. Information on the plans should include the following:

- Notification timelines
- Bridge operator communication responsibilities
- TSC and other region staff responsibilities
- Emergency contact list and who to contact first
- Master contact lists – Should include local municipalities and USCG.
- Flow chart for escalating malfunctions

Without a formal EAP or communication plan for bridge malfunctions some bridge tenders call former staff due to their proximity to the bridge to assist with malfunctions. These issues then don't always get relayed to Statewide Maintenance.

Other than the Grand Haven Bridge, there are no formal protocols in place for alerting the public on malfunctions. Bridge malfunctions are impactful to the surrounding communities so getting information out to the public quickly is desired.

It was reported by the Grand Region TSC that the Grand Haven Bridge has remote monitoring/access and that it has significantly reduced downtime. It should be noted that this is the only bridge that has remote monitoring/access and has shown to reduce outage time when it occurs. This is further evidence that remote monitoring/access can significantly reduce downtime.

In addition to the TSC interviews, interviews with Statewide Maintenance indicated that communication can be improved, especially in regard to bridge malfunctions. Due to a lack of a communication plan bridge malfunctions are communicated are different per bridge. Statewide maintenance wants to be notified first and within five (5) minutes of a bridge malfunction; however, several of the bridges are operated by contractors. Some of these contractors require that the bridge operators communicate with their management first before communicating with MDOT. This process can take up to 15 minutes.

Similar to the TSC's request for recuring meetings, Statewide Maintenance also indicated that recurring meetings would help each stakeholder more insight to the varying and potentially competing priorities. The TSC staff does not necessarily want or need input but would like to know about future projects and maintenance activities. It is recommended that the following meetings be scheduled:

- Maintenance Meetings – Initially a monthly maintenance meeting was suggested, which seems excessive, while an annual meeting to discuss maintenance is likely not enough. A bi-monthly or quarterly maintenance meeting is likely sufficient.

- Long-Term Planning and Project Discussions – An annual meeting to discuss the long-term plans and upcoming projects/inspections was suggested and would be appropriate to keep the stakeholders informed.

5.2 Maintenance and Emergency Response

5.2.1 Maintenance Schedules

During the MDOT interviews it was confirmed that each bridge goes through some type of routine maintenance at the beginning of each navigation season and receives regular maintenance the rest of the year.

While maintenance is being carried out, there is no formal documentation of what maintenance activities are required at each bridge. A logbook is kept at each bridge for recording when maintenance was performed, but the specific items are not identified. The logbook also stays at the bridge locally and is not available electronically. An electronic maintenance program could be utilized to plan, schedule, and log activities, helping ensure that maintenance has been performed.

In-depth inspections have been helpful, bringing some concerns to MDOT's attention, especially if they can be addressed by Statewide Maintenance.

5.2.2 Opening for Season Maintenance

Before the start of each navigation season each bridge goes through some type of routine maintenance. The maintenance performed includes washing the bridge, lubrication, pre-inspections, limit switch inspections, loose wire/terminations checks, etc.

Specifically for electrical components, previous malfunctions get added to the maintenance activities for each bridge to help ensure they don't replicate in the future.

Some recommendations from the detailed inspection reports will be addressed by Statewide Maintenance. Those that Statewide Maintenance cannot address are sent to design teams to be incorporated into future projects.

Every effort is made to have maintenance staff on-site for the first opening of the year. This is an important effort as there is a higher chance of malfunctions if the bridge hasn't opened in a while.

5.2.3 In-season Maintenance

All bridges are lubricated monthly, typically around the first of the month. Electrical preventative maintenance is performed monthly and includes checking limits switches, replacing seals, and checking fluids for generators.

While in-season maintenance is typically done monthly, emergencies and other work requirements do interfere. Some bridges have gone several months before maintenance staff can return due to other commitments. Some routine maintenance doesn't happen as often as it should due to accessibility issues, especially if the bridge needs to be opened for the maintenance to be performed. Some bridge operators don't like to open the bridge due to the inconvenience to roadway users unless necessary. While this can happen, it is typically not a significant issue as maintenance staff can typically perform routine and preventative maintenance during regularly scheduled openings.

Generators and ATS are tested weekly/monthly but are not load tested by operating the bridge with the generator. Load testing the generators by allowing the ATS to operate and then operating the movable span could help identify potential issues during maintenance activities. Generators are only serviced by MDOT and repaired by MDOT. Other than servicing the generators and ATS's, Statewide maintenance isn't overly familiar with the equipment to recommend replacements. Having an ATS and generator vendor familiar with the equipment perform annual or biennial maintenance could also help MDOT identify potentially obsolete parts or equipment that is no longer available from the manufacturer.

5.2.4 Spare Equipment and Equipment Preferences

Spare equipment is available for the bridges; however, it was not known exactly where the spare equipment was located and how many of each component the

statewide crews were in possession. Not all spare equipment is replaced when taken from the inventory. Similar to an electronic maintenance program, an electronic inventory management system could also be utilized to track inventory or provide locations of spare parts.

There is also no tracking of when various components, such as limit switches, solenoid valves, hydraulic hoses, and wear components have been replaced, which could also be tracked in an electronic maintenance management system. This can create issues, such as the span lock guides at Grand Haven that needed to be replaced during a construction project, which required a contract modification.

5.2.5 Mechanical Equipment Maintenance and Spare Equipment

Replacement of hydraulic lines can be difficult. Equipment that is difficult to replace typically doesn't get the attention it deserves. This leaves the equipment more vulnerable to malfunctions or failures.

Spare mechanical equipment is stored in Lansing or local to each bridge.

Hydraulic bridges (St. Clair, Military Street) have a lot of parts, which are typically custom. New parts typically don't fit the existing equipment and routinely need to be modified or customized.

5.2.6 Electrical Equipment Maintenance and Spare Equipment

Spare electrical equipment that is common to all bridges, such as relays, are kept on the electrical crews' trucks. Equipment that is specific to each bridge is kept locally at the bridge. Statewide Maintenance noted that consistent sets of spare parts between bridges would be helpful.

Parts obsolescence is a significant issue, especially when parts are not common between bridges. For example, Manistee had an older style thyristor drive which was obsolete. Replacement parts were not kept on hand due to not knowing they were no longer available. Getting a replacement was difficult due to no manufacturing support.

6. TRAFFIC OPTIMIZATION DURING DOWNTIME

6.1 Vehicular Traffic Optimization Goals

Optimizing traffic operations is essential in mitigating user delays. This analysis is focused on optimizing detours for vehicular traffic that is affected by movable bridge openings, rather than providing a universal traffic congestion solution. This section reviewed existing detour plans to determine if a more efficient detour can be utilized. If there was not a detour plan in place, one was developed. ITS, DMS locations and other methods of communication were reviewed to develop recommendations for public communication improvements. Current EAPs were assessed. A template for EAPs was developed that can be applied to bridges within MDOT's inventory. For these bridges, there are opportunities to optimize performance, particularly in areas such as communication with local law enforcement, troubleshooting efficiency, and improving overall response times. Enhancing the ability of bridge operators to respond effectively in emergency situations could significantly improve outcomes. This could be accomplished by equipping them with the knowledge to troubleshoot or mitigate issues independently. Additionally, consistent and timely public notifications during incidents will be discussed. Ensuring the bridges have a unique procedure catered to each situation, while capitalizing on consistency for notifications and training, can ultimately improve operations for all bridges in the inventory.

6.2 Ways to Optimize Traffic

6.2.1 Detours

To optimize traffic flow, the first priority is ensuring there are designated routes for vehicles in the event a bridge becomes nonoperational. Traffic issues at each bridge were assessed to determine which locations have room for improvement or where consistency among operation can be implemented. For instance, Portage Lake has no alternative detour for vehicles, while the Grand Haven, and Charlevoix Bridge each have lengthy detours. In contrast, all the other bridges have alternative routes that are not as inefficient in terms of time or effort by drivers.

Detour maps, located in Appendix B, outline the alternative routes suggested for vehicles. Detour plans for Charlevoix and Grand Haven are already in place. For all other bridges, detour plans were developed. The appended detour plans offer the most efficient routes while avoiding residential areas by prioritizing use of MDOT owned roads.

Table 2: Detours and Travel Time Associated

Bridge Name	Detour Length (miles)	Approx. Travel Time (min)
Veterans Memorial STR 646	1.2	3
Twin Cities Bicentennial STR 778	0.7	5
Blossomland/M-63 STR 880	1.1	5
U.S. Route 31 over the Pine River (Charlevoix) STR 1471	67	85
State Street (U.S. Route 23) (Cheboygan) STR 1501	3	7
US-41/M-26 over Portage Lake STR 3380	None	None
U.S. 31 Highway over the Manistee River STR 6436	.5	2
U.S. Route 31 over the Grand River (Grand Haven) STR 8699	25	30
I-94BL/I-69BL over the Black River	1.5	5

Bridge Name	Detour Length (miles)	Approx. Travel Time (min)
(Military Street) STR 9956		
M-29 over the Pine River (St. Clair) STR 9977	5	10
M-85 over the Rouge River (Fort Street) STR 13311	4.5	10
Lafayette Street STR 586	1.2	3

It can be crucial that these detours are enacted quickly and effectively in an effort to reduce congestion and ensure safety. Implementing the detours commonly falls to the local police departments according to most operators. Even if the detours are not conducted by MDOT staff, notifying the local authorities of the detour plan could be instrumental in ensuring it is executed effectively and in a timely manner. Doing this leads little to confusion as to where the vehicles should be detoured to.

Even with local authorities implementing the detours, having appropriate signage will be helpful. Communicating to the public that the bridge is closed and that there is now a detour in place is an important first step in effectively rerouting traffic. Signage, such as a flip sign, to notify drivers the bridge is non-operational and to follow detours would be a cost-efficient method of notification at each bridge.

6.2.2 Dynamic Message Signs

Dynamic Message Signs (DMS) can be extremely important for early warning systems intending to help vehicles be aware if there is an issue especially for bridges with no easy alternate route. They are programable signs that can produce any message requested. They are commonly used to warn drivers about weather, traffic,

and situations with surrounding roads. In Figure 4, it shows the DMS locations near the Grand Haven Bascule bridge according to MI Drive.

Figure 4: DMS Signs Near Grand Haven

As seen in the Figure 4, there is ample warning for anyone travelling from major highways/roads. Grand Haven is a bridge that has a detour of 30 minutes, and because of this, it is a priority to warn vehicles as far in advance as possible. This method could be implemented for any movable bridge in the state, with the Charlevoix Bridge being a high priority.

Charlevoix has one of the longest detours spanning 67 miles, which can be seen in Appendix B. Within this area there are no DMS from any entry point into the city. Adding these signs could help reduce the amount of time spent waiting at the bridge for it to be operational or the time it takes drivers to learn the bridge is closed. In Figure 5, there are suggested locations for DMS signs. These signs are placed in

positions to catch vehicles from the north, south and east to provide notification of the closure and a suggested alternative route.

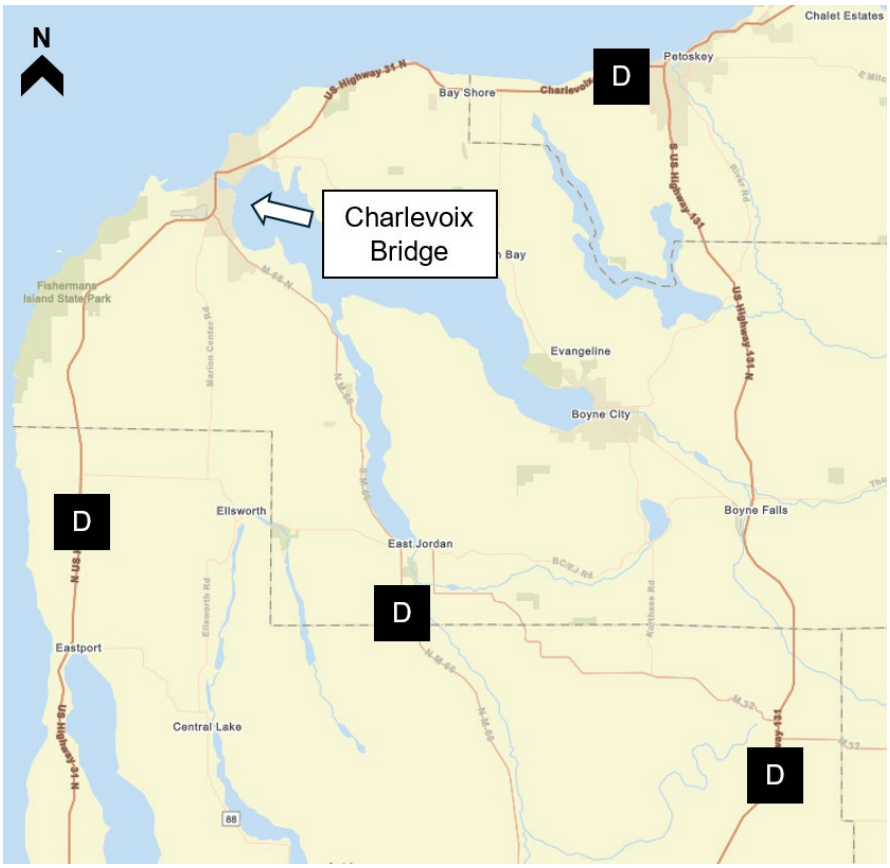

Figure 5: Recommended DMS Sign Locations near Charlevoix, MI

While many other bridges in the MDOT inventory could benefit from DMS signage, Charlevoix should be the highest priority as its detour takes around an hour and a half. The other bridges without DMS have detours that are ten minutes or less, which leads to the conclusion that early warning may not be as beneficial as other methods of communication. In those situations, simple detours could be effectively carried out by the local police department as they will cause fewer impacts on traffic.

6.2.3 Social Media

Social media is one of the most efficient and easiest ways to notify people of movable bridge issues. MDOT currently operates an account on the social media platform "X", Instagram, and Facebook. On the X account, MDOT posts about

accidents on highways, ongoing construction and other information the public needs to know to minimize delays while traveling on MDOT's roadways and bridges. Social media is instantaneous, drivers can be updated minutes after the event occurs and also provide a follow up post when the incident has been cleared. Instagram and Facebook could also be used for updates on nonoperational bridges or emergencies with them. Social media could be the simplest, yet impactful way to ensure vehicles are informed, positively impacting traffic.

6.2.4 Operator Action Plans

Within Appendix E, there are emergency action plan templates for the bridge operator if there is an emergency with the bridge. Currently, Grand Haven is the only bridge with one in place. These plans are intended to add a level of consistency for how each bridge is operated, what is done during emergencies and other important notes that operators should be aware of. These plans will include the time at which an incident should be identified, based on the original bridge opening time, barring any incidents. bridges original opening. After this, there are bolded names of various personnel that states who should be called in what order and that the operator should continue to contact the list until an answer is received from each person. These also include a comprehensive contact list which provides contact information for important MDOT personnel, coast guard, local government personnel and more. The list can be specialized for each bridge and the county/city it is located in to have the most specific, recent and detailed information. For certain bridges it can be crucial to contact local hospitals, schools, or emergency services such as police and fire departments. This document can be a location in which those contacts are specified to ensure they're contacted as efficiently as possible. The document also includes important information that the operator should know, which is bridge specific. This information could include actions that should not be done by the operator or potentially a small fix that could be performed by the operator.

6.2.5 Mi Drive

From the interviews with MDOT, a common theme was reporting issues occurring with the bridge on Mi Drive. Mi Drive is a website that contains a large selection of information that MDOT provides for drivers. This includes locations of construction, traffic cameras, road closures, DMS locations and more. Bridge outages are reported on Mi Drive. This process, however, can be more comprehensive as some bridges may not be reporting or if they are, it could be too late to make a significant impact on traffic. Within the action plans mentioned previously, there is a step where operators are instructed to report it to Mi Drive to warn drivers in advance.

7. CONCLUSIONS AND IMPLEMENTATION

During the investigation, it became clear that there isn't a singular item that creates movable bridge malfunctions nor is there a singular way to prevent future malfunctions or delays. While some malfunctions are likely inevitable, the research did uncover potential ways for MDOT to reduce the number and length of future outages. These potential improvements range from formal MDOT procedures (communication plans, maintenance plans, etc.) to advance equipment diagnostics and accesses (I/O Links and remote monitoring/troubleshooting).

During the investigation it was noted that there are few formal documents or procedures on how MDOT staff are supposed to react to malfunctions or when maintenance checks are required on a bridge-by-bridge basis. Most of these procedures are informal and are communicated to MDOT during field training. Key areas for improvement include developing formalized bridge specific: Communication Plans, EAPs, malfunction logs, and preventative maintenance items/checklists (including backup system testing and logs for when preventative maintenance has been performed, especially on hydraulic systems). These additional procedures and checklists should be considered a "living document" so that there is an ability to readily update them when the need arises. At a minimum, these documents should be reviewed annually for each bridge and updated as

needed. It is also important that these documents are available locally at each bridge and electronically.

In addition to the creation of new documentation, it was noted that the latest and most relevant information is not always readily available nor is the information all in one location. For example, a complete set of latest as-built schematics are not always located on the bridge nor within one document. Since the majority of bridge malfunctions are related to the control system, the as-built drawings accuracy is vital in reducing outage lengths. Enacting procedures on how to formalize the as-built drawings are to be documented and distributed can help ensure the documentation is recorded accurately and stored appropriately.

While having additional documentation can help with reducing malfunctions and the length of outages, it is also important that the various maintenance procedures, spare components and historical malfunctions and remedies are tracked/documented. It was noted during the investigation that monthly maintenance is sometimes missed due to other work activities. Maintenance staff do not know what spare components are available, and the malfunction logs only note the issue, but not the remedy. Being able to track when maintenance was last completed, the number of spare components with locations, and the remedy for malfunctions can help MDOT ensure proper maintenance is being performed. This will ultimately reduce effort and budget for replacement parts. These tracking logs should be electronic logs that can be updated as needed. The tracking logs can also be utilized to ensure that changes to the as-built drawings can be documented and tracked.

Optimizing traffic operations for MDOT's movable bridges is essential to reduce user delays and improve efficiency. This includes the development of specified detours, enhanced public communication strategies, and implementing EAPs for each bridge, which are important to increase efficiency. For bridges with longer detours, such as Charlevoix, systems to warn drivers, such as DMS, are recommended to notify drivers early and reduce disruptions to traffic.

Also, using social media as a real-time communication tool will increase public awareness about bridge operations and detours. Incorporating these strategies to improve signage, create proactive communication and have pertinent information available when emergencies do occur will be essential in improving the overall reliability of each bridge.

In addition to enhanced documentation and procedures, there are technology improvements that MDOT could take advantage of to help reduce the amount and length of bridge outages. Likely the "most powerful" tool that MDOT could implement would be to utilize advanced diagnostics, remote monitoring and remote troubleshooting. While each of these are different, they are all related to each other and can be done at the same time. Each bridge that is equipped with a PLC has these capabilities. Creating a pilot project for a specific bridge will allow MDOT to determine what information is useful and what is not needed. Lafayette Bridge, currently under construction, or the Portage Lake control system, to be designed in the near future, are both excellent choices for consideration, as these features could be efficiently incorporated into the projects before construction is completed. After the pilot project is finished it can be rolled out to the remaining bridges.

In addition to technology improvements noted above, additional products have come to the market in the last 10+ years, such as ethernet connected motor starters and I/O-Links. These new products have the ability to provide additional diagnostic information for the various movable bridge equipment that can alert MDOT for potential preventative maintenance activities or preventative replacement of components, such as limit switches. Having the ability to proactively address maintenance items or replace equipment before failure could significantly decrease the amount of bridge malfunctions. Developing a pilot program to implement these new products could help MDOT identify what equipment is worthwhile before it is implemented throughout MDOTs movable bridge inventory. Military Street Bridge would be an excellent candidate for consideration as the hydraulic system includes redundant solenoid valves and other equipment. Due to how the control and

hydraulic systems are currently designed, it would allow MDOT the ability to experiment with I/O-Links while keeping a backup relay system operational.

Table 3 below presents a summary of the recommendations, including notes that define each priority level. The purpose of this table is to identify and categorize the recommendations within each priority level. The priority levels are broken down into three (3) levels, with Level 1 being the highest priority and Level 3 being the least priority.

Table 3: Recommendations with Priority Level

Recommendation	Priority
Create a Formal Communication Plan for Each Bridge	1
Create a Formal EAP for Each Bridge	1
Create a Formal Maintenance Checklist for Each Bridge	1
Create a Formal Malfunction Log that Includes Solutions for Each Bridge	1
Create/Update a Procedure for Updating As-Built Drawings and O&Ms	1
Create an Electronic Tracking System to Monitor Maintenance Activities, Spare Equipment Inventory and Malfunction Logs/Remedies	2
Develop Specified Detours	2
Development of Enhancements for Public Communication Strategies	1
Create a Pilot Program to Implement Remote Monitoring and Troubleshooting	2
Create a Pilot Program to Implement Advanced Diagnostics and I/O Links – Note that a Remote Monitoring Program Should be Implemented First	3
Create MDOT Specific Design Guidelines, such as Control System Preference (PLC vs PLC with Relay Backup)	2

Notes:

1. Level 1 priorities are primarily updating and formalizing activities that MDOT already performs and likely the simplest to implement.
2. Level 2 priorities are recommendations that are most likely to decrease bridge malfunctions and shorten outages but take longer to implement and require additional stakeholder input.

3. Level 3 priorities show promise to significantly decrease malfunctions and shorten outages but come with drawbacks that need to be carefully considered before implementation, such as limited abilities for relay control with I/O-Links.

While innovative technologies are important considerations, it is equally important to focus on cost-effective improvements, such as enhancing communication and promoting consistency across MDOT's inventory. Overall, taking a holistic approach to these recommendations will support the reliability and effectiveness of MDOT's movable bridge operations.

8. BIBLIOGRAPHY

1. Biwer, Lyn, "Maintainability of Movable Bridge." Heavy Movable Structures Symposium, 1992.

2. Bloom, William, and Bowden, William, "Maintenance Procedures for Electrical Controls on Movable Bridges." Heavy Movable Structures Symposium, 1985.

3. Bloomquist, Robert, "Computerized Predictive Maintenance Program on a Trunnion Type Bascule Bridge." Heavy Movable Structures Symposium, 1987.

4. Arnold, Bill, "Considerations for Maintenance for Movable Bridges." Heavy Movable Structures Symposium, 1987.

5. Kaderbek, S.L., "Chicago Movable Bridge Maintenance, Operations and Capital Rehabilitation Strategies." Heavy Movable Structures Symposium, 2002.

6. Shaup, Steven, "Inspection, Assessment and Repair of Movable Bridges for Local Authorities Using a System Approach." Heavy Movable Structures Symposium, 2004.

7. Dume, Omar, "The Future in Moveable Bridge Control: Fault Tolerant PLC and Remote Operation and Maintenance." Heavy Movable Structures Symposium, 2006.

8. Barthle, Andrew, "A Maintenance-Centered Approach to Movable Bridge Electrical System Design." Heavy Movable Structures Symposium, 2012.

9. Catbas, F. Necati, Gul, Mustafa, Gokce, H. Burak, Zaurin, Ricardo, Grangopol, Dan M., and Grimmesman, Kirk A., "Critical Issues, Condition Assessment, and Monitoring of Heavy Movable Structures: Emphasis on Movable Bridges." TRID, 2014.

10. Catbas, F. Necati, Malekzadeh, Masoud, and Khuc, Tung, "Movable Bridge Maintenance Monitoring." TRID, 2013.

11. Research for AASHTO Standing Committee on Highways. Task 424. "AASHTO Guidelines for the Operation of Movable Bridges from Remote Locations." TRID, 2019.

12. Factors to Consider when Developing an Electrical System Design Philosophy for a Movable Bridge Project by Mitchell Wisniewski and Anthony Bartello

Appendix

9. APPENDICES

List of Acronyms and Abbreviations

ATS	Automatic Transfer Switch
DTMB	Department of Technology Management and Budget
DMS	Dynamic Message Signs
EAP	Emergency Action Plan
HMI	Human Machine Interface
HPU	Hydraulic Power Unit
I/O	Input Output
IEC	International Electrotechnical Commission
ISA	International Society of Automation
IT	Information Technology
ITS	Intelligent Transportation Systems
MDOT	Michigan Department of Transportation
MiBRIDGE	MDOT Asset Management Tool for Bridges
Mi Drive	MDOT construction and traffic information website
OIM	Operations, Inspection, and Maintenance Manuals
O&M	Operation and Maintenance
OT	Operational Technology
OEM	Original Equipment Manufacturer
PLC	Programmable Logic Controller
SCADA	Supervisory Control and Data Acquisition
SDCI	Single-Drop Digital Communication Interface
TOCs	Traffic Operation Centers
TMCs	Transportation Management Centers
TSA	Transportation Security Administration
TSC	Transportation Service Center
USCG	United States Coast Guard
VFD	Variable Frequency Drive
VPN	Virtual Private Network

Appendix A: Surveys and Interviews

MDOT Research Project OR23-016

Improving MDOT's Movable Bridge Reliability and Operations

Owner Survey

This survey should take approximately 30 minutes, this can vary based on the number of bridges in your inventory.

Name: Mark Hedglin, P.E. Caltrans Senior Mechanical Engineer Specialist.

Email: mark.hedglin@dot.ca.gov

Phone Number: 916-639-5954

1. How many movable bridges are in your agency's inventory?

Fourteen, see attached spread sheet for more information.

2. Please provide a brief description of each movable bridge, including major system types (deck, machinery, electrical) and history of rehabs/repairs (if tracked).

See attached spread sheet and inspection reports for more information

3. What is the average number of openings per month for each bridge in your region, including peak months and off-peak months? Alternatively, are scans/copies of opening logs for a typical year available electronically for review?

See attached samle opening log. Contact Donna Diaz for more information. donna.diaz@dot.ca.gov

4. Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)

It varies by bridge. The bridges that have undergone recent upgrades have operations manuals on site and our office of EMWW has electronic versions, but they are usually only for the electrical control systems. We are working with Hardesty and Hanover consultants to create comprehensive O&M manuals for most of the other bridges, and to include both Mechanical and Electrical.

5. Are electronic copies of the O&M manuals available for remote access and are they regularly updated due to maintenance, repairs, etc.?

The manuals are available for remote access only internally within Caltrans but are not updated regularly. Caltrans tracks maintenance and repairs through our Structures Maintenance and Investigations group SM&I who perform routine inspections of all State and Local bridges. EMWW (Caltrans office of Electrical, Mechanical, Water and Wastewater, assists with the M&E portions of inspections of movable bridges.

6. Have the O&M manuals been helpful during troubleshooting operations to resolve malfunctions?

The few O&M manuals we have are not comprehensive enough to be helpful to maintenance staff and are rarely if ever referenced.

7. Please provide an example of a recent implementation of troubleshooting measures from the O&M manuals, or when they are most typically referenced.

See response to question 6. It is Caltrans's plan to create usable manuals through our ongoing consultant task order.

8. What suggestions do you have for improvement(s) to the O&M manuals to provide more value and be more user friendly?

Include manufacturer cut sheets and O&M manuals for each piece of equipment. Refer to AASHTO Movable Bridge, Inspection, Evaluation, and Maintenance Manual for general maintenance requirements and intervals for each movable bridge type.

9. Do you have a dedicated movable bridge maintenance crew?

Caltrans does not have a single crew dedicated to maintaining our movable bridges. The bridges within specific areas called Districts, are maintained by the crews assigned to those bridges. Tower Bridge for example is maintained by District 3 crews, Little Potato and Old River District 10 and most of the others by District 4 Rio Vista Bridge Maintenance

10. Does the maintenance crew perform periodical inspections/maintenance and if so, how often?

The crews perform regular greasing and various electrical and mechanical maintenance on a monthly or less frequent basis based on the system involved. See attached sample grease plan sheets.

