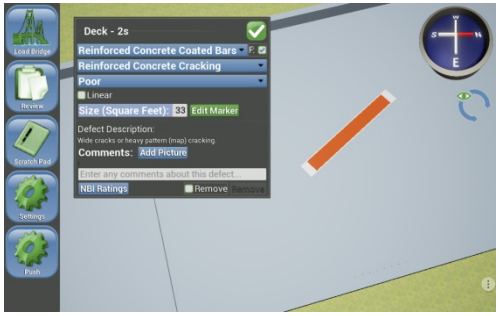
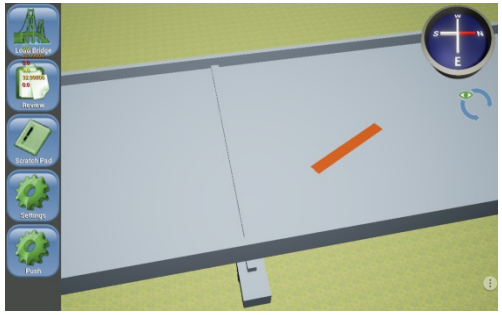
MDOT 3D Bridge App – The Digital Future Of Bridge Inspections





MDOT #2013-0067, Auth. No. 2

Reid Sawtell
Michigan Tech Research Institute
rwsawtel@mtu.edu
www.mtri.org

MDOT Michigan Department of Transportation

MichiganTech Research Institute
www.mtri.org

MichiganTech
Michigan Technological University
Department of Civil & Environmental Engineering

The Problem

- Faced with an aging bridge inventory and increasing federal regulations for collecting element level data, MDOT wishes to increase the efficiency and reliability of collected data.

The Problem

- Current bridge inspection practices at MDOT)utilize paper forms followed by a manual data entry step to populate their database.

The Problem

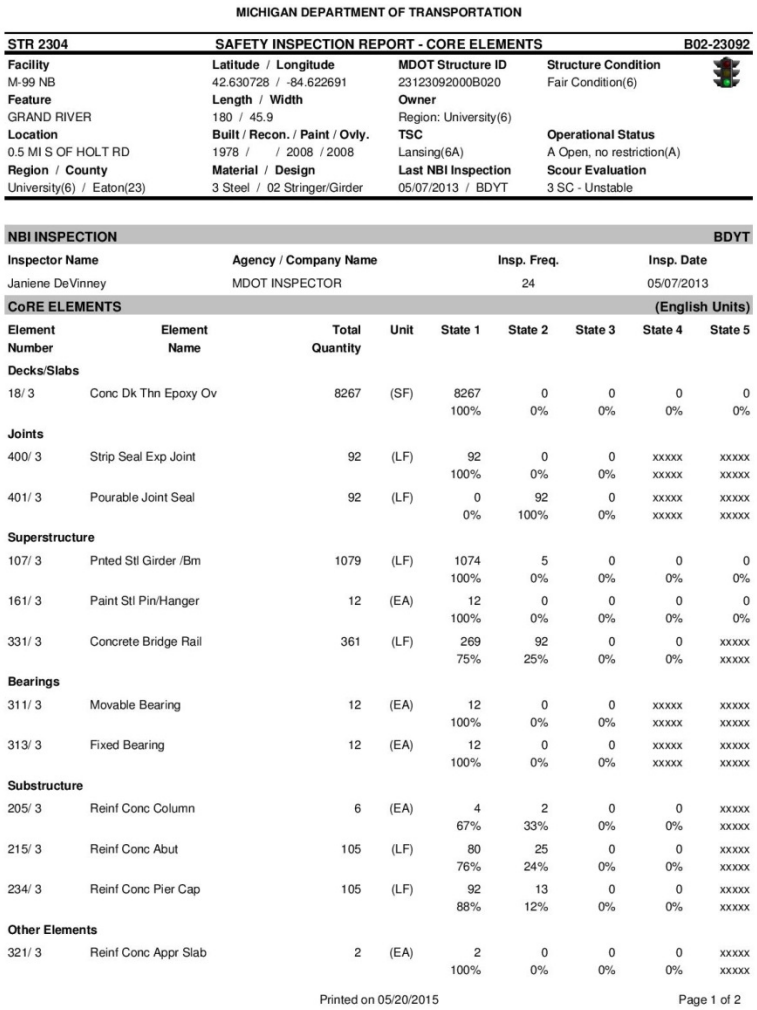
- Additionally, photographs documenting bridge deterioration are collected and stored separately from inspection data.

The Problem

- MDOT inspectors must also carry reference manuals and past inspection reports to help verify the accuracy of the data they are collecting.

The Problem

- The exact locations of bridge defects are not stored which creates an inconvenience as the data are difficult to visualize, to tabulate overall defect quantities, & to duplicate inspections.
- Federal regulations now require inspectors to collect AASHTO Element level data. Current processes don't enable the efficient collection of this data.



MICHIGAN DEPARTMENT OF TRANSPORTATION

STR 2304	SAFETY INSPECTION REPORT - CORE ELEMENTS		B02-23092
Facility	**Latitude / Longitude**	**MDOT Structure ID**	**Structure Condition**
M-99 NB	42.630728 / -84.622691	23123092000B020	Fair Condition(6)
Feature	**Length / Width**	**Owner**	
GRAND RIVER	180 / 45.9	Region: University(6)	
Location	**Built / Recon. / Paint / Ovly.**	**TSC**	**Operational Status**
0.5 MI S OF HOLT RD	1978 / / 2008 / 2008	Lansing(6A)	A Open, no restriction(A)
Region / County	**Material / Design**	**Last NBI Inspection**	**Scour Evaluation**
University(6) / Eaton(23)	3 Steel / 02 Stringer/Girder	05/07/2013 / BDYT	3 SC - Unstable

NBI INSPECTION — BDYT

Inspector Name	Agency / Company Name	Insp. Freq.	Insp. Date
Janiene DeVinney	MDOT INSPECTOR	24	05/07/2013

CoRE ELEMENTS — (English Units)

Element Number	Element Name	Total Quantity	Unit	State 1	State 2	State 3	State 4	State 5
Decks/Slabs								
18/ 3	Conc Dk Thn Epoxy Ov	8267	(SF)	8267	0	0	0	0
				100%	0%	0%	0%	0%
Joints								
400/ 3	Strip Seal Exp Joint	92	(LF)	92	0	0	xxxxx	xxxxx
				100%	0%	0%	xxxxx	xxxxx
401/ 3	Pourable Joint Seal	92	(LF)	0	92	0	xxxxx	xxxxx
				0%	100%	0%	xxxxx	xxxxx
Superstructure								
107/ 3	Pnted Stl Girder /Bm	1079	(LF)	1074	5	0	0	0
				100%	0%	0%	0%	0%
161/ 3	Paint Stl Pin/Hanger	12	(EA)	12	0	0	0	0
				100%	0%	0%	0%	0%
331/ 3	Concrete Bridge Rail	361	(LF)	269	92	0	0	xxxxx
				75%	25%	0%	0%	xxxxx
Bearings								
311/ 3	Movable Bearing	12	(EA)	12	0	0	xxxxx	xxxxx
				100%	0%	0%	xxxxx	xxxxx
313/ 3	Fixed Bearing	12	(EA)	12	0	0	xxxxx	xxxxx
				100%	0%	0%	xxxxx	xxxxx
Substructure								
205/ 3	Reinf Conc Column	6	(EA)	4	2	0	0	xxxxx
				67%	33%	0%	0%	xxxxx
215/ 3	Reinf Conc Abut	105	(LF)	80	25	0	0	xxxxx
				76%	24%	0%	0%	xxxxx
234/ 3	Reinf Conc Pier Cap	105	(LF)	92	13	0	0	xxxxx
				88%	12%	0%	0%	xxxxx
Other Elements								
321/ 3	Reinf Conc Appr Slab	2	(EA)	2	0	0	0	xxxxx
				100%	0%	0%	0%	xxxxx

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Objectives of MDOT Wireless Bridge Inspection Study

- The goal is to help MDOT take advantage of the advances in portable data entry technologies, reduce the time needed for field staff to collect bridge inspection data and thereby help have a safer bridge inspection program, and help provide a compatible path forward to a more efficient bridge inspection process that is available to all appropriate levels of MDOT.

Objectives of MDOT Wireless Study

- Develop a wireless web/tablet based bridge inspection data collection system. This system would:
  - Use 3D models to help collect data.
  - Integrate with MDOT Michigan Bridge Reporting System and other current MDOT bridge inspection processes.

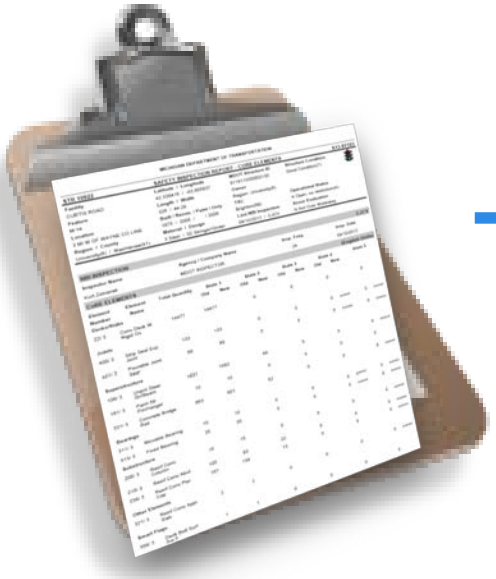
MDOT's Solution

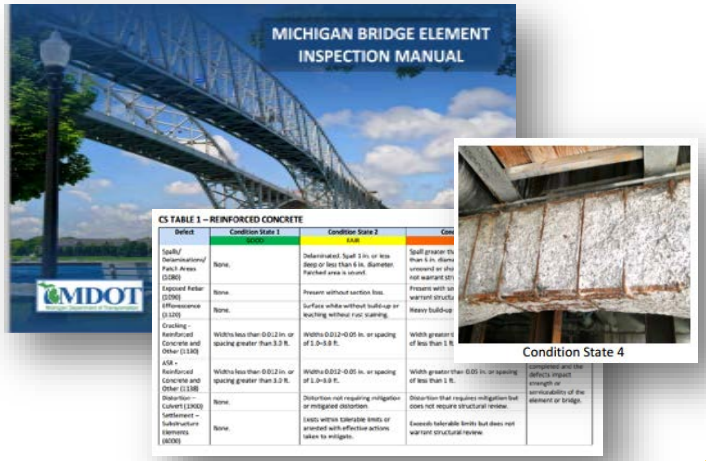
- A tablet application for MDOT Bridge Inspectors for the collection, display, and summarizing of Bridge Inspection Data.
- Leverages the latest in game development technology: Unreal Engine 4
  - Provides cross platform compatibility on everything from Windows Desktops to Android/iOS phones or tablets.

The 3D BRIDGE app

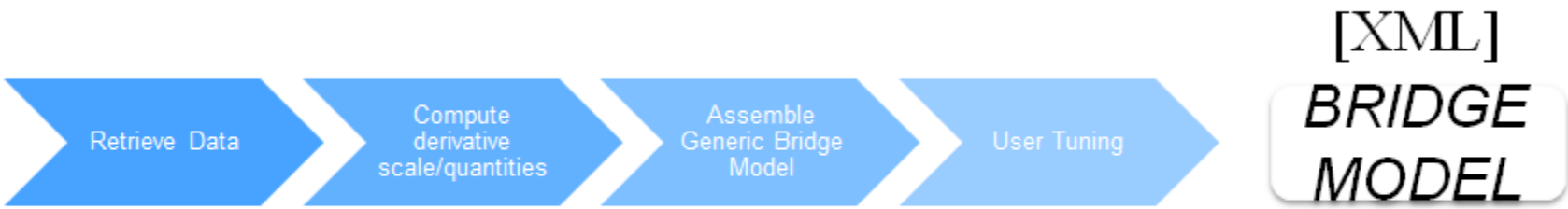
- The 3D BRIDGE app helps MDOT take advantage of the advances in portable data entry technologies, reduce the need for field staff time to collect bridge inspection, and facilitate the bridge inspection process

How will this tool work from the Bridge Inspector's point of view?





