



Transport Infrastructure Management and Digitization using Smart Sensing, AI and BIM

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Ground Robot



Aerial Drone



Underwater Drone



Camera



LIDAR



Virtual Reality



**Smart Cities and Communities (SCC)
Laboratory**



Augmented Reality



Outline

- Next-generation digitization of civil infrastructure
- BIMification of transport infrastructure and existing challenges
- Proposed research and innovation
- Ongoing at-scale deployments in HIFP project

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United Nation's 2024 Sustainable Development Goals (SDGs)¹

- Meet the urgent need and grand challenges of our society
- Provide the blueprint of immediate actions through global partnerships to satisfy the **2030 agenda for Sustainable Developments**
- **Two** specific SDGs (#9 and #11) are directly related to civil and infrastructure engineering!
- Key action item is to **build resilient and sustainable infrastructure, smart communities, and cities**
- **Resiliency** and **sustainability** - a long-standing goal for civil and transportation engineers!

¹<https://sdgs.un.org/goals>

Root-causes of Reduced Level of Sustainability in Transport Infrastructure

- Extreme weather and pressing construction scheduling
- Human errors and subjective actions in large-scale job site
- Time-intensive installation of pre-fabricated members
- Accessibility issues and lack of automation and operational productivity

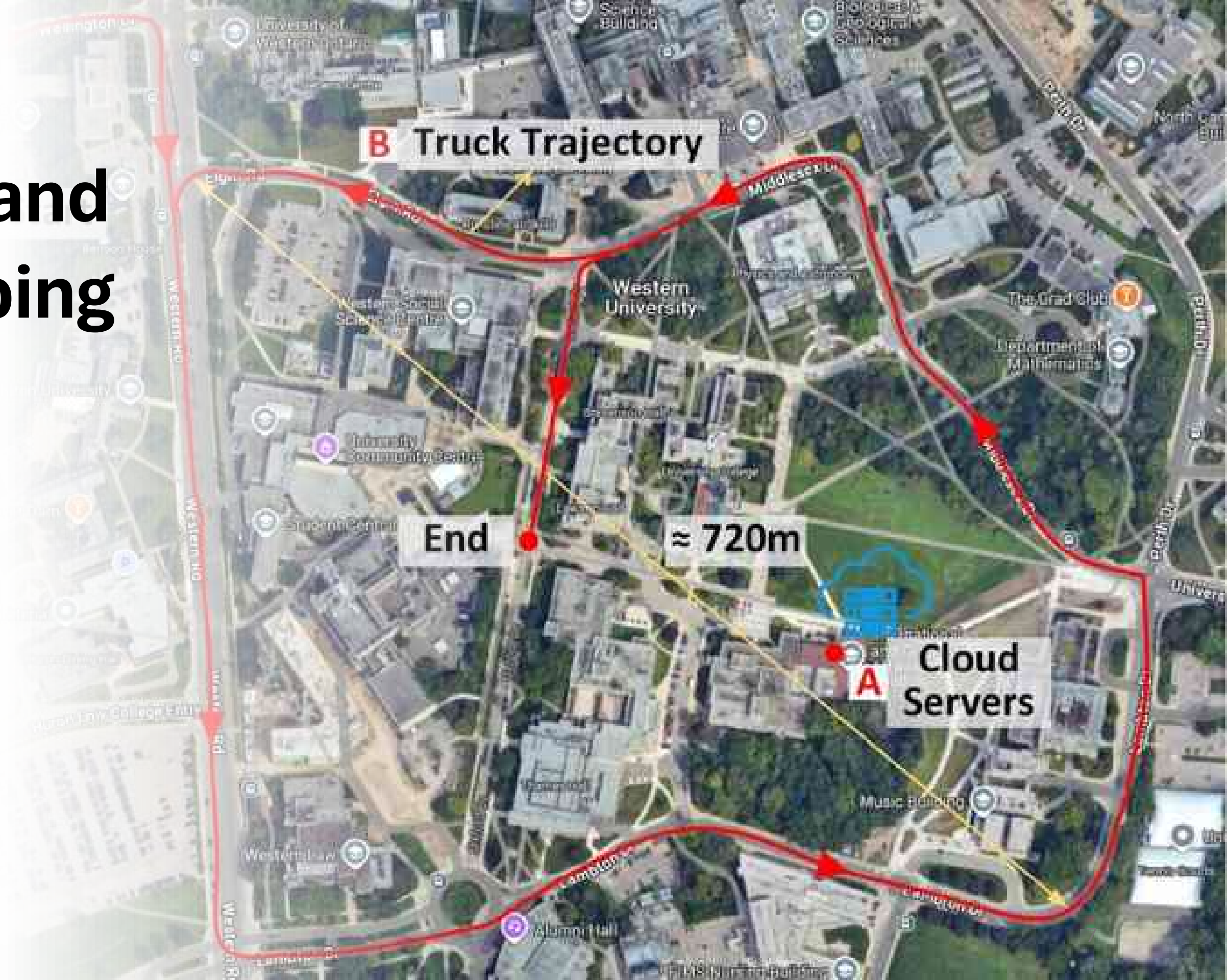
Potential Solutions

Need **autonomous and digitized inspection, as-built modeling, and mapping technology** for rapid and accurate asset management at construction and maintenance sites