11. Which type of maintenance do they mostly perform (reactive/corrective or preventive/predictive)?

Reactive / corrective, except for the regular greasing.

12. Are maintenance charts, identifying lubrication type, frequency, and machinery component located on site for reference during maintenance activities?

The only two greasing charts available are for 3 Mile and Rio Vista, see attached. All the other bridges rely on training from more experienced maintenance staff.

13. Are any maintenance activities challenging to complete due to access issues or safety, and therefore not as regularly implemented?

Most maintenance can be done easily as all the bridge drive equipment is accessible. Equipment over water requiring access from a boat with a lift, for example greasing bearings on a wedge drive shaft at Old River is not done. Maintenance crews can do their own traffic control either through lane closures or using bridge traffic control gates to do maintenance.

14. With regards to asset management, is there a regularly scheduled/planned electrical component testing and replacement of electrical equipment?

There is no planned electrical component testing or maintenance. The only testing is done by EMWW electrical engineers annually during routine inspections. Megger, and current readings are taken on all equipment drive motors and brakes.

15. With regards to asset management, is there a regularly scheduled/planned mechanical component testing and replacement of mechanical equipment?

There is no planned mechanical component testing or maintenance. The only testing is done by EMWW mechanical engineers annually during routine inspections. Most of the mechanical inspections consist of visual inspection with some measurement of operating rope tension, and strain gauge readings of shaft torque. Caltrans has had H&H perform several in-depth inspections where gear tooth wear and other machinery wear is measured.

16. What alternative limit switch technology and/or proximity sensors are employed on your bridges to improve reliability, other than mechanical limit switches?

Caltrans uses motor encoders for bascule and swing span position. Rocker arm limit switches are used for bascule and lift span nearly open/closed and fully open/closed position and interlock. Some proximity switches have been used on the newly upgraded Rio Vista bridge. The large rocker arm limit switches have proven to be the most reliable. The proximity switches haven't been in use long enough to give a good assessment of their reliability.

17. Are the findings and recommendations from the latest bridge inspection reports available to maintenance to identify areas requiring special attention?

Yes, Caltrans has a thorough data base system "SMART" where inspection reports by SM&I Civil engineers and EMWW Mechanical and Electrical engineers enter element and defect data according to FHWA guidelines. The defects and work recommendations are all sent monthly to the maintenance crews. Work recommendations can then be completed and marked as done to be removed from the system. Longer term work recs like upgrade of M&E systems can be tracked and programmed into projects.

18. Is there a formal process in place to predict mechanical and/or electrical component failure(s)?

No, we have no formal process to predict mechanical or electrical component failure.

19. Are there any redundant systems at this bridge (backup motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc.)?

Most of Caltrans's movable bridges have a backup generator on site that can power the bridge equipment during a power failure. The mechanical backup drive systems vary per bridge. Tower Bridge has a diesel engine, the bascule bridges have chain wheels and pinions that can be slid into place to operate the spans in a limited fashion. Caltrans is currently upgrading Rio Vista, 3 Mile Slough, Steamboat, Paintersville, and Isleton to include backup electrical drive systems. The newer swing bridges usually have two drive motors with one being capable of moving the span.

20. Do you have a formal bridge operator/tender training program in place to reduce incidence of operator error that can lead to equipment damage and malfunctions?

Contact Donna Diaz for more information. donna.diaz@dot.ca.gov, new operators are trained by more experienced operators and are required to have a set number of supervised openings before they are allowed to operate the spans by themselves.

21. What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?

Each maintenance yard responsible for their bridges stores what few spare parts they may have for each bridge they are responsible for. Caltrans does not collect diagnostic data or proactively monitor equipment information outside of what is collected in the annual inspection reports.

22. What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?

This varies considerably. Most months there is no down time. On average every 6 months or so one bridge may be down for a day due to some component failure. See attached Incident log of historical failures.

23. What is the permissible traffic stoppage for bridge operations and at what point are the local authorities notified?

Contact Donna Diaz for more information. donna.diaz@dot.ca.gov, generally if traffic is stopped for more than 20 minutes due to equipment failure then authorities are notified. If a bridge is unable to open for maritime traffic the USCG is notified immediately.

24. What procedures are in place to optimize traffic operations during movable bridge downtime? (i.e. detour plans where feasible, VMS, mobile alerts, etc.)

Contact Donna Diaz for more information. donna.diaz@dot.ca.gov, all of the above are utilized with coordination through California Highway Patrol, CHP.

25. Are there Intelligent Transportation Systems (ITS) in place for each movable bridge in the region? What are the capabilities?

Caltrans has no ITS in place at any bridge currently. The bridges currently undergoing upgrades will have SCADA capable PLC systems installed for a possible ITS system.

26. What is the official protocol for elevating bridge malfunctions, i.e. who gets contacted, when, and what is the response time for maintenance to arrive?

Contact Donna Diaz for more information. donna.diaz@dot.ca.gov, usually to protocol is the bridge operators contact their district maintenance supervisor, and they coordinate emergency maintenance staff response to the bridge. Once on site if maintenance staff are unable to correct the problem M&E engineers are contacted to assist. I don't believe there is a set response time, it is usually ASAP.

27. Is there a 24/7 contractor that can be summoned to assist with troubleshooting emergencies, such as a control systems integrator or mechanical (millwright) contractor?

No Caltrans does not have a 24/7 contractor. In the case of a major equipment failure that cannot be addressed by maintenance, then the district will initiate an emergency director's order and hire a contractor, usually within days to assist with the repairs.

28. Are you willing to provide additional information regarding your movable bridge inventory over a brief, follow-up phone call? If yes, please provide dates and times when available.

Yes, please contact me as needed.

MDOT Research Project OR23-016

Improving MDOT's Movable Bridge Reliability and Operations

Owner Survey

This survey should take approximately 30 minutes, this can vary based on the number of bridges in your inventory.

Name: Jim McDowell

Email: jim.mcdowell@dot.wi.gov

Phone Number: 920-360-5792

1. How many movable bridges are in your agency's inventory?

12

2. Please provide a brief description of each movable bridge, including major system types (deck, machinery, electrical) and history of rehabs/repairs (if tracked).

Mostly rolling bascule, one trunnion

3. What is the average number of openings per month for each bridge in your region, including peak months and off-peak months? Alternatively, are scans/copies of opening logs for a typical year available electronically for review?

200 roughly yes we have digital copies

4. Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)

Yes

5. Are electronic copies of the O&M manuals available for remote access and are they regularly updated due to maintenance, repairs, etc.?

Yes

6. Have the O&M manuals been helpful during troubleshooting operations to resolve malfunctions?

Yes

7. Please provide an example of a recent implementation of troubleshooting measures from the O&M manuals, or when they are most typically referenced.

Gear box replacement on Oregon Jackson Bridge in Oshkosh

8. What suggestions do you have for improvement(s) to the O&M manuals to provide more value and be more user friendly?

Include all shop drawings

9. Do you have a dedicated movable bridge maintenance crew?

WisDOT has 1 full time employee that manages the bridges and 4 employee that help out. In Wisconsin we hire the counties to complete our work and we have 2 in Winnebago County, One in Brown Count, one in Door County and one in Marinette County.

10. Does the maintenance crew perform periodical inspections/maintenance and if so, how often?

Monthly

11. Which type of maintenance do they mostly perform (reactive/corrective or preventive/predictive)?

Preventative

12. Are maintenance charts, identifying lubrication type, frequency, and machinery component located on site for reference during maintenance activities?

Only on newer structures post 2000's

13. Are any maintenance activities challenging to complete due to access issues or safety, and therefore not as regularly implemented?

no

14. With regards to asset management, is there a regularly scheduled/planned electrical component testing and replacement of electrical equipment?

yes

15. With regards to asset management, is there a regularly scheduled/planned mechanical component testing and replacement of mechanical equipment?

no

16. What alternative limit switch technology and/or proximity sensors are employed on your bridges to improve reliability, other than mechanical limit switches?

Most mechanical switches are replaced with prox switches.

17. Are the findings and recommendations from the latest bridge inspection reports available to maintenance to identify areas requiring special attention?

Yes

18. Is there a formal process in place to predict mechanical and/or electrical component failure(s)?

Not a formal one

19. Are there any redundant systems at this bridge (backup motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc.)?

Most built after the 50's unless there is little to no commercial traffic

20. Do you have a formal bridge operator/tender training program in place to reduce incidence of operator error that can lead to equipment damage and malfunctions?

Yes

21. What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?

Some spare parts are stocking according to lead times and liklyhood of failure.

22. What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?

Very low

23. What is the permissible traffic stoppage for bridge operations and at what point are the local authorities notified?

Depends on location. Some places call for each lift others if it will be an extended lift for commical. Lifts for pleasure very rarely.

24. What procedures are in place to optimize traffic operations during movable bridge downtime? (i.e. detour plans where feasible, VMS, mobile alerts, etc.)

Motorists are directed to use closest bridge for scheduled closures otherwise none.

25. Are there Intelligent Transportation Systems (ITS) in place for each movable bridge in the region? What are the capabilities?

No

26. What is the official protocol for elevating bridge malfunctions, i.e. who gets contacted, when, and what is the response time for maintenance to arrive?

Head tender to Bridge superintendent to lift bridge PM.

27. Is there a 24/7 contractor that can be summoned to assist with troubleshooting emergencies, such as a control systems integrator or mechanical (millwright) contractor?

Yes we have contractors on call for cameras, controls, electrical, hydraulic and mechanical

28. Are you willing to provide additional information regarding your movable bridge inventory over a brief, follow-up phone call? If yes, please provide dates and times when available.

Monday through Thursday 7-3:00 central time. I will most likely invite Jim Mcdowell our Moveable Bridge Program Manager. He helped me fill out this survey also.

Owner Survey

Name: __Steve Benczik_____

Email: __stbenczik@INDOT.in.gov_____

Phone Number: _____219-352-7519_____

1. How many movable bridges are in your agency's inventory?

One

2. Please provide a brief description of each movable bridge, including major system types (deck, machinery, electrical) and history of rehabs/repairs (if tracked).

Bridge 3100 is a double-leaf bascule bridge carrying US 12 (Indianapolis Blvd.) over Lake George Canal in East Chicago, Indiana. The bridge is located 0.51 miles west of US 20. Bridge 3100 has a main span that is a single span, double leaf, Scherzer rolling lift bascule bridge with a two-girder superstructure, and two multi-girder approach spans. The bridge is oriented in the north-south direction and has a main span length of 100 feet. The structure has an approximate zero-degree skew. The girders and floor beams are built-up welded I-shaped members. The main girder webs vary in depth from 8 feet-6 1/4 inches at the rolling center to 4 feet-7 inches near the center lock. The floor beam webs also vary in depth to create a crown at the center of the roadway. Stringers span between the floor beams, and the bridge uses a steel open grid deck. The bridge utilizes a hydraulic drive system to raise and lower the spans.

Our bridge is on a 12-hour notice approved by the USCG due to the unique location and when it needs to be opened. Basically it provides a channel to a dead-end branch of the canal that has a containment pond used to store and dewater dredged material out of the Indiana Harbor Canal. No other vessels use the channel except barges and other dredging equipment. This summer the containment pond was "closed" to raise the walls to allow more capacity for dredged material. We expect the dredging to resume next summer. We hired an outside contractor to operate the bridge when dredging operations are underway

The original year of construction for Bridge 3100 is 1987. The bridge was rehabilitated in 2010 and the work included minor structural repairs, repairs to the hydraulic drive system, replacement of the rear lock drives, cleaning and re-lubricating bearings and gears, and extensive electrical and control system modifications. The structural steel framing was repainted in 2015. A deck (steel grating) replacement project was completed in 2019 followed by a rebalancing contract. Recent maintenance work in 2020 for the structure included replacement of

the shim stacks at the girder live load bearings and numerous mechanical and electrical repairs, including cleaning and relubrication of the bearings, tightening loose fasteners, replacement of several hydraulic hoses, cleaning and relubrication of the tail lock machinery, installation of an emergency lighting system, and cleaning and removal of corrosion product from electrical systems.

3. What is the average number of openings per month for each bridge in your region, including peak months and off-peak months? Alternatively, are scans/copies of opening logs for a typical year available electronic for review?

When dredging, approx. 10+ openings typically per day, 5 – 7 days per week from April 1st through the end of November. No openings outside that time period for dredging . We open the bridge approximately every 2 weeks outside the dredging period with our own personnel to maintain the bridge and assure it operates as needed. We do not operate the bridge during cold weather (less than freezing temperatures) because the hydraulic oil must be heated to not damage components. Note: heaters are installed into the hydraulic oil reservoirs, but we prefer not to use them if it is not necessary.

4. Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)

They were until they "disappeared' last summer. We intend to provide a copy for next season.

5. Are electronic copies of the O&M manuals available for remote access and are they regularly updated due to maintenance, repairs, etc.?

Have not typically been updated.

6. Have the O&M manuals been helpful during troubleshooting operations to resolve malfunctions?

They were available and utilized as needed.

7. Please provide an example of a recent implementation of troubleshooting measures from the O&M manuals, or when they are most typically referenced.

They were referred to for control and wiring diagrams.

8. What suggestions do you have for improvement(s) to the O&M manuals to provide more value and be more user friendly?

Provide multiple copies and have one in control room at all times. Update as needed after repairs are completed. Keep date, plans and maintenance log of repairs and contracts included with manuals.Also update them as necessary.

9. Do you have a dedicated movable bridge maintenance crew?

No. Our crew is used for general bridge maintenance on all bridges. Due to recent personnel departures, the current crew has limited knowledge of the bridge and its systems. We rely primarily on one contractor to provide maintenance, troubleshooting and repairs.

10. Does the maintenance crew perform periodical inspections?

No; we hire an outside consultant familiar with lift bridges to inspect the bridge and systems every 2 years.

11. Which type of maintenance do they mostly perform (reactive/corrective or preventive/predictive)?

Primarily repairs to react to issues found during the inspections mentioned above. When we have a repair scheduled, we also have the contractor perform preventive maintenance activities. Our intent is to have the same contractor perform maintenance on a regular schedule in the fall and in the spring.

12. Are maintenance charts, identifying lubrication type, frequency, and machinery component located on site for reference during maintenance activities?

They are included in the O & M manuals.

13. Are any maintenance activities challenging to complete due to access issues or safety, and therefore not as regularly implemented?

Some areas are difficult to safely access. This is one reason we utilize an outside contractor to perform maintenance duties.

14. With regards to asset management, is there regularly scheduled/planned electrical component testing and replacement of electrical equipment?

No; we typically react to component malfunctions rather than testing and scheduled replacements.

15. With regards to asset management, is there regularly scheduled/planned mechanical component testing and replacement of mechanical equipment?

No. The only activity we conduct when the bridge is not regularly opened is periodic opening to check all systems are operating properly. Our inspection consultant thoroughly tests all mechanical, electrical and control systems every 2 years and provides a detailed report of their findings. This report lists recommendations upon which we prepare a maintenance and repair contract for our repair contractor.

16. Are the findings and recommendations from the latest bridge inspection reports available to maintenance to identify areas requiring special attention?

Yes; we share the report with our Maintenance group. However, they are not set up to perform the majority of maintenance activities and we then rely on an outside contractor to complete most of our maintenance.

17. Is there a formal process in place to predict mechanical and/or electrical component failure(s)?

No; no process established.

18. Are there any redundant systems at this bridge (backup motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc.)?

The bridge is provided with a generator termination box and an associated disconnect switch at the entrance area to the bridge control house to connect with a portable generator

19. What spare parts are typically stocked and where are they stored (distance from bridge)?

Spare parts are not stocked and purchased as needed.

20. What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?

One to 2 hours

21. What is the permissible traffic stoppage for bridge operations and at what point are the local authorities notified?

After 30 minutes, local authorities are notified and traffic is diverted to alternate routes

22. What procedures are in place to optimize traffic operations during movable bridge downtime? (i.e. detour plans where feasible, VMS, mobile alerts, etc.)

A sister lift bridge not in INDOT's inventory is located within 1 mile of this bridge and traffic is diverted onto that road.

23. Are there Intelligent Transportation Systems (ITS) in place for each movable bridge in the region? What are the capabilities?

No. This was contemplated, but the cost, complexity and opening frequency was considered too great to justify an ITS solution. Additionally, we felt the USCG would not readily accept remote operation of this bridge.

24. What is the official protocol for elevating bridge malfunctions, i.e. who gets contacted, when, and what is the response time for maintenance to arrive?

Our District Operations Manager is notified who then notifies the Bridge Crew Supervisor. If our personnel cannot make the repairs, then we would notify our outside contractor to make repairs.

25. Is there a 24/7 contractor that can be summoned to assist with troubleshooting emergencies, such as a control systems integrator or mechanical (millwright) contractor?

Yes; we have a local contractor who can be called for emergencies.

26. Are you willing to provide additional information regarding your movable bridge inventory over a brief, follow-up phone call? If yes, please provide dates and times when available.

Yes; my contact information is at the top of this form. You may call or email to set up a time for follow-up.

MDOT Research Project OR23-016

Improving MDOT's Movable Bridge Reliability and Operations

Owner Survey

This survey should take approximately 30 minutes, this can vary based on the number of bridges in your inventory.

Name: Nicholas Chaney & Tom Partridge (Ashtabula County)

Email: Nicholas.Chaney@dot.ohio.gov

Phone Number: 330-786-4858

1. How many movable bridges are in your agency's inventory?

District 4 has one movable bridge in our inventory, ATB-531-0917 (Ashtabula W. 5th St. over Ashtabula River)

2. Please provide a brief description of each movable bridge, including major system types (deck, machinery, electrical) and history of rehabs/repairs (if tracked).

1927 Single Leaf Bascule, with rehabs in 1985 and 2010. Currently on a construction project to repair some rivets.

3. What is the average number of openings per month for each bridge in your region, including peak months and off-peak months? Alternatively, are scans/copies of opening logs for a typical year available electronically for review?

1,000 peak & 200 non-peak. No electronic logs are kept.

4. Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)

Yes.

5. Are electronic copies of the O&M manuals available for remote access and are they regularly updated due to maintenance, repairs, etc.?

No

6. Have the O&M manuals been helpful during troubleshooting operations to resolve malfunctions?

Yes.

7. Please provide an example of a recent implementation of troubleshooting measures from the O&M manuals, or when they are most typically referenced.

They are referenced anytime a troubleshooting gets involved enough to require it.

8. What suggestions do you have for improvement(s) to the O&M manuals to provide more value and be more user friendly?

None

9. Do you have a dedicated movable bridge maintenance crew?

No, but Ashtabula Co. has 3-4 staff members that are most familiar with the bridge who take care of it.

10. Does the maintenance crew perform periodical inspections/maintenance and if so, how often?

Intervals of 500 lifts, the mechanisms are greased and at that time inspected.

11. Which type of maintenance do they mostly perform (reactive/corrective or preventive/predictive)?

Preventative

12. Are maintenance charts, identifying lubrication type, frequency, and machinery component located on site for reference during maintenance activities?

Yes.

13. Are any maintenance activities challenging to complete due to access issues or safety, and therefore not as regularly implemented?

No

14. With regards to asset management, is there a regularly scheduled/planned electrical component testing and replacement of electrical equipment?

No

15. With regards to asset management, is there a regularly scheduled/planned mechanical component testing and replacement of mechanical equipment?

No

16. What alternative limit switch technology and/or proximity sensors are employed on your bridges to improve reliability, other than mechanical limit switches?

None.

17. Are the findings and recommendations from the latest bridge inspection reports available to maintenance to identify areas requiring special attention?

When applicable, otherwise no. However, reports can be provided if requested.

18. Is there a formal process in place to predict mechanical and/or electrical component failure(s)?

No

19. Are there any redundant systems at this bridge (backup motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc.)?

A standby generator that only operates traffic control. There is a manual lift system and instructions if needed.

20. Do you have a formal bridge operator/tender training program in place to reduce incidence of operator error that can lead to equipment damage and malfunctions?

No formal training program. The most senior operator trains new employees.

21. What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?

Small parts are located at the bridge, but larger items are stored at Ashtabula County Highway Department which is 15 miles from bridge. There is no predictive monitoring in place.

22. What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?

Over the last two years it has been 0. However, there are times when this may happen.

23. What is the permissible traffic stoppage for bridge operations and at what point are the local authorities notified?

There is no written rule. The bridge remains open until the boat has cleared. Local authorities are notified usually after 10 mins.

24. What procedures are in place to optimize traffic operations during movable bridge downtime? (i.e. detour plans where feasible, VMS, mobile alerts, etc.)

River traffic takes precedence and road traffic will be closed if need be.

25. Are there Intelligent Transportation Systems (ITS) in place for each movable bridge in the region? What are the capabilities?

No

26. What is the official protocol for elevating bridge malfunctions, i.e. who gets contacted, when, and what is the response time for maintenance to arrive?

In the event there is a bridge malfunction, the operator notifies the engineer's staff. Typical time for response is 30 min to 1 hour.

27. Is there a 24/7 contractor that can be summoned to assist with troubleshooting emergencies, such as a control systems integrator or mechanical (millwright) contractor?

Electrical contract is 24/7. All else takes more time.

28. Are you willing to provide additional information regarding your movable bridge inventory over a brief, follow-up phone call? If yes, please provide dates and times when available.

Tom Partridge 440-576-3013 Mon-Fri 7:30am to 4:00pm Est.

MDOT Research Project OR23-016

Improving MDOT's Movable Bridge Reliability and Operations

Owner Survey

This survey should take approximately 30 minutes, this can vary based on the number of bridges in your inventory.

Name: Ashley Stoll & Marc Stecker

Email: ashley.stoll@vdot.virginia.gov, marc.stecker@vdot.virginia.gov

Phone Number: 757-956-3221, 540-820-2685

Please see appendix for summary on VDOTs movable bridge inventory

1. How many movable bridges are in your agency's inventory?

Hampton Roads District – 5, Richmond District – 1, Fredericksburg District - 2

2. Please provide a brief description of each movable bridge, including major system types (deck, machinery, electrical) and history of rehabs/repairs (if tracked).

Hampton Roads District:

Berkley Westbound and Berkley Eastbound are twin double leaf rolling bascules. The Berkley bridges operate using thyristor drives and machinery located on a platform below the deck. The bridges have an open steel grid deck with an epoxy filled section over the machinery platform. The bridges are currently having new onshore generators installed to replace the existing. These bridges will be starting a 5-year overhaul soon. The James River Bridge (JRB) is a tower driven vertical lift with thyristor drives and a new steel grid deck. The bridge is currently in the process of adding a new Emergency drive system with VFD drives. A wire rope replacement has recently been awarded and the drives are planned to be replaced within the next couple of years. High Rise Bridge (HRB) is a double leaf trunnion bascule with SCR drives and machinery located in front of the bascule pit below the deck. The steel grid deck is currently being replaced. New gates have recently been installed as the bridge has gone from bi-directional to directional as a new fixed bridge has been built alongside. Coleman Bridge is the second largest double swing span in the world utilizing four low speed high torque hydraulic motors per span. The deck is concrete with end flaps and the 3 span breaks. The wedge motors and gear boxes and the balance track segments are being rehabilitated currently. The bridge is PLC operated which was updated within the past few years. Chincoteague Bridge is a small single leaf trunnion bascule bridge with the machinery located above the machinery pit. The control system is mainly relay logic controlled.

Richmond District:

Benjamin Harrison Bridge (BHB) is a tower driven vertical lift with thyristor drives and a steel grid deck. The bridge is currently in the process of adding new aerial cables to replace the submarine cables, installing new onshore generators, upgrading the emergency drive and preparing to replace the existing thyristor drives with VFD drives. A wire rope and clutch replacement was performed in recent years.

Fredericksburg District:

Eltham Bridge is a double leaf trunnion bascule with machinery located in front of the bascule pit below the deck. The deck is a concrete deck. The control system is relay logic controlled. The bridge is currently in the preliminary phase for replacement of the current generator with a new onshore generator and

installation of lighting and surge protection. Gwynn's Island Bridge is a through truss swing span with an open grid deck, with a concrete filled portion over the center pier. The bridge is currently undergoing a full mechanical and electrical rehabilitation. The new drive machinery is located on the center pier driving a single pinion with 3 separate wedge drives and new centering latches. The control system is a new relay-based system.

3. What is the average number of openings per month for each bridge in your region, including peak months and off-peak months? Alternatively, are scans/copies of opening logs for a typical year available electronically for review?

Bridge	Number of Openings
Berkley Westbound	90
Berkley Eastbound	90
James River Bridge	60
Coleman	20
High Rise Bridge	4
Chincoteague	30
Eltham	4
Gwynn's Island	290
Benjamin Harrison	60

4. Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)

Yes, generally located in operators house or electrical rooms.

5. Are electronic copies of the O&M manuals available for remote access and are they regularly updated due to maintenance, repairs, etc.?

Yes, generally updated with major projects.

6. Have the O&M manuals been helpful during troubleshooting operations to resolve malfunctions?

Yes, the schematics within the manuals have been used in emergency cases to resolve issues.

7. Please provide an example of a recent implementation of troubleshooting measures from the O&M manuals, or when they are most typically referenced.

During a recent operational issue with the High Rise Bridge, the schematics and manuals were used for adjusting the drives to allow for proper operation without tripping.

8. What suggestions do you have for improvement(s) to the O&M manuals to provide more value and be more user friendly?

An onsite tablet, with all of the information readily available would make searching for and finding the necessary information much easier.

9. Do you have a dedicated movable bridge maintenance crew?

Hampton Roads District and Fredericksburg have their own maintenance crews that are supplemented by a contracted third party. Richmond District has only a contracted third party that maintains its bridge.

10. Does the maintenance crew perform periodical inspections/maintenance and if so, how often?

Hampton Roads District and Fredericksburg District record weekly, they have a HMMS (Highway Maintenance Management System) computer system that all inspections, repairs, upgrades are recorded daily. Richmond district performs weekly maintenance utilizing their third party maintenance and repair contractor.

11. Which type of maintenance do they mostly perform (reactive/corrective or preventive/predictive)?

The maintenance crews perform both reactive/corrective and preventative/predictive maintenance. The bridges in VDOT's inventory range in age from 13 to 85 years in age so reactive/corrective action is inevitable. However, all VDOT districts have a good plan in place to perform preventative/predictive maintenance including incorporating AASHTO inspection report recommendations.

12. Are maintenance charts, identifying lubrication type, frequency, and machinery component located on site for reference during maintenance activities?

Yes, all bridges include lubrication charts framed on the walls of the machinery rooms or control houses as well as within the Operation and Maintenance Manuals.

13. Are any maintenance activities challenging to complete due to access issues or safety, and therefore not as regularly implemented?

Access for some of the bridges or portion of bridges can be an issue due to shutting down of interstate traffic, or main travel routes. This can hamper routine maintenance efforts.

14. With regards to asset management, is there a regularly scheduled/planned electrical component testing and replacement of electrical equipment?

All districts have the following scheduled/planned maintenance for electrical component: The switchgears are cleaned and tested every 3 years. Load bank testing is performed every 5 years. The generators are serviced yearly. Megger testing of the electric span drive motors is performed every 2 years. Routine inspection of all electrical equipment is performed every 2 years. In-depth inspection including interlock testing and is performed every 6 years. Megger testing of feeders, submarine/aerial cables, ancillary electric equipment etc is performed upon request.