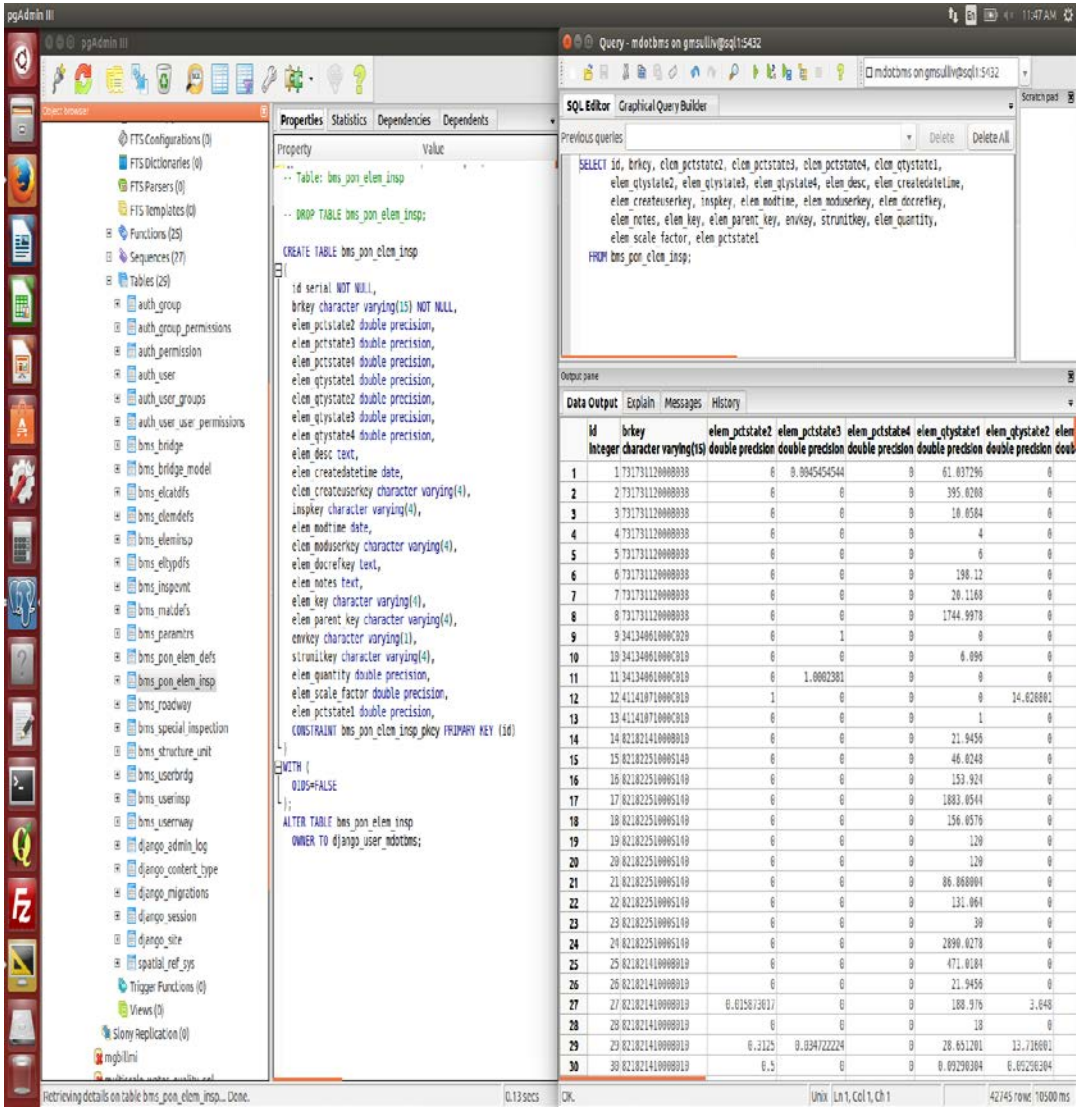
The 3D BRIDGE App Grabs Data from BMS Database



- With no previous 3D models of the bridges available, a model had to be created from scratch
- Large amounts of descriptive information within MDOT's Bridge Management Database

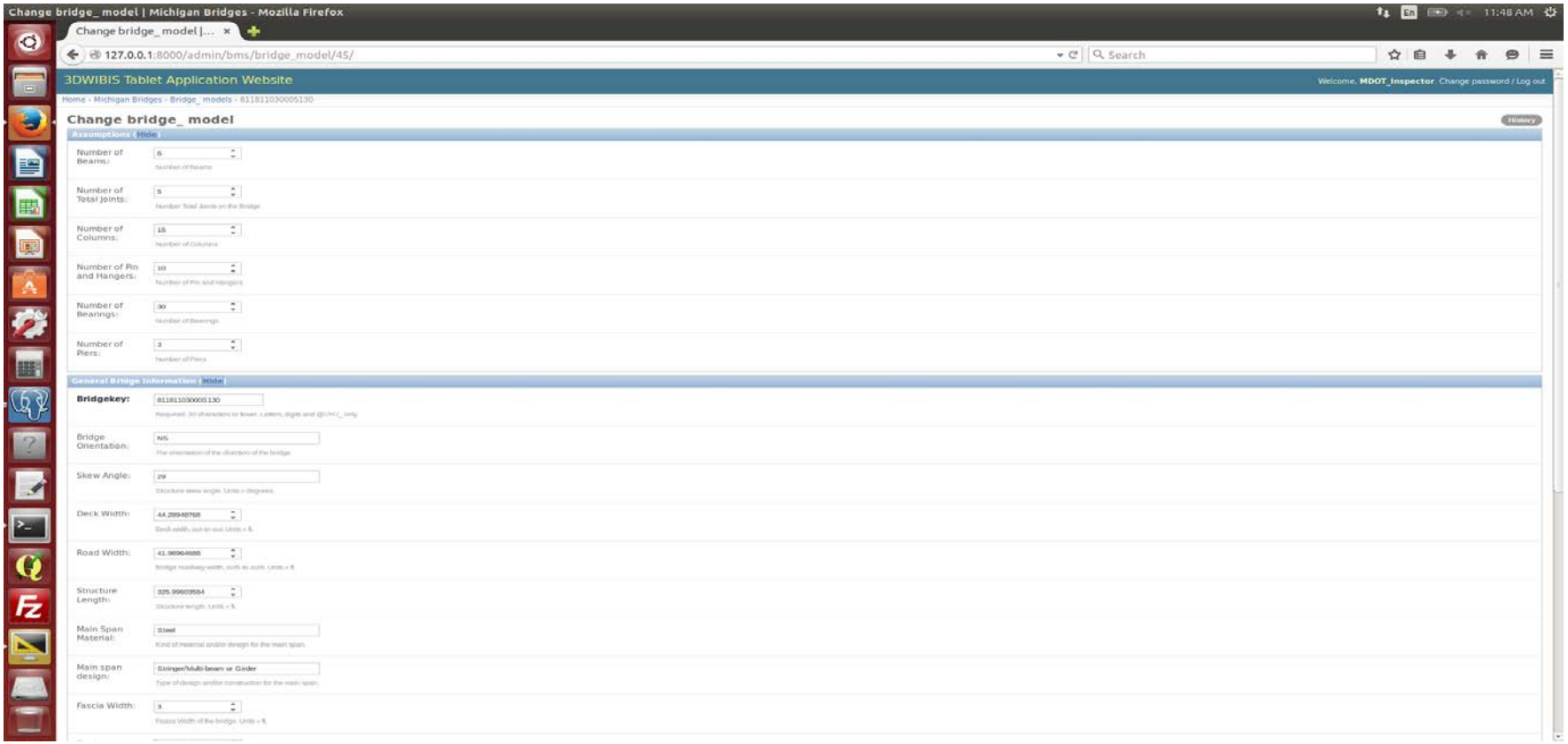
The 3D BRIDGE App Grabs Data from BMS Database

- Queries all of the data from a static copy of MDOT's database.
  - Static copy recent as of October 2018
- The MDOT bridge management database is composed of 16 tables.
- The 3D BRIDGE App queries from almost all of them.



User Tuning

- Created a user interface for fine tuning the 3D Bridge model
- Missing data is filled in with generic assumptions.
- User can alter data to fix any assumptions that were mistakes.

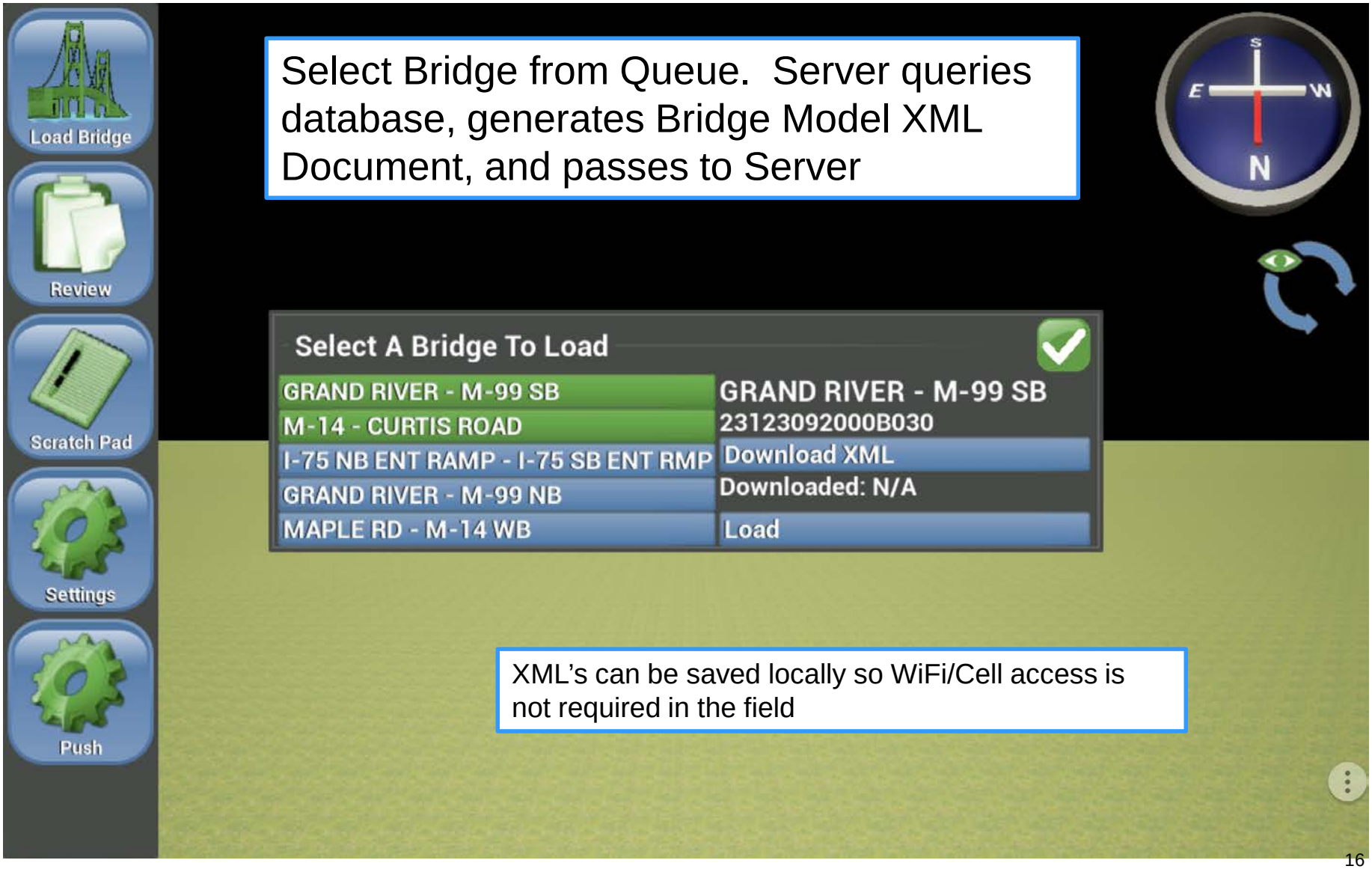


Backend Outputs XML to Frontend

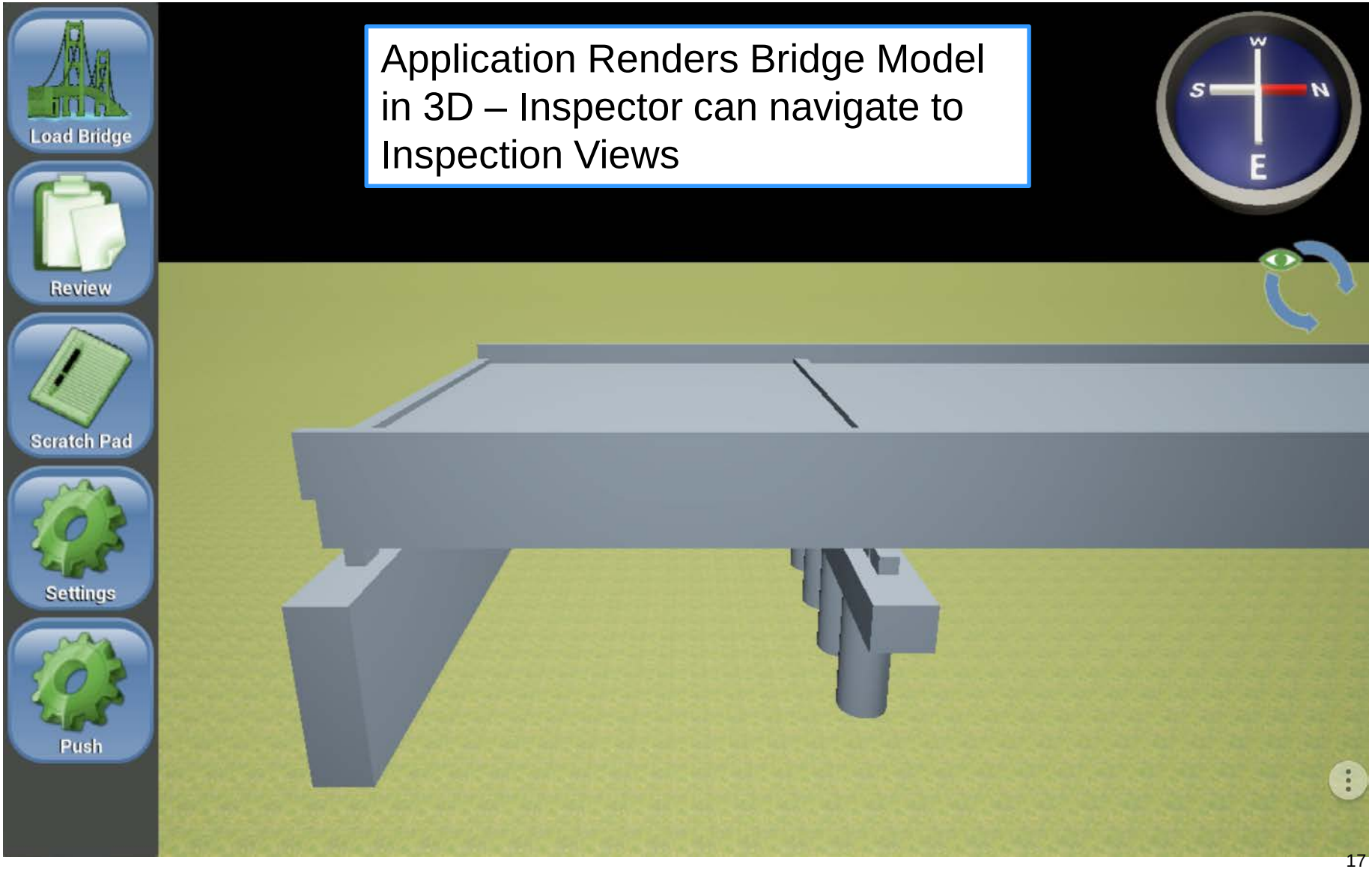
- Outputs bridge XML to create model.

```
- <Member>
    <role>Deck</role>
    <type>Concrete Deck - Coated Bars</type>
    <name>2S</name>
    <length>1451.98234368</length>
    <width>491.47385216</width>
    <height>15.0</height>
    <AASHTO_Element_803>803</AASHTO_Element_803>
    <x>1229.9850432</x>
    <y>265.73692608</y>
    <z>270.5133888</z>
```

