Digital Twin Case Study

DOT/CBIPS FINAL PRESENTATION
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Center for Buildings, Infrastructure & Public Space

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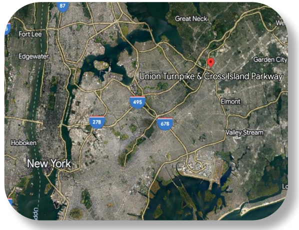
Outline

NEW YORK CITY DOT

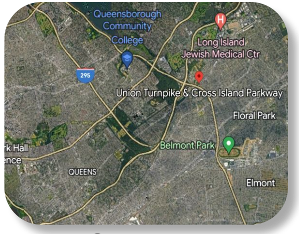
Center for Buildings, Infrastructure & Public Space

1. Case Study Overview

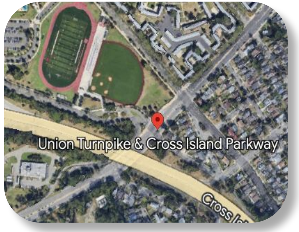
- Located in the intersection of **Union Turnpike** and **Cross Island Ave**
- Arch bridge **built in 1939**
- Total length = 100 ft, Span = 49 ft, max Height = 14 ft
- Material = reinforced concrete
- Project for **demolish** and **replace** the existing bridge with a girder bridge scheduled for 2024

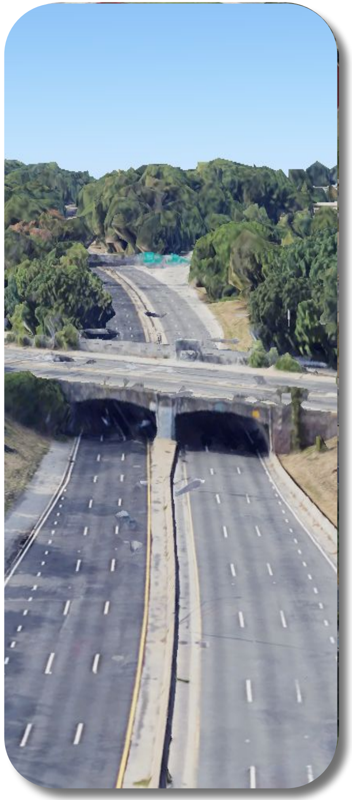


NYC



Queens




Google Earth (2023)

2. Research Objectives

01

3D Visualization

New, old structure, pipes, and construction scenarios

02

Specification Integration

Integrate spec. Into the 3D model

03

Digital Twin

Connectivity of the model with a future digital twin

04

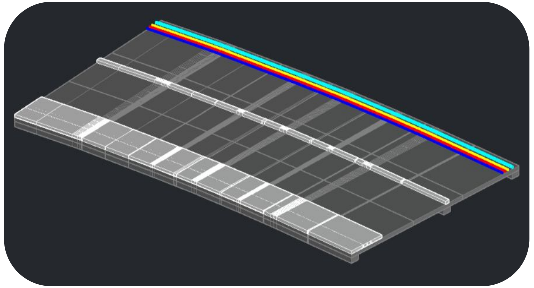
Guidelines: Ch.6

Digitalization for legacy projects

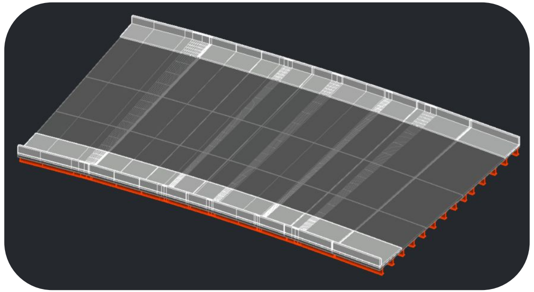
3. 3D Visualization

1. Import the **point data** into Civil 3D
2. Create the **surface** with the points
3. **Filter points** with wrong elevations
4. **Define the boundaries** of the model (google earth as a reference)
5. Create the **alignment** of the bridge (google earth as reference)
6. Create the **profile** using the surface as a reference
7. Create the **assembly** based on the sections of the survey
8. Create the **corridor** with the alignment, the profile, and the assembly
9. Extract the **3D objects** from the corridor
10. Repeat the same process for the New Bridge
11. **Link** the three models: current bridge, new bridge, and pipeline to Navisworks
12. Superimpose the pipe of the current bridge with the new bridge for **clash detection**

