East Alburgh Swing Span Automation: Modernizing a 100-year-old Movable Bridge

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Word Count = 2,253

ABSTRACT

This paper is a case history on the automation of a 100-year-old movable bridge, and a performance review in the two years since it has been in service. The swing span is part of the East Alburgh Trestle, a 3,800-ft-long wood railroad trestle on Lake Champlain in northwestern, Vermont. The bridge is owned and operated by the New England Central Railroad, a Genesee & Wyoming-owned shortline. Prior to automation in 2011, a bridge tender operated the bridge manually with a hand crank. The swing span automation involved the controls and mechanical equipment so that the railroad dispatcher can open and close the swing span remotely from St. Albans, Vermont. The opening process requires the release of the miter rails and retraction of the wedge bearings, prior to the rotation of the 102-ft-long steel thru-girder bridge. The closing process is just the opposite with the final steps being the extension of the alignment device just prior to the engagement of the miter rails followed by the retraction of the alignment device. The automation is a complex system of navigation warning lights, horns, marine vessel messages, video cameras, timers, relay switches, limit switches, actuating motors, turning motors, braking mechanisms, alignment devices, submarine cables, backup power with automatic transfer switches, and other components.
BACKGROUND

Project Location

The swing span bridge is part of the East Alburgh Trestle at milepost 15.4 of the Swanton Subdivision on the New England Central Railroad (Reporting Mark: NECR), a shortline railroad owned by the Genesee & Wyoming. The east-west aligned trestle crosses the northeastern end of Lake Champlain between the towns of Alburgh and Swanton, Vermont (Figure 1). Lake Champlain is classified as navigable waters which requires unimpeded access through the trestle. The navigable waters are mostly utilized by recreational boaters, US Coast Guard, and US Border Patrol. The bridge is located about 3 miles from the US-Canadian border.
Bridge History & Construction

The swing span was designed and constructed by the Pennsylvania Steel Company of Steelton, PA in 1912. The railroad owner at that time was the Central Vermont Railway (CV) which connected Montreal to New London, CT. The 102-foot-long swing span bridge (overall length) was designed and constructed as a typical through girder construction for Cooper E-50 loads. It is located approximately midway through the 3,800-linear-foot-long wood trestle (Figure 2). The swing span was built to be manually operated with a hand crank inserted through the bridge deck (Figure 3).

The center support bears on a wood-cribbed stone-filled pier. The abutments consist of timber bents on friction piles supported in the lake-bottom sediments. The construction drawings indicate that the piles are founded in silt and clay with a probable “rock bottom” at the bridge. However, the adjacent piles were driven to between 1 and 4 inches of penetration over the last hammer strike of driving, apparently in the clay layer. (Note: This unusually soft foundation support speaks to the concern for stiffness of the trestle foundation at the approaches to the movable bridge. This condition is a concern for the reliable performance of the bridge over hundreds of open/close cycles.)
How the Automation Works

The swing span automation provides the controls and mechanical equipment so that the railroad dispatcher can open and close the swing span remotely from St. Albans, Vermont. The opening process requires the release of the miter rails and retraction of the wedge bearings, prior to the rotation of the 102-ft-long steel thru-girder bridge. The closing process is just the opposite with the final steps being the extension of the alignment device just prior to the engagement of the miter rails followed by the retraction of the alignment device. The automation is a complex system of navigation warning lights, horns, marine vessel messages, video cameras, timers, relay switches, limit switches, actuating motors, turning motors, braking mechanisms, alignment devices, submarine cables, backup power with automatic transfer switches, and other components.

The NECR Dispatcher receives status information on the bridge position and movements. A cam switch provides four indications on the bridge position status: 1) Bridge Open (lined with channel), 2) Bridge Partly Open (on way to open), 3) Bridge Closed (lined with track), and 4) Bridge Partly Closed (on way to closure)
Once the bridge is lined with the tracks, the miter rails are engaged, and the alignment devices are retracted which triggers a limit switch causing the system to send the Dispatcher a notification that the bridge is in position and ready for trains. The last step prior to allowing trains to pass is for the Dispatcher to visually verify the bridge alignment using the surveillance cameras.

**Engineering**

Engineering was provided by HDR Engineering of Newark, NJ under contract to Rail America, the parent company of NECR prior to the acquisition by Genesee & Wyoming in July 2012.

**Project Funding**

The project was funded by a $1.78M grant from the US Department of Transportation. The purpose of the grant was to “improve railroad efficiency and allow more commercial and recreational traffic on the channel” by reducing the response time for opening and closing the bridge.

**CONSTRUCTION**

**Project Duration**

The original project scope was constructed over two construction seasons; from August 2010 to November 2011. During that time, Lake Champlain experienced a record high level of El. 103.19 feet above mean sea level, which had several negative effects on the project.

Much of the gear reconditioning work was done during the winter months when the swing span movements were not required. Ice typically forms in this area of Lake Champlain as early as December and might last until early April.