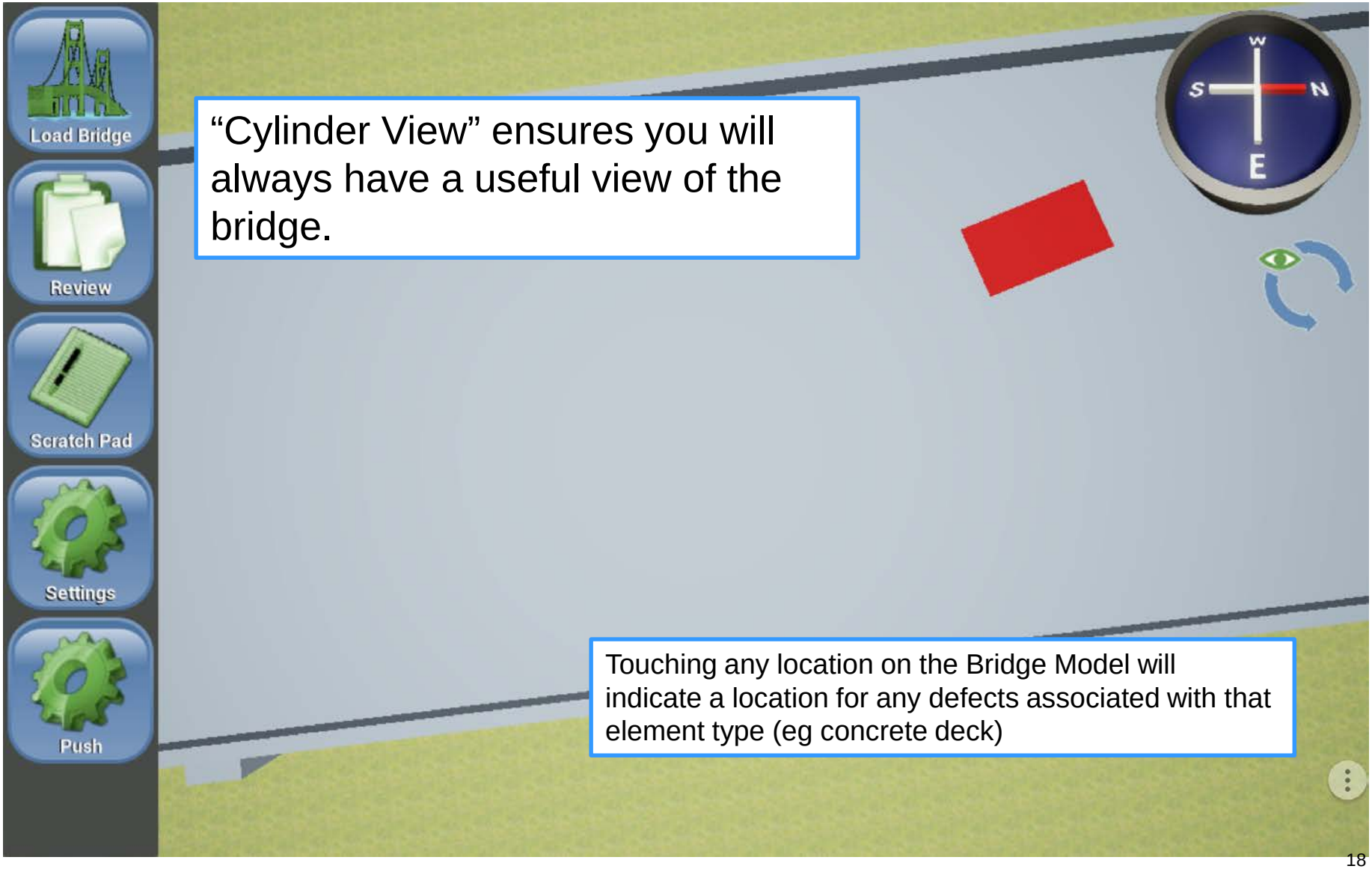
Select bridge by Region / StructureID



Desired bridge loads and is rendered

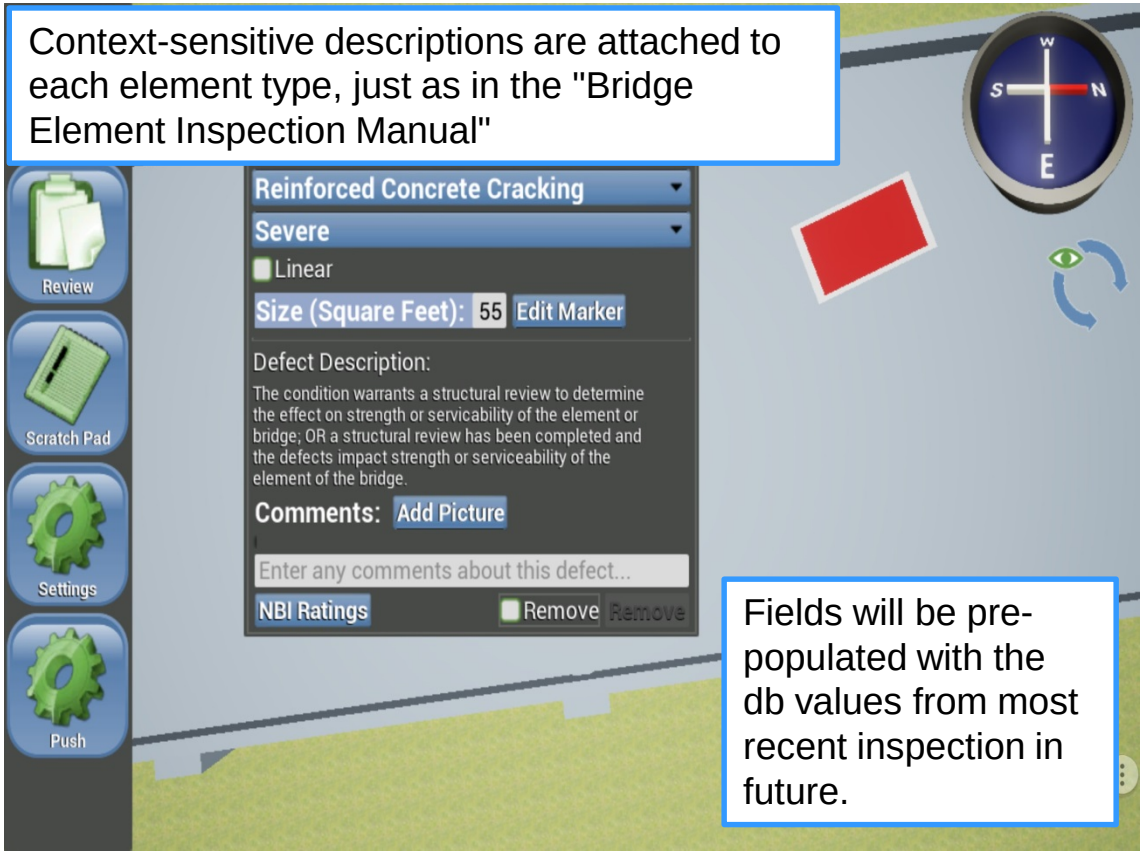


Navigation is constrained to an orbit around the bridge

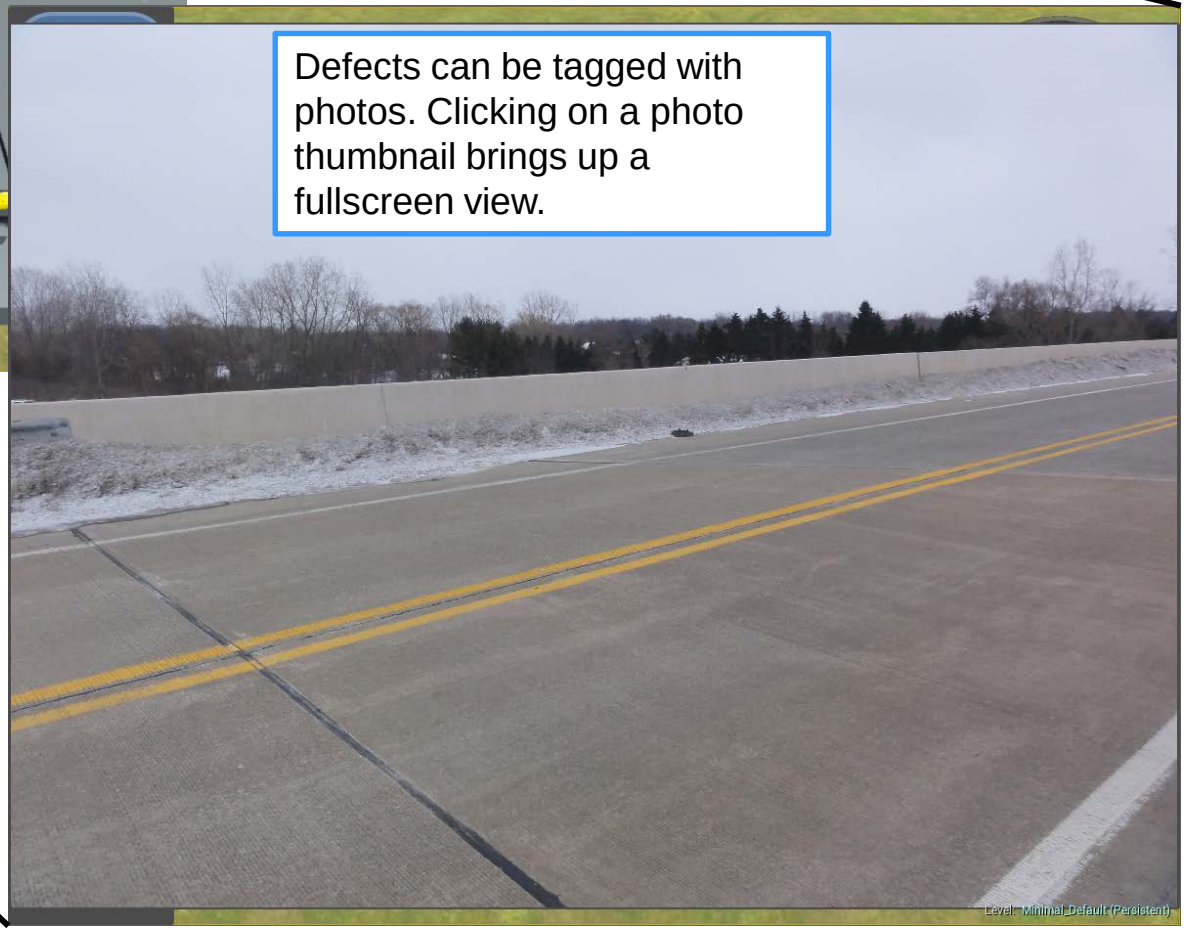


3D BRIDGE App Usage

- The 3D BRIDGE App enables bridge inspectors to collect and record all of the necessary data for the bridge inspection process in one tool.
- Each individual defect can be annotated with a description, photos, and quantity.
- Inspectors no longer have to carry the Bridge Element Inspection Manual