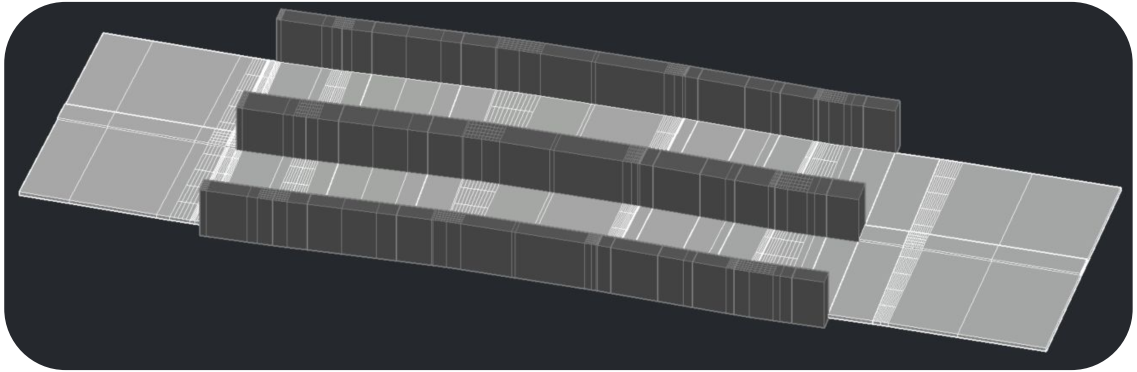
3. 3D Visualization



Current Union Turnpike Bridge



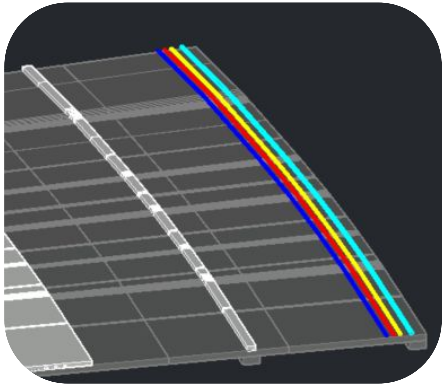
New Union Turnpike Bridge



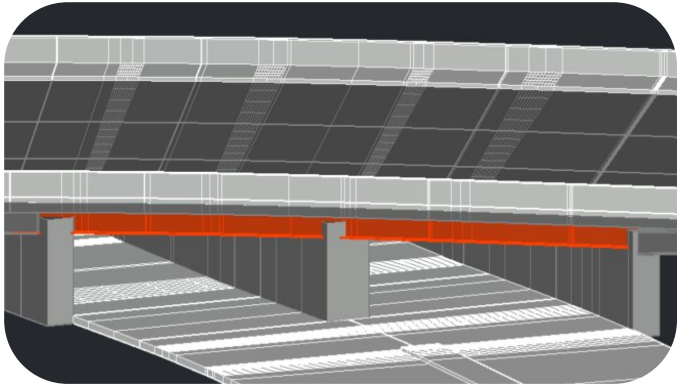
Cross Island Park

Google Earth (2023)