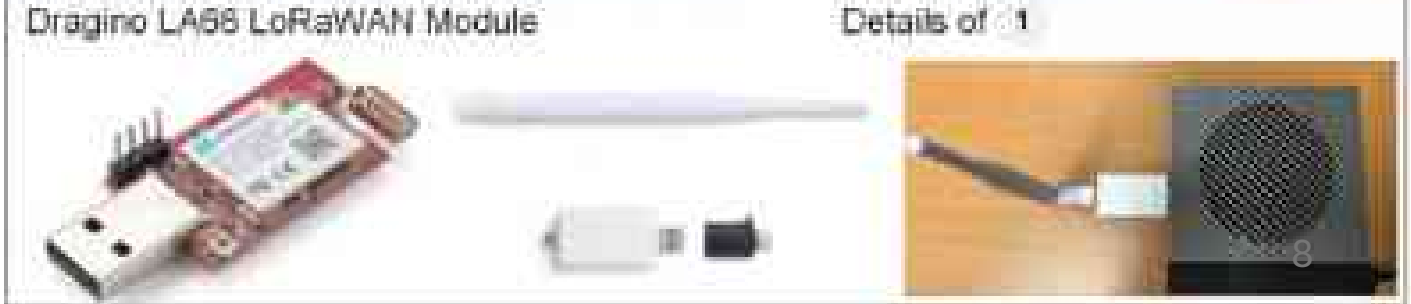
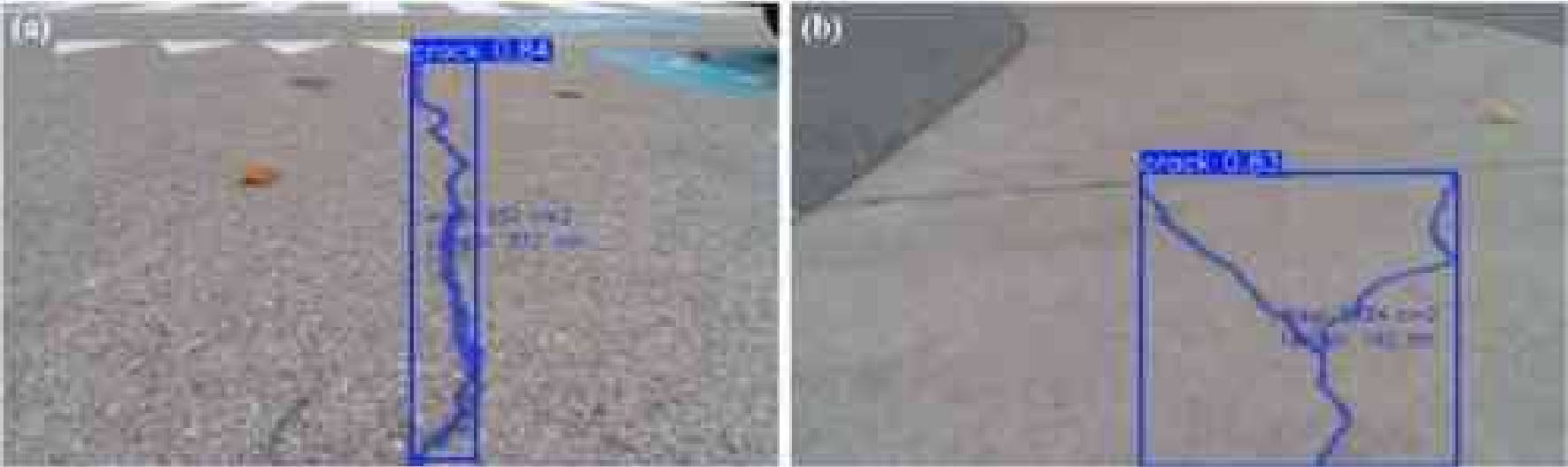
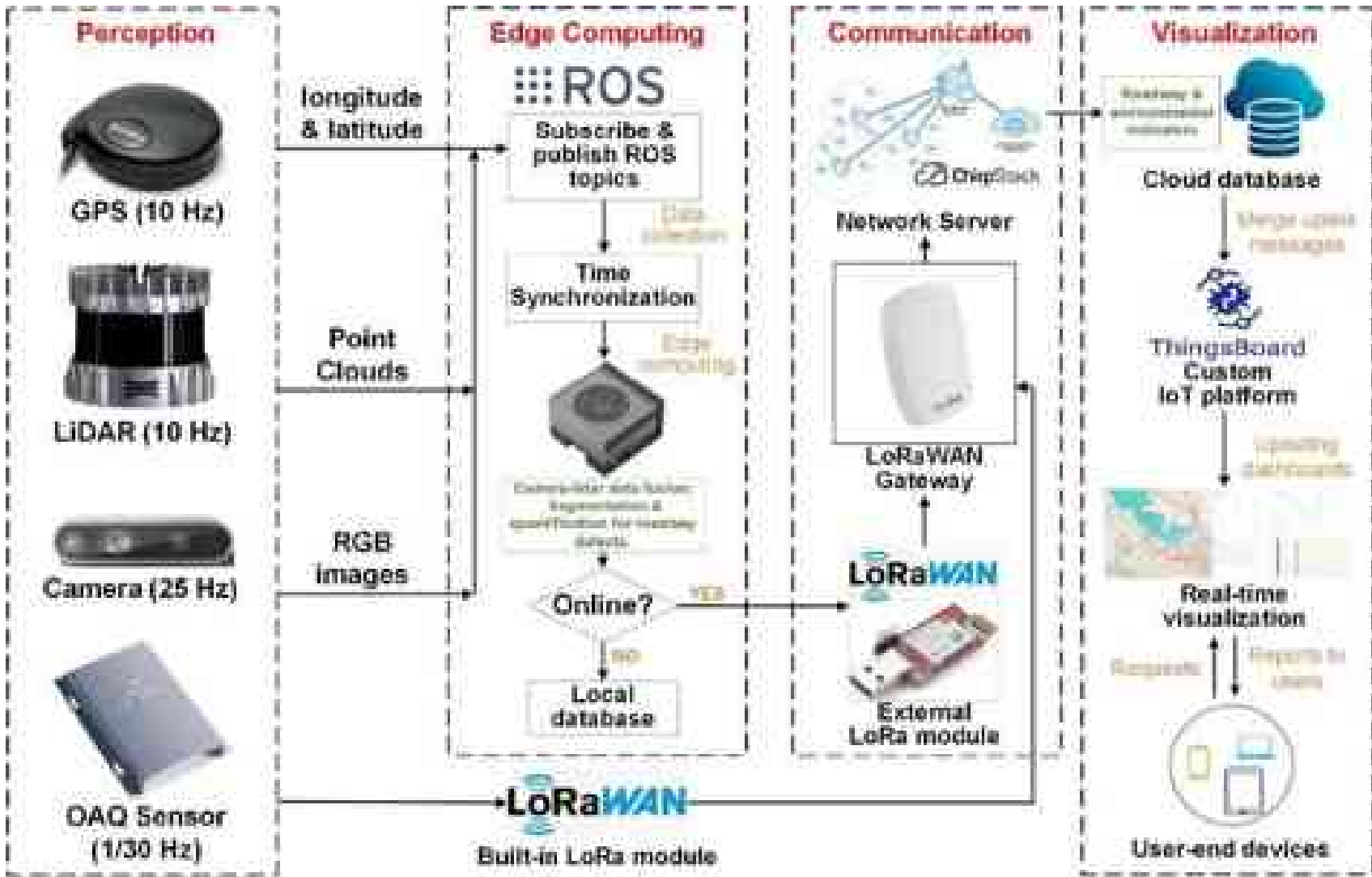
My Ongoing Research and Innovation:

Smart sensing + structural inspection + AI + BIM = Automation and Digitization = **Digital Twin (DT)**

**Real-time and
rapid mapping
and DT of
roadway
condition**



Methodological framework (SCCV)²



²Ge and Sadhu (2025)

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Building Information Modelling (BIM) in Civil Infrastructure



Limitations and Potential Innovations in BIMification

Limitations in BIM

1. Requires extensive **manual** modeling and human expertise to model infrastructure
2. Missing or unavailable drawing files of the existing **as-built environment**
3. Not investing in **BIM in initial phases** of infrastructure lifecycle makes it challenging to reproduce the project in BIM at a later stage

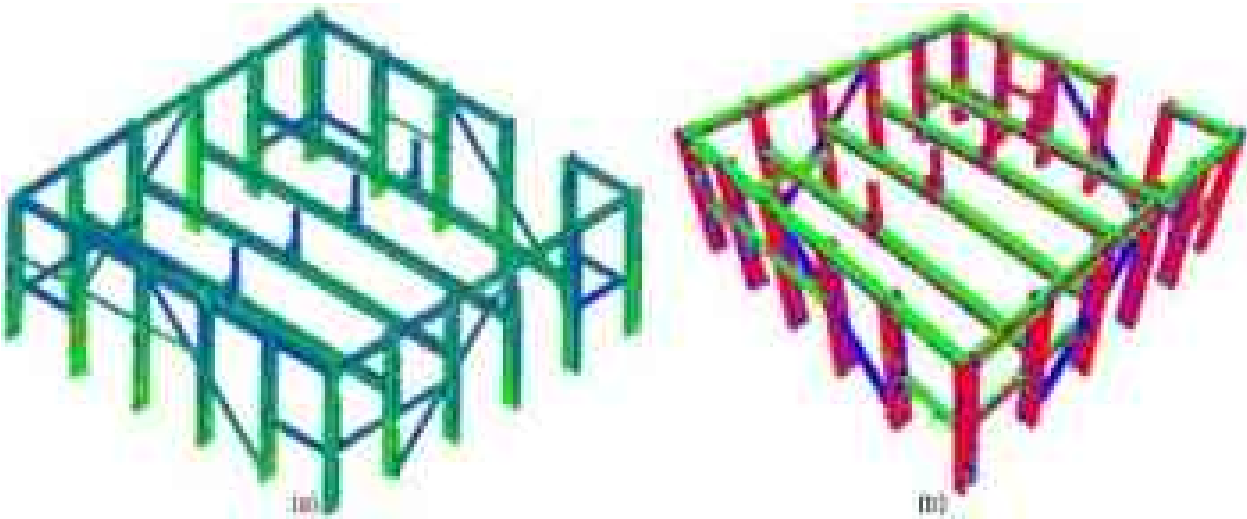
Potential Innovations using AI

1. Introducing AI tools for reserving human intervention only for decision making tasks
2. The use of high accuracy LiDAR to capture as-built BIM of large-scale infrastructure
3. Converting CAD drawings to 3D BIM objects using AI