15. With regards to asset management, is there a regularly scheduled/planned mechanical component testing and replacement of mechanical equipment?

All districts have the following scheduled/planned maintenance for mechanical components: Oil samples of gearboxes are tested annually and replaced as recommended. Routine inspection of all mechanical

equipment every 2 years. In-depth inspection including wire rope measurements, gear tooth measurements, in-depth coupling and bearing inspection every 6 years.

16. What alternative limit switch technology and/or proximity sensors are employed on your bridges to improve reliability, other than mechanical limit switches?

Many of the bridges utilize Topworx model 81 proximity switches in lieu of or in conjunction with mechanical limit switches such as the Cutler Hammer E49 and E51 or older U5 limit switches.

17. Are the findings and recommendations from the latest bridge inspection reports available to maintenance to identify areas requiring special attention?

Yes, and the reports include list of recommendations broken down by Priority and Routine repairs and are ordered in the level of priority.

18. Is there a formal process in place to predict mechanical and/or electrical component failure(s)?

Testing and sampling as mentioned above, AASHTO Movable Bridge Inspection, Evaluation and Maintenance Manual and VDOT is in the process of developing a Health Index to monitor the health of their bridges over time to allow them to determine when funding will need to be applied to prevent breakdowns.

19. Are there any redundant systems at this bridge (backup motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc.)?

Hampton Roads District:

The James River Bridge (JRB) has redundant main drive motors and drives and is currently having a emergency drive system installed. The Coleman Bridge has 2 redundant PLC's and can run on half of the current drive machinery. The Chincoteague Bridge has redundant main drive motors and backup drive motors. The High Rise Bridge has main and emergency drive systems. The Berkley bridges have both main and emergency drive systems and can be hand cranked open as a last resort. All of the bridges have backup generators with Berkley and High Rise Bridge getting new ones install currently.

Fredericksburg District:

The Eltham Bridge has redundant main drive motors/drive systems with a backup generator. The Gwynn's Island Bridge has new main and emergency drives, a new backup generator and can be hand cranked open as a last resort.

Richmond District:

The Benjamin Harrison Bridge has main and emergency drive system, new backup generators, a separate backup generator that can operate the emergency drive only and can be hand cranked open as a last resort.

20. Do you have a formal bridge operator/tender training program in place to reduce incidence of operator error that can lead to equipment damage and malfunctions?

New bridge tenders are trained by veteran bridge tender they need to perform a minimum of 10 openings, half of which are at night. The new tender will then be tested and qualified if they pass. In general many of the bridge have with the exception of those operating on demand, will have several qualified operators on site for openings. At many of the on-demand bridge, there are also maintenance staff on site that can assist should an emergency occur.

21. What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?

All small parts are kept on the bridge in inventory and the larger items like motors, brakes, gates are at the shop anywhere from 1 to 15 miles away. Other spare parts stored include items such as wire rope, bearing, and coupling lubricant, limit switches, control system parts such as PLC cards, drive cards, relays, spare wiring, lights and limit switches.

22. What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?

Less than an hour, due to maintenance and proactive repairs, downtime on the VDOT bridges are rare.

23. What is the permissible traffic stoppage for bridge operations and at what point are the local authorities notified?

All bridges are different and USCG controlled. Most don't open during rush hour (5 AM - 9 AM 3 PM -7 PM). Assuming this question is regarding vehicular traffic, openings are generally limited to no more than 20 minutes and up to 30 minutes with Traffic Engineering approval. Emergency and planned work is communicated to USCG, local authorities, and Traffic Engineering.

24. What procedures are in place to optimize traffic operations during movable bridge downtime? (i.e. detour plans where feasible, VMS, mobile alerts, etc.)

Procedures are bridge specific depending on a variety of factors including route type (interstate or primary) traffic count, detour availability, etc. Chincoteague and Gwynn's Island bridges do not have detour routes. Other detour lengths vary from 5 to 80 miles.

25. Are there Intelligent Transportation Systems (ITS) in place for each movable bridge in the region? What are the capabilities?

VDOT has Virginia 511 and security cameras on most bridges.

26. What is the official protocol for elevating bridge malfunctions, i.e. who gets contacted, when, and what is the response time for maintenance to arrive?

VDOT has an On Call person 24/7/365 that will respond in less than an hour, TOC is notified, Supervisor puts out a group text to district managers and that is kept up until the issue is resolved. VDOT will involve the on-call contractor depending on the urgency or critical nature of the emergency.

27. Is there a 24/7 contractor that can be summoned to assist with troubleshooting emergencies, such as a control systems integrator or mechanical (millwright) contractor?

VDOT has an on-call contract that is used for inspections, design and emergency response in the event of a failure. There are also several local contractors in the area that are familiar with the bridges if emergency repairs beyond the capability of the maintenance crews are needed.

28. Are you willing to provide additional information regarding your movable bridge inventory over a brief, follow-up phone call? If yes, please provide dates and times when available.

Yes, please contact Ashley Stoll at 757-956-3221 and/or Marc Stecker at 540-820-2685 to schedule a date and time.

APPENDIX OF MOVABLE BRIDGES:

Number	***Bridge Name***	***Description***
1	Eltham	Trunnion Bascule
2	Gwynn's Island	Center Bearing Swing Span
3	Berkley	Rolling Bascule
4	Coleman	Double-swing-span bridge
5	High Rise	Trunnion Bascule
6	James River	Tower Driven Vertical Lift Bridge
7	Chincoteague	Trunnion Bascule
8	Benjamin Harrison	Tower Driven Vertical Lift Bridge

December 5, 2023

Responses to HDR Survey:

Name: Chris Feely

Email: feelych@wsdot.wa.gov

Phone Number: 360-705-2573

How many movable bridges are in your agency's inventory?

The Washington State Department of Transportation (WSDOT) has 14 movable bridges: six bascule bridges, four lift bridges, three swing bridges, and one floating bridge with retractable pontoons.

Please provide a brief description of each movable bridge, including major system types (deck, machinery, electrical) and history of rehabs/repairs (if tracked).

1. 12/915: Snake River Bridge
    - Location: Clarkston, WA – Lewiston, ID
    - Movable Span Type: Lift
    - Year built: 1939
    - Feature Crossed: Snake River between Clarkston, WA and Lewiston, ID
    - Movable Span Length: 200 ft

2. 513/12: Montlake Bridge
    - Location: Seattle, WA
    - Movable Span Type: Bascule
    - Year built: 1924
    - Feature Crossed: Montlake Cut
    - Movable Span Length: 182 ft

3. 529/10E: Snohomish River Bridge, Northbound
    - Location: Everett, WA
    - Movable Span Type: Lift
    - Year built: 1927
    - Feature Crossed: Snohomish River
    - Movable Span Length: 145 ft

4. 529/10W: Snohomish River Bridge, Southbound
    - Location: Everett, WA
    - Movable Span Type: Lift
    - Year built: 1954
    - Feature Crossed: Snohomish River
    - Movable Span Length: 141 ft
5. 529/20E: Steamboat Slough, Northbound
    - Location: Marysville, WA
    - Movable Span Type: Swing
    - Year built: 1954
    - Feature Crossed: Steamboat Slough
    - Movable Span Length: 288 ft

6. 529/20W: Steamboat Slough, Southbound
    - Location: Marysville, WA
    - Movable Span Type: Swing
    - Year built: 1927
    - Feature Crossed: Steamboat Slough
    - Movable Span Length: 141 ft

7. 99/530E: First Avenue Bridge, Northbound
    - Location: Seattle, WA
    - Movable Span Type: Bascule
    - Year built: 1956
    - Feature Crossed: Duwamish River
    - Movable Span Length: 175 ft

8. 99/530W: First Avenue Bridge, Southbound
    - Location: Seattle, WA
    - Movable Span Type: Bascule
    - Year built: 1996
    - Feature Crossed: Duwamish River
    - Movable Span Length: 175 ft

9. 101/115: Chehalis River Bridge
    - Location: Aberdeen, WA
    - Movable Span Type: Bascule Bridge
    - Year built: 1955
    - Feature Crossed: Chehalis River
    - Movable Span Length: 236 ft

10. 101/125E: Riverside Bridge

- Location: Hoquiam, WA
- Movable Span Type: Lift Span
- Year built: 1970
- Feature Crossed: Hoquiam River
- Movable Span Length: 213 ft

11. 101/125W: Simpson Avenue Bridge
    - Location: Hoquiam, WA
    - Movable Span Type: Bascule Bridge
    - Year built: 1928
    - Feature Crossed: Hoquiam River
    - Movable Span Length 200 ft

12. 104/5: Hood Canal Floating Bridge
    - Location: Hood Canal near Port Gamble, WA
    - Movable Span Type: (2) 300-ft Retractable Floating Pontoons
    - Year built: 2009
    - Feature Crossed: Hood Canal
    - Movable Span Length: 600 ft

13. 12/12N: Wishkah River Bridge
    - Location: Aberdeen, WA
    - Movable Span Type: Steel Truss, Single Leaf Bascule Bridge
    - Year built: 1925
    - Feature Crossed: Wishkah River
    - Movable Span Length: 215 ft

14. 12/12S: Heron Street Bridge
    - Location: Aberdeen, WA
    - Movable Span Type: Swing
    - Year built: 1949
    - Feature Crossed: Wishkah River
    - Movable Span Length: 190 ft

What is the average number of openings per month for each bridge in your region, including peak months and off-peak months? Alternatively, are scans/copies of opening logs for a typical year available electronically for review?

A copy of an opening log is attached that lists each of the bridges. The attachment provides opening data for each bridge for a recent calendar year (2022).

Are Operations & Maintenance (O & M) manuals available on site for each bridge? (Please skip to question 9 if not available.)

Copies of Operation, Inspection, and Maintenance (OIM) manuals that are tailored to each bridge are available. One or more copies are on each bridge site. Additional copies are provided to supervisors responsible for managing the assigned bridge maintenance crews. A master copy of each OIM manual version is kept in the Movable Bridge Mechanical-Electrical Section office of the WSDOT Bridge Preservation Office.

Are electronic copies of the O&M manuals available for remote access and are they regularly updated due to maintenance, repairs, etc.?

Electronic copies are not available for remote access. WSDOT provides physical copies in binders that are kept on each bridge site for maintenance staff and supervisors to use as a reference. Each manual version is updated to reflect the current inspection and maintenance needs of each bridge.

A PDF copy of our OIM manual for the Hood Canal Floating Bridge is attached.

Have the O&M manuals been helpful during troubleshooting operations to resolve malfunctions?

The manuals are helpful. Chapter 7 in each manual provides an objective list of maintenance tasks to be performed, along with a schedule for each task.

The manuals also provide step-by-step guidelines for operating each bridge. Diagrams of operation panel layouts are provided for each step. The manuals are helpful as a reference for both troubleshooting and for new bridge tenders during their training period.

Please provide an example of a recent implementation of troubleshooting measures from the O&M manuals, or when they are most typically referenced.

The OIM manuals are referenced as a guideline for maintenance procedures and frequency for mechanical, electrical, and structural maintenance task items. New bridge staff use the manuals as a training tool.

What suggestions do you have for improvement(s) to the O&M manuals to provide more value and be more user-friendly?

WSDOT's manuals are user-friendly. Each manual contains a master table of contents at the beginning of the manual and additional tables of contents at the beginning of each section. Each manual version is comprised of eight sections: Introduction, Operations, Inspection, Maintenance, Emergency Response, Photographs, Maintenance Forms, and Emergency Telephone List.

Do you have a dedicated movable bridge maintenance crew?

Yes, each bridge is assigned a crew that is responsible for maintaining the bridge as directed in the established OIM guidelines.

Does the maintenance crew perform periodical inspections/maintenance and, if so, how often?

Periodic inspections and maintenance tasks are performed as required for each individual movable bridge. Electrical and mechanical task lists are identified on maintenance forms included in Chapter 7 of each OIM manual. The tasks are organized by periodic need: daily, weekly, monthly, three-month, six-month, annual, two-year, five-year, and longer time intervals as required.

Which type of maintenance do they mostly perform (reactive/corrective or preventive/predictive)?

Nearly all maintenance is preventative/predictive. Movable bridges are inspected biennially. In-depth inspections are performed every six years. During these inspections, individual components are assessed for likelihood of failure. Those components identified as not being reliable are rebuilt or replaced as appropriate.

Are maintenance charts, identifying lubrication type, frequency, and machinery component located on site for reference during maintenance activities?

Lubricant needs (type and replacement schedule) for bridge components are identified in the OIM manual. Lubricants are identified by type/grade and, where appropriate, by brand name.

Are any maintenance activities challenging to complete due to access issues or safety and, therefore, not as regularly implemented?

There are some maintenance activities that are performed in a non-ideal, but practical manner. An example is replacing grease in large bearings. Owing to the size and weight of the bearings, grease removal is accomplished by using new grease to hydraulically purge the old.

With regard to asset management, is there a regularly scheduled/planned electrical component testing and replacement of electrical equipment?

This assessment is completed during the inspections.

What alternative limit switches technology and/or proximity sensors are employed on your bridges to improve reliability, other than mechanical limit switches?

Most limit switches are mechanical. Some sites make use of magnetic limit switches.

Are the findings and recommendations from the latest bridge inspection reports available to maintenance to identify areas requiring special attention?

Yes, the results of the inspection reports are made available to the maintenance crews.

Is there a formal process in place to predict mechanical and/or electrical component failure(s)?

Yes, through objective measurement of mechanical part wear or electrical irregularities during the scheduled inspections. Current inspection results are compared with previous inspection reports to monitor mechanical part wear, differing electrical resistance measurements, or other deficiencies. Should on-site bridge maintenance personnel have concerns, electrical and mechanical engineers from the Bridge Preservation Office Movable Bridge Engineering section will visit the site to investigate.

Are there any redundant systems at this bridge (backup motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc.)?

Redundant systems and backup equipment is available at each site to ensure that the bridge can be opened in case of emergency and closed should a failure occur in the open position. Backup generators are available to provide power to bridge operational equipment should a power failure occur. Hand-operated bypass assemblies are incorporated into bridge sites that allow for closure should mechanical equipment fail to operate.

Do you have a formal bridge operator/tender training program in place to reduce incidence of operator error that can lead to equipment damage and malfunctions?

WSDOT's new bridge tenders are trained on the job under the supervision of experienced bridge operators.

What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?

Each movable bridge maintenance facility keeps spare parts on hand to facilitate the rapid replacement of failed components. Spare parts include switches, motors, actuators, hydraulic hoses, etc. An inventory list of spare parts is maintained by WSDOT's Bridge Preservation Office.

What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?

Downtime is very minimal. We believe this is the result of predictive/preventative maintenance and careful observation of the bridge components during periodical inspections by our well-trained bridge maintenance crews. Unscheduled downtime does occur infrequently as a result of vandalism (for example, wire theft by derelicts camped in the state right-of-way near the bridges).

What is the permissible traffic stoppage for bridge operations and at what point are the local authorities notified?

WSDOT has Transportation Management Centers (TMCs) that monitor and administrate traffic flow. The TMCs maintain established detour routes should extended bridge openings become necessary.

What procedures are in place to optimize traffic operations during movable bridge downtime? (i.e. detour plans where feasible, VMA, mobile alerts, etc.)

WSDOT's TMCs monitor and handle these tasks.

Are there intelligent Transportation Systems (ITS) in place for each movable bridge in the region? What are the capabilities?

WSDOT's TMCs are responsible for traffic control on all WSDOT highways and bridges.

What is the official protocol for elevating bridge malfunctions, i.e., who gets contacted, when, and what is the response time for maintenance to arrive?

A contact list containing key personnel names and contact information is provided in Chapter 8 in each OIM manual. Also provided is contact information for utilities serving the bridge, the United States Coast Guard, Ecology, and others.

Is there a 24/7 contractor that can be summoned to assist with troubleshooting emergencies, such as a control systems integrator or mechanical (millwright) contractor?

No. Initial problem assessment is completed by the Bridge Office mechanical and electrical engineering staff.

Are you willing to provide additional information regarding your movable bridge inventory over brief, follow-up phone call? If yes, please provide dates and times when available.

You may contact Duane Stone, Bridge Preservation Section, 360-570-2576, Tuesday through Friday, 8:00 am – 4:00 pm Pacific Time.

MDOT Research Project OR23-016

Improving MDOT's Movable Bridge Reliability and Operations

Owner Survey

This survey should take approximately 30 minutes, this can vary based on the number of bridges in your inventory.

Name: Angelo Genna

Email: Angelo.Genna@mtacd.org

Phone Number: 718 692 5644

Please see appendix for summary on NJDOTs movable bridge inventory, please verify for accuracy.

1. How many movable bridges are in your agency's inventory?

2

2. Please provide a brief description of each movable bridge, including major system types (deck, machinery, electrical) and history of rehabs/repairs (if tracked).

Vertical Lift Bridges – RFK and MPB (Marine Parkway Bridge)

3. What is the average number of openings per month for each bridge in your region, including peak months and off-peak months? Alternatively, are scans/copies of opening logs for a typical year available electronically for review?

MPB - 4

4. Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)

Yes

5. Are electronic copies of the O&M manuals available for remote access and are they regularly updated due to maintenance, repairs, etc.?

Yes

6. Have the O&M manuals been helpful during troubleshooting operations to resolve malfunctions?

Yes

7. Please provide an example of a recent implementation of troubleshooting measures from the O&M manuals, or when they are most typically referenced.

Troubleshooting PLC logic

8. What suggestions do you have for improvement(s) to the O&M manuals to provide more value and be more user friendly?

Allow for digital use/mobile use

9. Do you have a dedicated movable bridge maintenance crew?

No

10. Does the maintenance crew perform periodical inspections/maintenance and if so, how often?

Yes- as needed for specified bridge components

11. Which type of maintenance do they mostly perform (reactive/corrective or preventive/predictive)?

preventative

12. Are maintenance charts, identifying lubrication type, frequency, and machinery component located on site for reference during maintenance activities?

yes

13. Are any maintenance activities challenging to complete due to access issues or safety, and therefore not as regularly implemented?

yes

14. With regards to asset management, is there a regularly scheduled/planned electrical component testing and replacement of electrical equipment?

yes

15. With regards to asset management, is there a regularly scheduled/planned mechanical component testing and replacement of mechanical equipment?

yes

16. What alternative limit switch technology and/or proximity sensors are employed on your bridges to improve reliability, other than mechanical limit switches?

Plunger switches and proximity switches

17. Are the findings and recommendations from the latest bridge inspection reports available to maintenance to identify areas requiring special attention?

yes

18. Is there a formal process in place to predict mechanical and/or electrical component failure(s)?

yes

19. Are there any redundant systems at this bridge (backup motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc.)?

yes

20. Do you have a formal bridge operator/tender training program in place to reduce incidence of operator error that can lead to equipment damage and malfunctions?

yes

21. What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?

HMI screens, Motors, PLC

22. What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?

0

23. What is the permissible traffic stoppage for bridge operations and at what point are the local authorities notified?

20 minutes

24. What procedures are in place to optimize traffic operations during movable bridge downtime? (i.e. detour plans where feasible, VMS, mobile alerts, etc.)

Detours, VMS, advanced notification

25. Are there Intelligent Transportation Systems (ITS) in place for each movable bridge in the region? What are the capabilities?

No

26. What is the official protocol for elevating bridge malfunctions, i.e. who gets contacted, when, and what is the response time for maintenance to arrive?

Maintenance staff on-call for a 4 hour window

27. Is there a 24/7 contractor that can be summoned to assist with troubleshooting emergencies, such as a control systems integrator or mechanical (millwright) contractor?

Yes

28. Are you willing to provide additional information regarding your movable bridge inventory over a brief, follow-up phone call? If yes, please provide dates and times when available.

Click or tap here to enter text.

Vets Memorial - Operator

NAME	EMAIL	POSITION
Gary Bryce	989-737-3793; no email	Gary Bryce is supervisor and has been operator. Gary oversees four bridges, 2 bay city and 2 MDOT.

ATTENDEES Paul Jackubiki, Jennifer Bernardan

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	No because no maintenance done on site, MDOT does all maintenance. No drawings stored onsite, only electrical prints.
6	Does maintenance follow a formal, regularly scheduled preventative maintenance program for each bridge?	Bridge washing once a year, seasonal and controlled by coast guard. April 1 - December 31
8	Are any maintenance activities challenging to complete due to access issues or safety, and therefore not as regularly implemented?	Zero issues for maintenance this year, once they start operational within 30 months for rehab work
13	Are there any redundant systems at this bridge (backup motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc.)?	Prior to rehab work the issues was the limit switch.
14	What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?	If anything happens no bypass, must call for assistance. All operators know they are not allowed to do any bypassing.
15	What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?	None
17	What procedures are in place to optimize traffic operations during movable bridge downtime? (i.e. - detour plans where feasible, VMS, mobile alerts, etc.)	Immediately notify if bridge is closed for work, authorities so traffic can be re routed. 911 is called first for traffic and then Gary called so he calls the mechanical electrical person, Sean or Mike. Two city bridges overseen by Bay City Bridge partners and Bay City maintenance department does the maintenance on the bridge. Facility manger for Bay City Bridge partners is notified and he contacts maintenance department.
20	Is there a 24/7 contractor (on-call contractor or other) that can be summoned to assist with troubleshooting emergencies, such as a control systems integrator or mechanical (millwright) contractor?	Gary is on call 24/7

General Notes
Formal training a week or more and opens and closes, operator, 911, all types of procedures to review. Gary is available 24 hours a day and 7 days a week if anyone needs
Liberty bridge was rehabbed last year and has a 500kw generator and 250 kw generator. The bigger generator is used because it runs the tolling shelter and cameras - tolling shelter is a building built that hold all the data etc. Need extra generator for the tolling shelter. 250kw generator is meant just for the bridge operation.
Independence has its own generators that will be installed after the rehab. Independence has 4 spans. South spans are operational and in December switch, lower north span and put in new gear over the winter. Right now 2 lanes of traffic instead of 4. Once fully operational has 4 lanes, just during rehab only 2 lanes.
Vet's has a generator and Lafiet's generator is in the tower.
Control desks - there is a screen to help operator find issues. CRT screen on vets bridge. Touch screen.
Summer has more traffic - ie sailboats and pleasure crafts. Liberty is the busiest two marines. Independence is higher. Sometimes Independence and
Lafiet, Vets, Liberty and Independence - shorts to tallest and about 5 feet difference. Water level will fluctuate and change things a little. Coast guard has most accurate information and operators do not know the height.
Cameras on all except Lafielt. Can see pedestrians etc.
CRT screen has the history of the faults that you can access anytime.
Log for operators with open and close. Every bridge has to record all their openings. There is a separate maintenance (fault) log at each bridge.
Nothing could be changed at this time, as long as everything is working the way it is supposed to work. Issues over the years but all issues have been addressed with
No issues with cross vernalization
Worst issues that have had in the past are limit switches getting jammed.

Charlevoix-Operator

NAME	EMAIL	POSITION
Mary Ramsey	RamseyM@michigan.gov	Charlevoix Operator

ATTENDEES Paul Jakubicki, Jonathan Kohler, Jennifer Bernardin

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	A manual that is referred to an as built plan and technicians reference when they are onsite for troubleshooting etc.
6	Does maintenance follow a formal, regularly scheduled preventative maintenance program for each bridge?	Seasonal issues - bridge just got a remake and running totally different than in years. Mary been there 24 years, and no issues at first but then over time issues. After each remake and two in the last couple years the bridge works better. 3-4 years ago season with limit switch issues, but then changed from cooper to brass bolt or vice versa and since they did that no issues. This was done as part of maintenance, certain screw kept vibrating loose, Sean.
13	Are there any redundant systems at this bridge (backup motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc.)?	Limit switches
17	What procedures are in place to optimize traffic operations during movable bridge downtime? (i.e. - detour plans where feasible, VMS, mobile alerts, etc.)	Detour is long, and unless from the area there are short cuts that can be taken. The detour is 40-45 miles out of the way.
19	What is the official protocol for elevating bridge malfunctions, i.e. who gets contacted, when, and what is the response time for maintenance to arrive?	First call Sean and he walk through if can solve over the phone, or at least get back down if stuck open. A crew is sent at the same time while on the phone that is closest to the site.
20	Is there a 24/7 contractor (on-call contractor or other) that can be summoned to assist with troubleshooting emergencies, such as a control systems integrator or mechanical (millwright) contractor?	Central dispatch via radio and coast guard is notified if not functioning and local authorities, there is a phone list in the bridge for other operators.
21	Are you willing to provide additional information regarding your movable bridge inventory over a brief, follow-up phone call? If yes, please provide dates and times when available.	Always available for more questions and comments.