3. 3D Visualization



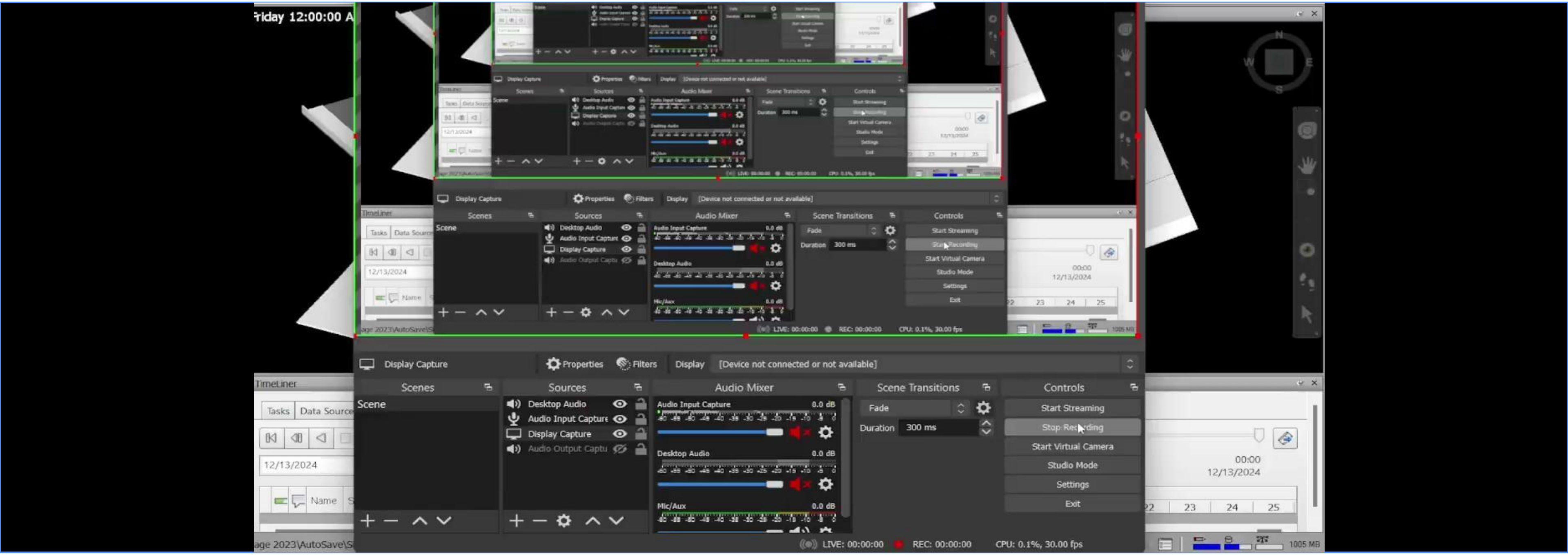
Union Turnpike Old Bridge
(Utilities and structures superimposed)



Union Turnpike New Bridge
(CIP and New UTP superimposed)

Google Earth (2023)

3. 3D Visualization - Construction Scenarios



3. 3D Visualization - Tools

1. **Longitudinal Modeling**
   - OpenBridge
   - Civil 3D
2. **3D Objects**
   - Microstation
   - Autocad
3. **Complex Geometry Modeling**
   - OpenBridge Designer
   - Dynamo + Civil 3D
4. **Information input**
   - Bentley Architecture
   - Revit
5. **Clash detection and construction scenarios**
   - Bentley Navigator
   - Navisworks

Bentley suite
Autodesk suite

4. Model Connectivity

- The 3D model is not just a visualization tool; it serves as a **nexus to project documentation**.
- Navisworks offers the possibility of **linking files in the cloud** to the model.
- Every file should be tailored for this purpose. Consequently, projects will have a larger number of **drawings, specifications, quantities**, etcetera.

4. Model Connectivity

Model 3D

Specification Integration: Drawings, Specifications, Quantities

Data that shows what is already built (doesn't change once the project is completed). Useful for decisions regarding demolitions, renewals or maintenance.

Digital Twin: Traffic Data and Health monitoring

Data updated in real time and useful for asset management. Data has to be collected through sensors on daily basis.

5. Specification Integration

Drawings:

- Structural Elements and Non-Structural Elements can be directly linked to the drawings related to them.

Specifications

- Specifications and quantities can be linked through the creation of icons of different colors.

5. Specification Integration

Requirements/Recommendations:

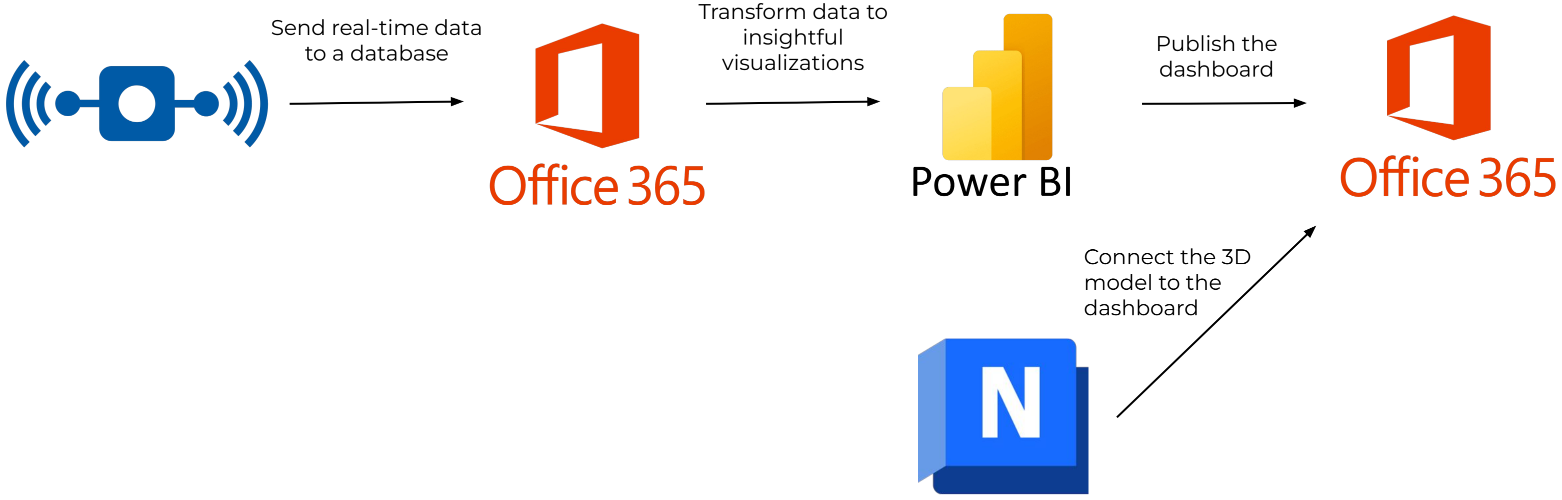
- The 3D model must always be the latest version, otherwise the new version should be updated with the links.
- Final documentation should be saved in the cloud to maintain confidentiality.
- Separate files for different elements and materials links should be created to enable agile navigation of the model. Avoid creating one big file, which can be difficult to manage and use effectively.

6. Digital Twin

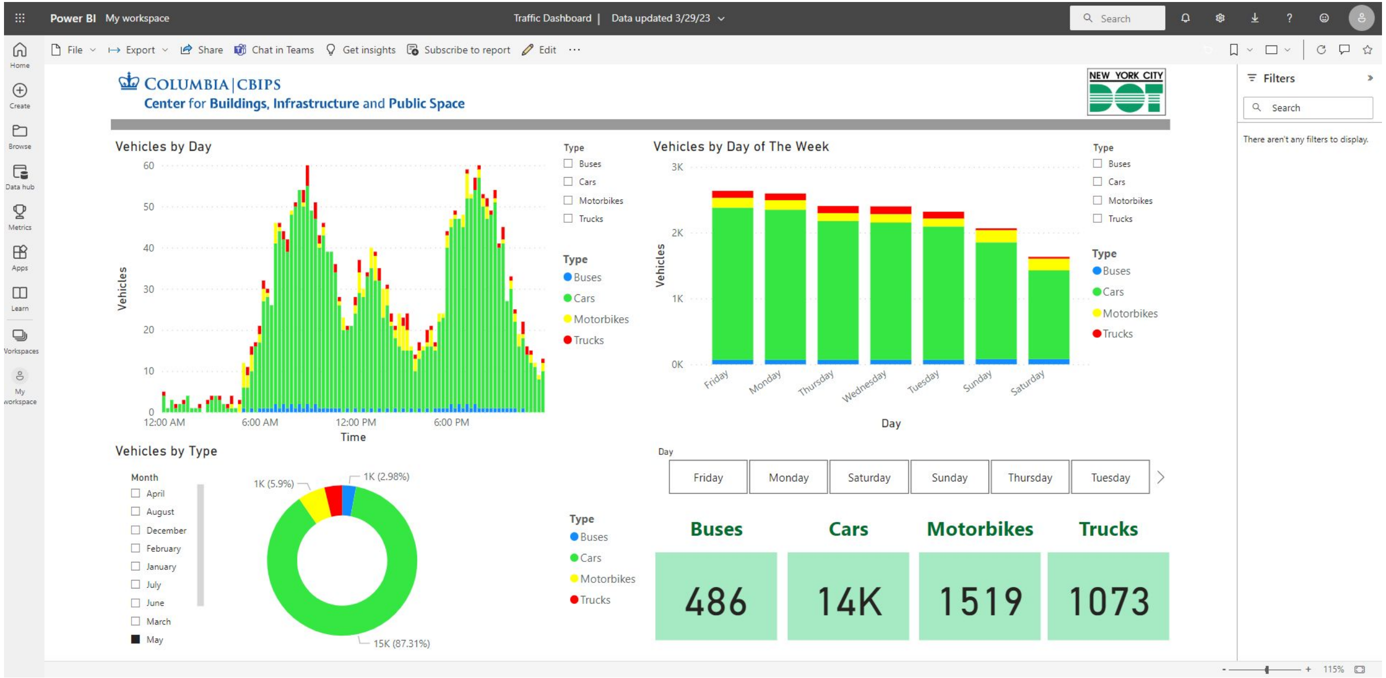
General Concepts:

- By creating a digital twin, users can access real-time data and use it for visualization, analysis, or alerting.
- A cloud system, such as Google Drive or Microsoft 365, is required for this purpose.
- In the model, an element acts as a link to a Power BI dashboard.
- Although Power BI offers enough flexibility to use the data in various ways, other software options may also work.

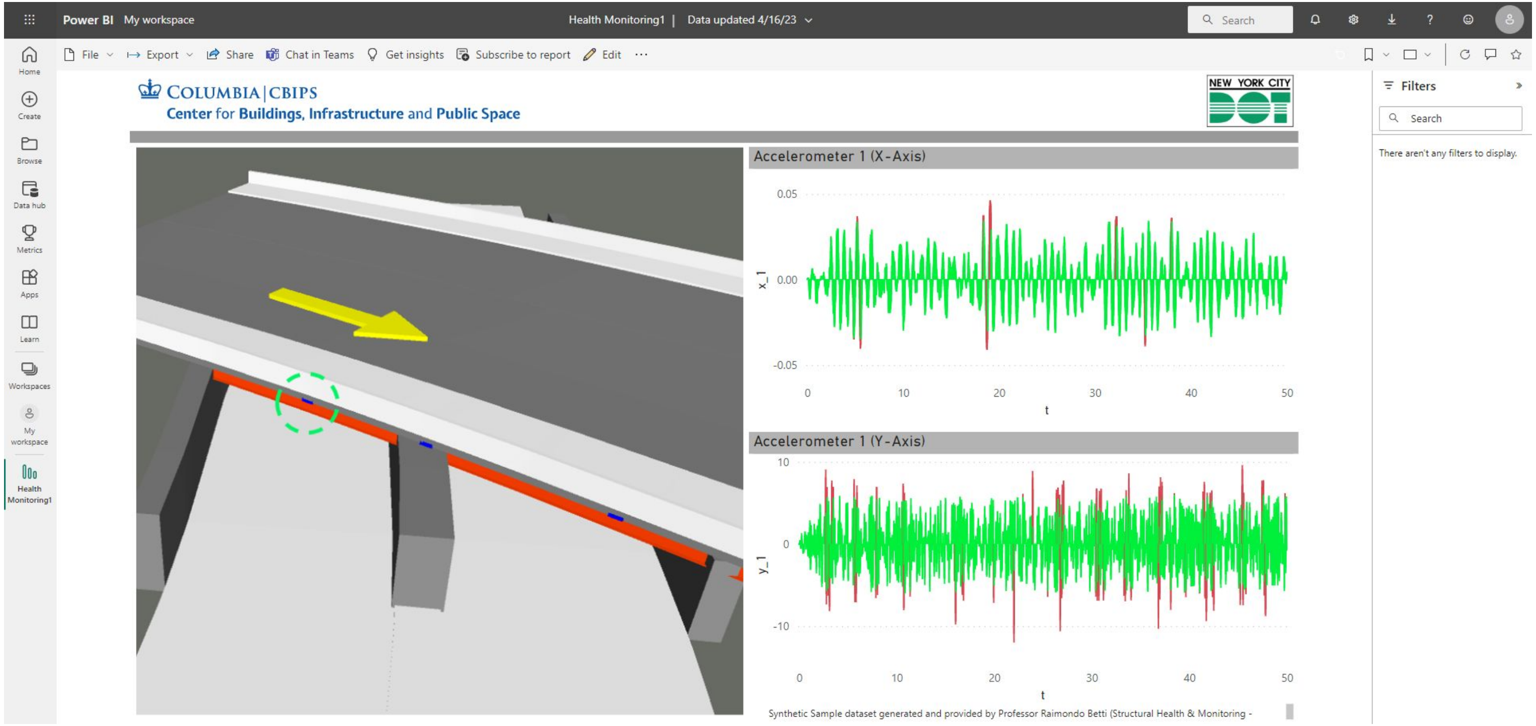
6. Digital Twin



7. Traffic Analysis (TA)

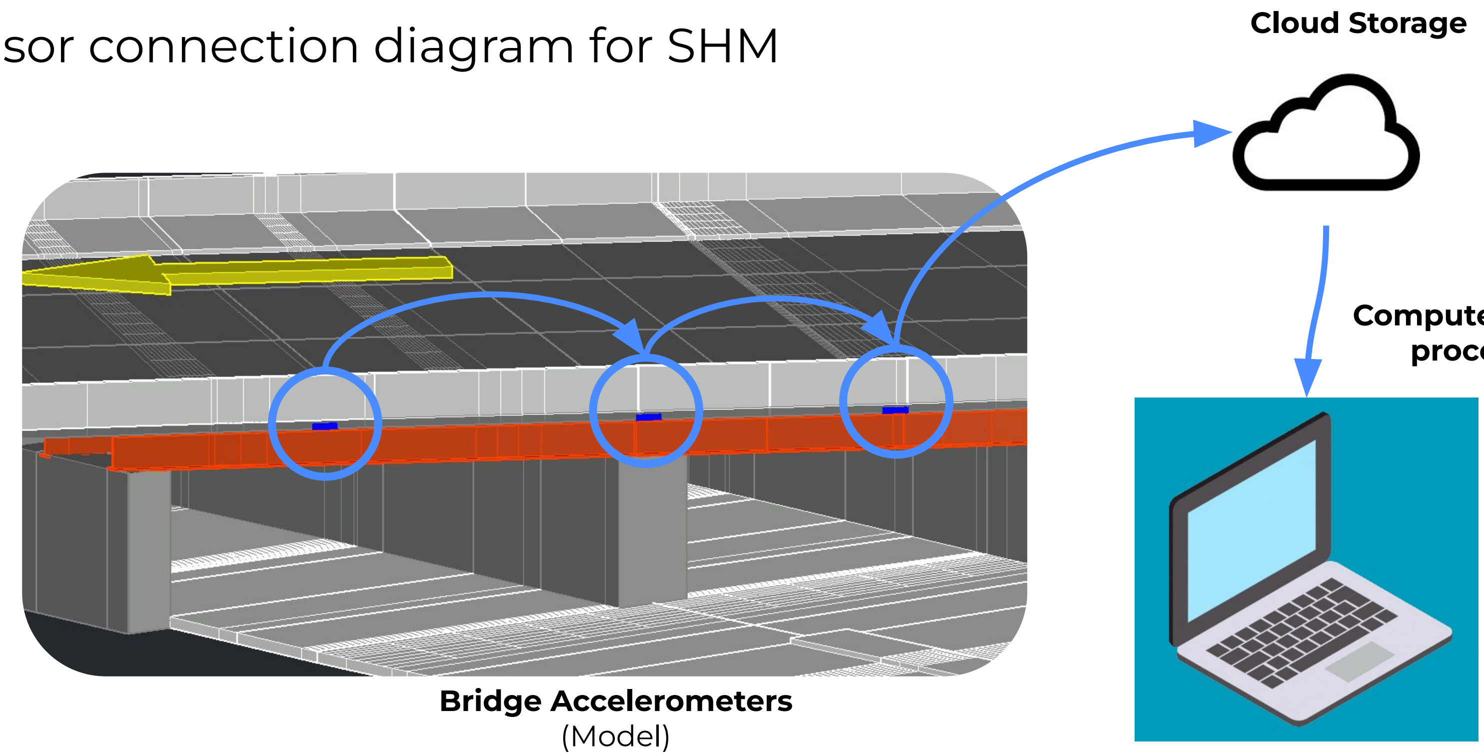


8. Structural and Health Monitoring (SHM)



8. SHM: Connectivity

Sensor connection diagram for SHM



Bridge Accelerometers
(Model)