Outline

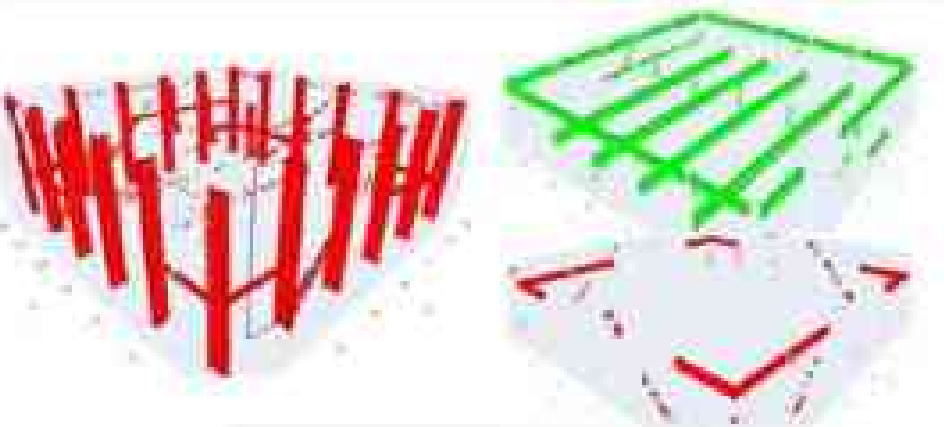
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Proposed Research: As-Built 3D Model Reconstruction using Lidar

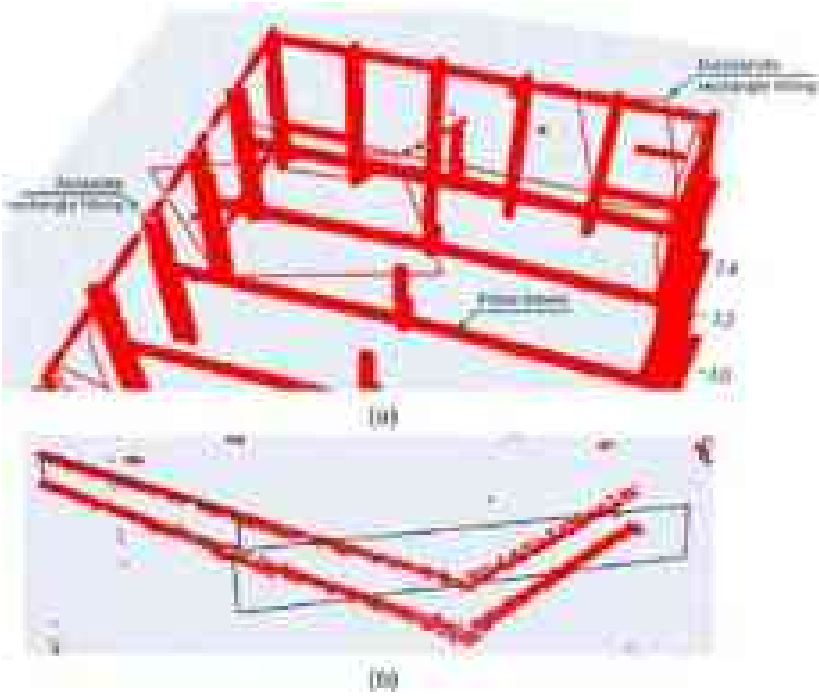
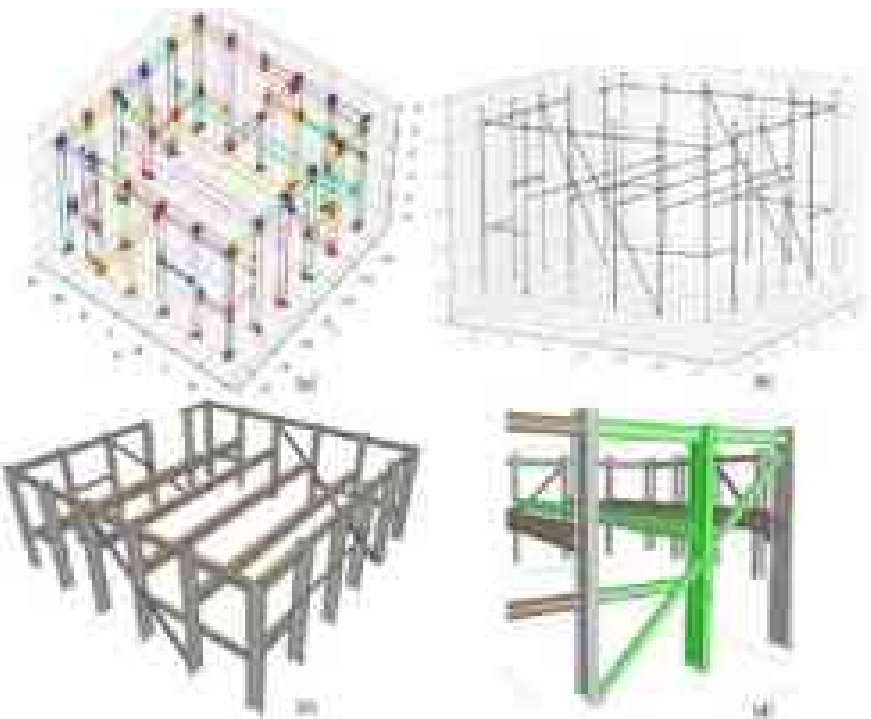