General Notes
Back up systems and air compressor can use but not sure. Hand crank gears taken out a couple years ago, and no secondary motor or any generator or back up system.
If something goes wrong it is usually the limit switch
Secondary back up - generator on site that taps into City of Charlevoix. Generator connected to Water Treatment Plant, but can use. Bridge just taps into it when they need it.
3 ring notebook black that is a log of what maintenance does and also record bridge failures in the book, diary of activities other than operations. Rehab is not in book but preventive and repair maintenance are put in to the book and maintenance is done once a month.
This bridge is April 1-December 31, seasonal.
Mary does training with new operators and works with for 2 weeks or until she is comfortable and then pass off to afternoon operator since traffic and openings are different. There are only 4 people working with so most of time call other operators if need help. Very workable. This is a 24
3800 average openings per year, usually every half an hour the bridge is used. Opening take 3-5 minutes.
Pleasure crafts have to wait for the half an hour but pleasure cruises come any time.
Operator house - list through supervisor i.e. roof leak, fixed but need to pain the roof. House has own issues with leaks and cant seem to fix it,
Wind driven rain comes through the wall
Smoke alarms on bridge, fire extinguishers on each level
CCTV cameras 2 cover channel and 2 cover roadway and skywalk but no recording. Requested recording street view to be helpful but not at this time, need to upgrade the cameras.
WIFI on the bridge.
PLC system set up on third floor but not using, console in operator is not hooked up. Installed 5 years ago and no buttons to use it. All manual
Bypass is available - i.e. gate failure can tell bridge to operate even though should - 6 bypasses
Usual items that have failed gate failure (someone hit or limit switch is not functioning)
Limit switch in motor room is the most often failure
Memorial day to December 31 lots of traffic
3,000 to 30,000 in summer and boats causes a lot of activity
Traffic lights and gates on the bridge provide enough warning to help operate the bridge.
Three color light and flashing yellow or red - there have been changes to this and it can be confusing
Swelling gerder was changed at the last maintenance and every breaker was changed on the bridge, mostly structural and mechanical
Couple years for limit switches and that was by MDOT

Portage Lake Operator

NAME **EMAIL** **POSITION**
David Poisson Houghton and Hancock Bridge - Operator
906-482-4877
ATTENDEES Jonathan Kohler, Paul Jakubicki, Jennifer Bernardin

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	Normally do not refer to them, but they are helpful for maintenance and troubleshooting, not sure if drawing are located in the manual.
3	Have the O&M manuals been helpful during troubleshooting operations to resolve malfunctions?	Yes, but since familiar with the procedures and bridge operator for many years.
6	Does maintenance follow a formal, regularly scheduled preventative maintenance program for each bridge?	Own set of maintenance program, individuals that do the work locally. Bridge operators do maintenance on their own. Every time run the bridge 15 openings go in machine room and grease the high speed barring's.
13	Are there any redundant systems at this bridge (backup motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc.)?	Generator and auxiliary motors
14	What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?	Unique bridge so have warehouse on site with spare parts for things that go wrong and if beyond what operator can do call for help with maintenance or electrician. Spare aeraulic hoses and fluids maintenance and seals. All on site.
15	What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?	None
20	Is there a 24/7 contractor (on-call contractor or other) that can be summoned to assist with troubleshooting emergencies, such as a control systems integrator or mechanical (millwright) contractor?	Outages - shutdowns where boat or barge cannot cross - no pretty reliable

GENERAL NOTES
Relay making noise when operator opened up for barge coming through.
Operators maintain the wire ropes once a year and 10/16/24 is the night, grease all the ropes. There are seven individuals, one runs bridge and three people in each tower to help, one guy spread grease. One side all the way up, bridge on bottom and all the way up, spay one side of cables and get on other side and spray all the way down, switch sides and do again. 25-30 min each time do that and both towers doing exactly the same. Behind because construction, replaced elevator and could not get up there until now. Normally anytime in October but usually before mid October. The steps are 188 feet steep, hard to climb with 5 gallong pail of grease.
Grease all traffic gates every three months. Grease all locks and seats one on each corner of lift span and have to be greased. Barings are
Operators do not touch the brakes unless have to release a manual, barriers grease is changed once a year.
For the last two years trying something new with the City and Coast Guard. On the house and half hour open for any vessel, and fire fighters can go through anytime. Over 300 feet lift for emergency services anytime. Weekends are on demand, no set hours.
Shut down bridge week of the weekend of the week of December 15, few barges that come through. Reopen on April 1. Off for 4 months.
Landmark bridge and lots of photos, only way across to the island. Heaviest vertical lift bridge in the world. Double deck vertical deck not sure if heaviest, train use to run on the bottom. Two level bridge. Traffic is upper level so don't have to lift for every pleasure boat. In November
A lot of time catch people that want to jump off bridge. November the roads get icy and car wreaks on the approaches slide into median coming
Snow removal and sand is by the cities, each gets one half of the bridge. City of Houton cleans snow, operators clean sidewalks with tractor
Change a lot of light bulbs, maintenance for generator monthly (run it and test and change oil, antifreeze). If power goes out generator kicks on
were too stiff to work. Hydraulic fluids used and in the past get stuck and have to manually put out the lock. One lock right now giving problems. Working better with the heat on the cylinders and hydraulic lines.
Can aways get bridge back down, give heads up to emergency services. Like tonight for the cables call 911 and let them know bridge closed each 20-30 minutes at a time and can call and we can stop and let ambulance through.
MDOT purchased scanner for fire call etc., and if sailboard as them to hold off to let ambulance through.
Contact list for formal emergency on site. Maintenance and electrician number and can work over the phone to figure out and if not fly from
Biggest problem item is limit switch and have spares, have to spay lubricant on all the switches and arm, have to do that quite often. They get dirty and stiff and once trip stay that way don't come back. Lubricate very often.
Windy with pick up trucks and sucks everything out so pick up or cars swerve.
21 cameras and told supposed to get more, which really helps. See down the sidewalk and under the bridge and really helps.
Bridge house do the maintenance in there sweep mop floor wax clean control panel polished like a navy ship. Clean windows. Security system on the bridge and set it when leave in December. Not really do in the summer because here all the time, only 4 hours that none here, 24-7 up until 4 years ago and only two 10 hour shifts now. 4am-2pm first shift 2pm-midnight call out number posted under the bridge for a vessel that comes through and call out number and calls service center and they call our supervisor and calls one of us out if they need to get through. David been called twice since that started 4 years ago and no one else called.
Contractor call up if issue on the bridge for demand for mechanical - phone center and they call who they need to for repair for anything else.
National guard has a potable bridge in place in case something happens, which is located in the Sioux. Couple years ago tried to use it. It is like
running controls in bypass because cant' get the lock in and if one step doesn't work next step doesn't work. On bypass you can bypass it and run the bridge, current situation right now. Still working on it.
Lock is biggest problem right now, the first one below the operator house.
Oversized load over 14 feet high drop bridge all the way down and the equipment ride on rail board bed so don't have to unload anything,
Spring time hose the bridge due to road salt and sand, put well pumps in water and wash from one end to the other sidewalks and span and get
Bridge crews point out that this bridge gets more maintenance than others.
Call a programmer, no remote access to connect to bridge. The guy that set up the bridge in Rhode Island (Dave Cot) can connect to this

Military- Operator

NAME	EMAIL	POSITION
Gary Caughel 810-984-9785		Military Street Bascule Bridge operators in Port Huron - Operator
ATTENDEES	Jonathan Kohler, Paul Jakubicki, Jennifer Bernardin	

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	Black River Bridge operations manual with no as-builts, nothing to do with parts and has an MDOT phone that takes care of problems.
5	What suggestions do you have for improvement(s) to the O&M manuals to provide more value and be more user friendly?	None
13	Are there any redundant systems at this bridge (backup motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc.)?	No generator, two utility feeds.

GENERAL NOTES
Knows when there are problems and the bridge won't lift or not working properly. Lights on the desk show you what is not working properly - north brake not release etc.
Hydraulics is usually what slows things down. Good year this year but keep an eye on it.
Automatic most of the time and if not working then do it manually.
List of people and MDOT phone in the bridge house to call directly.
If something happens call and leave in up or down position and get in touch with Coast Guard and there are two bridges so another option for traffic.
What is typically the electrical item that gives the most problems - traffic arms. Most of electrical works and doing well. Lights on dash and controls give problems once in a while (burnout).
First started in 2013 and lots of problems but not much now.
Hand controls are used when no power and operator can operate - open tail locks and all the other breaks and when come back down do the south north brakes and as long as rear locks - no problems
They train the operators and have an operations manual, spend a couple days with each operator for a total of a week.
Emergency Action Plan has numbers to call and there is an operation schedule for cost guard who to reach at certain times.
24 hour operations until October 31, then closed until March.
Bypass written on the top and emergency and so serve all do everything by hand with joysicks

Cheboygan - Operator

NAME	EMAIL	POSITION
Shane		Supervisor
Brian		Operator - 231-627-5436 State street bridge operator house
ATTENDEES	Paul Jackubucki and Jennifer Bernardin	

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	All we do at the bridge is man it, no maintenance other than grass cut. MDOT does all the maintenance and MDOT uses the maintenance log; wipe window etc. MDOT starts generator and starts once a month and greases it. Not a regular schedule but at least once a month.
8	Are any maintenance activities challenging to complete due to access issues or safety, and therefore not as regularly implemented?	Fairly reliable and not many outages
10	With regards to asset management, is there regularly scheduled/planned mechanical component testing and replacement of mechanical equipment?	Trouble shooting and assist with what MDOT needs, MDOT does the trouble shooting just assist.
13	Are there any redundant systems at this bridge (backup motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc.)?	No ongoing issues, maybe gate valve or light issues but nothing else. Tail lock ceased in place two years ago and they removed and went without last year and then it was replaced. This spring gate valve stuck dinging all the time versus only when down. This bridge closes on December 15 and opens April 1. No boat traffic and no ice. Bridge is not manned all winter long, seasonal. Once fire up there might be a few issues starting up.
14	What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?	Limit switches etc are with MDOT on the truck and don't need anything onsite.
15	What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?	On top of monthly preventive schedule there are very small issues, i.e. street light out if anything. Maybe air conditioner inside building. Last year may not have called at all for anything related to unscheduled visit. All electric bridge with 770 volt panels so MDOT does not want workers near the panels.
17	What procedures are in place to optimize traffic operations during movable bridge downtime? (i.e. - detour plans where feasible, VMS, mobile alerts, etc.)	Traffic along bridge - small town but tourist place. A lot of boat traffic and passing through. More traffic in summer months. 20 cars in an 8 hour shift. Relatively peaceful. Might be same car three or four times a day.
20	Is there a 24/7 contractor (on-call contractor or other) that can be summoned to assist with troubleshooting emergencies, such as a control systems integrator or mechanical (millwright) contractor?	List of mechanical and electricians to call if help is needed. There is not a priority list per se. Mike and Chris and Brad. If bridge closed to traffic for malfunction superior gets called and 911 is called and set up barricades for a mile and a half detour to get back to M27. Also call fire chief and police chief if 911 does not let them know.

GENERAL NOTES
2-3 days and does openings and cheat sheet on site for steps to open and close. Step by step instructions. Training is on the job with an individual with witness and hands on.
they are onsite pretty quick. MDOT does not want anyone to touch anything. Bypass switches or manually lower the bridge - yes both are on site. Auxiliary motor is on site too. Makes the bridge run slow when used. Back up is onsite. Generator is onsite and ran once a month. Use a bridge opening when test generator once a month.
Cameras are onsite and shoot upstream and downstream. Visibility is used to check if traffic is stopped behind the gates. Cameras are used at night a lot easier to see the lights on the water. No cameras on the road, all windows and great visibility.
Hooked into 911 for radio calls and can help and assist to hold bridge if needed etc.
Cell phone face time where caller can help troubleshoot remotely - never been brought up but willing to do it if asked.
No HMI screen that can take a picture of or troubleshoot and tell what is going on.
Electrical schematic is in the cabinet and usually the first book used when MDOT gets on site. The book is kept up to date. Andrew who does yearly inspections was going to make it electronically available - discussed last year.
Is there any redundancy - only one electrical system with back up motor.
Traffic signals and barrier gates - arms come down so can't drive into the river. Gated all the way along both sides of the bridge and
Span locks that are engaged or automatic that self engage- seating button and tail locks. Everything works in steps, 3-4 to get open and 8-9 to get closed. Mechanical and have to do half a dozen steps to open and 8-10 steps to get it closed.
Not push button to open, have a switch to slow speed before go to full speed. Each span, east and west, can control the speed separately.
This bridge house is newer and old one across the way. Newer in 2000 time frame
In 2008 or 2009 had to rerun cable at bottom of river, otherwise nothing unusual.
Good locking door, no security issues.
No windows that open or screens, windows spin around to wash. Door opens and no screen so can't open for air.
Suggestion: screen windows to keep open. All glass but can't open for fresh air, air conditioner runs all the time either really hot or really
Plumbing facilities on site - bathroom yes.
Marine radio on site for communications with marina and boats.
Log up or down stream and boat or number associated with it in a log each time open or close.
3,000 lifts per year.
A lot of regular vessels June July and August and September regular boat traffic go away.
Openings are whenever needed for commercial. Pleasure crafts are on the 1/4 and 3/4 hour.
Seasonal bridge washing done two weeks ago. Andrew inspects with ipad and looks over really well.

Fort St Operator

NAME	EMAIL	POSITION
Chaduhary Mahmood		
Alex Shteynvil		
Daniel Godfrey		
Harold Inman		
Chris Idisuyi		
ATTENDEES	Robert, Korinda, Paul, Jon, Anglie Yax	

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	Yes a current one from 2022.
3	Have the O&M manuals been helpful during troubleshooting operations to resolve malfunctions?	Does not use often, only when needed. In 8 years have not really used. Robert worked with Korinda 8 years too. Robert has not encountered any issues for troubleshooting at this bridge, this bridge is the most reliable. About 9-10 years old. The last 4-5 years have been no major problems. If need the O&M manual it is pretty dense but not very helpful, could be better.
6	Does maintenance follow a formal, regularly scheduled preventative maintenance program for each bridge?	Robert - Outside of changing light bulbs not able to get into any mechanical issues. Anything with bridge operations not allowed to do anything, need to call.
13	Are there any redundant systems at this bridge (backup motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc.)?	Fuses blow, last one was three to four years ago. Utility power fuses. There is a generator at the site. Automatically switches to the generator if loose power. Control panel has a switch that can use but not aux power that can switch.
14	What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?	Light bulbs, only minor repairs. There are a few thing but not major things. Normal basic stuff to use to fix, extra screws and light bulbs. No gate arms or limit switches
15	What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?	Monthly basis has not gotten stuck and no problems in the last three or four years. Very reliable.
16	What is the permissible traffic stoppage for bridge operations and at what point are the local authorities notified?	Local detour route that vehicles can take, post actual signs to go to other bridges. Physical signs and phone calls. Bridge closed and use alternative route.
17	What procedures are in place to optimize traffic operations during movable bridge downtime? (i.e. - detour plans where feasible, VMS, mobile alerts, etc.)	Anything over 30 minutes put out signs and call coast guard and local police, Korinda and MDOT Maintenance. Shift worker has all the numbers listed on the chain of command.
20	Is there a 24/7 contractor (on-call contractor or other) that can be summoned to assist with troubleshooting emergencies, such as a control systems integrator or mechanical (millwright) contractor?	Korinda, and MDOT

GENERAL NOTES

but cannot do without getting huge unit involved. There is a leak issue on the roof and has not been fixed. The state has had people out to fix several times, issue with contractor. If in control room there is a gap when walk through and water coming through. Put shielding up but water still an issue. Coming through the upper part to the south and coming through the walls - all

Angie - There is a barrier gate stuck in the air that don't use. MDOT said they would replace soon. Do not use because do not operate the correct way. Can't remember the last time they were used.

Korinda - direction of the Italian restaurant - South - that way there is a light, request that no turn on red. For a while gates people would go through them as a concern.

Almost every opening you get cars that try to beat the gate. Complete control of the lowering and can see cars try to beat the

Control panel that has series of red lights - relay control bridge. No HMI - only bicentennial bridge.

Issues a few years ago during the night shift was blowing a fuse.

At some point Sara was doing a lot and when found out MDOT started to come out more. Sara would try to do more then what she should have. Ie grease fan lock which is mechanical and MDOT should take care of that

MDOT does not give advance notice for working on bridge for other bridges. Andrew or MDOT will call the day before. Usually a heads up before hand with this bridge.

Bicentennial (M-63) Operator

NAME	EMAIL	POSITION
Dan Jackson 269-519-0900	danjackson_38@comcast.net	Bicentennial Bridge - Operator

ATTENDEES Jonathan Kohler, Paul Jakubicki, Korinda Windelmann, Dan Jackson, Jennifer Bernardin

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	Dan - Have one that is 72 pages but not really that comprehensive, last update was 23 years ago. Most of material is stuff Dan has picked up over 7 years so doesn't refer to often. Made the two new people this year aware of the manual, which is located on the desk in front of the operator. No schematics and outdated material, i.e. do not use lane control systems and nothing about HMI system which is used to operate the bridge.
2	Are electronic copies of the O&M manuals available for convenient remote access?	N/A
3	Have the O&M manuals been helpful during troubleshooting operations to resolve malfunctions?	See above
4	Please provide an example of a recent implementation of troubleshooting measures from the O&M manuals, or when they are most typically referenced.	N/A
5	What suggestions do you have for improvement(s) to the O&M manuals to provide more value and be more user friendly?	See above
6	Does maintenance follow a formal, regularly scheduled preventative maintenance program for each bridge?	Maintenance for local items like changing light bulbs, but not go into electrical panels or adjust switches.
7	Are maintenance charts, identifying lubrication type, frequency, and machinery component located on site for reference during maintenance activities?	Daily communication logs are kept and operators are required to begin shift 15 minutes early to discuss the day or anything with transition. Most maintenance items are custodial. Judy assigned floors for custodia duties, not sure how Dan uses it. There is an area where things are stored for items changed out on site. Each pump room has a box of the pig pads and cleaners are on shelf by locker, so there is a stock onsite.
11	Are the findings and recommendations from the latest bridge inspection reports readily available to maintenance to identify areas requiring special attention?	Dan emails monthly report with bridge issues and other pertinent information with the contact sheets.
15	What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?	Dan - couple hours and sometimes a little longer. Maybe three times a year or every three months. They are really good about coordination and working with us and around things while we are there together. The bridge almost always encounters problems when it has been sitting all winter. In the beginning there is a day or two where it moves slow and something happens. There might be a day or so when it is down but nothing like what just happened. During the busy season there are 10-11 openings per day and sometimes even 15-16. The night shift has about 6-7 openings. The season is March 15 - December 15.
16	What is the permissible traffic stoppage for bridge operations and at what point are the local authorities notified?	Dan - lift time is 8 minutes and up to 11-12 minutes. Average is 10-12 and increased over last year not asked to perform full openings but now MDOT asked to do full openings. About 10 minutes to do a full opening. Notice posted that if bridge open more than 10 minutes contact dispatch. If can't get the gates to go up, try to trouble shoot and if can't figure out after 5-6 minutes then contact dispatch to tell road is closed. Police take care of the detour.
20	Is there a 24/7 contractor (on-call contractor or other) that can be summoned to assist with troubleshooting emergencies, such as a control systems integrator or mechanical (millwright) contractor?	MDOT handle this

GENERAL NOTES

Paul asked about failed cylinders. Dan - some of crew onsite for separate issue and closing of bridge and 6-10 inches from being fully seated. Doing in auxiliary and the leaves failed. Talking to Derek after who was a foot away when it failed, things looked normal and hear gunshot sound, and failed. Paul - crew on site and was able to assess the situation. Dan - electrician so limited but they made the call and got guys there to do the work, remove the boot and see exactly what happened. Took an hour and a half for Mike to get guys. Depends where the guys are located. Failed in down position so could open to highway traffic. Any need to contact coast guard? Dan contracted central lake Michigan over Milwaukie and contacted for water traffic. Dan said no ETA 1.5 or 2 hours before Mike's crew could get onsite to make a determination. Dan received calls throughout day and then called once a week for update.
Korinda got a call from coast guard and Lee did not get calls back from the state.
Once bridge repaired and Dan contacted Central Lake MI and they said to contact Lee. When under large project deal with Lee directly. If something breakdown and affects water traffic affects MDOT then Central Lake Michigan but if major thing contact him directly. Dan has number posted for own use in case happens again.
If issue with roadway contact dispatch and they have a road detour depends if it is a short duration. If 6-7 hours or couple days send out officers to block the roads on either side of the bridge but just a 20 min badge then do not close the road.
MDOT takes care of the detours.
don't want people calling him for a 2 hour circumstance. Only use this number for major project. There are notations on the contact sheet when each number should be called.
The bridge supervisor makes the calls for anything major.
Training topics covered - CFR, forms to fill out, questionnaire that talks about flag usage and different signals, walk through of bridge, contact sheets, chain of command for certain issues, bridge maintenance, day to day paperwork, explain situation things but not train until encounter problem. Classroom and on site how to operate the bridge. Training 7 days onsite and everyday a little bit of everything. Open twice and hour on schedule to get that down and in-between openings go over the CFR and questionnaire, accident reports etc.
Korinda will share the forms with HDR.
Korinda is scheduled for a 2 week period and 4-6 hours at each session to better retain information. Depends on the person training and how they are retaining info and if close to 2 week marks and not making it cut ties and go to next best person interviewed.
Dan reviews the bridge during training, running bridge in aux mode a few times, and experience helps. The bypasses go over all the steps. Some places have a dedicated control desk for training, not practical because expensive. There are clients that do go to the extreme.
Dan - uses HMI screen to operate the bridge. Hydrologic bridge.

Bicentennial (M-63) Operator

Jon - HMI screen help point to issues and predict items that might have? Yes in certain instances helps which is why the leaf stopped. Do have regular alarms ie for clogged filters and nothing wrong. In certain instances the alarms help diagnose instances.
Dan - alarms cleared quickly, always look at alarm to see what it is. Maybe pay not as much attention to the clogged filters.
Alarm - something SE leaf failing that is written in function sheet, communication log and put on the bridge issues if something that is frequent. Right now that is only every 10-15 opening. Not call Sean if alarm not consistent. If every 2 openings then yes call someone. If raise bridge 20 degrees it will fix itself. If frequent call Sean. Those forms are pulled into monthly summary. Electrician and Maintenance share monthly summary, daily comm, and bridge malfunction issues. Reports monthly for all bridges. (Sean, Mike Ed)
This bridge does not have a remote access ability
Anything else add to help with reliability - Dan suggest more periodic stops not just when an issue. Pop in once a month and ask if issues. They don't do that much anymore. Could be due to workload.
Limit switch issue - 90% of the time that is the issues. This year other than the cylinder issue not much. Blown fuse in past and over the last 2-3 years close to 90% limit switch issue. Are there locations that are more problematic or random. Dan - this year it has been one of two. NE leaf and SW leaf. After the cycler issue always the SE leaf. Prior to this year random any of the four leaves.
Dan is new but has a lot of good experience. 7th or 8th season with Korinda but new to supervisor.

Blossomland (I-94 BL) Operator

NAME	EMAIL	POSITION
Michael Bippley	Bippley, Michael (MDOT) <BippleyM@michigan.gov>	Operations Engineer
Pete Pfeiffer	Pfeiffer, Pete (MDOT) <PfeifferP@michigan.gov>	TSC Manager
Richard Stack	Stack, Richard (MDOT) <StackR@michigan.gov>	Region Bridge Engineer
ATTENDEES	Korinda, Jon, Jennifer, Paul, Kevin Cockrum	

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	O&M is the one he wrote himself includes an SOP on how to open and close, incident on bridge, covers how to fill out logs, instructions, troubleshooting etc. Contains emergency info on who to call and bypass information
2	Are electronic copies of the O&M manuals available for convenient remote access?	No HMI screen everything is likes, camera system but it is not hooked up, allows to see under bridge, roadway for traffic and peds
5	What suggestions do you have for improvement(s) to the O&M manuals to provide more value and be more user friendly?	Everything is contained in the manual that is needed. Kevin used a guide from the training material to create the SOP.
6	Does maintenance follow a formal, regularly scheduled preventative maintenance program for each bridge?	Only perform janitorial tasks. If there is something minor Kevin will try to fix it himself.
12	Is there a formal process in place to predict mechanical and/or electrical component failure(s)?	No but Kevin has an issues list.
13	Are there any redundant systems at this bridge (backup motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc.)?	Last one 3 hours was when the gates would not work correctly, something at the top of one of the gates would not go down. Also get calls for accidents on bridge. Knobs to hold to get gate down and if you don't hold it down all the way then gates will not go down all the way.
14	What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?	No
15	What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?	This bridge operationally does not have issues very often. The longest time in last 7 years that been open was 3 hours and needed to get a team there to fix it.
16	What is the permissible traffic stoppage for bridge operations and at what point are the local authorities notified?	10 minutes or more and local dispatch is called
17	What procedures are in place to optimize traffic operations during movable bridge downtime? (i.e. - detour plans where feasible, VMS, mobile alerts, etc.)	Local Police do detour routes
18	Are there Intelligent Transportation Systems (ITS) in place for each movable bridge in the region? What are the capabilities?	No there is not a VMS board and all goes to the police and goes to the coast guard for an unforeseen amount of time. Korinda - when report to the state, they usually put on an MDOT website to notify people.
19	What is the official protocol for elevating bridge malfunctions, i.e. who gets contacted, when, and what is the response time for maintenance to arrive?	Response time - sometimes it takes 2-3 hours and sometimes not make it until morning or next day.
21	Are you willing to provide additional information regarding your movable bridge inventory over a brief, follow-up phone call? If yes, please provide dates and times when available.	Better relations with local police and MDOT. A lot of running of red lights with the gate down. Kevin like to see more policing of traffic on the bridge. Also not much notice if doing shut down and wish there was more notice given. Employees belong to certain groups that enable communication beforehand, but it would be nice to get direct information before hand, last to know. Yesterday truck with flashers and mark out the bridge to get ready to replace traffic signals. No warning. The city is building a refugee island and city expanding parking lot all at the same time and no coordination.

GENERAL NOTES
Camera not working and just takes time for waiting for boats to get through and take a few minutes to look out the window to make sure no one in the way, adds a little time to the lift. Average lift is 4-6 minutes including boats. Ships take anywhere from 15-30 minutes. Dispatch local is called when not open for more than
If problems and takes long than 10 minutes to fix call dispatch and let them know for traffic.
Kevin calls Sean or Mike or Korinda if there is a problem
List of issues with Blossomland that is sent every month by Kevin that is on its third page, patches not secure, brick coming off, excessive list and only things that get handled are detrimental to the function of the bridge. Other items found do no focus on it but since bridge operating not the focus.
If they had more employees to help with the maintenance that would help per Kevin.
aligned and opening again. The generator will kick on because louvers are open and has happed the last two years. Not a huge issue but affects generator house each time the power goes out and the transformer to the generator and keeps blowing fuses in the generator that has happened three times in the past year.
Transformer owned by the utility. Start with Sean, he contacts the utility and they send someone to deal with it.
Last time the generator ran for 13 hours before the issue was fixed.
Korinda - we do walk throughs. Kevin explained that the operator before did not notice the blink, something small that was not noticed and happened after the walk through. Generator is running off natural gas.
The louvers are open the generator will run - it is a safety feature and designed that way. Replace the part that moves it with something that can be adjusted and
Improvements from the local - more money more employees for MDOT.
This bridge does not break down very often.
Issues list are structural things and things that can be put off because it doesn't affect the operation of the bridge yet.
Detour routes - local police do the detours when needed, if something wrong with the bridge. Road blocks at both ends of cannot drive over the bridge.
Auxiliary system has never been used, Kevin knows how to use it. It has not been used. Kevin did not include in the SOP because MDOT said never use the auxiliary. We put our foot on pedal and already in manual control of the bridge.
Operator error is most popular with the gates, not getting it down all the way
This bridge not many issues operational
2 weeks of training and 4-6 hours at a time. So much information and depends on the person. Certain people catch on quickly and can be released before but

Blossomland (I-94 BL) Operator

Kevin can usually train someone in 4 days, but that is not normal. One guy who was excited to learn the bridge and was so overwhelmed by the information and responsibility that he quit during training.
There are only two in time of training that did not catch on so part ways.
Rough time with staffing and main problem is people can't pass a drug test.
Does training include some basic trouble shooting or common things to look out for and getting the right people to address those - protocol for when bridge not operating normally. That is reviewed in training and driven home through training what needs to be done.
Kevin teaches trouble shooting for gate, traffic light, when bridge can't go up - go over steps - teach bypass and non bypass. MDOT has the gate locked and can't get in service doors. Have to use the cones to block the traffic. Sometimes that can be dangerous and only happened once when a gate broke.
Korinda created a sign in sheet to use when people show up with time and person. Even for door dash to know what is going on and who is on staff. MDOT did not want to sign in at first. So bridge employees document who is there and when. MDOT comes on site with no forewarning.