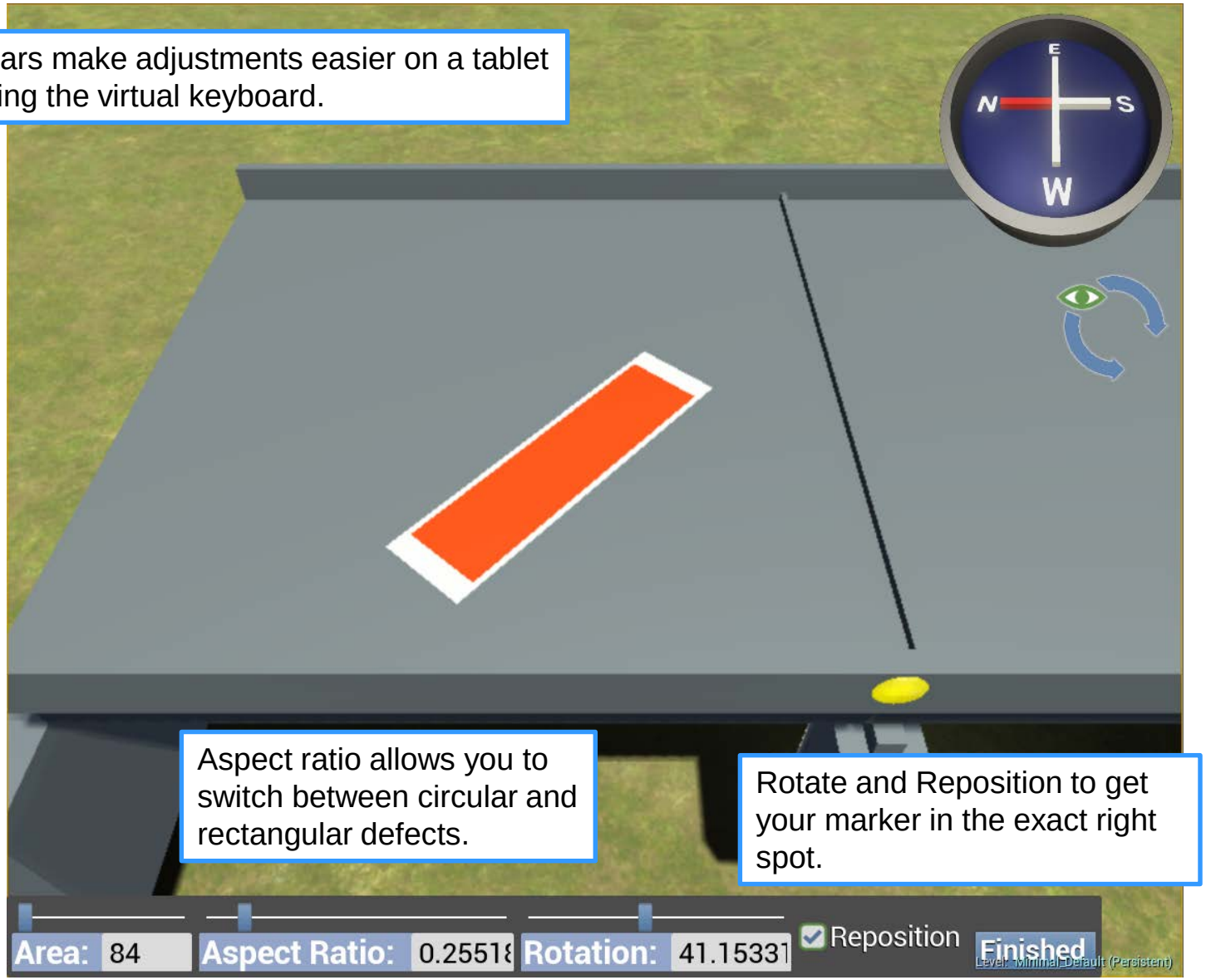


View Photos of the Desired Defect



Customize the Defect's Size and Shape

Slider bars make adjustments easier on a tablet than using the virtual keyboard.



Aspect ratio allows you to switch between circular and rectangular defects.

Rotate and Reposition to get your marker in the exact right spot.

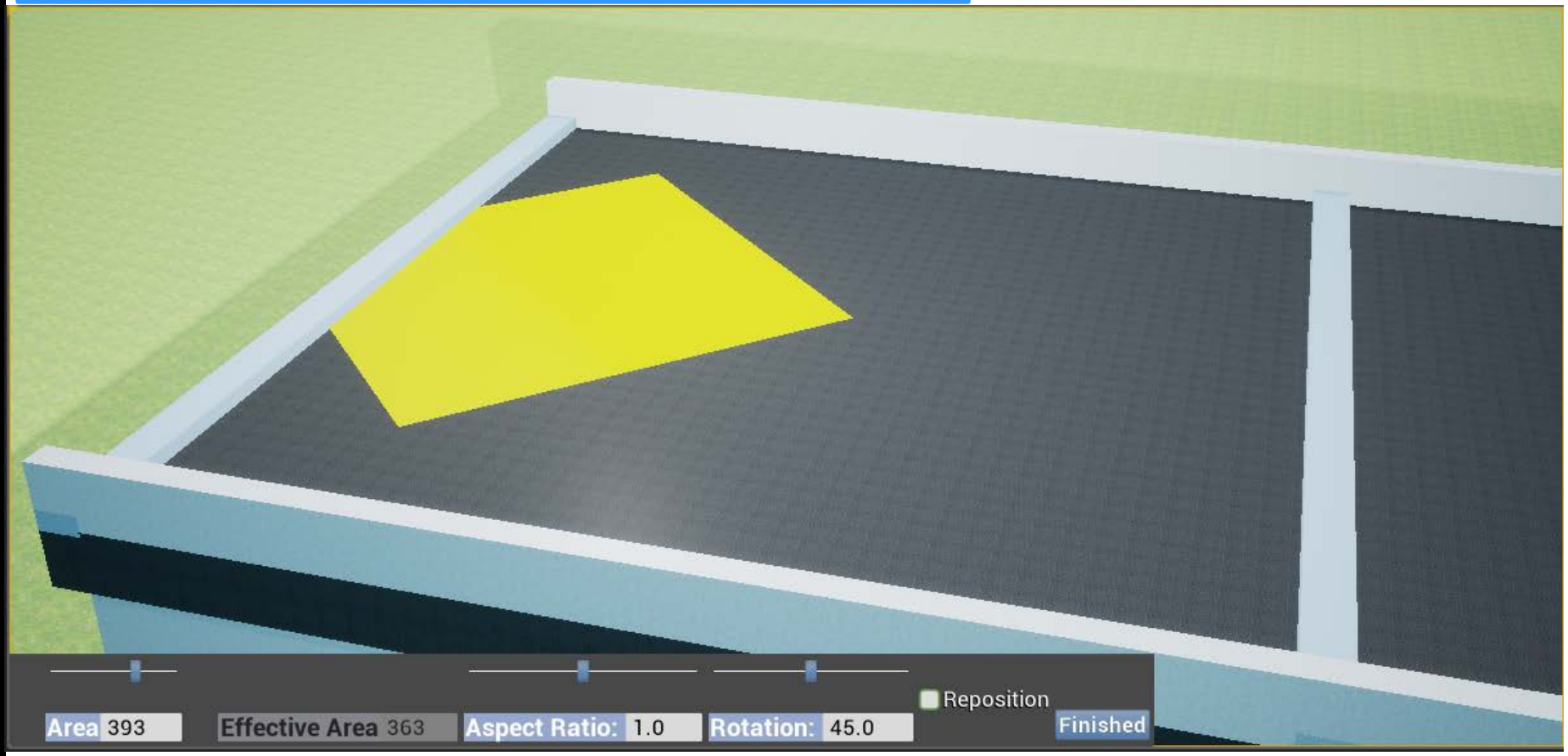
Copy/Paste Defects

Copy/Paste defects onto the same element type

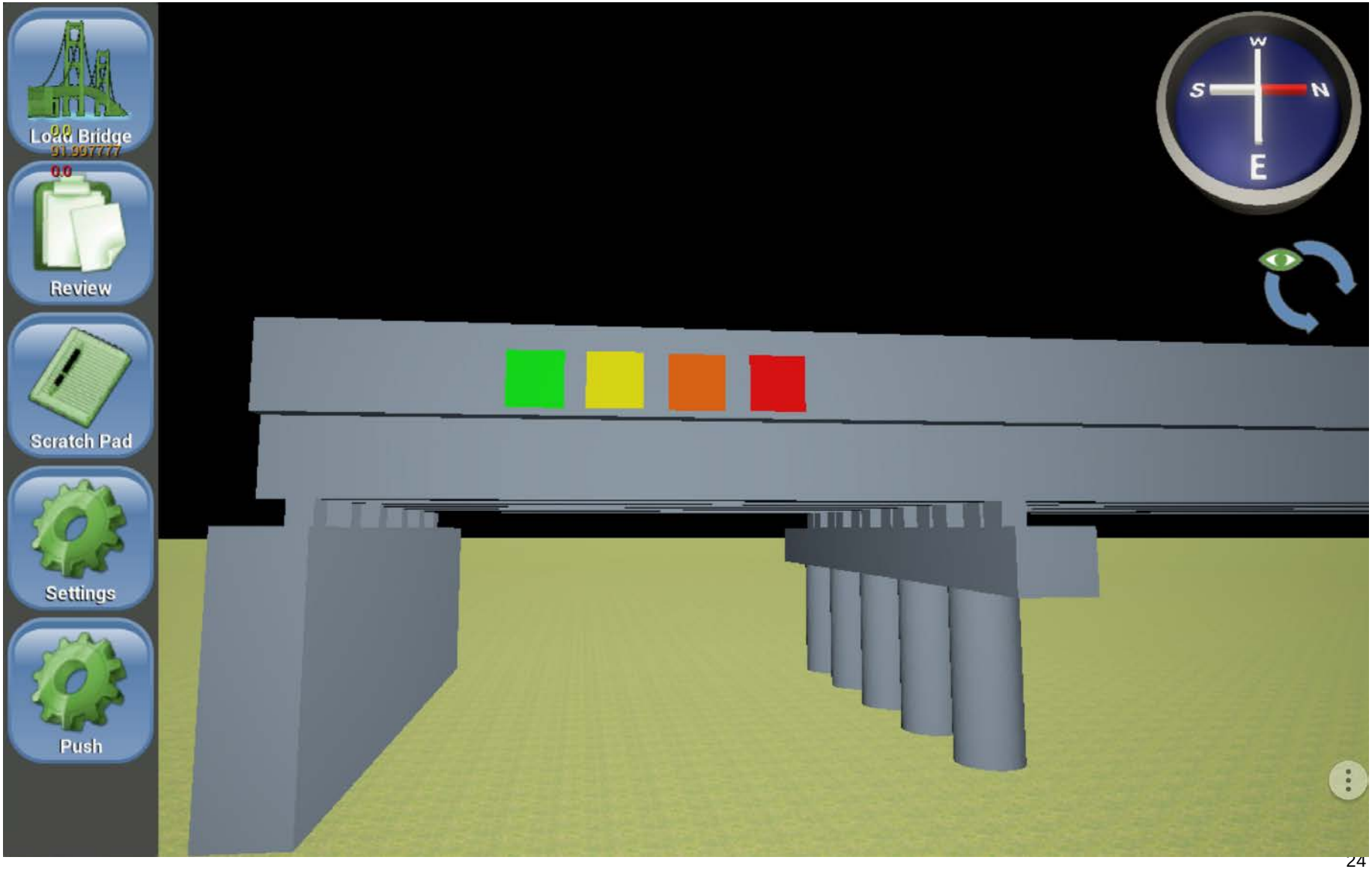
Will be developed into the ability to place defects on regular intervals: eg “vertical cracks every 10ft on railing”

Automatic Clipping

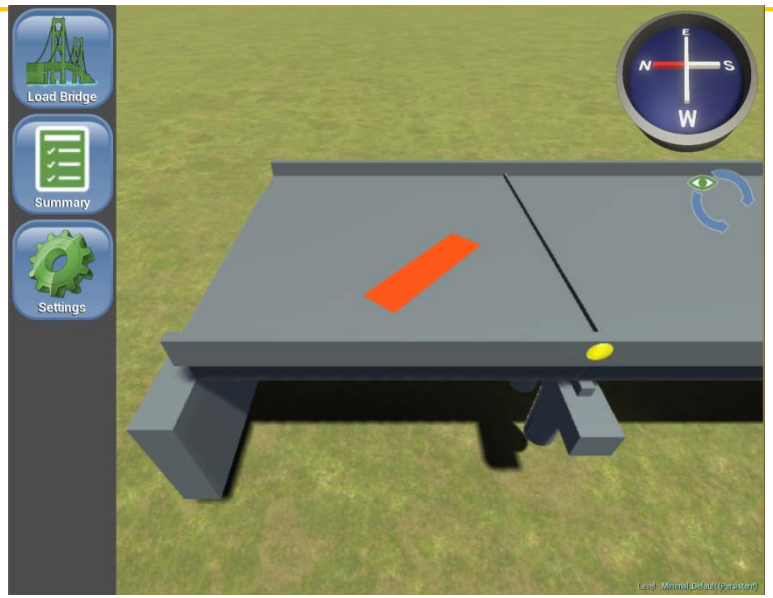
Defects are limited to the element they are attached to, and cannot extend beyond that to ensure accuracy of total quantity

