The Benjamin Harrison Bridge is a vertical lift bridge. The span on vertical lift bridges is lifted up and down just like an elevator. These bridges have a tower on each end, each of which encloses counterweights that offset the weight of the lift span. There are two main types of vertical lift bridges: Span Driven vertical lift bridges and Tower Driven vertical lift bridges. The Benjamin Harrison Bridge is a “tower-driven vertical lift bridge”, the operating machinery is located at the tops of each tower, with the lift span and counterweights located on either side of the operating drums. A schematic diagram of a tower driven vertical lift bridge is shown below:

1. Lift Span Truss
2. Approach Span Truss
3. Pier (Concrete Support)
4. Tower
5. Counterweight Trunion Bearing (Support)
6. Counterweight Trunion
7. Counterweight Sheave
8. Counterweight Ropes
9. Main Counterweight
10. Span Guide
11. Upper Span Guide
12. Lower Span Guide
13. Centering Bar and Span Lock Socket
14. Span Lock Actuator and Lockbar (Retracted)
15. Air Buffer

Schematic and description from FDOT “Bridge Maintenance Reference Manual”
### Movable Bridges - Major Projects in 30-Year Plan

<table>
<thead>
<tr>
<th>Project Number</th>
<th>Project Description</th>
<th>Start Year in 30-Year Plan</th>
<th>Cost (2018 Dollars)</th>
<th>Reason for Importance/Potential Consequences of Inaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Replace Generator, Wire Rope, Fender Rehabilitation</td>
<td>1</td>
<td>$23M</td>
<td>• Generator: Provides backup power for operation&lt;br&gt;• Wire Rope: Holds truss span aloft during opening&lt;br&gt;• Fender: Risk of vessel impact to piers</td>
</tr>
<tr>
<td>2</td>
<td>Replace Fender and Gates</td>
<td>11</td>
<td>$16M</td>
<td>• Gates: Risk that motorists will attempt to drive on structure during opening&lt;br&gt;• Fender: Risk of vessel impact to piers</td>
</tr>
<tr>
<td>3</td>
<td>Replace Deck</td>
<td>12</td>
<td>$4M</td>
<td>• Damage to the deck could damage car or truck tires, leading to impact to truss or to other vehicles</td>
</tr>
<tr>
<td>4</td>
<td>Replace Span Locks, Closed Circuit Television (CCTV), Machinery</td>
<td>13</td>
<td>$25M</td>
<td>• Span Locks: Risk that trucks will drive over “unlocked” span, overstressing structure&lt;br&gt;• CCTV: Risk of hazardous, overheight, or overweight trucks crossing bridge&lt;br&gt;• Machinery: Required to lift and close bridge</td>
</tr>
<tr>
<td>5</td>
<td>Mechanical Rehabilitation</td>
<td>15</td>
<td>$10M</td>
<td>• Risk that bridge will be unable to open or close. May be stuck in either position</td>
</tr>
<tr>
<td>6</td>
<td>Replacement</td>
<td>21</td>
<td>$182M</td>
<td>• Bridge will have exceeded its 50 year service life by 20 years. Possible design-build project.</td>
</tr>
</tbody>
</table>

**Benjamin Harrison Bridge 30-Year Plan Total in 2018 Dollars** $260M

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**Project #1 - Replace Generator, Wire Rope, Fender Rehabilitation – Start Year 1 in 30-Year Plan**

**B** The generator serves as a backup power source for the bridge’s lift motor. The primary power source is from a power line connected to the power grid. The generator is 54 years old, and their normal service life is 60 years. Photo B shows an example of a new backup generator.

The wire ropes hold up the lift span truss when it is in the elevated position (opened to let vessels through the channel). See element #8 of the schematic to understand the purpose of the wire ropes. A picture is also provided above. A failure of the wire ropes could cause severe damage to the lift span truss and the adjacent towers.

**D&E** Fender systems protect the bridge piers and towers from impacts from barges and other large vessels. Vessel impact can cause catastrophic damage, as occurred on the Benjamin Harrison Bridge in 1977, when the tanker “Marine Floridian” collided with the bridge, causing a section of the bridge to collapse.
Benjamin Harrison Bridge: Route 156 over James River (#1)

Project #2 - Replace Fender and Gates – Start Year 11 in 30-Year Plan

Rehabilitation of the fender system performed in Year 1 as part of Project #1 will stabilize the fenders until they reach the end of their useful life in Year 11, at which time Project #2 will commence. Given the size of the vessels passing under the bridge and the increased frequency of severe storms, a replacement fender system is required to protect the structure.

Project #3 - Replace Deck – Start Year 12 in 30-Year Plan

The lift span of the Benjamin Harrison Bridge has an open grid metal deck that has a limited life. After several decades the steel connections begin to fail progressively, requiring replacement of the deck.

Note that this project could be eliminated entirely if the replacement Project #6 were moved forward to start in Year 12.

Projects #4 & #5 - Replace Span Locks, Closed Circuit Television (CCTV), Machinery, Mechanical Repairs – Start Years 13 and 15 in the 30-Year Plan

Span Locks function in the manner that one would expect: they lock the movable span into place so that it doesn’t move or shift while conveying vehicular traffic. Nonfunctional span locks could lead to significant stress increases to critical structural members. The risk of non-functional span locks is having trucks drive over an “unlocked” span, which could lead to overstressing the structure. They also keep the movable span from incidental lifting that could pose a hazard to vehicles.

A functional CCTV system is critical for security and reduces the risk of hazardous, over-height, or overweight trucks crossing the bridge.

The machinery of movable bridges has a limited service life, as does all machinery.

Note that these projects could be eliminated entirely if the replacement project were moved forward to Year 13.

Project #6 - Replace Bridge – Start Year 21 in 30-Year Plan

As this movable bridge approaches 70 years old, it should be programmed for replacement with a fixed span bridge (non-movable). At this age the maintenance costs will accelerate, and the return on this investment will diminish with each year, as it will have reached the point where replacement will provide the best life-cycle investment. Furthermore, a fixed-span structure would reduce future maintenance and operations costs and risks for decades into the future.

While the bridge is being maintained regularly now, there are certain bridge components that simply will need to be replaced or addressed in a very comprehensive manner by the time the bridge approaches age 70. They include the deck and substructure, see pictures at left. Note also that the bridge’s superstructure (primary support beams and trusses) is fracture-critical, meaning it provides almost no redundancy in the event of a failure of a critical member. The trusses are also connected with rivets, a 1930s-era fastening technology that provides less resistance to repetitive loading than current methods.