Christopher I Jeff T

NAME	EMAIL	POSITION
Chris I	Idusuyic@michigan.gov	Structures Emergency Response Engineer
Jeff Triezenbu	TriezenbergJ@michigan.gov	Design Engineer

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	Chris - don't have everything for every bridge. Andrew Bouvy has been scanning these into MiBRIDGE (recently started). Doesn't contain all the O&M manuals for the components. Need great derail of improvement in this area, reference manuals regularly when trying to fix mechanical and electrical issues. Needs to be updated, supposed to be done during rehabs Jeff - contracts can be a bit ambiguous for rehab projects, contractors required to submit new documents though not always enforced or updated with the rest of manuals, submitted after construction complete. Language in specs is vague for what needs to be submitted. Full payment of LSUM should be contingent upon submittal. Going to be discussing with AASHTO bridge construction specs though a few years off. Chris - St Clair hydraulics - example where O&M not updated as parts replaced. Agree to tighten specs Jeff - good example of refurbishing cylinders, don't need a whole manual though need to document what's changed
2	Are electronic copies of the O&M manuals available for convenient remote access?	Some on MiBRIDGE
6	Does maintenance follow a formal, regularly scheduled preventative maintenance program for each bridge?	Chris - routine maintenance that statewide bridge does every season (washing/lubrication/pre-inspections). Recommendations from detailed inspections will be handled by state crews if possible, otherwise send to design Jeff - would be nice to have a way to track replacement of equipment, wear parts (limit switches, etc.). A log of these would be helpful. Grand Haven has guides for span locks and other parts that wear over time, difficult to inspect while in-service. Had to replace unexpectedly during construction, expensive contract mod. O&M manual could have a chart to help track these, whether by maintenance crews or by contract work. Chris - statewide crews will update log in bridge house. Need to compile all of this info and continue to update it. Interns could help with this. Log would be best maintained by MDOT and not a contractor during a rehab contract
9	With regards to asset management, is there regularly scheduled/planned electrical component testing and replacement of electrical equipment?	Chris - PLC and limit switches are typically 10 years and frequently become obsolete. Research can come up with recommendations for replacement periods for these parts Jeff - could be what to inspect during detailed inspections. Often test certain things (reducer oil) though not others (submarine cable contacts). Chris - example of wiring/conductors wearing on Charlevoix and then had to replace submarine cable
11	Are the findings and recommendations from the latest bridge inspection reports readily available to maintenance to identify areas requiring special attention?	Chris - yes, available on MiBRIDGE.
14	What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?	Chris - yes, on bridge. Spare parts required in rehab contracts to be kept on bridge. No inventory, though staff knows what is there, knows there are part but not how many.
16	What is the permissible traffic stoppage for bridge operations and at what point are the local authorities notified?	Chris - encourage operators to look at a log for this ahead of time. Certain bridges more sensitive than others
18	Are there Intelligent Transportation Systems (ITS) in place for each movable bridge in the region? What are the capabilities?	Chris - defer to Regions, bridge by bridge Jeff - Vet's has a camera that region uses
19	What is the official protocol for elevating bridge malfunctions, i.e. who gets contacted, when, and what is the response time for maintenance to arrive?	Chris - used to be all state employees operating bridge, now contracted out. Private operators are required to call supervisor, then call MDOT next. Operator should call Mike/Shawn directly. Don't have an issue with current process per se, but need to get in touch with Mike/Shawn immediately. Can improve this process.
20	Is there a 24/7 contractor (on-call contractor or other) that can be summoned to assist with troubleshooting emergencies, such as a control systems integrator or mechanical (millwright) contractor?	Chris - current 3 year contract of companies Mike/Shawn can call currently in place. Strain, Faith, etc. Not with Panatrol due to costs. Jeff - if contract in place, there's ways to work with different companies

GENERAL NOTES

staff tied off. Safety recommendations would be appreciated in report. Hydraulics can get dicey, training for new staff would be helpful (3 bridges). Hydraulic structures tend to have limit switch problems. Need series of switches to tell bridge position, though one fails in series and difficult to determine which one, is redundancy helpful?

remote data logging at bridges? - Chris - something we have talked about for remote troubleshooting. Haven't tried yet. Would be ideal for Houghton. Needs to be secure from IT standpoint.

obsolescence of parts, is there a timeframe to replace these? - Chris - yes if identified during detailed inspection. Jeff - typically identified during detailed inspections. Chris - Mike/Shawn don't typically look at this, more reactive. Typically rely on industry to let MDOT know things are no longer made.

redundancy - have MDOT ever turned PLC off to see if that is involved? - Chris - only if a problem exists, or if a problem with a drive then would just use relays / manual mode. Haven't tried this to see if bridge can run with PLC off. Should put load on generators often though not currently done.

limit switches biggest cause of issues? - Chris - limit switches are first line of defense against failure of other parts, indicative of other issues. Limit switches can be particularly hard to in some cases once bridges are stuck. Interested in other prolonged life switches, ways to prevent moisture, etc.

higher failure rate between proximity switches or lever switches? - Chris - more failures on specific bridges based on location, hydraulic bridges aren't the same as others, going to proportional valve on Military St.

processors.

Chris - Lafayette hand changes from cast iron to built up plates, bolts had different lengths, kept breaking, eventually plate fell off… issues like this can

problems would be too bad if left to wait. Bridges are getting so old that with so many issues, not practical to wait for longer timeframe. Chris - Charlevoix had crack in girder, retrofit was a weldment attached to girder, 2 years later there was a crack in weldment. Prompted another project.
Electrical/mechanical have to be taken care of immediately. Structures are more bolted repairs, etc. Regions don't always understand. Bigger projects can be efficient but not always possible. Jeff - may result in replacing items more proactively so as not to wait until next 10+ year project. Always have to sell

Not any bridges currently programmed for replacement after Lafayette

Shawn Wigent Mike Wakely

NAME	EMAIL	POSITION
Shawn Wigent	WigentS1@michigan.gov	Electrician Specialist
Mike Wakely		

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	Shawn - most have operation procedures for operators
2	Are electronic copies of the O&M manuals available for convenient remote access?	Shawn - no, usually in 3 ring binders in bridge house
3	Have the O&M manuals been helpful during troubleshooting operations to resolve malfunctions?	Shawn - yes, very helpful. Charlevoix was having brake issues or tail limit switch issue, read through procedures moving bridge up and down then realized limit switch was not the problem, but instead a 20 amp fuse being blown. Could tell it wasn't in brakes but the brake control (drum controller) transformer.
5	What suggestions do you have for improvement(s) to the O&M manuals to provide more value and be more user friendly?	Shawn - hard to tell location of switches and process to use them.
6	Does maintenance follow a formal, regularly scheduled preventative maintenance program for each bridge?	Shawn - typically a new set after redlines from a rehab, not always updated though getting better, redlines not always legible.
7	Are maintenance charts, identifying lubrication type, frequency, and machinery component located on site for reference during maintenance activities?	Mike - monthly greasing of bridges, 1st of each month bearings, rack/pinions, center locks, gates, etc. Shawn - check limits switches once a month, check rubber seal and replace as needed. Using carbon fiber spray. Some bridges have generators and check fluid, run manually. Automatic transfer switches old and inadequate.
9	With regards to asset management, is there regularly scheduled/planned electrical component testing and replacement of electrical equipment?	Shawn - changed out power transformer for Cheboygan, bridge was loud and did some testing, realized it was going bad and knew bridge would be stuck. If something is seen going bad, try to get to it in time (i.e. tail locks). Mike and Shawn's teams make notes and put in work orders regularly. Inspections every few years bring things to light and maintenance crews handle what they can, rest of work recommendations go into report and fixed in a few years
11	Are the findings and recommendations from the latest bridge inspection reports readily available to maintenance to identify areas requiring special attention?	Mike - yes
13	Are there any redundant systems at this bridge (backup motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc.)?	Shawn - some bridges have 2 power feeds, Charlevoix has city generator, joystick operation on hydraulic driven can bypass PLCs, most bridges have some sort of backup auxiliary motors, drive system, etc.
14	What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?	~~Mike - some spare parts kept in Lansing. Others are stored on site~~ Shawn - some parts kept on trucks. If specific to a bridge, it's kept on-site and charged to be ready when needed Mike - operators on bridges tend to be older, user error often causes errors and can be tracked over the phone, this is more common than an issue with bridge, panic and start pressing buttons... Shawn - often a step is missed and then operator doesn't know how to use backup systems to
15	What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?	Shawn - Lafayette a trouble bridge, can usually resolve before getting on-site, electricians spread out and can get to each bridge within an hour or two. Mike - Lafayette has issues in 90 degree range as tail locks get stuck, fire department will spray down deck to get locks to release so bridge will open. Finger joints get stuck then tail locks can't move
16	What is the permissible traffic stoppage for bridge operations and at what point are the local authorities notified?	Shawn - some contractors want operators to call supervisor first before MDOT, can be up to 15 minutes for that process. Had issue at Lafayette where experienced operator lived a block away and came to fix it and help green operator. **Will always send someone out to review/check what happened.** Depends on operator and communication plan
17	What procedures are in place to optimize traffic operations during movable bridge downtime? (i.e. - detour plans where feasible, VMS, mobile alerts, etc.)	Shawn - Grand Haven has 40 minute bypass. Charlevoix has long detour. Houghton has no detour. Rest have easier detours. Grand Haven had a controller fire a few years ago, first responders setup traffic control.
20	Is there a 24/7 contractor (on-call contractor or other) that can be summoned to assist with troubleshooting emergencies, such as a control systems integrator or mechanical (millwright) contractor?	Shawn - nope, that Mike and Shawn. Jonathan from HDR and others on call. Mike - Strain Electric also on call and worked on almost every bridge (Bob). Chris Drago for hydraulic issues. Shawn - looking into contract with Panatrol, though hasn't come through yet. Other electrical contractors than Strain don't have history or know bridges as well. Knowledge base is aging and approaching retirement

GENERAL NOTES
If parts are unavailable obsolete - Shawn - has a few places that keep old stock, usually realize parts aren't made anymore when it fails and going to fix it. Manistee issue with drives, though old equipment going away in rehab.
Shawn - logbook at each bridge to record maintenance activities. Don't log type of grease. Manistee has long history going back to '68 (Edmund Fitzgerald caught on a cable is recorded). Most bridges have logbook. Charlevoix issues with breakers getting bridge stuck and which breaker went bad recorded.
Maintenance that doesn't happen due to inaccessibility - Mike - hydraulic lines going bad can be hard to get to. Shawn - if access requires bridge opening, can be difficult depending on operator. Typically minimal issues. Try to do work during regularly scheduled openings. Grand Haven has limited opening windows and can be
Remote data logging - Shawn - smartphones to FaceTime and show control panels, see what's going on and walk through what needs to be done. Fort St stuck open in winter storm and this was used to troubleshoot (ice on lever arm switches building up, got under cover, moved limit switch to safer spot), similar instance at Port Huron. No way to log into bridge remotely. Can call Panatrol and they can login, though need Mike or Shawn on site
Aware of emergency management plans - Mike - at region's discretion. Shawn - Muskegon TSC has plan. Typically coordinate openings with City and they notified public. Had issue with communication with bridge operator contractors and region and BOBS staff last Friday, had to troubleshoot on phone, didn't follow protocol to notify BOBS of operation not in season (Carinda). Had follow up with contractor afterwards.
Look at wires/limit switches over winter. Check mechanical items in spring prior to opening for season. Have staff on site in case something goes wrong in first
Can get to Houghton in 3-4 hours via flight and 8-10 hours for parts, been awhile since that has happened.

Shawn Wigent Mike Wakely

click when checking brakes. Find loose wires in motor rooms from vibrations and blow fuses, shutting down bridges. PLC kept point to fuse fault and was hard to find, not in prints. Usually cycle primary components
Limit switches most common issue - Shawn - say 80% of failures related to limit switches. Often have a million cycle life though not applicable in outdoor weather. Better in motor rooms (up to 30 years). Usually lose a few each year that are outside. Losing coils is another common issue and can be difficult to track down to
Limit switches in high vibration areas - Shawn - hasn't seen this as a problem, motor rooms get less vibration. Typically the elements are the issue
Has cable been issue running to limit switches - Shawn - using potted switches, most have been updated. Cable can be chased down to junction boxes to inspect for
Shawn - tied to laptop for remote operation, always with him. 4 different types of limit switches. Would love to buy a single type of limit switch. Communication could
Shawn - consistent parts would be very helpful
Shawn - 5 year inspections and get report, sometimes 2-3 years before repairs are done, it's a budget thing. Works with inspectors.
Shawn - electronic copies of information stored at bridge house would be very helpful, searchable pdf would be efficient
Shawn - tough to tell if more cameras would be helpful, can't always zoom in/out, usually better to just talk to operator
Shawn - standby power is essential, equipment from transfer switch to generator are aging and need to be updated. Mike - oil changed every 5 years in generators, typically run about 1 hour a month. Shawn - say 20 hours a year if there's outages, otherwise just a few hours a year. MDOT doesn't fix generators just routine maintenance. Should be load tested periodically. A contractor could be hired to service these components periodically.
Mike - hydraulic bridges more problematic. Can't get parts, lots of custom parts. New parts don't fit and have to come up with workarounds. Talk of converting Port
Shawn - takes a few cycles on hydraulic bridges to start season to get smooth operation. Temperature swings can be problematic
Shawn - heat tracing and tape at Houghton very helpful. Mike - heat tape and insulation eventually caused leaking and had to be removed. Still trying to find leak
Communication Improvements and Standardization of parts

Grand Haven

NAME	EMAIL	POSITION
Marc Fredricks	FredricksonM@michigan.gov	TSC Manager
Michael Wilsor	WilsonM23@michigan.gov	Grand Region Bridge Engineer
Matt Block	BlockM@michigan.gov	TSC Operations Engineer

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	Marc - yes, as far as he knows. Should be brand new manuals with recent equipment upgrades (hasn't physically verified)
2	Are electronic copies of the O&M manuals available for convenient remote access?	Marc - unsure, can reach out and ask. Recommended emailing Jeff T and Shawn Wigent.
3	Have the O&M manuals been helpful during troubleshooting operations to resolve malfunctions?	Marc - very limited playbook for operators. Not trained to troubleshoot and not authorized to do much. Call Shawn when issue arises. Recent issue with gate last summer. Separate cell phone for operator house to utilize (stays there at all times), very handy for video chats to share with Shawn the issue. Not sure how much manuals get used in this process.
5	What suggestions do you have for improvement(s) to the O&M manuals to provide more value and be more user friendly?	Marc - nothing specific comes to mind. Some inspectors have concern that maintenance staff were not using the same grease, lubricants, etc. as specified from other contracts. Unclear where material specification is coming from.
6	Does maintenance follow a formal, regularly scheduled preventative maintenance program for each bridge?	Marc - not aware of frequency. Staff would like to see monthly meeting. Statewide staff would have knowledge of maintenance schedule. Not tracked at TSC level.
8	Are any maintenance activities challenging to complete due to access issues or safety, and therefore not as regularly implemented?	Marc - local staff does not have lift that can physically reach to area between leafs. Area is not inspected regularly. Issues found from neglect in recent contract when area was finally accessed, a number of items required fixing. Bridge has catwalks ~20 years old that gives some ability, centered on 3 lanes, does not reach between bridges.
9	With regards to asset management, is there regularly scheduled/planned electrical component testing and replacement of electrical equipment?	Marc - Seasonal testing in April before opening bridge that TSC is involved with. Not aware of anything else. Standard protocol is for Lansing to handle rest. Night time testing after issues with Lansing staff prior to putting back in operation.
11	Are the findings and recommendations from the latest bridge inspection reports readily available to maintenance to identify areas requiring special attention?	Marc - not involved with this work. No TSC staff that does physical maintenance. Defer to Shawn and his group.
12	Is there a formal process in place to predict mechanical and/or electrical component failure(s)?	Marc - interesting, but not aware of anything. Would like to see it.
13	Are there any redundant systems at this bridge (backup motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc.)?	Marc - mechanical has 2nd set of motors, 2nd power source - natural gas generator to backup electrical grid (recent issues with this working), 3rd generator on trailer available in area
14	What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?	Marc - not familiar with details. Normal issues that required parts available at structure. Small electrical items. 2nd hand conversations, not directly involved. Thinks extra limit switches are on hand though can't confirm. Latest equipment upgrades did include ability to track readings (data logging) from issues and able to access remotely.
15	What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?	Marc - reset with recent project. Prior to that, about 1.5 times a month over a season. Maybe a dozen or less a year. One or two major incidents a year from 2015-2020 (ballpark). Last year had 3 - 4 minor issues. Ability to see remote data has greatly reduced downtime.
16	What is the permissible traffic stoppage for bridge operations and at what point are the local authorities notified?	Marc - standard protocol opening is less than 10 minutes (typically 8 minutes prior to upgrades, 4-6 minutes after). Document with TOC in Grand Region to update DMS board to direct traffic to M-231. Send media/emails to public after 10 minutes. Unless reason says it will be open shortly. Will share document
17	What procedures are in place to optimize traffic operations during movable bridge downtime? (i.e. - detour plans where feasible, VMS, mobile alerts, etc.)	Marc - M-45, M-231, I-96 is loop around bridge. M-231 is next adjacent crossing. Known route that locals are familiar with. Messaging capabilities available to notify public. DMS board south of Grand Haven for NB traffic, South of M-45. PCMS used previously in that area (remote access). Getting updated in traffic document.
18	Are there Intelligent Transportation Systems (ITS) in place for each movable bridge in the region? What are the capabilities?	Marc - 2 different systems. Closed loop system for bridge operator with cameras for nautical traffic (new addition). Nothing prior for visual confirmation beyond line of sight. TOC in Grand Rapids oversees camera system on highway network which have visual on bridge (north of bridge in interchange). Cameras south as well that can see queuing of traffic. Latter system for managing traffic.
19	What is the official protocol for elevating bridge malfunctions, i.e. who gets contacted, when, and what is the response time for maintenance to arrive?	Marc - Shawn is first point of contact for maintenance staff and he directs next steps. Traffic described above. Shawn is closest in statewide group (30-40 miles away).
20	Is there a 24/7 contractor (on-call contractor or other) that can be summoned to assist with troubleshooting emergencies, such as a control systems integrator or mechanical (millwright) contractor?	Marc - Strain (not in communication plan) called in a lot from previous project (had open contract, unique circumstance). Not part of plan today to call them in though Shawn has ability to reach out to private company. Most issues are electrical. No knowledge of mechanical contractor.

GENERAL NOTES
Contractors (Strain) have history on bridge to help when bridge malfunctions and are local
Sit down of 8 TSC staff recently with history on bridge to discuss issues/projects. Construction, maintenance staff, etc.
equipment on north side disconnected from rest of bridge, recently installed new equipment (cameras, etc.)
Ottawa County holds contract for operation. Due at end of this coming operating season and new contract coming
Contacts will be updated shortly in traffic document, happy to share names/details if questions after reviewing.
Remote monitoring - operator board is now digital instead of old board. Connected to a laptop and readings available. Closed circuit in operator house. A few MDOT staff has access, TSC would like camera access for better understanding of what is going on (nautical as well), Coast Guard has inquired about this as well.
One issue - sequence of stopping traffic. Causes delay and issues is gates. NB US-31 next to operator house. NW corner gate on SB is far away from operator house and no good visual reference. Can't tell where vehicles stop. Also at merge point with M-104 traffic. Traffic gets too far forward to avoid gate, pulls forward, then has to back up. Bus for local transit authority (small bus, dozen people) didn't realize gate was lowering coming from ramp, struck gate and broke it. Had to abort opening and vessel had to wait for bridge to re-open. Looking at having regional signal guys to add signal head (3rd, 2 currently). A formal stop bar or yield bar may help (stop bar may not fit MUTCD), curious if other traffic direction used throughout the state. Bridge at transition for speed from local speed to south and freeway speeds to north.
Snowplowing technology has ability to show cab driver see if blade up/down, can physically check for obstacle. Similar technology could be applied to gates?
A study was performed late 90s early 2000s to use movable bridge and adjust interchange (raised grade, most powerboats would fit). Price tag very large and not considering at this point. Maybe tunnel would be cheaper? Never been a priority, far down the road.
RR swing bridge gets stuck sometimes. Operators have procedure that is to stop nautical traffic so not stuck between bridges. Radio communication.

Grand Haven

Operator training process for new equipment. Lansing staff does help. Would prefer formal training requirement each season (6-8 operators contract) or training course. Walking through faults and scenarios would better prepare them what to do when it happens and what information needs to be provided. Experienced operators do better. Stressful for operators with lots of folks to contact while traffic backing up. Annual training across state could better utilize resources. More
Bridge log in excel format would be better than handwritten log. Use as a predictive document instead of history. Ability to sort, etc. more useful than pdfs.
Operator house locked from outside. Single operator most of the time. Not sure EMS has access to building if medical or building emergency. Few MDOT staff have key for access. Keypad would be much better.
Structure has non-motorized path on it. Pedestrians can sometimes get hidden from bridge house. Separate gates for path. One more thing for operators to watch. Redundancy/safety measures would be appreciated. New cameras didn't capture path.
All staff very appreciated of communication plan for bridge. Encourage other areas to develop something similar.
Operator house laptop is not MDOT supplied or on MDOT network. MDOT only supplies cell phone.

Portage Lake

NAME	EMAIL	POSITION
Ken Filpus		
Robert Tervo		
Jordy Maloney		filling in for Brandon Boatman
Al Anderson		

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	Ken - hasn't looked at manuals, would have to talk to operators. Manual created a few years ago for maintenance responsibilities of operators. How to work through common re-occurring bridge faults. Would need to confirm how much it's used. Kept in bridge house.
2	Are electronic copies of the O&M manuals available for convenient remote access?	Ken - yes, it is available in pdf (one from 1959). One local office drive. Rob - making a phone call if issues not covered in manual, assumes statewide crew has access to pdf
6	Does maintenance follow a formal, regularly scheduled preventative maintenance program for each bridge?	Ken - spring has bridge cleaning when operators come back in April, may push to May for weather. Operators have an opening list to go through in springtime. Monthly tasks through the summer. Washing and greasing lift cables at night are most important/challenging for local crews. Jordy - also good to include Andrew Bouvy in interviews, knows bridge well
9	With regards to asset management, is there regularly scheduled/planned electrical component testing and replacement of electrical equipment?	Ken - handled by statewide crew, unaware of anything Rob - looks for cracks in shafts, etc. in detailed inspections, every 5 years or so
11	Are the findings and recommendations from the latest bridge inspection reports readily available to maintenance to identify areas requiring special attention?	Ken - yes, copies are available of latest copies of inspection reports. Jordy - detailed inspections are typically every 5 years, unsure exact intervals, condition based and can be updated based on recent construction projects. Not familiar enough with this bridge. Ken - construction projects scoped off of detailed inspection, maintenance scopes comes from detailed or routine inspections Jordy - work recommendations in MiBRIDGE for any MDOT staff to see, may need to request access
14	What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?	Ken - spare barrier gate in bridge house. 2016 project stored some grease for cables at MDOT Houghton facility. Warehouse on north side that could store some components Rob - thinks some obsolete items are stored, unaware of anything stored locally, statewide crew would know
15	What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?	Rob - very few if any Ken - scheduled outages when needed. 0 unscheduled in the last year. Finger joint project had some downtime. Press releases to notify public. Rob - greasing cables is a slow lift process, maybe 4 times/year between midnight and 5 am. Any work that will require an outage scheduled as much as possible at night
17	What procedures are in place to optimize traffic operations during movable bridge downtime? (i.e. - detour plans where feasible, VMS, mobile alerts, etc.)	Rob - nothing in place, just MiDRIVE, no DMS boards, Houghton-Hancock police departments would help direct traffic. PCMS used for projects Al - Maybe half a dozen times after 2015 project with an unschedule outage, say 1 hour per year of unscheduled downtime.
18	Are there Intelligent Transportation Systems (ITS) in place for each movable bridge in the region? What are the capabilities?	Rob - no
19	What is the official protocol for elevating bridge malfunctions, i.e. who gets contacted, when, and what is the response time for maintenance to arrive?	Ken - statewide bridge would fly as soon as possible. Able to get staff there in a few hours. For traffic, emergency management plan in place for outages and designated areas on each side of canal to direct people to. Wouldn't activate if outage is less than an hour, would enact if unsure of duration or longer. Press release would be sent out. Other part of plan is getting appropriate staff on the phone to troubleshoot the issue. Local governments very involved. Last updated in 2018 and will be getting updated this coming year. Was stuck in up position for 3 hours in 2010. Most recent 1 hour outage in 2018 for skew fault. Rob - recalled one outage for barrier gates due to switch in cabinet, had been manually pushed with other work and left door ajar, say 40 minutes, around 2017 Al - had similar issue at end of 2015 project during closeout with door switch Rob - drill kept in cabinet to manually raise/lower gates
20	Is there a 24/7 contractor (on-call contractor or other) that can be summoned to assist with troubleshooting emergencies, such as a control systems integrator or mechanical (millwright) contractor?	Al - yes, contacts are available for controls, Faith or Link Ken - Strain now available for current contract, no mechanical contractor

GENERAL NOTES
Are diagnostic data recorded - Ken - operators record this in a log. Rob - some PLCs may be able to record info but local staff wouldn't know how to access it
Jonathan asked about biggest/consistent electrical issues, are they generally related to limit switches? - Al - speed sensor issue previously, though yes. Did get better with new motors and variable speed drives. Brakes now operating more consistently.
Ken - operators mention bridge is a bit "slow" in fall starting in intermediate position.
Rob - did a lot of bypassing after 2015 project, though has been much better lately.
Rob - reliability is key issue, need it to move when needed
Al - lots of deterioration at bearings is a concern, bearing points at lift span. Hard to tell extents without cleaning/coating.
Rob - certain areas difficult to work on that aren't accessible
Ken - recurring issue with welding down deck grating. Next lift bridge project supposed to address this
Al - management of funding for bridge - lots of jobs grow every 3-5 years, hard to manage traffic with unplanned scope creep. Better to do larger projects instead of
Rob - 20 year plan would be better, would be good to be communicated to local/TSC level
Al - find out about projects a few years out, deck project in 2027, learned about that in '21 though schedule has pushed, was going to be complete paint and now
Jordy - curious if big bridge folks are interacting with locals, doesn't see much at region level
Rob - doesn't think there's any formal communication between big bridge/statewide ahead of time, some informal conversations
Jordy - big bridge priorities don't necessarily line up with local priorities for handling day-to-day operation. Agrees more long-term discussions would be helpful
Rob - this would be a good process improvement, plans like this don't exist and would be more efficient coordination
Ken - 20 year plan for roads, yearly meeting to update plan for each section of road, very helpful for coordination, something similar for lift bridge would be great
Jordy - doesn't think big bridge has longer than a 5-6 year plan
Rob - also looking at security plans, talking with MBA

Veteran's

NAME	EMAIL	POSITION
Marissa Irish		
Linda Burchell		
Steve Katenhus		
Adam Rivard		

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	Linda - no clue, though Chris may know. Steve - has seen one in Lafayette, not sure about Vet's. Should be inside. Marissa - don't get much info typically. Did get question recently and had to track it down. Recent difficulty tracking down logs for Port Huron bridges. Current discrepancy for what's being tracked in logs between bridge tenders in Port Huron and St Clair. Adam - doubts O&M manuals at bridges
3	Have the O&M manuals been helpful during troubleshooting operations to resolve malfunctions?	Linda - Chris Lane to follow up. Marissa - if bridges have issues, this group on call is not typically called. Statewide called first then they call Region. Marissa/TSC managers called when traffic is impacted. Steve - Vet's and Lafayette - operators first contact is Dan at Region, who goes to bridge then calls Statewide crew.
11	Are the findings and recommendations from the latest bridge inspection reports readily available to maintenance to identify areas requiring special attention?	Marissa - available on MiBRIDGE though does not look at them. Lansing handles everything with these bridges.
14	What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?	Linda - if not at bridge itself, not aware of any storage facilities.
15	What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?	Linda - not significant, usually an event twice a year and resolved in a matter of hours. Follow up afterwards with minimal traffic impacts
17	What procedures are in place to optimize traffic operations during movable bridge downtime? (i.e. - detour plans where feasible, VMS, mobile alerts, etc.)	Adam - MDOT can put out a press release. Linda - can be put on MiDRIVE. Steve - communications rep can notify media bridge is closed. Coordinators call 911 to let EMS know.
18	Are there Intelligent Transportation Systems (ITS) in place for each movable bridge in the region? What are the capabilities?	Linda - not aware of any. Adam - don't know of any. Marissa - DMS boards on I-75.