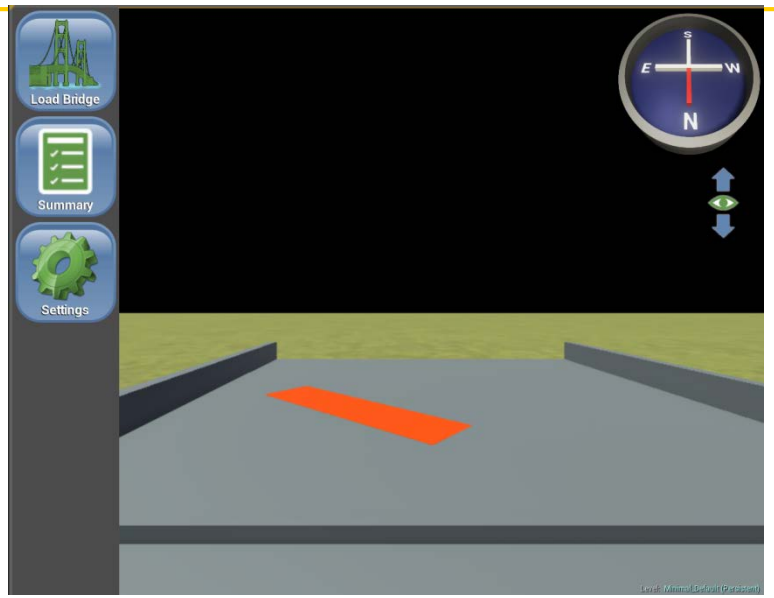


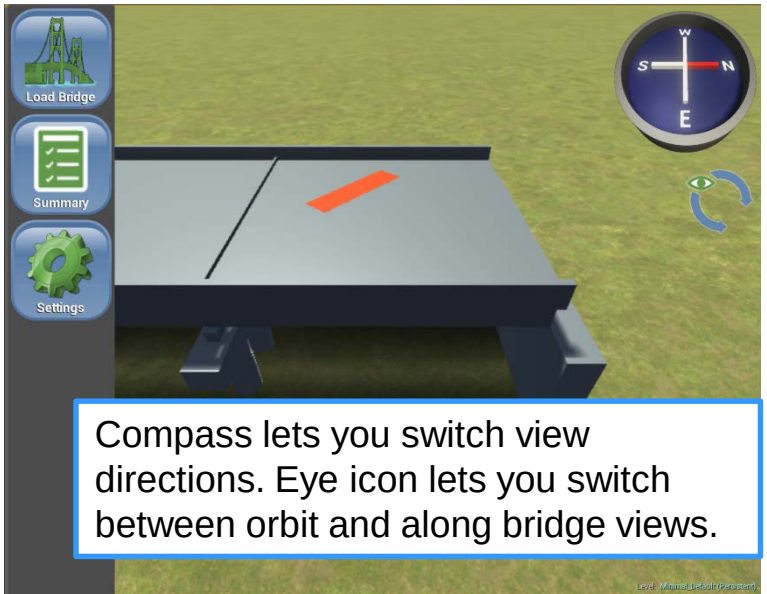
Colors indicate condition states, and relative sizes are proportional to "quantity"



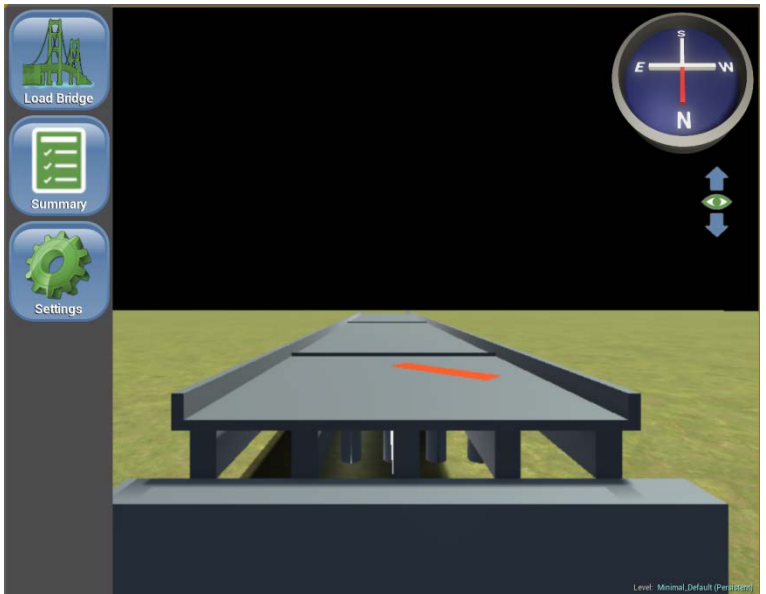
Saves the Defect's 3D Position For Future Inspections





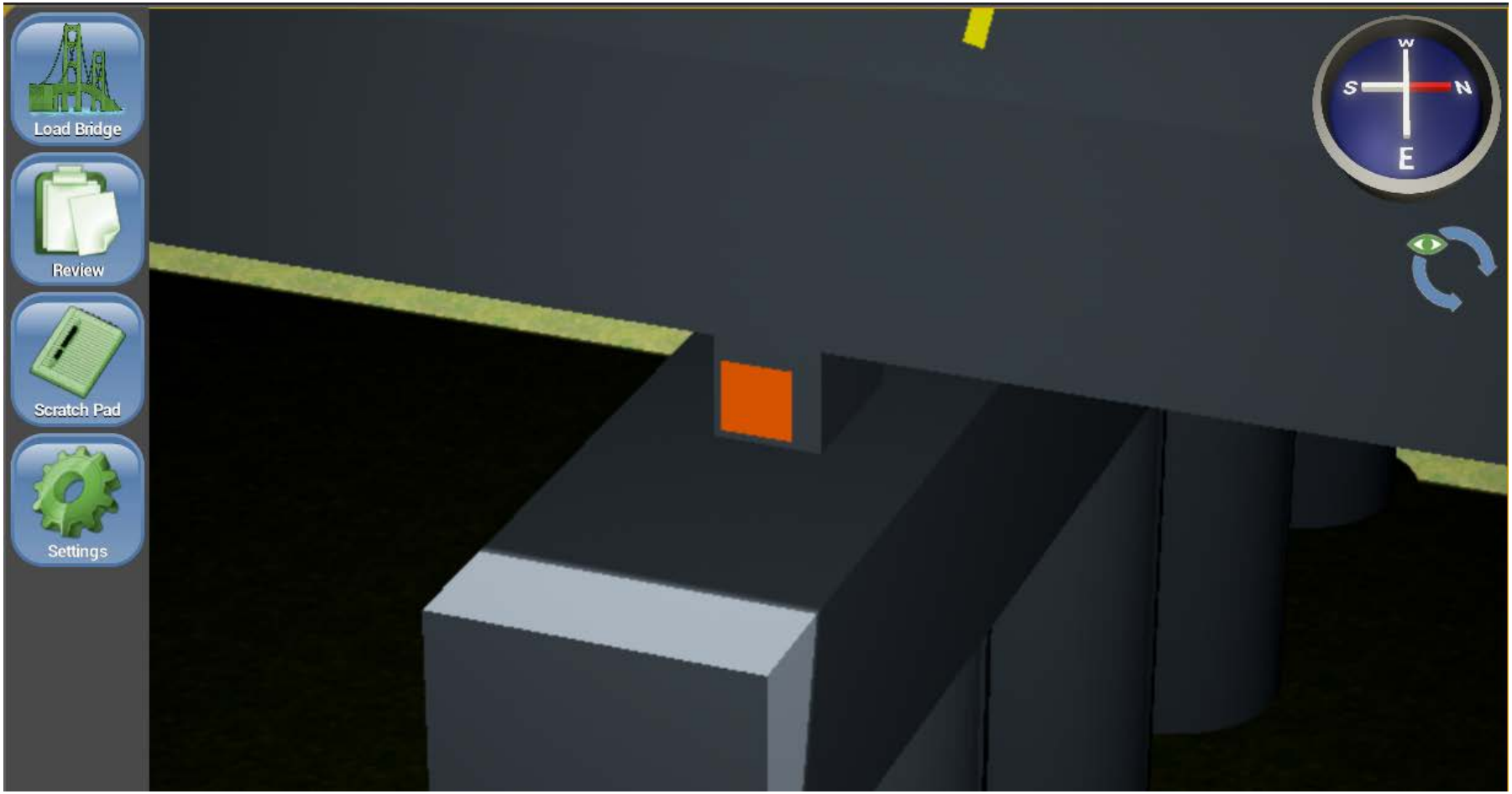


Compass lets you switch view directions. Eye icon lets you switch between orbit and along bridge views.



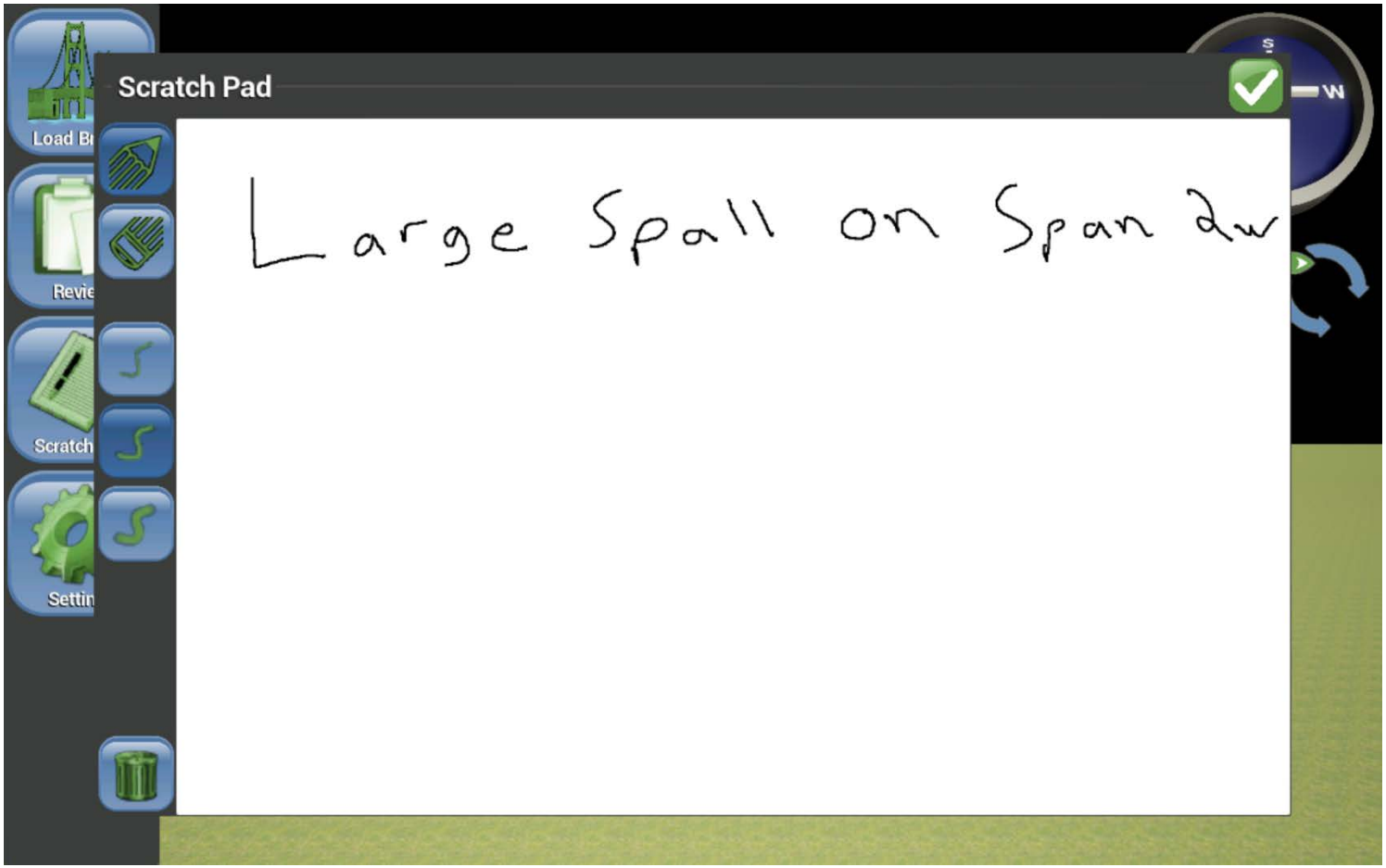
Pinch to Zoom

- Pinch to zoom in on a part of the bridge, or a defect.