8. SHM: Type of Measurements

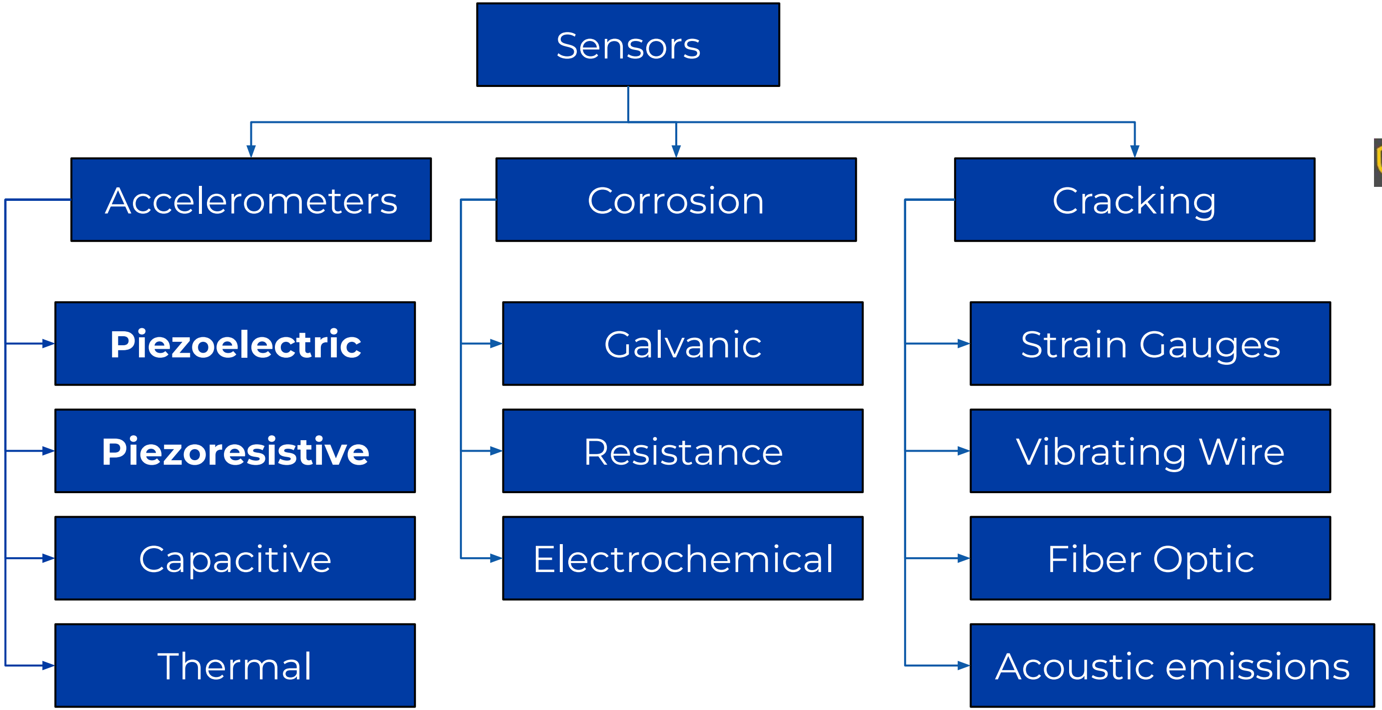
- **Input Measurements:**
  - Ground Acceleration
  - Ground Displacement
  - Wind speed
  - Temperature change
  - % of Humidity

x(k)

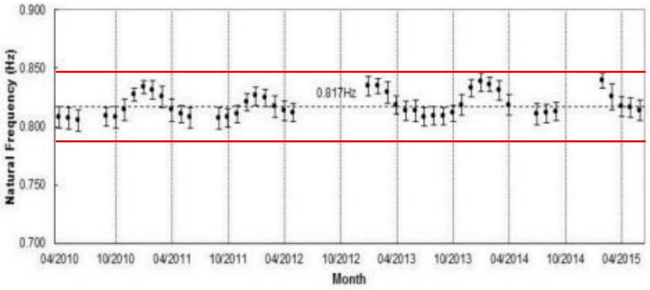
- **Output Measurements:**
  - Structure Acceleration
  - Structure Displacement
  - Inner Deformation
  - Corrosion

y(k)