GENERAL NOTES

Linda - Mike Wakely is fabulous. Port Huron recently stuck open a few weeks ago and was able to help from other side of state. St Clair rehab last year and should be operating OK.
Linda - routes have standard detours for Port Huron and St. Clair. Maintenance contracts with municipalities for detour setup. Not sure if documented though general practice. Steve - at Vet's, automatically detour on state routes. No local streets. Lafayette has same detour. Linda - no other state routes available.
Statewide crew good at notifying local staff of malfunctions. Marissa - feels like notifications are quick. Adam - TOC notified by statewide crews.
not aware of marine traffic issues. Linda - operators open bridge when they see a boat. Steve - opens bridges at coast guard times. Adam - Vet's coordinates with other local bridges. Marissa - more communication at Bay City due to heavy shipping and longer communication channel. Bridges talking with each other. Should be notice to other bridges if one goes down.
opportunities for standardization/optimizing? - Marissa - not sure what to standardize. Use of bridges is different between Bay City and St Clair/Port Huron. Different sites. Linda - on board with Marissa that each setting has it's own operations dynamic and standardization may not provide much benefit.
Adam - city owned bridges will become toll bridges and likely shifts in traffic patterns and working with private company. Vet's closing will impact Lafayette more since Vet's is bigger. Expecting a learning curve and need to give it time to let traffic settle
Bay City bridges operated through a lease from the City. MDOT still works through Bay City. Direct communication will likely change. May need some communication updates between operators.
Linda - could use local contracts to find space for storage if needed. Willing to facilitate conversation if needed.
can anything be done better - Linda - I'm good. Steve - more reactive, but not equipped to fix, handle traffic while specialists handle issue. Maintenance comes out about once a month for greasing, balancing every few years. Detailed inspections every several years. Washing is good. Small items provide good long term service. Linda - good electricians in Bay Region and fortunate. Very responsive and can fix things prior to statewide showing up. Big advantage.
Steve - is there a succession plan for staff and knowledge transfer? Something to look into.
Linda - city has operations logs for St Clair/Port Huron but don't send to MDOT, working through Chris to get this info.
Liberty - Tolling shelter, 500 kw generator, 250 Kw for bridge, Aux generator
Veterans/Lafayette - Generator
All have HMI screens besides Lafayette

Fort St

NAME	EMAIL	POSITION
Chaduhary Mahmood		
Alex Shteynvil		
Daniel Godfrey		
Harold Inman		
Chris Idisuyi		

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	Shawn - yes, O&M manuals present, use electrical prints more than anything, newer bridge and haven't had to use them yet
6	Does maintenance follow a formal, regularly scheduled preventative maintenance program for each bridge?	Chris - statewide handles, opening bearing caps is challenging for detailed inspections. No other challenges so far with regular maintenance. Span locks are accessible from underneath. Shawn - relocated limit switches a few years ago, had caused previous issues being exposed to elements.
11	Are the findings and recommendations from the latest bridge inspection reports readily available to maintenance to identify areas requiring special attention?	Yes - on MiBRIDGE (inspection report accessibility)
13	Are there any redundant systems at this bridge (backup motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc.)?	Shawn - power source has redundant system
14	What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?	Chris - yes. Shawn - limit switches are stocked in parts room downstairs. Spare drive when it was new and used when failed. Fixed leak that caused problem, never replaced spare. Chris - spare gate arm is there. Barrier gate arm has been a problem since installation - manufacturer is unreliable. Shawn - semi drove through arm, hasn't worked properly since.
15	What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?	Shawn - limit switch issue during winter storm was several years ago. Bridge was stuck open for about 5 hours. Bearing is only other issue to cause outages. Otherwise it doesn't have outage.
16	What is the permissible traffic stoppage for bridge operations and at what point are the local authorities notified?	Shawn - other routes available.
17	What procedures are in place to optimize traffic operations during movable bridge downtime? (i.e. - detour plans where feasible, VMS, mobile alerts, etc.)	Harold - unsure if any written plans in place. Calls statewide crew. TSC helps with scheduled maintenance. No coordination issues with Wayne County. Had to coordinate construction on other routes.
18	Are there Intelligent Transportation Systems (ITS) in place for each movable bridge in the region? What are the capabilities?	Harold - no, operators would call Harold, who would notify SEMCOG. ITS along I-75.
20	Is there a 24/7 contractor (on-call contractor or other) that can be summoned to assist with troubleshooting emergencies, such as a control systems integrator or mechanical (millwright) contractor?	Chris - call Strain Electric when Shawn needs additional support, rely on consultants like Jonathan, H&H, M&M. Shawn - a few staff within an hour to hour and a half of this bridge. Known to call Jonathan. Usually start troubleshooting while en route to bridge with operator, have a good idea of problem when arriving. No one to call that could be there sooner.

GENERAL NOTES
shifted. Contract currently in place to fix this. Bearing at span lock. Roof is also a problem - connections with stainless steel, leakage. Previous contract to fix though needing to fix again.
Is backup drive rebuilt? - Shawn - no, thought was still under warranty though no fix has happened. Been out for about 5 years.
Chris - detailed inspection coming up soon, can create scope to address outstanding items.
Chris - CCTV system did not work, warranty issue that was never corrected. DVR system was obsolete. Looking to fix.
Alex - concerned with software hacking.
Harold - not much TSC can do for equipment or knowledge. Coordinate with Chris and Shawn. May help out with light
Alex - never involved with inspection for Metro Region. Instance of loose barge hitting bridge previously though not involved.
Chris - barge hit old bridge, before my time. Has happened on other bridges with miscommunications with vessels.
Harold - DTE power outage affected bridge operation before. Arm on east side is connected to signal, can't recall specific issue. Shawn - accident hit signal box. Power transferred to other side though not for signals, had some damage. Harold - had to put
Chris - new bridge, fenders designed heavy impacts. Older bridges are not designed for it. Old designs use timber piles - Blossomland hit where it destroyed pile cap.
Chris - barrier gates and roof are biggest issue.
Chris - noise when bridge rolls on track, currently monitoring, could be misalignment. Happens more in warmer temperatures. Have found sheared bolts on bottom flat track, not vertical bolts into girder. Inspection coming up and planning to do more
Chris - every issues come back to construction, lots of balancing issues, contractor hadn't built bridge like this before, tried to improve specs on projects since this one.

Charlevoix

NAME	EMAIL	POSITION
Dan Wagner		
Jason Gailitis		
Chad Skrocki		
Krista Philips		
Matt Radulski		

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	Chad - most day-to-day maintenance handled through statewide crew. Spring cleanings each year. Unaware of specifics for maintenance schedules. Jason - handled by BOBS, not aware of any
2	Are electronic copies of the O&M manuals available for convenient remote access?	Chad - not aware of electronic copies, not "owners" of bridges at region level. Dan - learning terms currently through Manistee project. DPW staff serves as bridge operators there. Charlevoix operated by MDOT. Very little background or knowledge.
6	Does maintenance follow a formal, regularly scheduled preventative maintenance program for each bridge?	Chad - local staff handles cleaning and traffic control, BOBS handles this.
9	With regards to asset management, is there regularly scheduled/planned electrical component testing and replacement of electrical equipment?	Chad - all captured during detailed inspection, items identified through inspection Jason - 5/6 years ago, bridge stuck in up position, 60 mile detour, limit switch problem and replaced all switches on bridge Chad - call Mike Wakely/welders when issues arise.
11	Are the findings and recommendations from the latest bridge inspection reports readily available to maintenance to identify areas requiring special attention?	Chad - reports in MiBRIDGE, easily accessible, managed through Lansing / Big Bridge
14	What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?	Chad - statewide welders keep spare parts
15	What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?	Chad - Charlevoix was "problem child", hopefully better after project Matt - Cheboygan had 1 minor issue in last 10 years, Charlevoix had issues with fuses and replaced all of them, some mechanical issues with winter contracts to fix these. Chad - not uncommon to find missing rivet heads, broken bolts at Charlevoix prior to project
16	What is the permissible traffic stoppage for bridge operations and at what point are the local authorities notified?	Jason - construction contracts for intermittent closures at nighttime is ~15 minutes. Not familiar with allowed/not allowed policy. Dan - Manistee has had deck issues, upstream rail structure and have to involve RR, current work under permits. Manistee generally reliable other than deck issue. Manistee has un-posted, city owned structure close by. Make a public service announcement, good relationship with local media, not a big deal
17	What procedures are in place to optimize traffic operations during movable bridge downtime? (i.e. - detour plans where feasible, VMS, mobile alerts, etc.)	Dan - no protocol in place, get word out to local partners. No advance warning signage. Extensive detour/signage for construction projects. Stronach Rd is detour for commercial traffic for Manistee. Signage starts in Ludington to divert traffic. Chad - about 2 weeks to a month advance notice for closures for bridge washing Dan - will forward public announcements to local authorities Jason - similar arrangement with Cheboygan and Charlevoix
18	Are there Intelligent Transportation Systems (ITS) in place for each movable bridge in the region? What are the capabilities?	Chad - not aware of any Jason - contemplated ITS infrastructure around Charlevoix a few years back, was nixed, looked at advanced warning/flashing signs, scaled back design and then nixed. Nothing at Cheboygan, may have some signal connection with bridges at Charlevoix. Wasn't realistic to post signs far away when evaluating previously. Questioned effectiveness. Chad - operator would be first line of communication Jason - traffic can queue up to M-66
19	What is the official protocol for elevating bridge malfunctions, i.e. who gets contacted, when, and what is the response time for maintenance to arrive?	asked about emergency action plans: Jason - had discussed placing signage permanently for outages for county network, just leaned away from it when getting into logistics. Matt - "flip-up" signs if bridges were closed, Rob maintenance guy looking into it Jason - others involved, sees staff getting away from idea
20	Is there a 24/7 contractor (on-call contractor or other) that can be summoned to assist with troubleshooting emergencies, such as a control systems integrator or mechanical (millwright) contractor?	Chad - nothing formal in-place. As-needed consultants that can be called on through Andrew Bouvy.

GENERAL NOTES
Chad - no remote data logging/connections for the bridges, Dan/Jason agree
Detour route/plan - Dan - not aware of any, would reach out to Kalkaska maintenance garage to start setting up a detour. City of Manistee staff handle issues at
Dan mentioned issue of oil sheen on Manistee Lake, thought it may be from MDOT storm sewer, 911 operator called local MDOT staff, then called Dan, then they both went to bridge. Would likely be notified by dispatch or city staff directly. Would call Chad/Brandon first.
Chad - call maintenance coordinator first, then reach out to county to get traffic control setup, most counties can respond within 2 hours depending on time of day, etc. Police will shut down initially until county gets signage up.
Dan - could get someone to each bridge in an hour
Jonathan asked about remote monitoring capability - Chad - not aware of any, not 100% certain though, Dan - Tod Cramer lead inspector for Manistee, could weigh in on anything getting installed in rehab project. Jason - not aware of any
Jonathan asked about most common component failure - is it limit switches? Chad - hears most about limit switches, statewide crew handles it
Jason - similar recollection with previous issues, though been better last few years
Chad - hopes most of recent issues being addressed in current projects. Nothing major at Cheboygan.
Dan - at Manistee, Coast Guard navigable waterway issues and having to go outside of permit window

Charlevoix

Dan - bridges are historical and maintaining them in perpetuity… seems bizarre, questions long-term strategy and investments. Would like to see long term plan.
Charlevoix, nightly closures on current project, major impacts if bridge goes down for long periods of time, large risk to keep "kicking can down the road", Charlevoix is a risk
Chad - this is a statewide issue, hard to have a long-term strategy, about 5-10 year plan
remote operation
Dan - original ask for detour by locals was for $1M to improve route, MDOT agreed to pay for paving on another local project, trend is that MDOT is getting more requests and demands from local road owners when MDOT asks to use local roads for detours
Dan - always get good help from BOBS

Bicentennial (M-63)

NAME	EMAIL	POSITION
Michael Bippl	Bippley, Michael (MDOT) <BippleyM@michigan.gov>	Operations Engineer
Pete Pfeiffer	Pfeiffer, Pete (MDOT) <PfeifferP@michigan.gov>	TSC Manager
Richard Stack	Stack, Richard (MDOT) <StackR@michigan.gov>	Region Bridge Engineer

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	Pete - does not know, Richard - electrical in MiBRIDGE for O&M
5	What suggestions do you have for improvement(s) to the O&M manuals to provide more value and be more user friendly?	Pete - from Coloma business office perspective - very convoluted for 2 bridges and who is responsible for operations. Coloma responsible, SW Bridge maintenance crews responsible for operator contracts and oversight (vendor doing what they're supposed to do). When issues arrive, who is notified? Martin (general maintenance coordinator) is asked to take on responsibility to coordinate with maintenance crews and troubleshoot issues though doesn't know much about bridges. Rich's area has inspection responsibilities. Statewide bridge crews comes in when gates don't work, etc. Lines for who is responsible for what are very unclear. Rich - region bridge crew doesn't do much with maintenance and troubleshooting. Chris I and Mike Wakely handle most issues. Rich is notified though these bridges are managed at statewide level. Thinks O&M
6	Does maintenance follow a formal, regularly scheduled preventative maintenance program for each bridge?	Rich - Statewide crew handles this. Lubricates items when needed. Local maintenance staff assists sometimes. Pete - we don't know from Coloma business office perspective, schedule unknown.
7	Are maintenance charts, identifying lubrication type, frequency, and machinery component located on site for reference during maintenance activities?	Unknown
9	With regards to asset management, is there regularly scheduled/planned electrical component testing and replacement of electrical equipment?	Statewide handles. Pete - operator house, local coordinator had to troubleshoot air conditioner issue, ended up permanently disabled. Don't know if this is looked at regularly. Portable units purchased to keep operators in reasonable conditions. Permanent units unavailable at the time.
11	Are the findings and recommendations from the latest bridge inspection reports readily available to maintenance to identify areas requiring special attention?	Rich - only Mike in special crews garage has access. Doesn't think anyone else does.
13	Are there any redundant systems at this bridge (backup motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc.)?	Unsure - better for operators to answer.
14	What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?	No standardization between bridges and not stockpiled on site. Coloma Maintenance garage would be logical place to stockpile items, about 10 minute drive.
15	What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?	Pete - Bicentennial arms not going down. Michael - intermittent issues, unpredictable.
16	What is the permissible traffic stoppage for bridge operations and at what point are the local authorities notified?	Pete - no specific timeframe. Two cities involved and impacted (St Joseph and Benton Harbor). St Joseph quickly contacts MDOT after a short closure. 15-20 minute stoppages for maintenance would be a bit long but fair
17	What procedures are in place to optimize traffic operations during movable bridge downtime? (i.e. - detour plans where feasible, VMS, mobile alerts, etc.)	Use other bridge when one is down.
18	Are there Intelligent Transportation Systems (ITS) in place for each movable bridge in the region? What are the capabilities?	Bridges not tied into ITS infrastructure. None nearby, all near freeways. No plans for ITS. Upcoming traffic signal project may provide opportunity to tie into signals, will be connected to Lansing. Blossomland Bridge have signals modernized.
19	What is the official protocol for elevating bridge malfunctions, i.e. who gets contacted, when, and what is the response time for maintenance to arrive?	~2 hours for Lansing staff to arrive.
20	Is there a 24/7 contractor (on-call contractor or other) that can be summoned to assist with troubleshooting emergencies, such as a control systems integrator or mechanical (millwright) contractor?	Unaware, handled internally with Statewide Crew

GENERAL NOTES
More issues with Bicentennial than Blossomland due to equipment
Carinda Winkleman - never heard of her
Maintenance challenges - don't know, involvement is limited
Is there anything operators can do when malfunctions occur? Only hear about it when workarounds don't work. Ed Martin started career as a bridge operator at these bridges and now maintenance supervisor. Operators will call him first.
Do inconsistencies get passed to statewide crews? Unsure
always this way. Would sometimes show up unexpected. Very impactful to two cities and need to let local authorities know when outages are to occur. Getting better particularly when Mike Halloran took job in Lansing. Ideal would be about a 3 day notice so other construction work in area can be coordinated, work around festivals, etc. 1 day notice not enough time.
Rich - FCM engineer gives months of advance notice, can get revised about a week ahead. Single lane closures
routes.
Rich - considering reactivating another plant Palisaides (spelling) that is a little farther
Pete - if one area "owns" bridge, that would simplify operations and get rid of convoluted current scenario. Too many cooks in the kitchen.

Michael - agrees with Pete's point above. A contact sheet for positions (not names) would be very helpful, flowchart of who to call
Rich - these are statewide assets and managed out of Lansing, who has to rely on local support. An annual movable bridge coordination meeting
Michael - hard to keep up with where staff are moving to
Rich - funding for repairs/projects handled through Lansing and statewide big bridge program. No specific movable bridge engineer.
Pete - from scheduling standpoint, would be good to stagger when projects happen on such bridges. Previously let together. Understands economies of scale standpoint, but project went on for 3 years since work could not happen at same time. If projects were staggered, could be more advantageous since work would go faster. Could be a wash
Rich - on same maintenance schedule. Consultants perform the designs. Would lean towards way it was done before but understands Pete's
Pete - not specific to interview, at a meeting in St Joseph earlier this week for future road project, City Manager mentioned Blossomland Bridge east quadrant stairwell, concrete wall above stairwell struck by motorist. Unsure if this has been reported. Another example of convoluted responsibilities. Questionable if MDOT even heard about it, not sure if bridge tenders at house.
Rich - annual coordination meeting would help review processes.

Panatrol (control software)

NAME	EMAIL	POSITION
Bruce		Panatrol
Brandon		Panatrol
Chris		MDOT
Shawn		MDOT

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	Most times nothing, contract drawings not as helpful as as-builts. Sometimes partial information available, original files generally not updated. At least one up to date set of manuals should be on bridge.
2	Are electronic copies of the O&M manuals available for convenient remote access?	Most common failure points, limit switches? FAT and commissioning determines if relay/IO cards bad, surges for IO cards. UPS's need to be maintained, batteries go bad, then UPS gets bypassed. Interposing relays for surge protection? Industry changing to 24V for sensors and controls rather than 120V (due to distance between IO and device). IO islands, enough IO for an area. Limit switches with diagnostics? Would need laptop to replace limit switch, undesirable. MCs with smart overloads, networked control over every motor starter, need techs - too complicated. Distributed IO in MCC. Smart overload on starter.
3	Have the O&M manuals been helpful during troubleshooting operations to resolve malfunctions?	Lever arm switches and fully seated could have feedback but poor. Rotary cams best with spare cams for repairing. 2 Inclinometers for redundancy, never depend on 1 analog device. If disagreement between devices generates fault to run at slow speed until fixed. HMIs show when limit switches activate. See bad PLC programming and HMIs, program assumes everything is OK - calibrations wander off - need good alarming. Learn from HMI w/o laptop, or prints. Alarms need to be clearly written.
5	What suggestions do you have for improvement(s) to the O&M manuals to provide more value and be more user friendly?	Alarming and diagnostics, is there standard or from design specs? All (analog and digital) discrete inputs have alarm unless pushbutton. Hydraulic pressure switch is example of alarm. E-stop may cause 25 alarms and E-stop gets lost (alarm flooding). If redundancy, need proper alarming, ring network example. Network too complicated, less reliable. Network CPUs, IOs, HMIs, and drives - key things. Fans of wireless, need right stuff, then works great. 900Mhz WiFi works well, plenty of bandwidth and secure. Needs to be redundant.
9	With regards to asset management, is there regularly scheduled/planned electrical component testing and replacement of electrical equipment?	Disaster recovery, are all programs available for PLC programs? Flash memory, SD card, Shawn calls Brandon. Online remote troubleshooting and access is hugely important. Laptop to laptop, but do not leave hooked up to internet. Use "remote PC" for security. Remote control may be problem if not a dedicated network. IT dept if over web. Shawn used 3 times last summer, Lafayette and port Huron, one hour remotely saves budget.
13	Are there any redundant systems at this bridge (backup motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc.)?	Good redundancy? CPUs cold redundant for surge protection, hot redundancy for remote control. Hybrid system. IO racks exist twice, one powered, one not. Relay system in parallel too complicated, not fans. Redundant processor failures? Processors fine, lost memory. If backup fails, should be repaired. Careful with synching if master loses memory.
14	What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?	No spare parts stocked, maybe two different types of PLCs. Question need for spare rotary cam switches or spare motors/brakes that are left/right handed.
15	What is the average number of hours of unscheduled downtime (unable to open due to maintenance issue) of the bridge per month?	General suggestions: High tech but keep it simple. "Stream of consciousness designs" - not well written. Put in specs, direct, simple, not bit heads, need engineer. Guidelines for writing programs, organization, HMI programming and optimization. What colors should be for different states, running, faults, alarms. Indicators can also have text, "driven", "pulled".
16	What is the permissible traffic stappage for bridge operations and at what point are the local authorities notified?	In cabinet wiring, all wiring to cabinet should follow manufacturer's recommendation, U0508 rule, not 14 GA throughout as per AASHTO

GENERAL NOTES
O&M manuals – use frequently, particularly older bridge. Sometimes don't know anything about them and in some cases no manuals, flying blind and figuring things out as you go. Don't have to be hard copy, but would need computer to read pdfs. Contract drawings are limited in use since not always most current. Need shop drawings. Don't recall running into that on MDOT's bridges. Has own schematics for Lafayette. Sometimes some effort getting info for MDOT rehabs but eventually gets them. Not always stored at bridge. Sometimes get partials, markups inconsistent. Original files not always updated and issues on older bridges all over the country. Recommends at least 1 up-to-date set at each bridge.
Most common failure at bridges outside of limit switches – Limits switches definitely #1, live the hardest life. Relays and I/O cards usually fail early if they do. I/O cards going bad often a symptom of something else going bad in the field (surge, wiring, etc.). Relay failures are rare. UPS's often bypassed or taken out. Anything with batteries need to be replaced or stores energy just ages and wears out, needs to be replaced. Can't always keep a spare battery on the shelf (also goes bad).
Other industry practices – typically inside a factory, most have switched to 24V and different types of cards. Very little 120V I/O cards. 120V on bridges makes sense given distance to travel, would be tough to implement 24V on a bridge – need "islands" with distributed I/O. Wouldn't recommend placing near the tip of a leaf.
I/O links – haven't used much. "smart" sensors have to be configured when replaced. Would need a laptop to do it with a technician, engineer, backup files, etc. Doesn't
Difficult to setup connected hardware. Prefer to put distributed I/O near control center and don't get as much diagnostics. Looking to try smart overload on starter.
Electrical issues can be a symptom of something mechanical or electrical, and electrical can be easily manipulated to get bridge moving again.
Chris – is it possible to predict life of limit switch? Not sure – can look at alarm history of switch, takes a person to look at it. Can start alarming when sticky and slow but not failed. Rotary cam switches hard to replace, though only failure was on Lafayette since it was hit. Arm switches easier.
Shawn – 3 year cycle life on switches exposed to elements. "Wishlist" to operate Benton Harbor off of inclinometers instead of limit switches. Lose 1-2 switches a year, difficult to track down which one. No indicator lights. 4 up and 3 switches down. Bruce – don't always want to rely on 1 analog item. Use multiple and software to watch both. Flags inconsistency and allows bridge to move slowly and safely. Has a maintenance screen with a matrix on PLC bridges to show when limit switches are activated/deactivated. Helps with commissioning/startup of bridge. In favor of PLC – though see lots of bad PLC programming and causes uneasiness, can opt for relays instead. Need good alarming and HMI to monitor.
Alarming/diagnostic tools – are these from specs for a project or done by Panatrol? Guide rule is that all inputs have an alarm except for push buttons on console. Have to figure out when things will be an alarm (on/off, gate up/down, etc.). For both digital and analog inputs, hydraulic systems, etc. Lots of alarms. Have to filter alarms selectively, say for an E-stop, so important ones are not lost. Can't have 30 alarms at once. Can be put into a specification.
Need proper alarming and diagnostics for any system with redundancy. Gave example of "parallel redundancy protocol" which was too convoluted. Need to have redundancy but can't make network too complicated. Things that are networked or connected to PLCs need to be minimum/what's needed or can get lots of alarms. Can snowball quickly.
Also big fans of wireless since useful to get across a channel though needs correct hardware (example of supplier giving wrong equipment). Using more wifi than radio. 900 megahertz is a good option, plenty of bandwidth of a sensible bridge network. Chris not a fan. Used when sub cables aren't practical/reliable or unable to install.
Redundancy – what is a good level of redundancy? What hasn't worked? Prefer cold redundant CPUs, sometimes need hot redundancy for remote control. Trying hybrid system with device outside that monitors temperature (work around). Redundant I/O systems where duplicate tracks with one powered at a time. Network has to survive I/O dropping out and reappearing. Prefer this to backup relays. Parallel relays complicated and not a fan. Not much redundant instrumentation – rare to see. Woodrow Wilson bridge had it. Would make sense for an inclinometer (can't take average). Shawn and Bruce shared confusion over new Charlevoix system with parallel relays and sub cable. Manistee is monitoring PLC with an HMI.
Backup processors – recommends alternating about once a month to make sure each working. Example where this didn't happen, first failed, then second failed a year later, then called in a panic. Had to reload and ship back. CN bridge with issue of processors getting overwritten. Need to have backups, flash memory, and updated/maintained to be effective.
What happens when programming lost? Difficult if older system, program may not be available on server. Shawn – MDOT keeps programming on SD card – would call Brandon to take care of it remotely. Lafayette system going away. Some MDOT bridges share processors. Don't have program available to load up – call Brandon.
Remote access – is this important for getting bridges in service more quickly? It's hugely important. Difference between getting bridge online today or in a couple of days with travel. Can do quick checks. It's laptop to laptop – needs to be hooked up on bridge. Don't advocate leaving bridges hooked up to internet and only needed when in use to reduce security issues. Can remote in to on-site laptop during troubleshooting and then disconnect on-site laptop. Need IT department to setup internet connection. Remote connection is fast and secure. Shawn in favor of this, been efficient and used 3 times last summer. More cost effective for MDOT in troubleshooting costs.
Other technologies? High tech is good but need to keep it simple. Been seeing complicated networks from consultants and questioning it. CA bridge too complicated and well written/structured well. Not sure on wording, but put into specs to keep things simple and straightforward. IEC has some codes/standards for programming but more into PLC manufacturing/language.
Standard/guidelines exist for HMIs – color standards have a history of getting out of hand. Consistent colors for type of issue would be helpful. Shawn agrees. Indicators on HMIs generally multi-state. Can change words as well as colors to give more context. Need consistent colors between bridges to help maintenance staff and operators.
Bruce/Brandon open to more discussions.
Would be good to have specs for in-cabinet wiring in specs. Provide gauge or refer to manufacturer's recommendations.
Does Panatrol keep spare parts for replacement? Don't stock parts, but use same parts routinely so often a part is available. Don't keep limit switches. Most bridges have spare list. Don't understand rotary cam switches on spare parts list since they don't go bad. Also doesn't understand spare motors or brakes since these are often right/left handed, and spare parts may not match.

Faith Technologies

NAME	EMAIL	POSITION
Jake Nolan		
Paul Bauman		

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	Paul - lots of effort can go into building O&M manual. Not sure how often they are used. Not sure of cost/benefit to manuals. As-built drawings are #1 things used other than O&M. Not sure what else is utilized after bridge is built. Run into issues where as-builts are no longer up-to-date (switches added, relays changed, etc.). Not sure how this can be managed and communicated to everyone. Shawn - do best to make detailed notes on plans stored at bridge.
14	What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?	Paul - don't hold inventory of parts. Projects often have requirements for spare parts that are delivered to bridge. Never used to be issue since distributors kept parts on hand. COVID issues dried up supply, though now returning to previous levels. Not sure how long it lasts until next supply chain disruption. Recommends contacting local distributors since they will stock/hold spare parts if asked. May sell part if needed but will re-order to replenish. Jake - some parts have shelf life. Faith doesn't hang on to certain parts for that reason.