**Scope of Work**

The automation is a complex system of navigation warning lights, horns, marine vessel messages, video cameras, timers, relay switches, limit switches, actuating motors, turning motors, braking mechanisms, alignment devices, submarine cables, backup power with automatic transfer switches, and other components.
The scope of work included numerous items related to the automation and other ancillary improvements:

- **Reconditioning of Gearing & Other Components** – The main ring gear (Figure 4) and the bearing were removed and reconditioned by a specialty machine shop. The casters were inspected, cleaned, and reused.

  ![Figure 4 - Reconditioned Ring Gear and Casters](image)

- **Additional Steel Framing** – The motor mounts, bumpers, and control house platform all required structural steel framing modification to the bridge and the adjacent area for the platform.

- **Linear Actuator & Motor Drives** – The swing span rotation is driven by a 5 hp DC variable speed motor. The wedge bearing are driven by a DC motor. The alignment device and miter rail movements are each driven by individual linear actuators powered by DC motors.
• Limit Switches – Wedge bearings and other moveable components were fitted up with limit switches to verify proper alignment. The wedge bearings (Figure 5) are wedge-shaped to allow for easy engagement and retraction during the transition from a simple span bridge to a center-supported span on a rotary bearing, ring gear, and caster system.

![Wedge Bearings](image)

Figure 5 - Wedge Bearings

• Miter Rails – New miter rails were installed on each end of the bridge with automation to retract and engage as the bridge was opened and closed (Figure 6).

• Controls and the Control Building – The control system involves a series of relay switches and switch cabinets (Figures 7 and 8). The opening and closing is initiated remotely by the railroad dispatcher. The controls and power from the control house to the bridge were transmitted through a heavy-duty armored submarine cable.
Figure 6 - Automated Miter Rail and Alignment Device in Foreground

Figure 7 - Relay Switch Cabinet
• Power and Backup Power – The project required an upgraded electrical service and backup power which consists of a 35 kw LPG generator located on the west shore, about 2,000 feet away from the control building.

• Security & Notification Systems – Part of the Coast Guard permitting to authorize the project was to provide appropriate navigation signage and alert horn to warn boaters that the bridge will move, and to provide contact information to request a bridge opening.

• Repairs to the Historic Tender House & Cribbing – The tender house (Figure 9) was built at about the time of the original bridge construction. The house had not been occupied for several decades and has been most recently used for storage. The project included extensive repairs to the timber crib foundation which had deteriorated from the 100 years of weathering.
TECHNICAL CHALLENGES DURING CONSTRUCTION

Abutments on Non-Rigid Foundations

As indicated above, the piles at the abutments appear to be fairly well founded on a firm bearing stratum, possibly rock. Fortunately, these piles are significantly better than the adjacent piles which advanced up to 4 inches in the final hammer strike during driving. We confirmed the relative rigidity of the combined pile and bent system by measurements from a loaded train. Total vertical displacement under live load was on the order of 3/16 inches. Therefore an early concern that the bridge would constantly require adjustment for a non-rigid abutment became a non-issue.

Control Logic & Programming

Control logic and programming for complex systems with numerous field parameters always seems to require field adjustments to actual conditions. This project included the typical trouble shooting.
Regulatory

Turtles and mussels were both an environmental concern. One of the few habitats on Lake Champlain for the threatened spiny soft-shell happens be in this area. Therefore, our work in the water was restricted during their 6-month-long hibernation period. Several species of endangered and threatened mussels were also a concern which necessitated a biology survey of the channel bottom where the submarine cable was installed. Fortunately none of the species of concern were encountered.

Working on Active Railroad

Railroad projects frequently involve scheduling the activities around railroad operations, and this project was no exception. The typical daily traffic consisted of one Canadian National freight train going to and returning from the NECR Yard in Saint Albans, about 10 miles south. The international border and language barriers (French) sometimes challenged our ability to be productive with minimum wait periods.

Working on Lake Champlain

Lake Champlain experiences fairly extreme weather from strong gusty wind to sub-zero temperatures (Figure 10). As indicated above, some of the work occurred in the winter when the swing span could be closed (lined with track and locked into position). Conditions during the winter can reach -20 degrees Fahrenheit. However, despite the frigid winter temperatures, the wind was the biggest weather factor in working safely and was the cause of the several canceled work days.
PERFORMANCE

Reliability

The electronics and motors have generally proven to be reliable through the 3 years of service since installation. The exception are the 5 linear actuators, of which 4 have been replaced on the miter rails. We believe that these failures were caused by the relatively high stress conditions the loaded miter rail system imparts back onto the relatively light-duty motors.

Thermal Expansion & Contraction Issues

The challenges have mostly revolved around the thermal expansion and contraction of the rail caused by the over 100 degree Fahrenheit temperature cycles. This problem is aggravated by the 3,800-foot-length of the trestle, which offers only limited longitudinal restraint due to the rather soft lateral pile flexibility. Despite the allowable travel of 3
inches for each miter joint, it became necessary to further accommodate the rail movements with expansion rail devices at each end of the bridge (Figure 11) which each allow for an addition travel of 30 inches.