3D Point Cloud Visualization and Selection

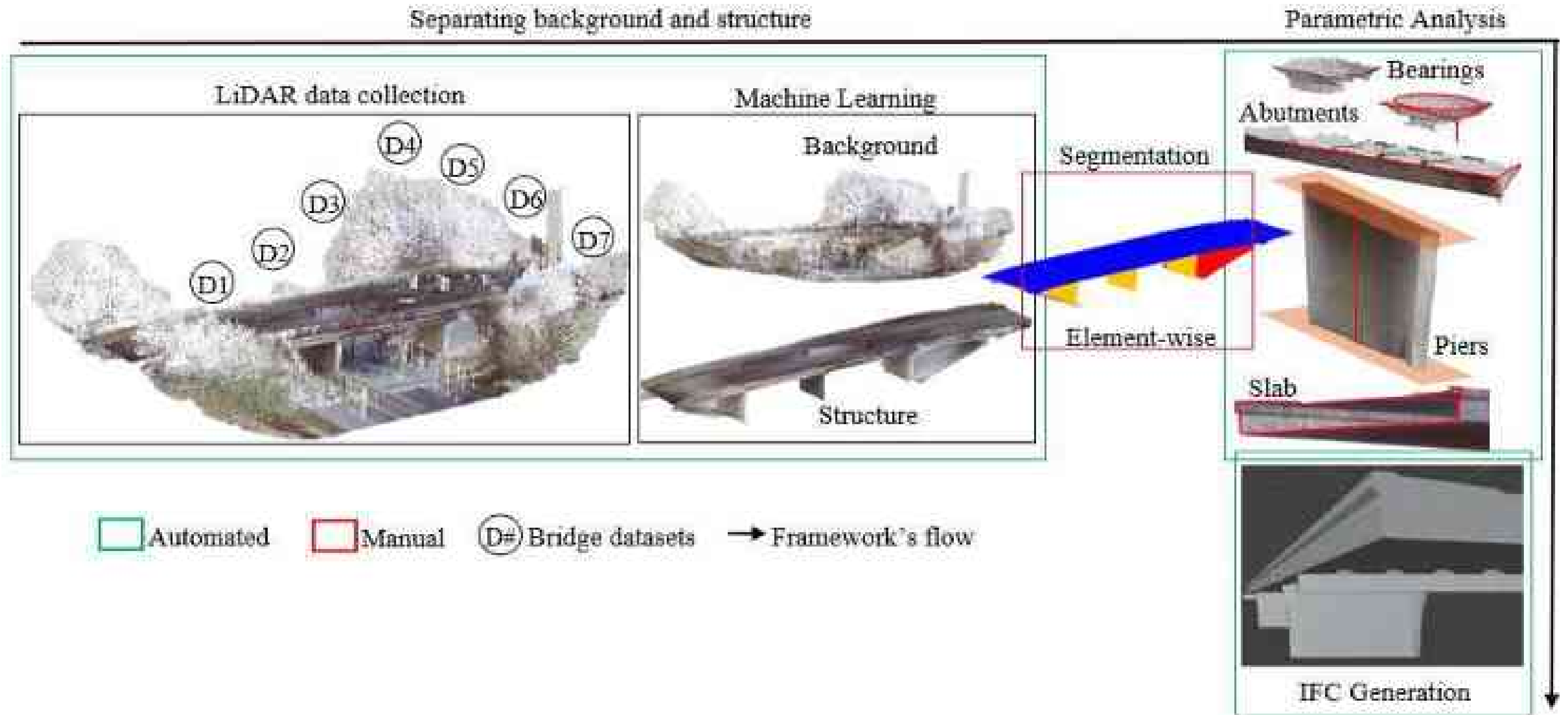
Columns	(a)	Beams	(b)
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Beams (a)



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Site A: Bridge construction site