GENERAL NOTES
Paul - favorite parts are no longer going to be available in the near future, trying to let owners know. Gave example of relays provided by Schnieder. Also gave example of drives. Cards as well. Lead times make inventory scarce even though trying to increase production. Challenge for industry
Paul - Getting away from resolvers would simplify design and construction. Take off of rotary cams and use transducers. Many specs still call from resolvers. Need a gateway module to make connection. HDR has already moved away from resolvers though see it from other firms. Limited to 100m for ethernet distance which can be a problem on bridges or if going through a sub cable.
Paul - analog cards - use Rockwell components, back to pre-pandemic stock levels for lead times. Drives have slight issue with updates for newer parts. May have to go up or down a size for stock availability. 6 week range for parts.
Paul - limit switches - not really a good answer, MDOT doesn't have issue with salt water. Jake - most calls late at night come from a limit switch, hard to put predictability behind it. One thought is to time operation and see how long it takes from time it's sending signal until it operates - if it grows could be a sign it's going bad.
Paul - no one has asked for I/O link yet. Could be some advantages. It's a communication protocol on an analog device and transmit data to system. Need specific cards to do this. Not as prominent on market and longer lead times. Some suppliers can provide. Concern is more complex than most electricians can diagnose on their own and adds a layer of troubleshooting. Likes to keep bridges simple. I/O link can be problematic on a bus system, better to direct to node. Not really tried on bridges yet though vendors pushing it. Used more in industrial space. Rockwell showcasing it. Could do a trial run parallel with a limit switch. I/O link limited to 20 m from node for cables. Should be looked at more.
Jake - location important for switches. Best to protect from salt and elements.
Jake - limit switches are common problems. Many bridges with remote operations and communication issues depending on where they are. Some run on satellite and latency can be problematic. Can be hard to from bridge to remote operation station. Example of hydraulic system overloading and unable to drive wedges. Electrician comes out and looks at program, was a grease problem backing things up but maintenance staff looked at electrical first.
Jake - with proper written program to create baseline of trends, can lead to predictability to failure.
Paul - predictability with vibration analysis in the last few years. Can measure in 2-3 axis on a part or transducer but comes at a cost. Need to balance.
Paul - redundancy in limit switches - sounds great at the surface, problem is with bypass switches, too easy to use since maintenance staff and operators take advantage of operation and then forget to go fix the first switch. Depends on how robust maintenance program is and protocols. Gave example of VA bridge where redundancy was added with multiple limit switches, was unclear which switch to trust if giving conflicting
Paul - dependent on other contractors for relay systems, workforce training for these systems has not happened and difficult to find. Jake - relays can get bypassed over time when working through issues and no longer represents original system over time.
Paul - spare processors can be kept on shelf but not great since they do not get updates. Don't fail often but can be a big problem when they do. Output cards fail more often - if something shorts, it can fail card at the point it connects and point becomes dead. Individual points fail, not
Jake - PLC system takes up less space then relay system.
Paul - preference is to get away from relay systems. Need operators that are comfortable with system.
Shawn - recent blow out on seal in drive system combined with electrical failure (UPS system) requiring to bypass PLC. Needed manual operation and down for 3 weeks. PLCs added after the fact and relay system kept for redundancy. Good and bad to relay systems. Charlevoix stuck last night due to bracket out of adjustment and wear on brake pads. Arc contact at limit switch which had to be replaced and reset bracket. Likes redundancy that there is a way to move bridge even when it fails
Paul - use cord/plug with UPS system, a bridge tender can disconnect and connect to control system to keep bridge running while new UPS system is getting installed.
Paul - remote connectivity - a benefit, particularly for PLC bridges. Crew in WI can access system (CSX) from anywhere. Need an IT group that has a robust firewall system for cybersecurity. Valuable practice. CCTV cameras and all equipment can be accessed.
Jake - remote connectivity - greatly reduced troubleshooting costs. No travel required and much faster time to resolve issue. Can point local staff to specific fault.
Jake - buy America build America - sees companies trying to find ways to work around this.
Paul - common parts - rely on Rockwell the most since they have best support 24/7, strongest support networks with immigrators and distributors. Other companies more hit and miss and regional with part supply and support. Allan Bradley parts used and team has been trained in it, used to it. Also trust with the parts.
Paul - Rockwell has new HMI platform that would be worth looking at, Optics, Rockwell's answer to Ignition, similar and web-based.

Strain Engineer

NAME	EMAIL	POSITION
Bob		Strain Electric
Shawn		MDOT
Chris		MDOT

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	How often involved with troubleshooting? On call w/Shawn, monthly talks. On site about twice a year but frequent comm. Answer general questions.
2	Are electronic copies of the O&M manuals available for convenient remote access?	O&M manuals rarely used, goes to schematic. Accurate drawings critical. 3-ring binder not as good as spiral binders. Thumb drive with plans per bridge very useful. Thumb drives in each bridge house suggested. Paper copies can add notes/updates. Upgrades to entire file, not piecemeal.
6	Does maintenance follow a formal, regularly scheduled preventative maintenance program for each bridge?	Cable routing or conduit? Rec. conduit and sealtite over droop cables. XHHW no issues with vibration inside conduits. Charlevoix conductor failures due to age. Cable trays lashing fails, loose cables susceptible to snagging. Good balance (toe heavier) results in less vibration and less floating. Proper seating is huge deal. Also wind down and set brakes to hold. Timing of brakes needs to ensure set before de-energizing motors. Strain gage testing for imbalance to assist electrical tuning as well as include for rehab work that may impact imbalance.
8	Are any maintenance activities challenging to complete due to access issues or safety, and therefore not as regularly implemented?	Controls items that can be improved upon? Important to require up to date modem driven accessibility for PLC controller. Panatrol used. Optional to access PLC remotely, preferred for troubleshooting. Remote access helps with outages? Monitoring faults helps, operators don't fully understand. Decide if need to go on site to repair. Shawn - SCADA lite monitors power loss or loss of comms. HMI is fairly animated to make easier (dummy proof). Determine if "oops". Access to HMI remotely would be helpful.
12	Is there a formal process in place to predict mechanical and/or electrical component failure(s)?	IO links can monitor limit switch health remotely (since 2012). Rec. a Go Switch for fully seated switches. Shawn - lose 1 to 3 limit switches a year. Epoxy filled limit switches, "encapsulated". More equipment on far side is frowned upon, further from operator house (drives, etc.). Need temperature control to protect, filters are too small and burn up fans. Drive and comm failures usually, requires driving around to far leaf if located there. Testing fiber optic not a common capability - subject to contamination due to wiping with finger, etc. Fusion butt splices instead of patch panels. Need minimum radius and not overtightening wire ties or else will break.
13	Are there any redundant systems at this bridge (backup motor/gearmotor, direct drive diesel engine, redundant PLCs, relay control, standby generator, etc.)?	Bob suggested keeping an open forum to discuss issues as they arise. Limit switch installation details? Be specific with brake limit switches - metric vs. 1/2" sealtite, rather see spring loaded terminals and mounting system to be vibration resistant and able to fine adjust. Kickstand for hand release, can be swung out undetected. Tied back with tie wraps to prevent inadvertant movement. Did not use plunger for offset cam position. Brake LS's should follow specs.
14	What spare parts are typically stocked and where are they stored (distance from bridge)? In other words, does the agency collect diagnostic data or proactively monitor things such as hydraulic pressure, electrical current, temperature of hydraulic fluid, no. of cycles, etc. that may be used to predict component failure?	Chris - Prox limit switches for harsh environments, chlorides? Bob - very hardy system, if on rack like St. Clair, need immediate response, needs to be accurate. GO switches great for vibrations, such as on railroads. Use magnets to increase sensing range. Shawn (Benton Harbor) - inclinometers as primary LS, rather than 9 per leaf, (Square D?) LS for operation. Take place of rotary cam switch that's not there.

GENERAL NOTES
Strain/Bob has an on-call with MDOT. Talks with Shawn monthly. On-site maybe twice a year though lots of communication. Bob has history working on bridges.
O&M manuals – rarely read manuals, follow schematics down path they lead to. Accurate drawings on site is incredibly important.
Usually something is on site. Have had to “dig” at times for information. More recent project installations more readily available. Other bridges are more out-of-
Paper copy with 3 ring binder is most inefficient. Spiral binders preferred. Hold up better and easier to use.
Thumb drive with plans per bridge is very useful to plug into laptop, recently received.
Laptops typically used to connect to PLC, could store files on laptops
Still loves paper copies, can make marks/updates easily
Most common type of failure – good question, limits switches are obvious.
Biggest pet peeve is a driftable balance on the leaf. Allows a +/- either direction, should be allowed to drift down. Structural changes over time creates problems. Imbalance of leaf is biggest structural obstacle, affects performance and tuning.
Brake and seating limits also prone to trouble. Signal from brakes can fail. Proxy switch (non-mechanical switch) can help with this.
Other breakdowns can be random.
Engineers don’t specify spring loaded terminals (in lieu of ring terminals) – unsure why not used more often. Constant pressure so vibrations are reduced. Terminals can back off over time. Shawn – checked at startup and once in summer. They do come loose during operation. Bob – no issues with fatigue, hold position well. Temperature expansion/contraction in wire can help hold tension.
Other improvements?
Starters, mechanical relays do well
Push buttons and contact driven apparatus under 120V are more susceptible to contamination (dust) and can fail. Higher voltage better for these controls. Push buttons at 24V fail quicker. Higher voltage can burn dust off where it’s an insulator for lower voltage.
Cabling details and routing – believer in conduit. Droop cables can be limiting where conduit is not. Would prefer to pull wire through conduit.
Failures due to vibration – don’t see it very often. Has seen cables over-packed which is a problem. If bridge is properly balanced and seats properly, vibrations
Motors will properly wind down, brakes will set, in time between mechanical brakes taking over – bridge will start to raise up (imbalance) during 3 – 4 second delay. Should stay in place once seated. (HDR team disagrees). Believes this is due to equipment weights, etc. causing imbalance. 90% of issues due to this vibration. Jonathan – strain gauge testing can check balance – can add to projects
Cable trays – lashing fails and then loose cables exposed and can be caught by something. OK with good containment.
Other control items that could use improvements? – no, important to require up-to-date, modem driven accessibility for controller. Use Panatrol the most (most confident), can be optional for them to access the PLC remotely, encourages doing this even if not required via spec.
Remote access and monitoring – good for monitoring faults, operators don’t know how to interpret. Tells others if they need to go visit site or not. Shawn – remote systems on pump stations (SCADA), monitors phase loss or communication, some have ability to restart pumps. It is handy. Bob – access to HMI screen would be good.
I/O links – monitor health of limit switch – experience with this? No, not familiar with it.
Shawn – more interested in trying ghost switches first
Bob – encapsulating limit switches would be helpful (epoxy filled)
Location of drives can be improved, keep on one side of bridge
Communication failures for equipment? Drive failures are usually drive related. Some communication failures – not everyone can check/test fiber optic, more susceptible to contaminants, saw this at Houghton (just had to be cleaned). Saw it at Grand Haven for cameras. Better to keep these things in controlled environment
Other items? – touched everything that comes to mind, will follow up later or Jonathan will call

Chris Drago

NAME	EMAIL	POSITION
Chris Drago		Hydralic Specilist

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	Never looked at one of them. Looks at prints and goes from there. Don't need to look at the manuals since not operating. Gets guidance from operator to move the bridge.
4	Please provide an example of a recent implementation of troubleshooting measures from the O&M manuals, or when they are most typically referenced.	Every bridge has unique design - should be way to adopt a standard common design. Use same components, same layout, etc. Power units are close to each other in size/capacity. Not an issue for Chris, though these are not simple for folks maintaining systems that don't see it every day. Thinks St. Clair is a good design, functions well. Military St. doesn't work as well, living with what's there. Can teach design/function on one and be used elsewhere. Things change over time (valves, etc.) though overall design essentially the same.

GENERAL NOTES

Gripes for troubleshooting - Needs to be a review on how to design the bridge hydraulic system to perform as intended. Old AASHTO specs were not good and based on RR requirements. Not strict positioning requirements. Old bridges would meet in middle and lock, not as much need for accuracy. H&H introduces jaw/lock but kept old design criteria and not compatible. Need tighter setup for bridges that require more accuracy (line sizes, etc.). Controls much better today. Review design from beginning to make sure it is tight. Get right flow/pressure for system.
troubleshoot. Can use common design for tail locks and use same cylinders (most bridges 2 1/2" bore). Just need a few simple modules.
Have to keep spares for uncommon parts. Spares don't always get replaced over time and parts become obsolete. Always a problem finding parts. Common parts across bridges in state would help
Not a big fan of vertical power units in any application, though worse in bridge. If coupling fails, it torpedos and now in tank. Rubber disintigrates and gets caught in system. Build with horizontals instead, easier to replace valves without contamination.
Learned lesson about building enclosures around power units. Need clean site and temperature controlled. Centerlock bridges with cylinder not as much of an issue, fluctuations of temperatures can impact operation.
Valve stacks at Military - Canfield light wafers can be integrated with stack - thoughts? Reps Canfield though don't know this product. Not sure what could be used to troubleshoot a bad valve, etc.
designs get overcooked and extra devices thrown in creating complications. Hydraulic bridges susceptible to "chucking"/movement when trucks drive over. Vacuum break valve can start to cavitate in tail lock, no need for this type of valve in tail lock since those aren't moving. Now direct path to tank and if valve gets stuck open, there's a big leak.
tail locks don't need to have a unique HPU, don't need separate system. Most bridges only have 2 movements - up/down and locks
had issue on Military St with low pressure at pump due to coupling failing and the pump wasn't turning, looking at lots of other things instead and took some time to find. Operation manual led them elsewhere. Control diagrams didn't follow through correctly, prints didn't match from control house to down below. Control layouts should be correct in new design and simple.
helpful to have system integrator on-site (Panatrol)? - no, just need someone to hook up laptop, doesn't work on control end of it since it can spiral into doing whole job, need someone to find circuit and force it on/off (coils). Say turn off all hydraulics and tail locks going on, just need to see bridge operator just that lights come on and connection is there. A common control platform is imperative
storing parts - keep architecture of systems the same, lots of ways to do it just be consistent
items to watch during inspections - CM20 system at Military St that can do online particle count, pressure and temperature, sensor in mainline and now obsolete. There are great predicive maintenance tools that can be installed within line, Military St was early example, much better systems now. particle counts - quantity is what's important to tell if line is clean, can also sense water (moisture can get in from heat/cool cycle). These can be networked and sent to server.
hardware - a lot of sensors are programmable, more electronic than hardware in today's market. Most sensors can be connected to I/O link system. Can be set as lower level network. Don't need to re-program as sensors replaced and detect when they go bad, monitor sensor health. Eton has power defense breaker that can report condition of breaker to network. Common technology for automakers. Can be integrated into existing setups depending on PLC
remote monitoring - can setup on unique cloud, own network to connect to bridge from anywhere, know who is in or out of system, grant control, etc. OEMs use this to save money sending staff on-site
relay systems - will only look at PLC that relay is connected to. Need feedback to device and had to be connected to PLC.
readily available. Automakers don't use AC anymore on control side, so 24V more available. Europe uses more 120V. Lead times an issue with 120V
Likes St Clair design though make it horizontal instead of vertical.
Floor space very important in manufacturing, builds "rack stacks", use horizontal design that can be stacked up to 3 high for power units, could use rack design for pump motor group that are modular. Could make this easier to apply to multiple bridges. Would have to hook up lines for same pump motor group. Works well in industrial world

Grosselle Free Operator (Not MDOT owned)

NAME	EMAIL	POSITION
Jeff Thornton	jthornton121@hotmail.com	Grosselle Free Bridge - Operator
269-519-0900		Not an MDOT Bridge - Wayne County

ATTENDEES Jonathan Kohler, Paul Jakubicki, Korinda Windelmann, Jeff Thornton, Jennifer Bernardin

NUMBER	QUESTION	ANSWER
1	Are Operations & Maintenance (O&M) manuals available on site for each bridge? (Please skip to question 9 if not available)	Jeff - Wayne county provided one and we have our own. Not an official trouble shooting manual. One sheet of paper that gives step by step instructions
3	Have the O&M manuals been helpful during troubleshooting operations to resolve malfunctions?	One page step by step instructions
4	Please provide an example of a recent implementation of troubleshooting measures from the O&M manuals, or when they are most typically referenced.	Typical protocol if malfunction. Jeff call David Miller Supervisor and he would send someone out immediately. Major Emergency contact police dept and coast guard if can't open for boat traffic. Do trial and error but if doesn't budge call immediately.
6	Does maintenance follow a formal, regularly scheduled preventative maintenance program for each bridge?	Do not reach out to Sean and Mike if need assistance from crews/This bridge is handled through Wayne County, one of the metro area bridges.

GENERAL NOTES

25 minutes to arrive. Contacts have changed over the years and sometimes call the coast guard. Currently calling coast

2-3 a month have to call for issues. Center wedge malfunction a couple days ago. Not able to open bride for 24 hours managers fixed the next day. Coast guard put out announcement. One of the issues that is could have been a limit switch. Once of the gears moved a quarter inch and cause to continuously spin. Gear was on the main drive. Also told a limit switch during the conversation. It is really quiet now but before was really loud. Value added repair.

County team that does regular scheduled main or local main - Jeff not allowed to do maintenance just janitorial. Wayne comes once week to do general inspections. Doing inspection on fixed span today. March 15-December 15 shut down for the winter.

Only custodial spare parts on site, county does not stock any common failure items.

Typical 6 minutes to open and close - typically 30 minutes. Otherwise notify ER services.

Local detour route is toll bridge, privately own. Charges 4 dollars one way. Traffic detour costs money - 13 minutes north of area. Top side of island.

Troubleshooting center wedge issue.

Jeff - switches only. Electrical and hand brake on the floor for the brake system. Deadman switch. All electrical no hydrologic.

Swing bridge - how difficult to align the end up for traffic. Takes some time but get better with practice. Two wheels and come in real slow and pop into the two wheels, there is an indication in the electrical that clicks so you know your fully closed and there is something that helps to get fully open.

Limit switches are most of troubles and malfunctions. End Wind that blew in 2019 mechanically. 95 percent of the time electrical issues

Pedestrian traffic - all visual and take your time. Go downstairs to see the blind spots. Check for peds or boats. One time there was a kid beneath the gate so used handheld speaker to tell kid to get out.

No remotely log in.

Not one of MDOT Bridges but dwgs would be helpful. Need from county and vintage and all relay and drum control switch but nothing technology wise to help make improvements. No back up generators

Request copy of daily sheets or whatever is turned in. Log was started last year. Korinda will get them for the Wayne County bridges on malfunctions and location specific for limit switches for example.

There is a camera under bridge that doesn't work all the time.

Korinda - when the big overhauls and maintenance occurs there is no advance warning. Last time we had to put all of our people on unemployment. Jeff tries to keep up locally on websites what is going on but better communication from Wayne county is needed.

Operators participate in remote trouble shooting like face time or real time - something that would be a consideration as an improvement for something to do.