Scratch Pad

- Write on the scratch pad to add any additional comments or drawings

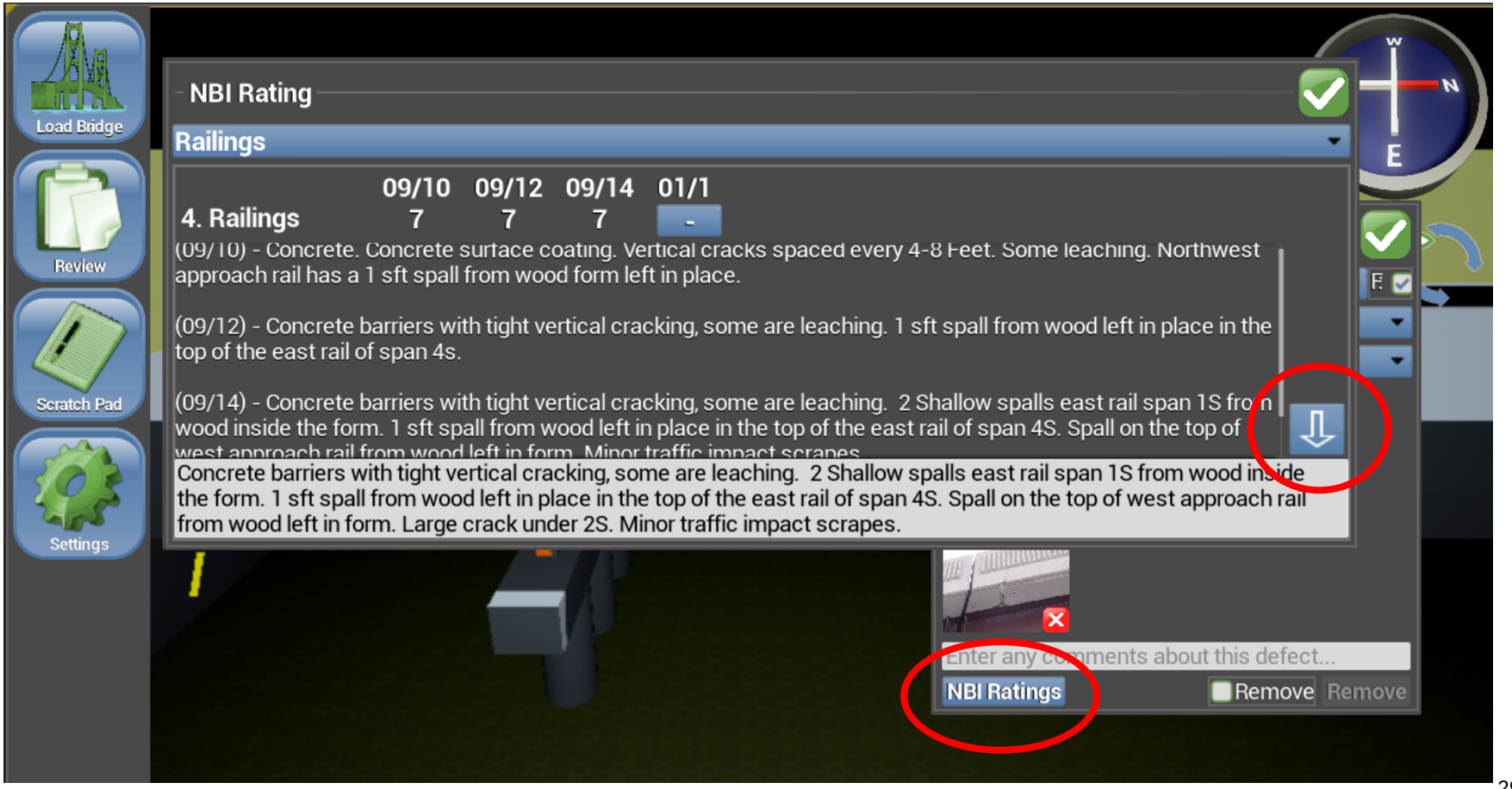


Collect and Display NBI Information

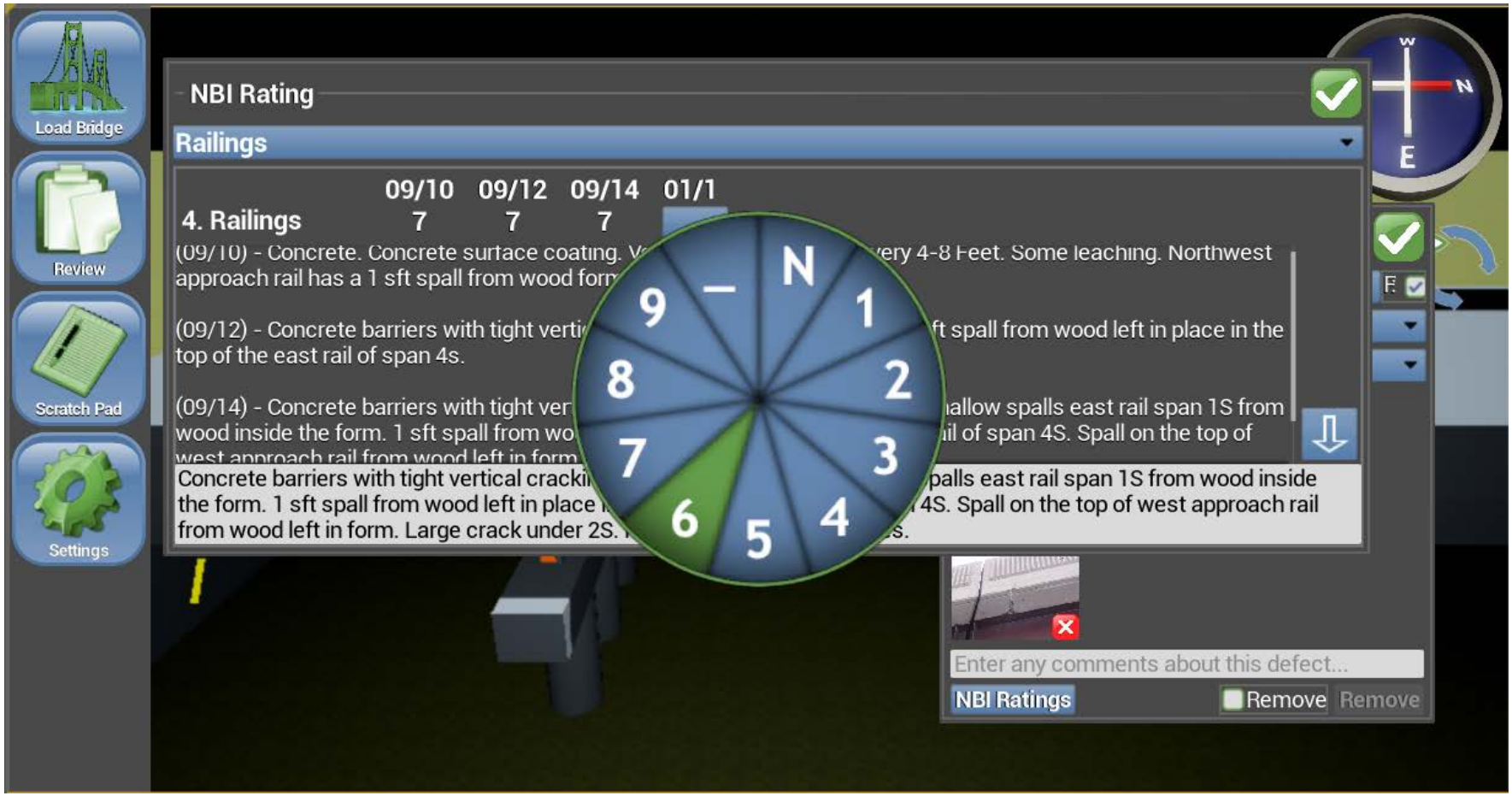
- Review NBI Report Information in the “NBI Report” Summary Tab, and expand the report according to the category.

Collect and Display NBI Information

- Enter in NBI Information by clicking the “NBI Ratings” button. Use previous comments from past NBI Reports using the “Download” arrow button

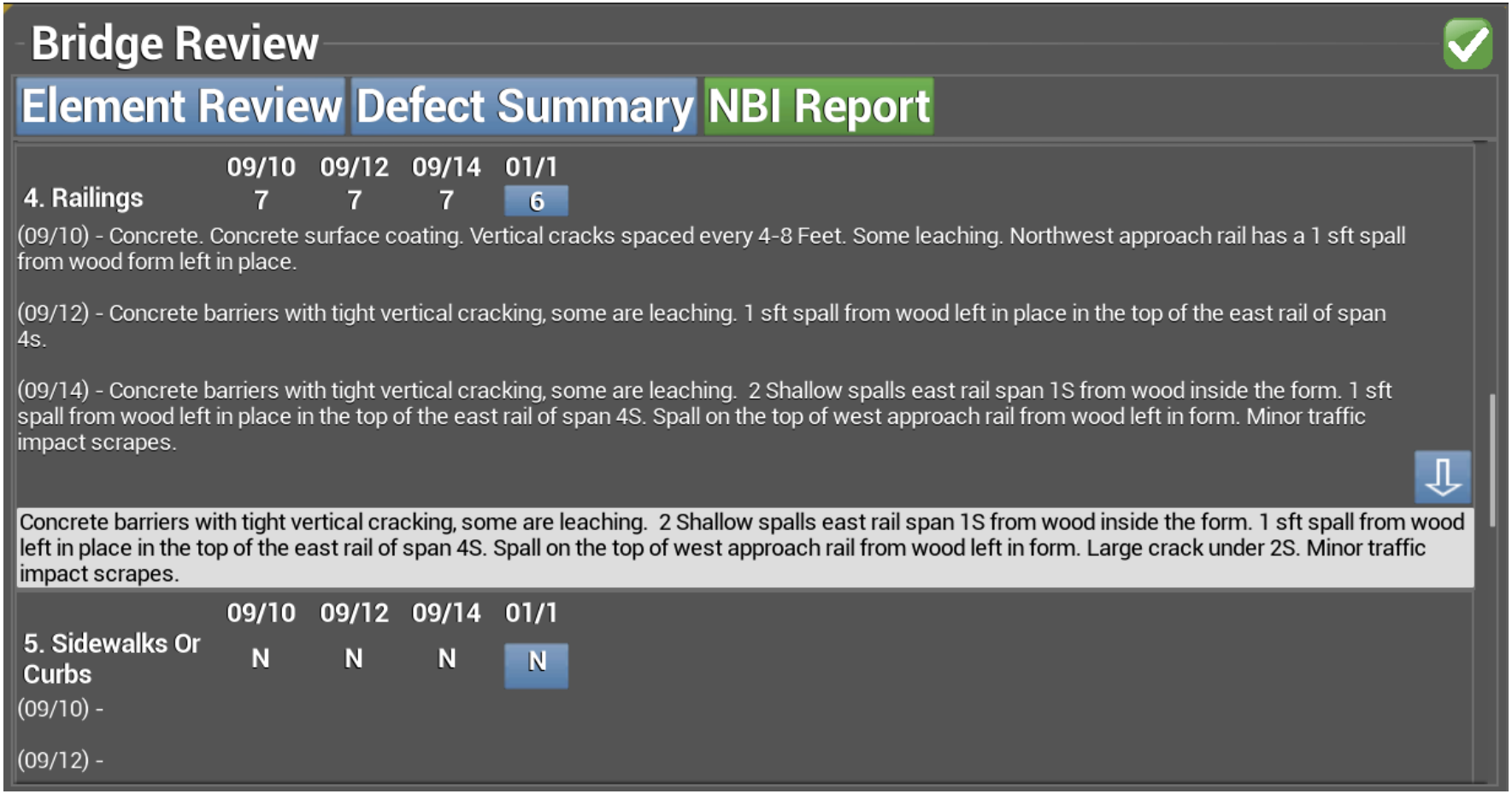


Collect and Display NBI Information



- Enter in the NBI Rating for a category by using user-friendly NBI Rating wheel

Collect and Display NBI Information



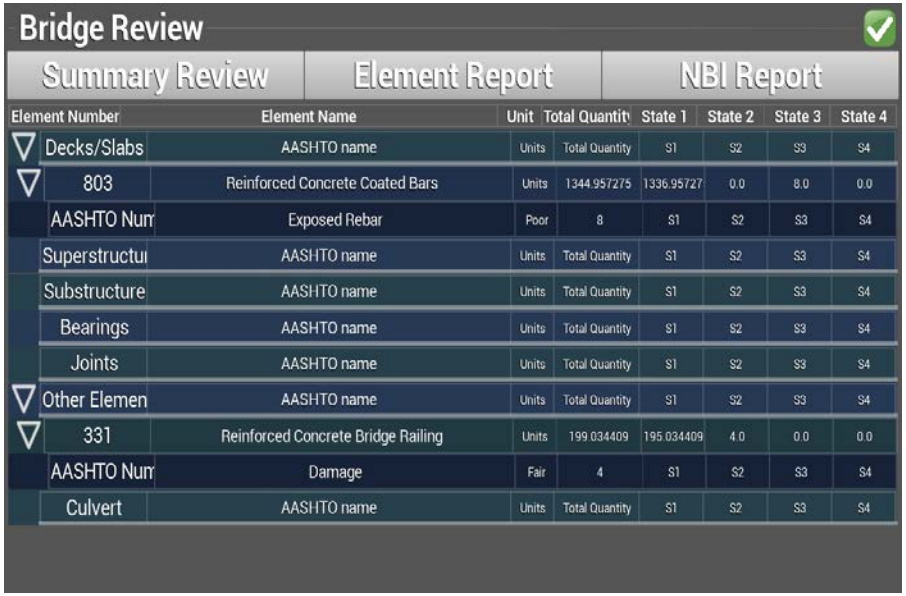
- Scroll through the entire report, and review NBI ratings of past and current reports