Site B: Bridge rehabilitation site

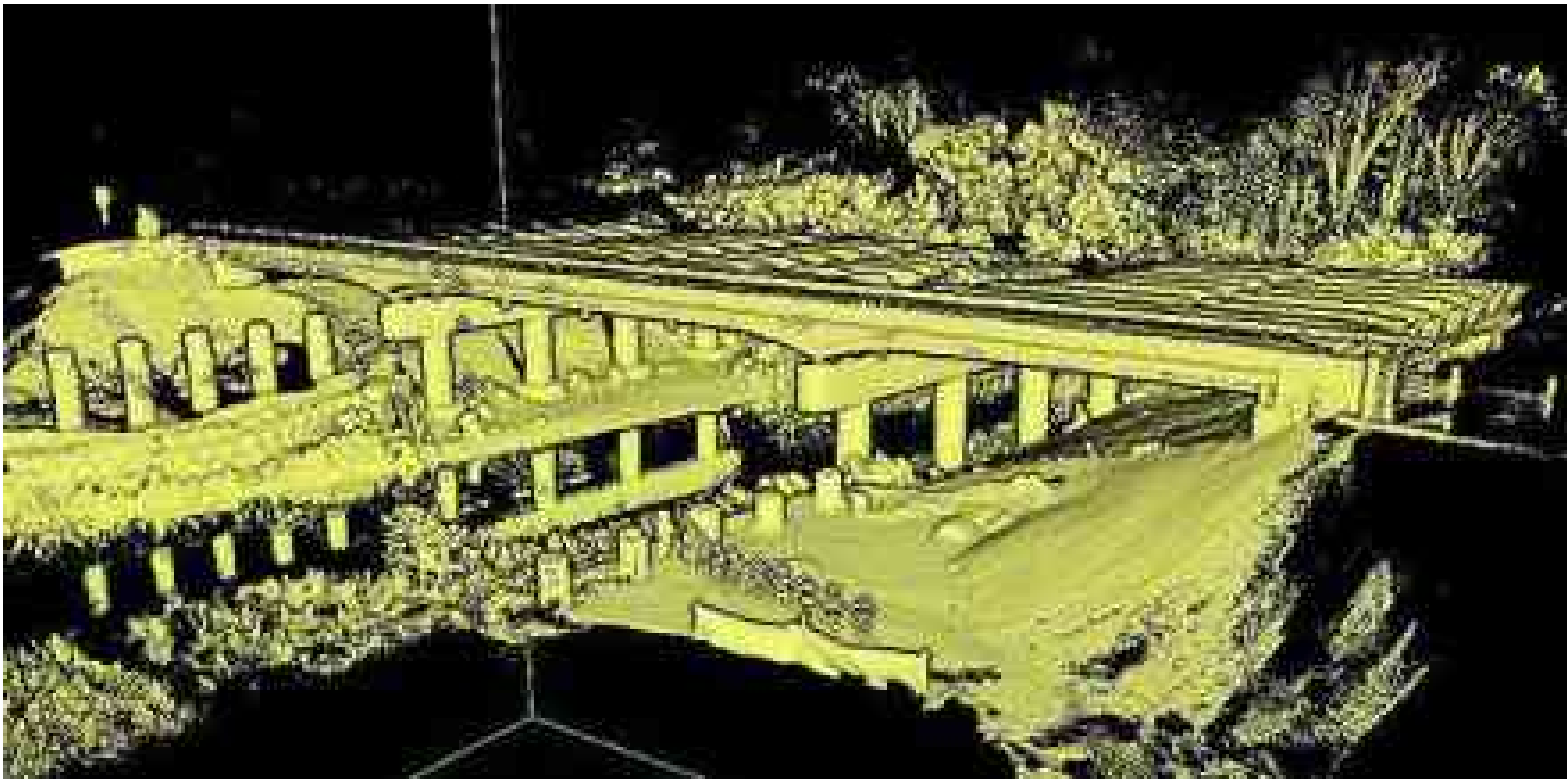


Drone scanning with camera and lidar



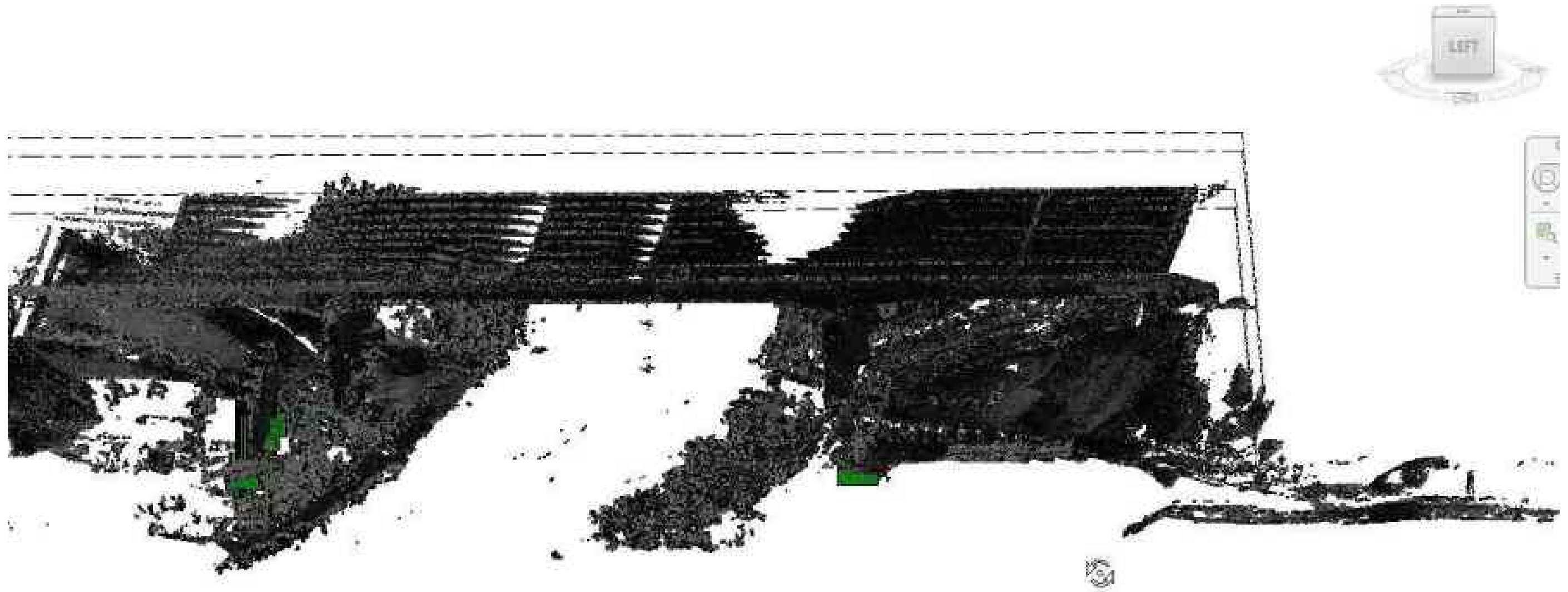
Scanning of construction site using hand-held lidar