8. SHM: Sensors



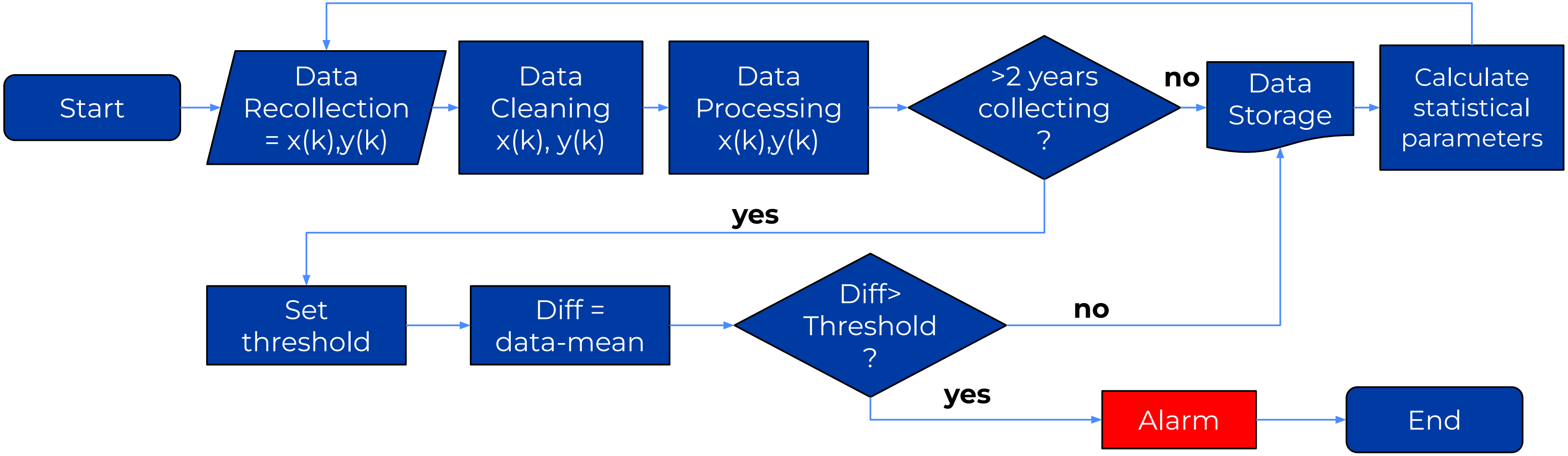
8. SHM: State of Art



Frequency change per season (Betti, 2022)

Procedure to monitor the bridge:

Data recollection = measurements from sensors
Data cleaning = remove noise from signals
Data processing = compute frequencies and mode shapes



8. SHM: Application into Digital Twin

Application into digital twins:

- Creation of a **3D model** that has the **location of each sensor** (by clicking, the user should be able to see the data).

- The **digital twin** itself must be **able to compute** the current **frequency** and **shape modes** of the bridge.

- Sent an **alert** if the current frequency has a **MSE > 10%**.

8. SHM: Limitations

- Data represents trends that can be compared only with past behavior of the same structure.
- Sensors does not allow providing conclusions regarding the structural situation of an infrastructure, can only give alerts for the public entities.
- A professional engineer needs to assess the data and analyze it before submitting a conclusion.
- The models to extract the frequencies from the data are complex, and involve AI for cleaning the data from noise.
- Most of this models assume elastic behavior.

9. Guidelines: Chapter 5

The Guidelines for this case study was divided into four parts as follows:

Part one - Surveying:

- What is surveying
- Purpose of surveying
- Surveying steps.

Part two - 3D Modeling:

- 3D-Modelling Definition
- 3D Modelling steps

Part Three- Structural Health Monitoring (SHM):

- What is structural health monitoring (SHM)
- Steps to perform SHM
- Difficulties in SHM application in US

Part Four- Traffic Analysis
Traffic analysis definition

- Purpose of Traffic analysis
- Traffic analysis Steps

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THANK YOU