View Different Summaries of the Recorded Data

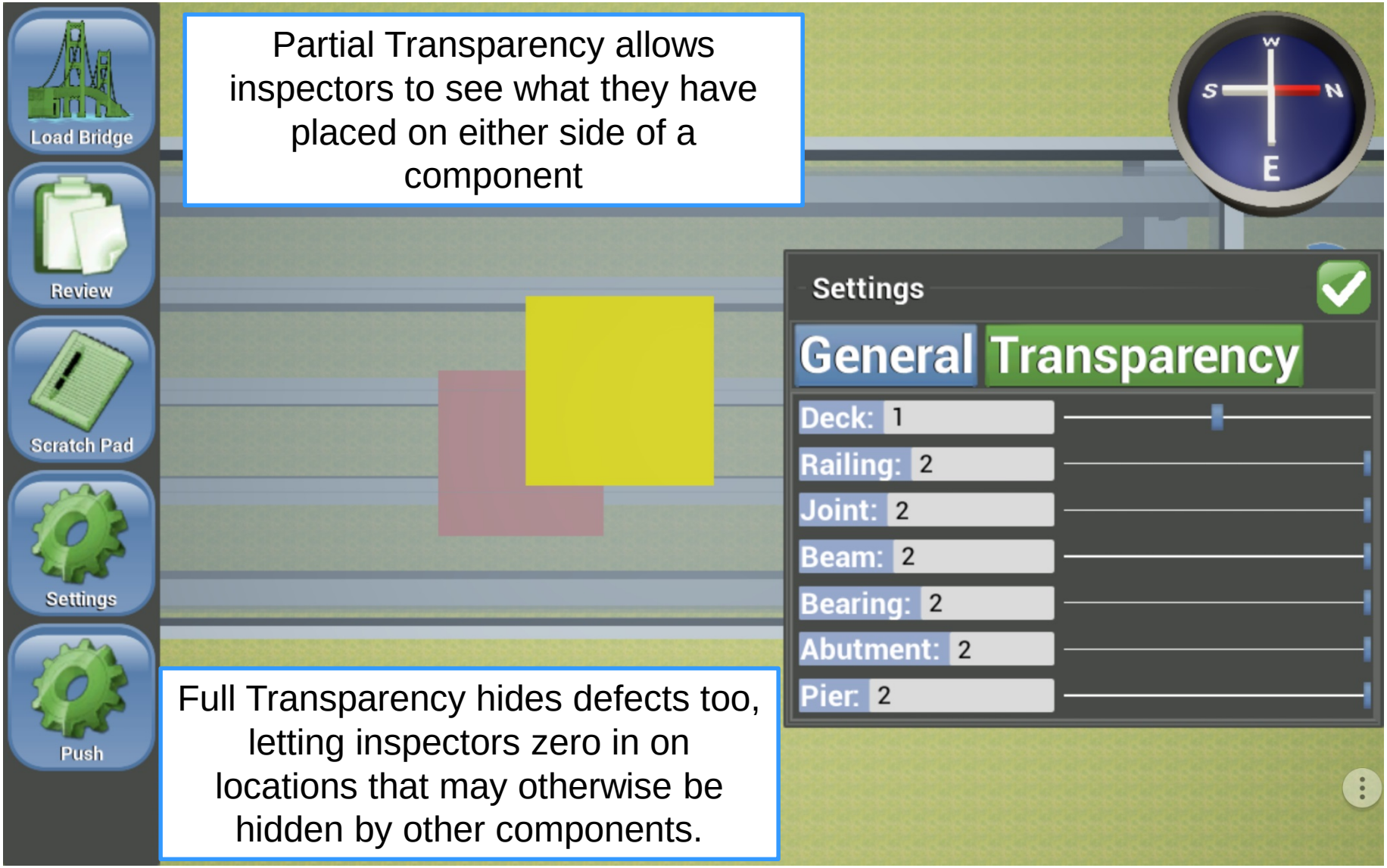
- Display and summarize the bridge inspection data with different views.

Bridge Review

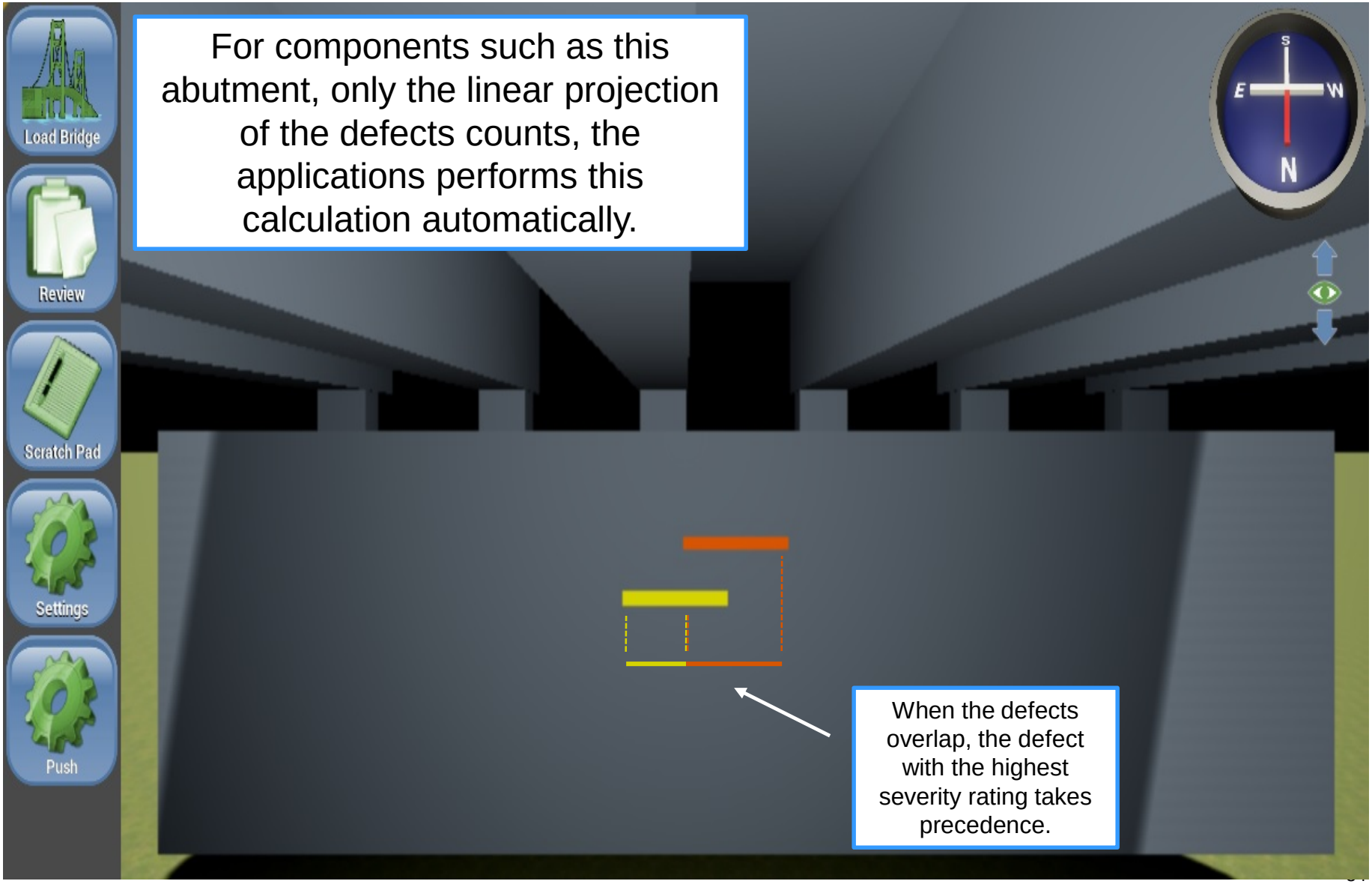
AASHTO Element Level Data View



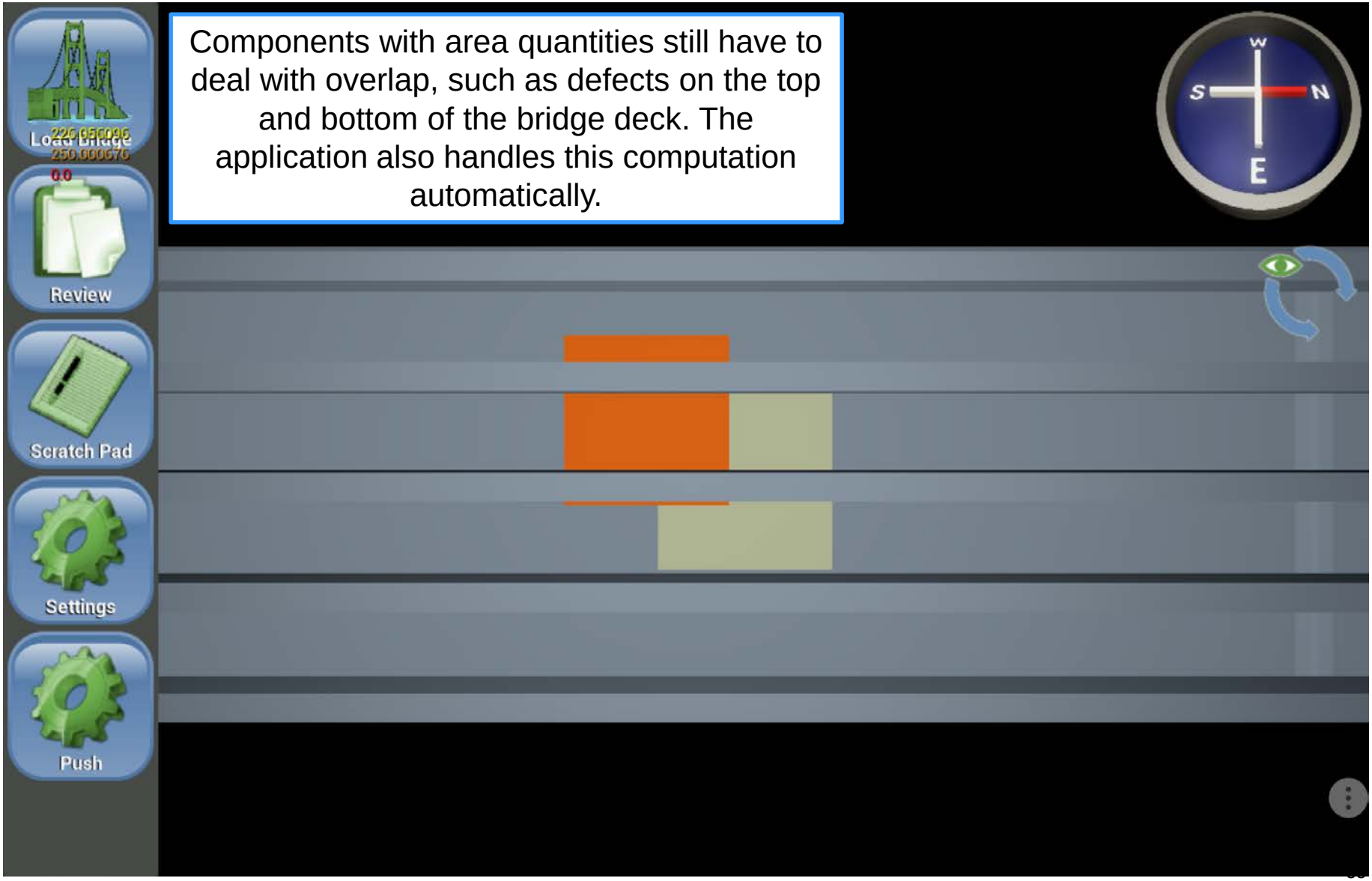
Transparency Setting



Linear Defect Calculator



Area Defect Calculator



Linear/Area Defect Calculator

Bridge Review

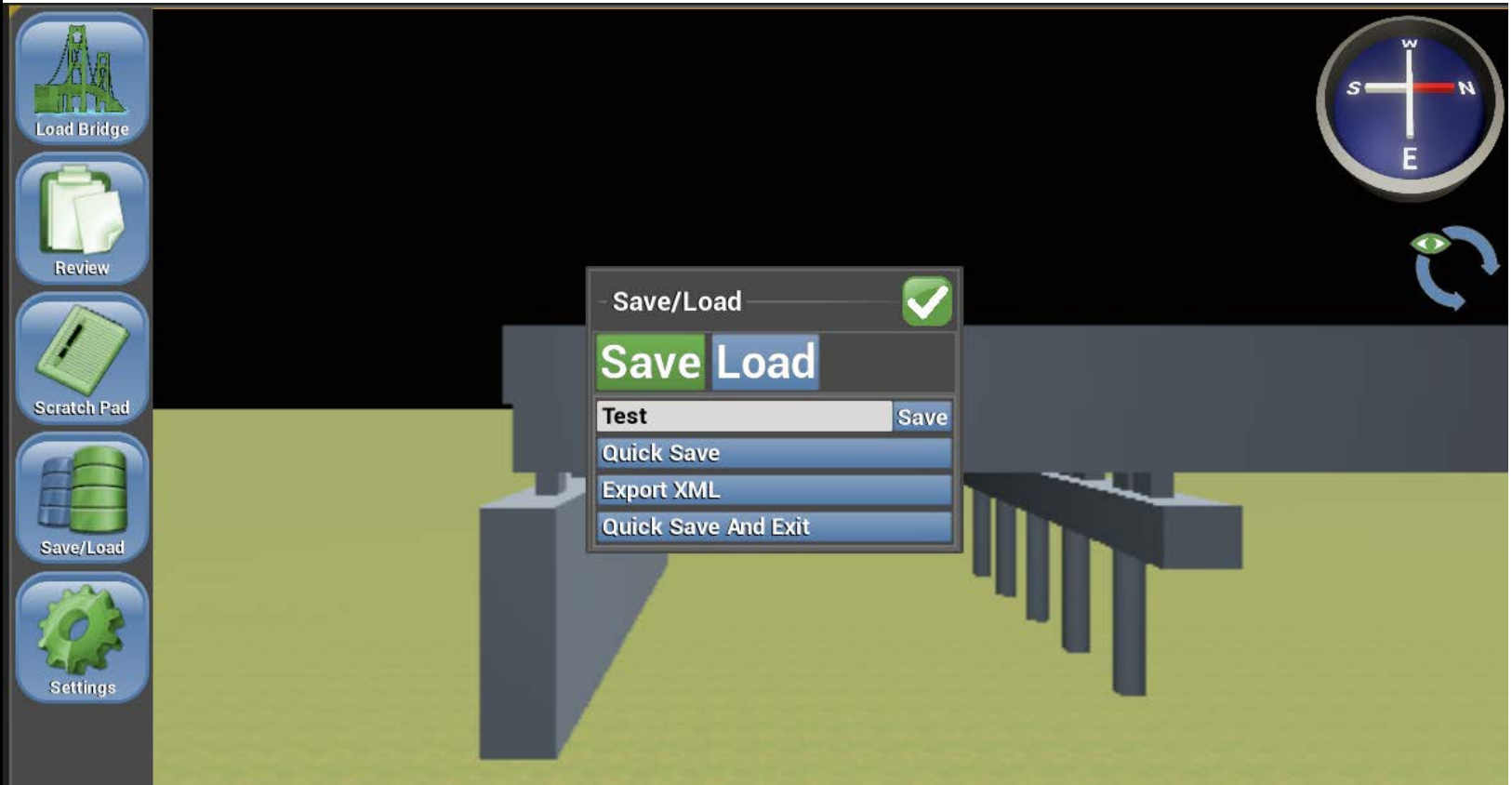
Element Review | **Defect Summary** | **NBI Report**

Element Number	Element Name	Unit	Quantity	Good	Fair	Poor	Severe
Decks/Slabs	-	Units	Total Quantity	CS1	CS2	CS3	CS4
Superstructure	-	Units	Total Quantity	CS1	CS2	CS3	CS4
Substructure	-	Units	Total Quantity	CS1	CS2	CS3	CS4
215	Reinforced Concrete Abutment	feet	112	96 86%	5 4%	10 9%	0 0%
215	Delamination/Spall/Patched Area	feet	10	-	0	10	0
215	Exposed Rebar	feet	10	-	10	0	0
Bearings	-	Units	Total Quantity	CS1	CS2	CS3	CS4
Joints	-						
Other Elements	-						
Culvert	-						

These calculations are reflected in the summary report. Here the fair defect partially overlapped the poor defect, both defects are reported but only half the fair defect counts towards the total quantity for the abutment.