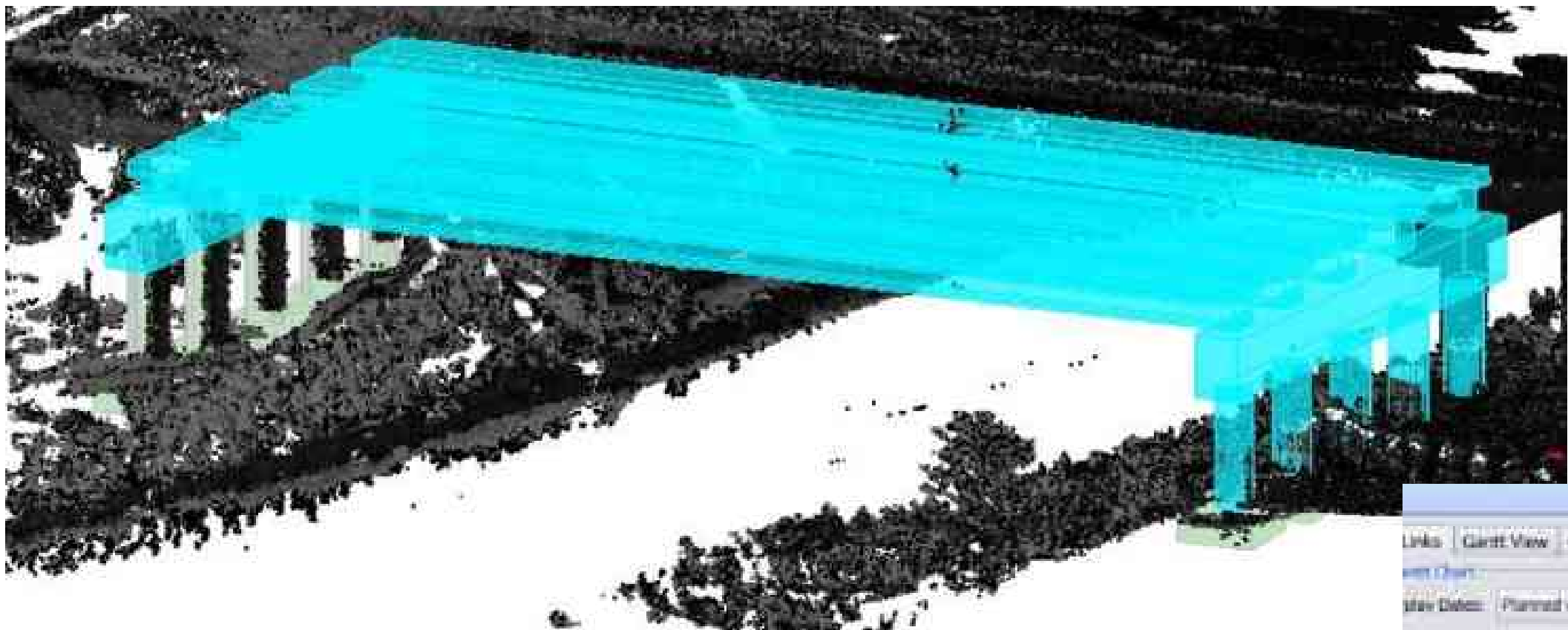




1) Construction-sector BIMification

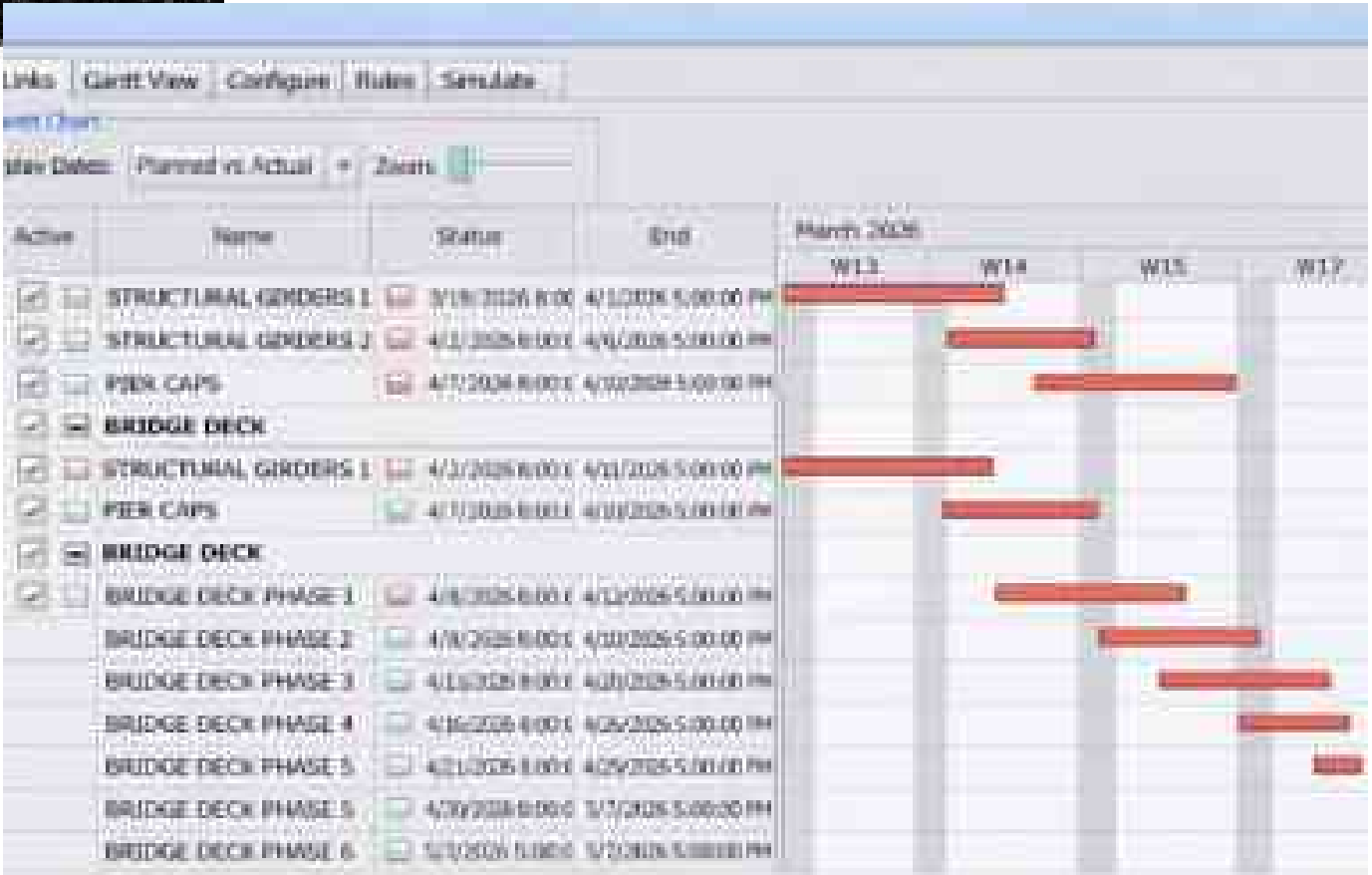


1) Construction-sector BIMification



- Generate scheduling plans for “yet to be built” components in structured timelines using BIM
- Compare any future construction with as-modeled BIM to study any delays or geometric deviations

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2) Maintenance-sector BLMification



2) Maintenance-sector BIMification

Structural	
Rebar Cover - Bottom Face:	Interior (framing, columns) <38>
Rebar Cover - Other Faces:	Interior (framing, columns) <38>
Top Attachment Distance:	2101 mm
Top Attachment Referenced End:	Start
Top Attachment Type:	Distance
Condition_Rating:	3
Damage_Extent_%%	12
Inspection_Class:	Level 2
Last_Inspection_Date:	2024-05-12
Observed_Damage:	Vertical cracking
Section Shape:	0
Data	
Asset_ID:	BR-P01-COL-03
Asset_Type:	Bridge Column
Strain Data:	https://opensource.salesforce.com/OmniXAI/latest/_images/demo_ts.png
Structure_System:	Substructure

Construction	
Attachment Justification At Top:	Tangent
Base Cut Style:	Perpendicular
Base Extension:	0 mm
Offset From Attachment At Top:	0 mm
Top Geometry Alignment:	Bottom of Beam
Concrete_Class:	C35/45
Construction_Year	1960
Cover_Thickness_mm:	45
Design_Service_Life:	100
Exposure_Class:	XC4 – XD3
Last_Major_Repair:	2018
Structural_Material:	Reinforced Concrete

BaseQuantities	
Length:	6200 mm
CrossSectionArea:	0.71 m2
OuterSurfaceArea:	18.50 m2
GrossVolume:	4.39 m3
NetVolume:	4.39 m3

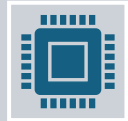
Advantages

- Predictive maintenance: Use real-time data to predict failure
- Cost optimization: Reduce regular unnecessary inspections
- Improved decision making: Everything is documented resulting in collective knowledge and decisions
- Digital Twin potential: Remote and digital monitoring

Conclusions



Noncontact **smart sensing** technology and **BIM** has revolutionary impact in construction and maintenance of transport infrastructure to improve sustainability, accessibility, and resiliency



AI can be leveraged to improve the automation, resulting in speedy inspection and accurate inspection at job site through **digital twin**



These technologies allows integration of **domain knowledge of engineers** with automation capabilities of AI and smart sensing



Construction and maintenance digitization will yield tremendous productivity at job sites and cost-saving, leading to create **more opportunities for construction and inspection, and more jobs!**



Industry-academia interdisciplinary collaboration is a must to develop robust and scalable solutions for unique problems and challenges

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Thanks for your attention!