Appendix B: Traffic Detours

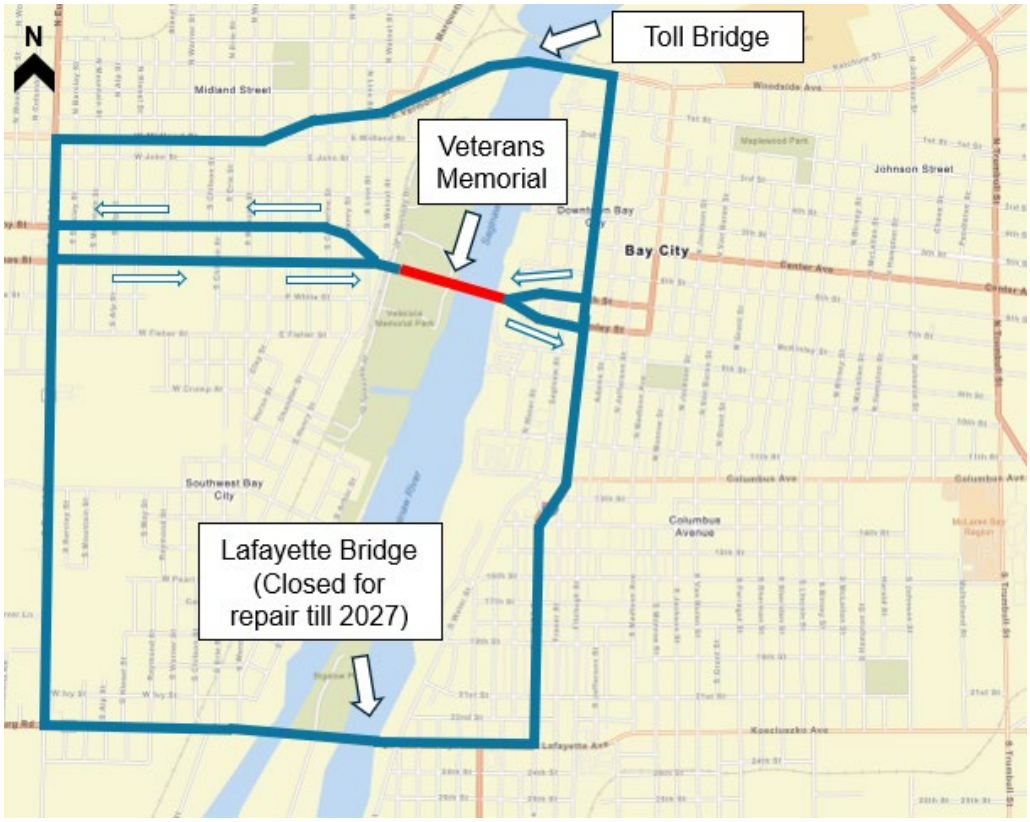

Figure 6: Detour Map for Veterans Memorial Bridge

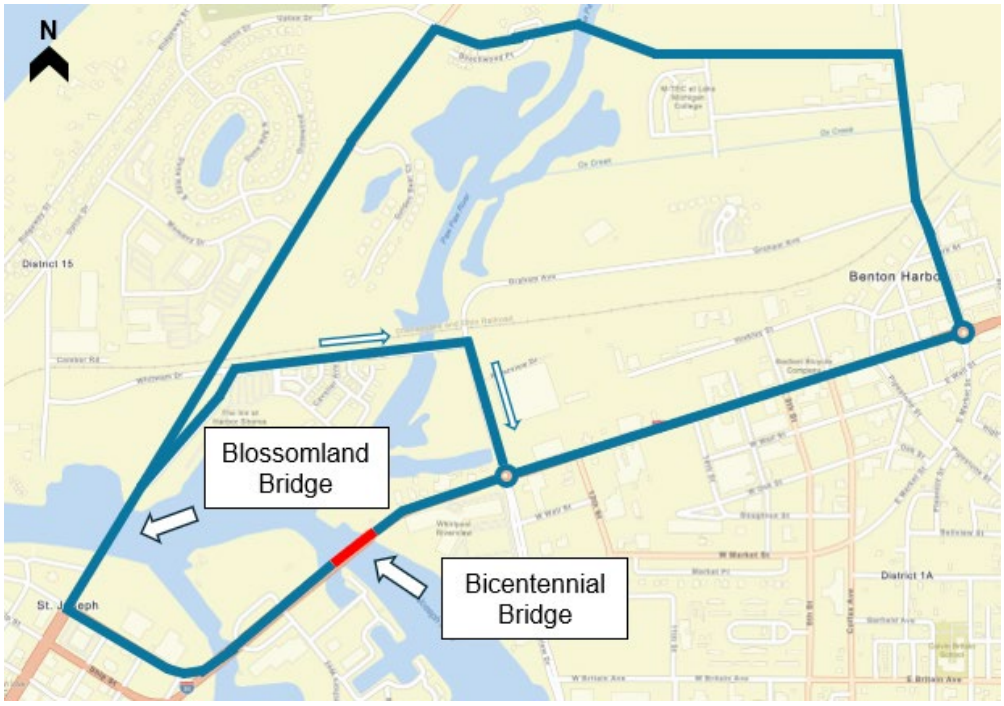

Figure 7: Detour Map for Bicentennial Bridge

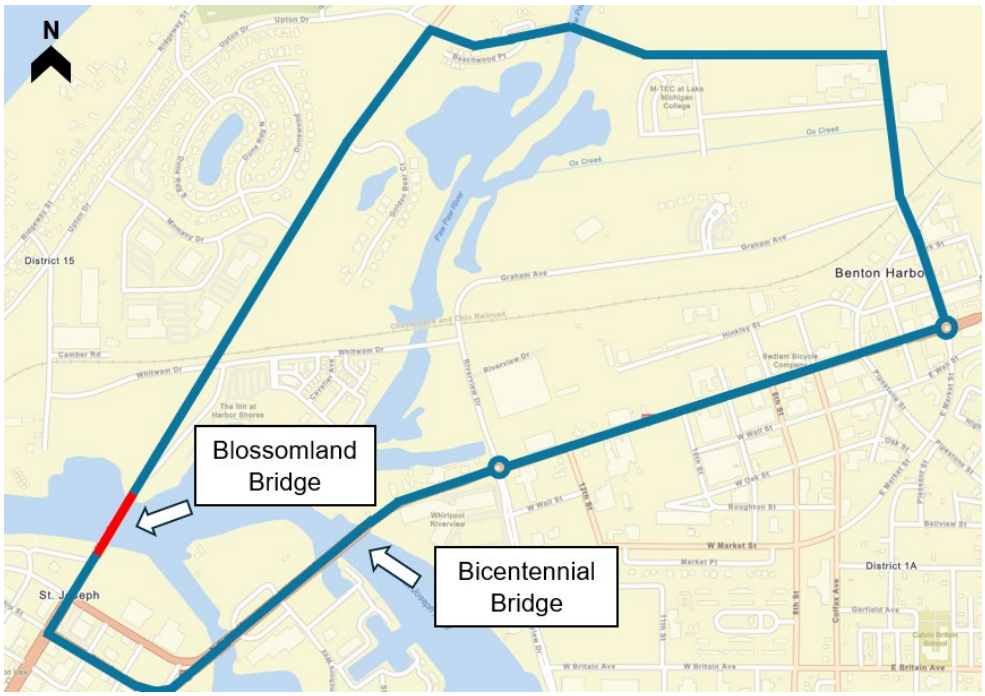

Figure 8: Detour Map for Blossomland Bridge

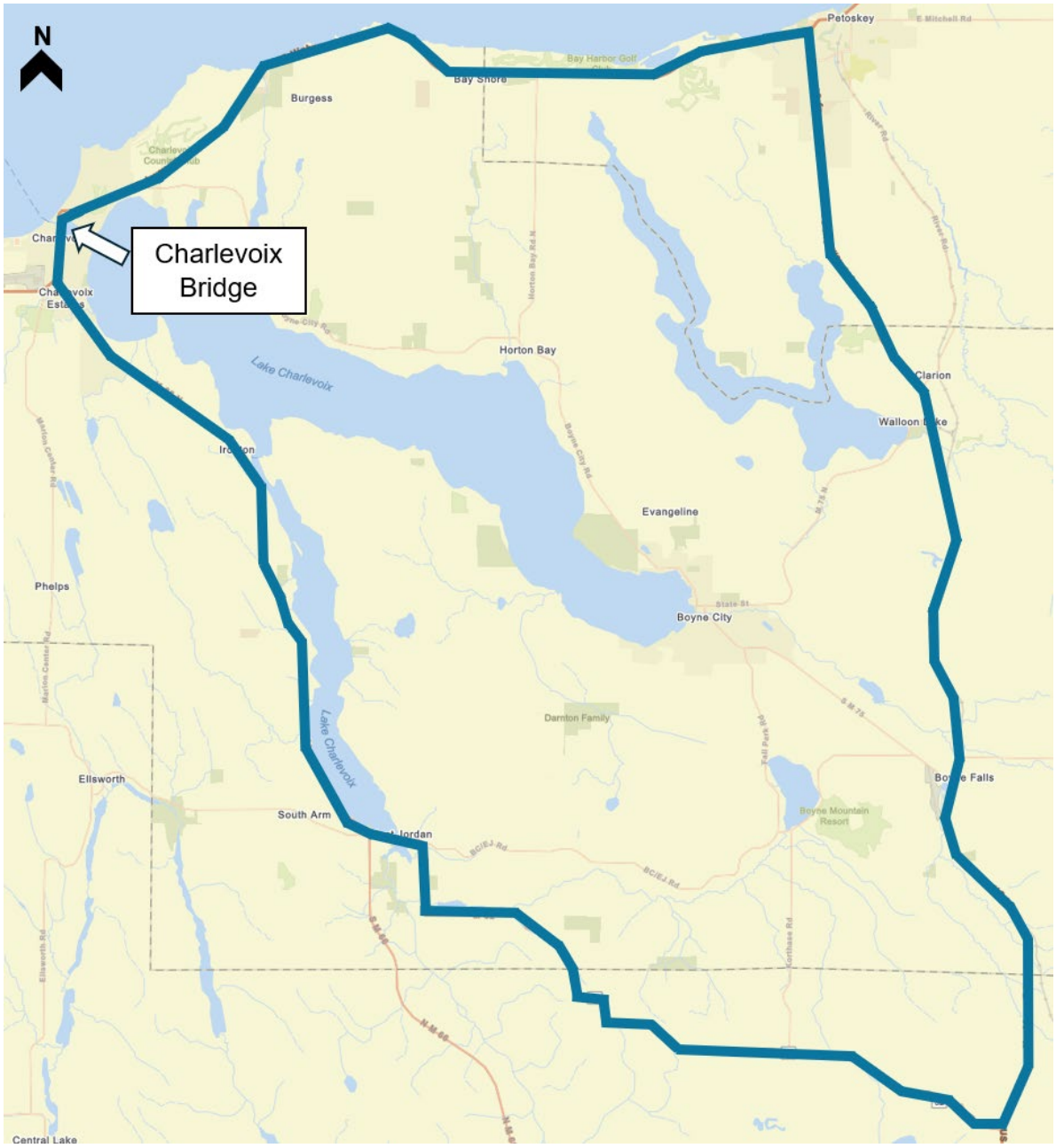

Figure 9: Detour Map for Charlevoix Bridge

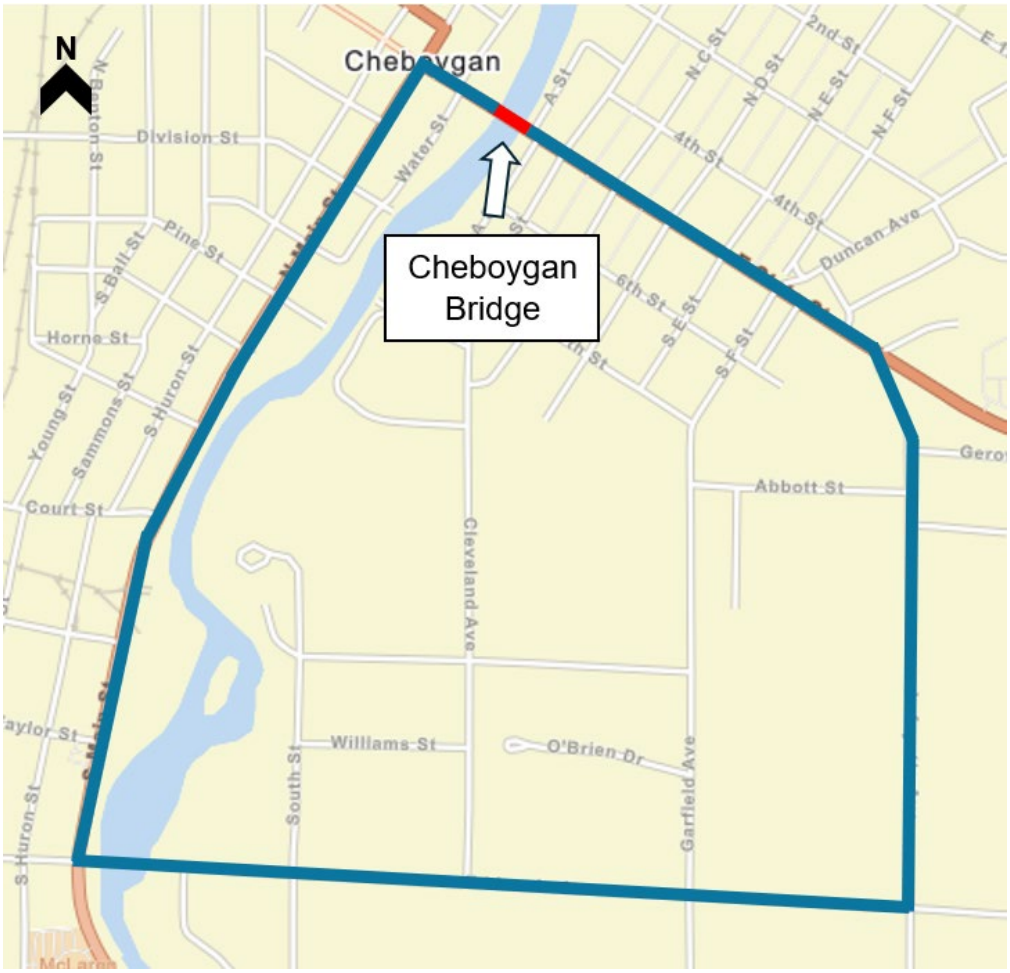

Figure 10: Detour Map for Cheboygan Bridge

Figure 11: No detour available for the Portage Lake Bridge

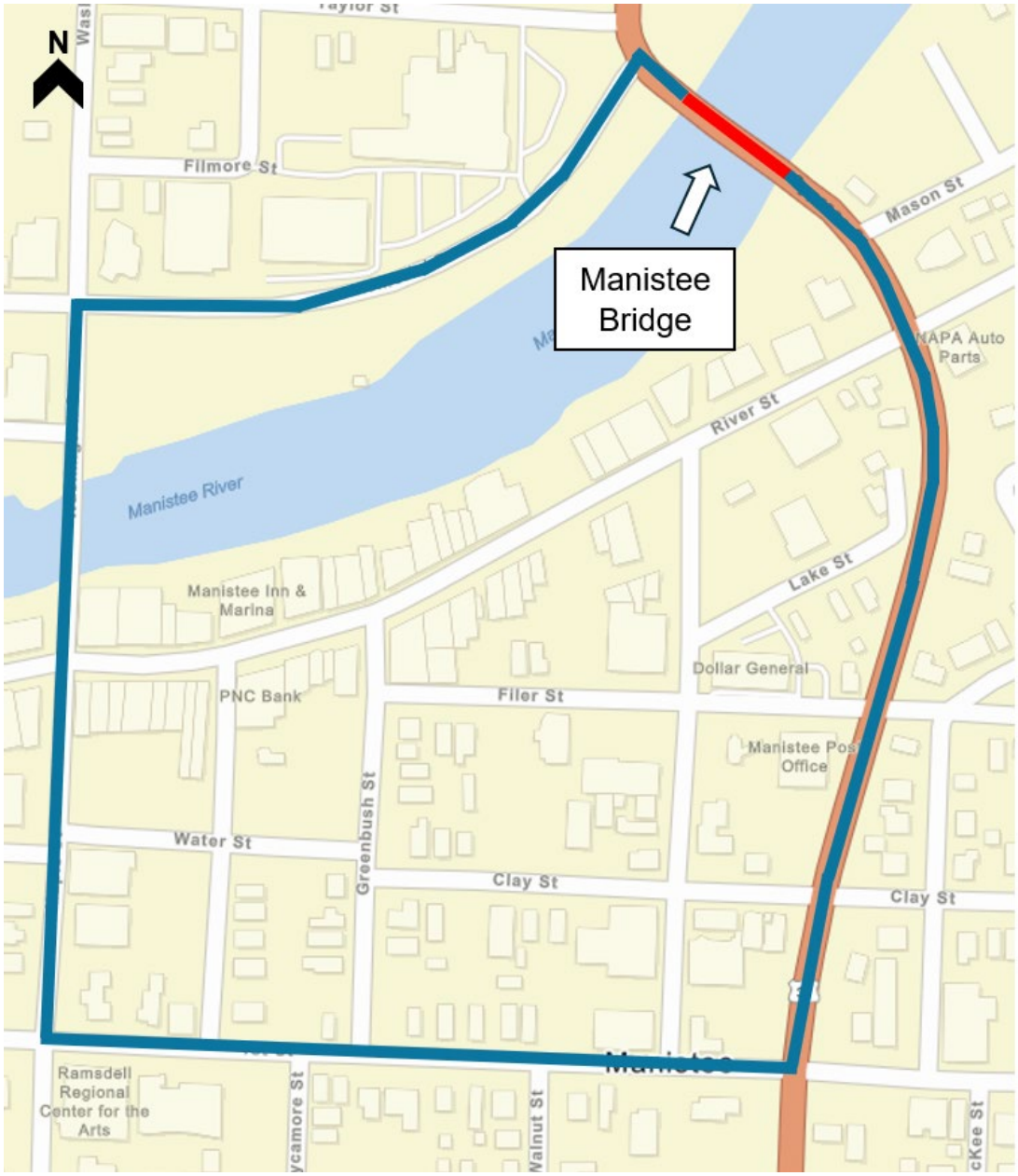

Figure 12: Detour Map for Manistee Bridge

Figure 13: Detour Map for Grand Haven Bridge

Figure 14: Detour Map for Military Street Bridge

Figure 15: Detour Map for St. Clair Bridge

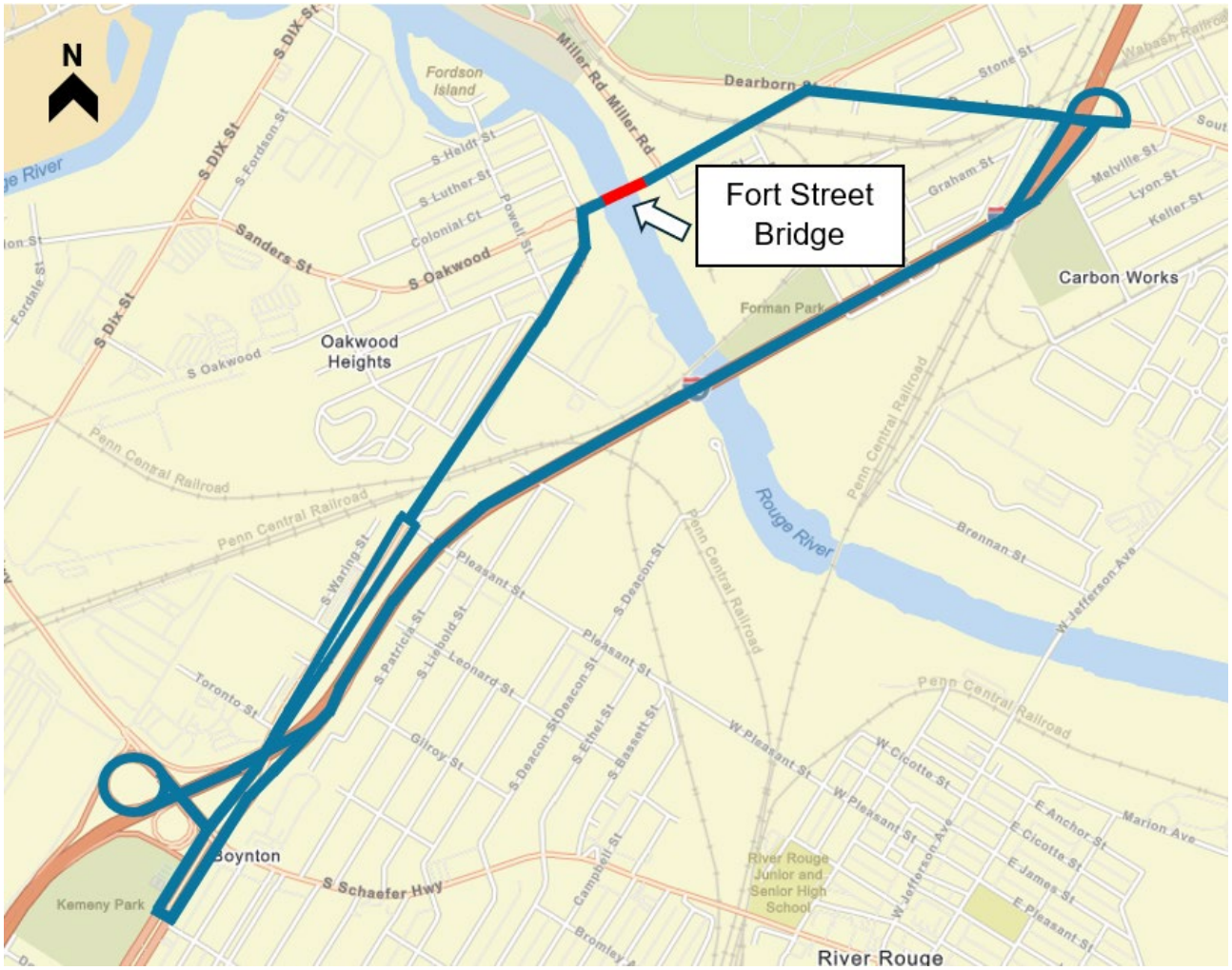

Figure 16: Detour Map of Fort Street Bridge

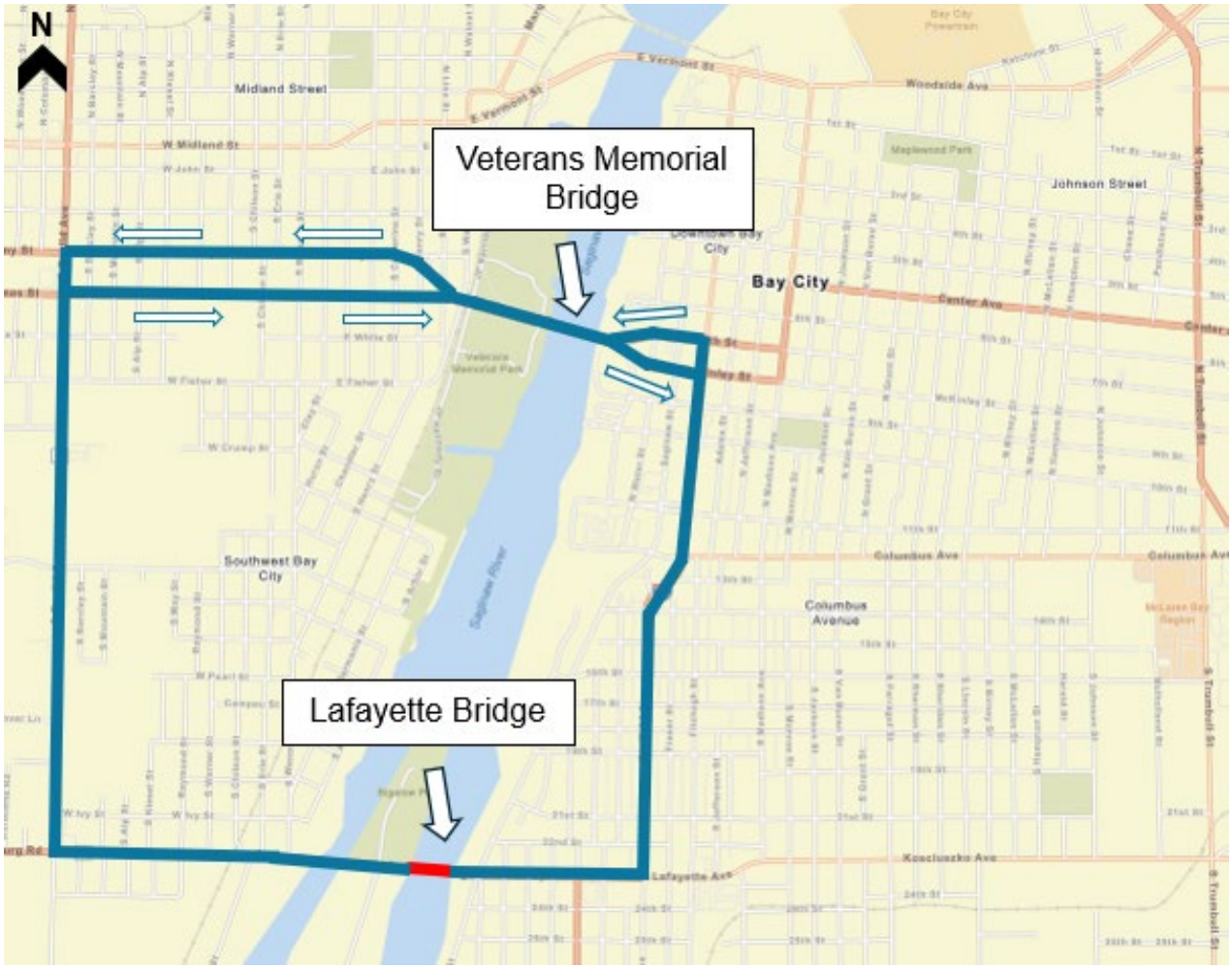

Figure 17: Detour Map for Lafayette Bridge

Appendix C: Maintenance Schedule Templates

Maintenance Schedules:

The following maintenance schedules are generic maintenance schedules intended to identify the minimum equipment that requires preventative maintenance. Due to each bridge being unique, each bridge should have its own maintenance schedule and checklist tailored to its specific equipment. The maintenance schedule and checklist should also be updated annually with additional items that may be identified as other maintenance is performed or issues arise.

Electronic maintenance schedules should be considered to help ensure that proper maintenance is being performed. Electronic maintenance schedules can also alert staff of upcoming preventative maintenance tasks or those that are overdue.

Sample Mechanical Maintenance Schedule

	Equipment and Inspection Item	Weekly	Biweekly	3 Months	6 Months	Monthly	Annual	2-3 Years	5 years	As-Needed
1	**Open Gear Sets (May be adjusted based on operation)**									
	Visual Inspection					X				
	Lubrication (May be adjusted based on operation)	X								
2	**Gear Reducers**									
	Visual Inspection					X				
	Oil Change					X			X	
	Seals									X
3	**Bearing Lubrication**									
	Visual Inspection					X				
	Plain Bearings (May be adjusted based on operation)		X							
	Roller Bearings (May be adjusted based on operation)						X			
	Flush Plain Bearing Grease Grooves							X		
4	**Couplings**									
	Visual Inspection					X				
	Lubrication (May be adjusted based on operation)							X		
	Seals									X
5	**Track and Tread**									
	Visual Inspection					X				
	Coat for Corrosion Protection (Dry Moly)					X				
6	**Generator**									
	Oil Change						X			
	Coolant Change								X	
	Replace Battery									X
7	**Span Locks / Tail Locks**									
	Visual Inspection					X				
	Guides/Receivers		X							
8	**Hydraulic Power Unit**									
	Visual Inspection					X				
	Filters						X			X
	Hydraulic Fluid							X		
9	**Hydraulic Hoses**									
	Visual Inspection					X				
	Replace Hoses								X	
10	**Hydraulic Hard Lines**									
	Visual Inspection					X				
11	**Hydraulic Cylinders / Motors**									
	Visual Inspection					X				
	Seals									X

Sample Electrical and Control System Maintenance Schedule

	Equipment and Inspection Item	Per Visit	Monthly	3 Months	6 Months	Annual	2-3 Years	5 years	As-Needed
1	**Emergency Lighting**								
	Operational Test	X							
	Functional Test					X			
2	**Lighting - Non-Emergency**								
	Functional Test	X							
3	**Generator/ATS**								
	Visual Inspection		X						
	Operational Test - Transfer and Operate under Load		X						
	Generator Oil/Fluid		X						
	Preventative Maintenance					X			
4	**Panelboards**								
	Visual Inspection					X			
	Infrared Scan					X			
5	**Transformers**								
	Visual Inspection					X			
	Infrared Scan					X			
6	**Circuit Breakers**								
	Infrared Scan					X			
	Manual/Hand Operation						X		
	Preventative Maintenance						X		
	Test Critical Circuit Breakers							X	
7	**Fuses**								
	Remove and Visually Inspction					X			
8	**Grounding/Bonding**								
	Visual Inspection					X			
9	**Disconnect**								
	Visual Inspection					X			
	Infrared Test					X			
10	**Motors/Brakes**								
	Visual Inspection					X			
	Operational Testing	X							
	Insulation Test					X			
	Infrared Scan					X			
	Brake Hand Release Testing					X			
11	**Motor Starters**								
	Visual Inspection					X			
	Operational Testing	X							
	Infrared Scan					X			
	Overloads - Review Settings						X		
12	**Traffic/Barrier Gates**								
	Visual Inspection	X							
	Operational Testing	X							
	Control Panel Inspection					X			
13	**Control System**								
	Operational Test - Normal Operations	X							
	Limit Switch Inspection					X			
	Auxiliary Control System - Functional Test					X			
	Bypass Functionality Testing					X			
	UPS - Capacity Test					X			
	UPS - Infrared Scan					X			
	Lever Arm & Prox. Limit Switches - Visual Inspection	X							
	Lever Arm & Prox. Limit Switches - Operational Test	X							
	Lever Arm & Prox. Limit Switches - Manual/Hand Test					X			
	Rotary Cam Limit Switches - Visual Inspection		X						
	Rotary Cam Limit Switches - Operational Test	X							
	Control Desk/Pilot Devices - Visual Inspection	X							
	Control Desk/Pilot Devices - Operational Test	X							
	Control Panels - Visual Inspection		X						
	Control Panels - Loose Terminations					X			
	Control Panel - Infrared Scan					X			
	PLC/HMI - Visual Inspection	X							
	PLC/HMI - Operational Testing	X							
	Interlock Testing							X	

	Hydraulic Valves - Visual Inspection	X							
	Hydraulic Valves - Operational Test	X							
	Conduit								
14	Visual Inspection					X			
	Conductors								
	Visual Inspection					X			
15	Loose Connections at Terminal Blocks					X			
	Infrared Scan at Termination Points					X			
	Insulation Test Spare Submarine/Aerial Cables					X			
	Navigation and Pier Lights								
16	Visual Inspection	X							
	Operational Test	X							
	Maintenance Schedule/Checklist								
17	Review for Completeness					X			
	Update for additional equipment					X			

Appendix D: Product Specifications

A PDF for IO-Link design guideline can be found at this link:

IO-Link_Design_Guideline_eng_2018.pdf

A PDF for IO-Link Interface and System can be found at this link:

IO-Link Interface and System Specification

Appendix E: Emergency Action Plan Template

_____ Action Plan

Updated: XX/XX/XXXX

Update Accordingly to Personnel and Bridge Specific Information

Contents

Timeline of Incident (Duration of Stopped Traffic)

- 0-XX minutes: Incident Identified
- X-XX minutes:
- Once incident is cleared/solved:

Bridge House Operator Communication Responsibilities

Prior to all bridge openings:

During/After Non-Incident Openings:

During Incident Openings:

- Proceed to go through the Operator Emergency Call List
- After event is cleared and traffic resumes, follow-up with a summary of the incident to _____ (via phone or email)

Bridge House Operator Emergency Call List

Start contacting these people below. Calling continues until contact is made.

1. MDOT Electrician- Shawn Wigent
   Cell: 517-614-1728

2. MDOT Electrician-
   Cell:

3. MDOT Region Maintenance-
   Cell:

4. TSC Operations Engineer-
   Cell:

5. Local Police
   General: 911

6. United States Coast Guard
   General:

Bridge House Operator Reminders

Master Contact List

Michigan Department of Transportation

Bridge Operator House – Office:

WMTOC:

TSC:

Police/Fire/Emergency - 911

United States Coast Guard

Coast Guard Station _____
Office:

City of _____

Director of Public Safety
Name:
Position:
Work:
Cell:

Local Fire Department – Office:

County of _____

Sherriffs Office – Office:
Road Commission:

Hospitals

Schools

Contractors/Other Useful Resources

Appendix F: Cost Estimates

General Cost Estimate

Estimates are based on the conceptual scope of work. These estimates should be considered a rough order of magnitude, with cost fluctuations expected between -50% to +100%. Budgets include equipment and labor estimates and are established using 2025 dollars with no escalation included.

Recommendation to Improve Reliability	Cost
Communication and Emergency Action Plan development – Cost is on a per bridge basis. As more bridges are done the cost will likely go down.	$10,000
Develop an electronic maintenance and inventory program for Mechanical and Electrical Equipment	$100,000
Develop Design Guidelines	$125,000

Electrical Cost Estimate

Estimates are based on the conceptual scope of work. These estimates should be considered a rough order of magnitude, with cost fluctuations expected between -50% to +100%. Budgets include equipment and labor estimates and are established using 2025 dollars with no escalation included.

Recommendation to Improve Reliability	Cost
Backup Equipment Testing – Testing should be done during preventative maintenance tasks	N/A
Update all as-built drawings, specifically electrical schematics – Costs are on a per bridge basis	$8,000
Scan all as-builts (schematics) and O&M Manuals into MiBRIDGE	$25,000
Develop a pilot project for enhanced PLC and HMI diagnostics. Pilot project includes increased limit switch and pilot device monitoring (push buttons, selector switches) and ethernet connected motor starters. Suggested bridges for the pilot project are the Lafayette Bridge or the Portage Lake Bridge due to the impending control system installation and/or design.	$250,000

Recommendation to Improve Reliability	Cost
Implement remote monitoring/access for the PLC controlled bridges (Veterans Memorial, Bicentennial, Portage Lake, Grand Haven, Military St. and Lafayette) – Costs include internet/telecommunication access at the bridge only, programming modifications, and remote server for data logging. Cybersecurity costs are not included due to coordination needed with DTMB.	$75,000 per bridge + $100,000 for remote server
Develop and initiate pilot project for IO-Link. It is suggested that the Military Street Bridge be selected for the pilot project due to the use of redundant equipment.	$150,000
Monitor the failure rate and effectiveness of proximity type limit switches that will be used at the new Lafayette Bridge.	$10,000
Inventory and procure spare equipment – Cost assumes equipment procurement is limited to relays, limit switches and spare PLC cards	$100,000
Install a PLC control system to allow for additional monitoring and troubleshooting capabilities at the relay-controlled bridges (Blossomland, Charlevoix, Cheboygan, Manistee, St. Clair and Fort Street). Costs are on a per bridge basis and include enhanced PLC diagnostics and remote monitoring/access.	$1,000,0000 - $1,500,000

Mechanical Cost Estimate

The total mechanical cost estimate is $20,000 which considers priority, contract work, and capital maintenance as are itemized below.

Recommendation to Improve Reliability (Priority)	Quantity (LS)	Cost
Adjust the near span SE motor brake torque	1	$2,500

Recommendation to Improve Reliability (Contract Work)	Quantity (LS)	Cost
Adjust the thrust gap at the NE B2 bearing thrust collar	1	$12,000

Recommendation to Improve Reliability (Capital Maintenance)	Quantity (LS)	Cost
Adjust the north emergency brake hand release position such that the cam does not come off the limit switch when hand release is fully rotated to release brake. Replace the hydraulic oil in the South HPU unit.	1	$1,000
Apply dry moly to the track and treads to prevent further corrosion.	1	$500
Clean and paint NE emergency brake shaft.	1	$1,250
Clean and touch up paint all span lock actuators where there is chipped paint and corrosion.	1	$2,750