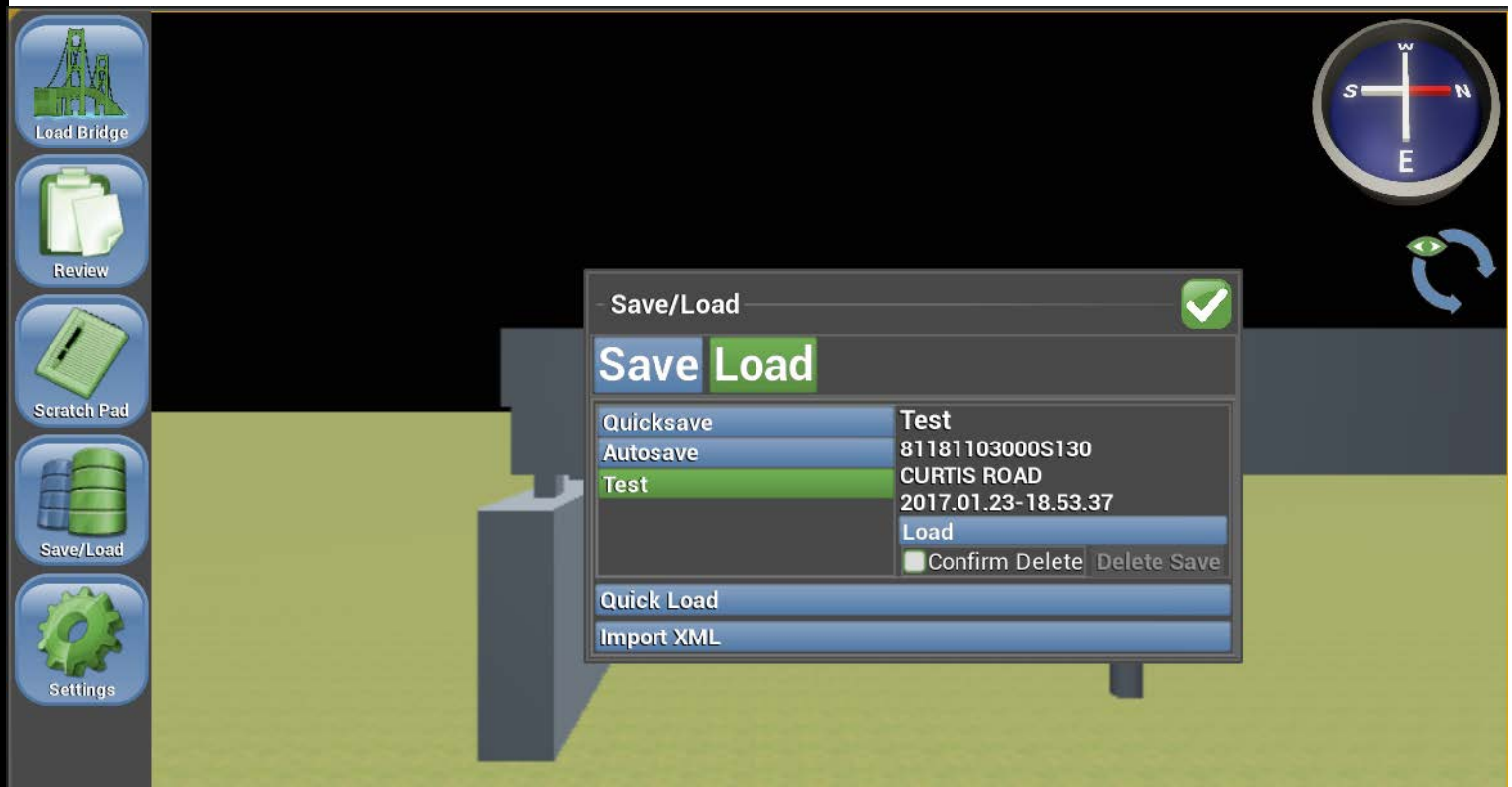
Save/Load

- User's can save the progress of their inspection on their mobile device using named save files.
- Application also autosaves their progress every time they make an update, so they can restore should their work be interrupted unexpectedly.



Save/Load

- Load menu gives a list of all save slots, selecting a save slot will list the bridge id, location, and date the save was created.
  - Can also delete unneeded/old saves



XML Import/Export

- It was necessary to develop a system to import/export data from the MDOT Bridge Management Database.
- All relevant data can be saved in an XML file for later upload to the database management system
  - While not as convenient as a direct uplink, it is also independent from MDOT's database (could be readily adapted to work with other database systems, as the bridge app does not need to change)

XML cont'd

```
        <aashto_number>331</aashto_number>
        <parent_key>0</parent_key>
        <total_quantity>652.992092328</total_quantity>
        <role>Other Elements</role>
        <unit>feet</unit>
      </aashto_element>
    - <aashto_element>
        <aashto_number>321</aashto_number>
        <parent_key>0</parent_key>
        <total_quantity>2969.92778296</total_quantity>
        <role>Other Elements</role>
        <unit>sq feet</unit>
      </aashto_element>
    </aashto_elements>
  - <defects>
    - <defect>
        <size>1</size>
        <aspect>1.0</aspect>
        <rotation>0.0</rotation>
        <severity>2</severity>
        <comment>narg</comment>
        <element>331</element>
        <type>1130</type>
        <linear>0</linear>
        <role>1</role>
        <location X="431.179199" Y="1349.943604" Z="747.372864"/>
        <orientation Yaw="-90.0" Pitch="-90.0" Roll="179.999985"/>
        <parent_location X="4968.179688" Y="1332.418823" Z="744.254028"/>
      </defect>
    </defects>
</bridge>
```

- XML contains the data needed to build the bridge model, previous NBI data, and current NBI ratings and bridge defects.
  - Does not currently contain photos, but all other defect information is stored
    - Photos are still on the tablet device and could be uploaded with whatever method is currently in place to deal with inspection photos.
- Exported XML files can be imported back into the app on any device.
  - Behaves like a save file, restoring the inspection to the state it was at when exported.

The Application is Cross-Platform

- The 3D BRIDGE App is compatible with Windows and Android, and iOS.

Windows

Where We Are At Now

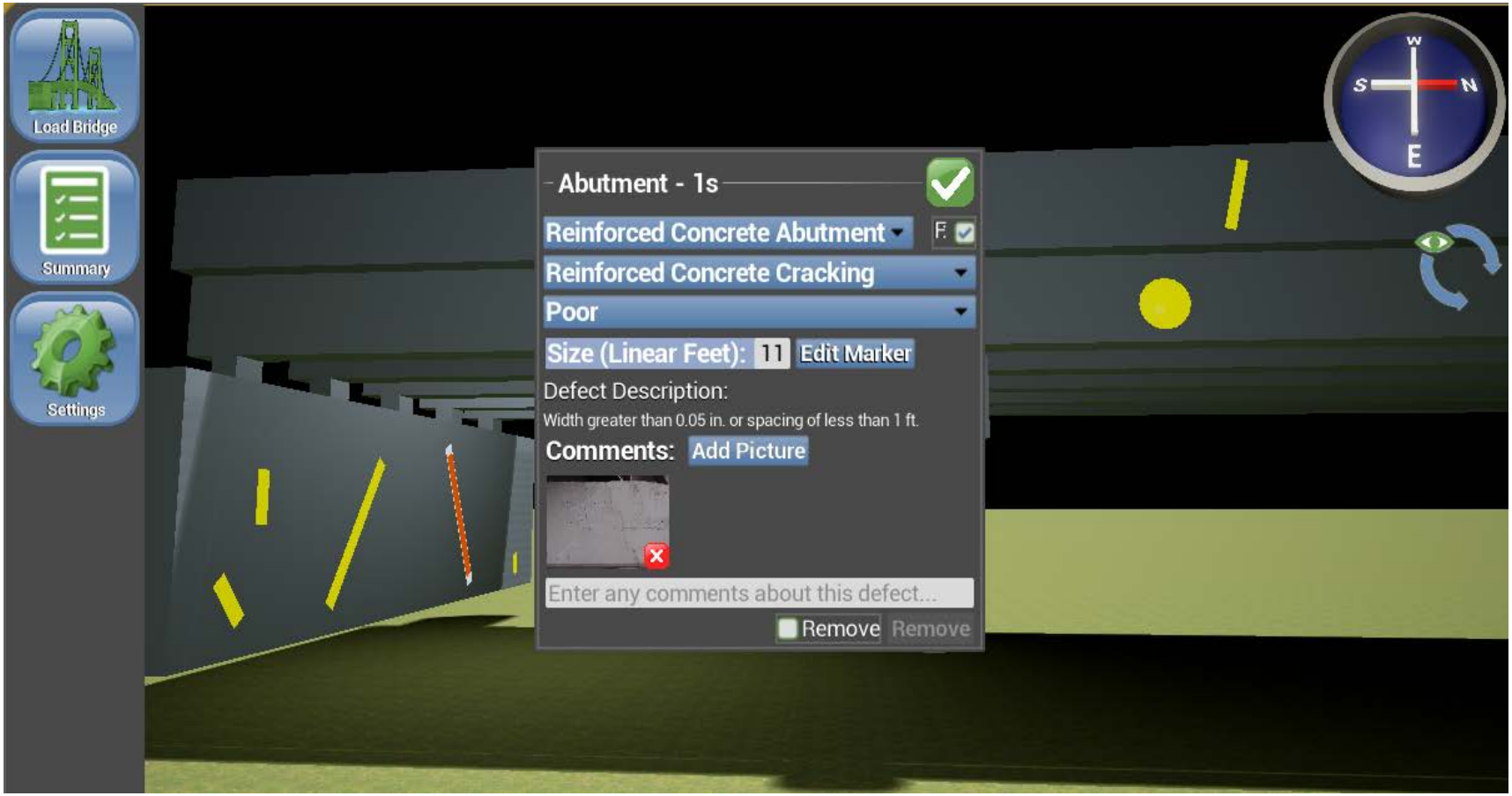
- Currently development is focused on meeting a few remaining key priorities of MDOT
  - Handling bridge skew in model generation
  - Adding additional model components
  - “Draw On Defects”, inspectors can draw a defect onto the surface
  - Automatic conversion to gridded format
    - Useful as input to deterioration modeling
  - We also have a whole list of suggestions from inspectors that we will tackle as we have time
- We are starting a limited testing this spring
  - Select inspectors will have access to the early app version to provide feedback
    - Critical to ensure application success, we want this app to work!
- Project goes to March 2020
  - ready-to-use tool through this year’s 2019 testing & updates

Benefits

- Benefits of using a location-specific 3D interface extend beyond inspection, but also a tool for future asset management
  - 3D BRIDGE App enables this future
    - Rich with research opportunities, such as integration of remote sensing data, improved bridge model representations, etc.
- Enables transportation agency users (MDOT, etc.) to tie condition and deterioration of one component to related components
- Improves forecasting of condition, bridge needs
  - Leads to better, more efficient asset management

The Future of Bridge Inspections

- 3D BRIDGE app is a key component towards the future goal of utilizing 3D models to monitor and review a bridge throughout its lifetime.



Contact Info

- Colin Brooks – Project lead
  - Cell phone: (734)-604-4196
  - Office Phone: (734)-913-6858
  - Email: cnbrooks@mtu.edu
- Tess Ahlborn, PhD, P.E., FACI, FPCI
  - Office Phone: (906)-487-2625
  - Email: tess@mtu.edu
- Reid Sawtell
  - Email: rwsawtel@mtu.edu
- Brian Zakrzewski (MDOT)
  - ZakrzewskiB@michigan.gov
- Allie Nadjarian (MDOT)
  - NadjarianA@michigan.gov

Michigan Department of Transportation