![Figure 11 - Crew Installing Expansion Joints](image)

A further aggravation of these rail movements is due to the primary north-to-south direction (actually west to east if reference is the trestle) of loaded freight cars which does not allow for the rail movements to readily come back to a neutral position.

**SUMMARY AND CONCLUSIONS**

The project has been very successful, despite the lingering challenges with the thermal expansion and contraction issues. During the recreational boating season, the bridge is kept open to the channel except to accommodate occasional train traffic. Beyond the boating season, the bridge is lined with the tracks and can be open by notifying the railroad dispatcher in accordance with the posted message. All of these bridge movements occur quickly and remotely by the railroad dispatcher. The new system also provides more rapid responses to Coast Guard and Border Patrol needs.
ACKNOWLEDGEMENTS

- To the ECI employees who worked under difficult weather conditions in the winter and with an incredible number of spiders under the bridge in the nicer weather.

- To numerous suppliers and vendors who supported this project and provided their expertise to make it successful.

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Project Team

• Owner/Rail Operator:
  – New England Central Railroad

• Contractor:
  – Engineers Construction, Inc.

• Engineer:
  – HDR Engineering

Construction Schedule & Funding

• Construction from August 2010 to November 2011

• Partly Funded with a $1.78M Grant from the US Department of Transportation

Background

Need for Automation of Bridge Operation:

– Improve Efficiency
– Encourage Freight by Rail; International Commerce
– Reduce Delays to Boaters through the Navigable Waters

1912 – A Brief History Lesson

• President Howard Taft
• RMS Titanic Sinks
• Fenway Park Opens
• Boston Red Sox World Series Champs (8 games)
• Stockholm Olympics (including Tug-of-War & Art)
• Construction starts on East Alburgh Swing Span

Project Location

• Northwestern Vermont
• Lake Champlain
• 3 Miles from Canada

Project Location: 1907 USGS Map
Aerial Photo Looking North: Sept 2012

The Trestle
- 3,800-ft-long
- Connect East Alburgh to Swanton, VT
- Swing Span at Approximate Middle

Swing Span - Jan 2011

Bridge Supports
- Swing Mode
  - Center Bearing
  - Casters on Ring Gear
- RR Traffic Mode
  - Six Wedge Bearings

Wedge Bearings
Wedge Shaped Bearings:
- Lift load off center bearing & casters when engaged
- Easy engagement and retraction.

Swing Span Rotation
- Center Bearing
- Casters on Ring Gear
How the Automation Works

- Remote Opening/Closing by RR Dispatcher
  - Opening:
    - Release of Miter Rail & Retraction of Wedges
    - Rotation of Bridge to Channel Alignment
  - Closing:
    - Rotation of Bridge to Track Alignment
    - Extension of Alignment Device
    - Closing of Miter Rail & Extension of Wedges

Open/Close Schedule

- During Recreational Boating Season:
  - Normally Aligned with Channel for Navigation
  - Aligned with Tracks for Train Movements
- After/Before Boating Season
  - Open by Request

Safety Mechanisms

- Dispatcher Receives Status Information on Bridge Position & Movements:
  - Cam Switch Provides Position Status
  - Limit Switches Indicate Alignment Devices Retracted
  - Visual Verification with Surveillance Cameras

New & Rehab Features for Automation

- Reconditioning of Gearing & Casters
- Add’l Steel Framing in Bridge & Control Platform
- Linear Actuator & Motor Drives
- Limit Switches to Verify Proper Alignment

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Features for Automation – Cont.

- Miter Rails for Detaching the Rail
- Controls & Control Buildings
- Power & Backup Power
- Security
- Navigation Notification Systems
- Repair to Historic Tender House

Reconditioned Center Bearing & Casters

Reconditioned Components

Miter Rails & Alignment Devices

Control House on New Steel Framing

Historic Tender House
Navigation Signage & Lighting

Submarine Control Cable

Controls & Relay Cabinets

Project Challenges

- Control & Logic Programming – Typical for Complex Systems

Project Challenges

- Regulatory – Endangered & Threatened Species of Mussels & Turtles

Project Challenges

- Working on Lake Champlain:
  - Marine Construction
  - High Winds
  - Cold Winter Temperatures
Unexpected Project Challenges

- Working on Lake Champlain:
  - Record High Lake Level
  - El. 103.19

Project Challenges

- Working in Cramped Quarters

Performance – Since 2011 Completion

- Reliability:
  - Electronics & DC Motors Generally Performed Well
  - 4 of 5 Linear Actuators have been Replaced
    - Recommend Heavy Duty Components

Thermal Expansion & Contraction Fix

- Two Pair of Expansion Rail Devices
- 30 inches of Allowable Travel for each Device
Expansion Rail

Summary

• Successful Project
• Improved Boating Access
  – Recreational Boaters
  – USCG & Border Patrol
• More Efficient Rail Traffic
• Reduced Operation Costs

Acknowledgements

• Thanks to the following:
  – The ECI Employees who worked under difficult weather conditions.
  – Our suppliers & Vendors who supported this project.

Thanks for Your Attention