AI/ML Driven Innovation for High Precision Construction, Inspections, and Management

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Center for Nuclear Energy Facilities & Structures

CNEFS

- Sustainability
- Resiliency and Severe Accident Management
- Reducing Cost of Building New Plants

CNEFS

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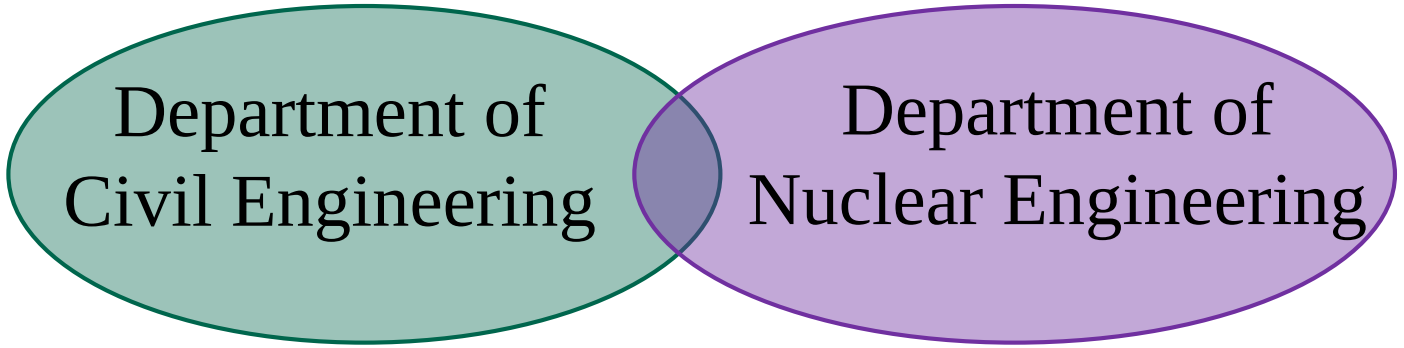

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Kevin Han
Giorgio T. Proestos
Ashly Cabas Mijares
Jim Rispoli

Nam Dinh
Kostadin Ivanov
Mihai A. Diaconeasa
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CNEFS Faculty

Faculty

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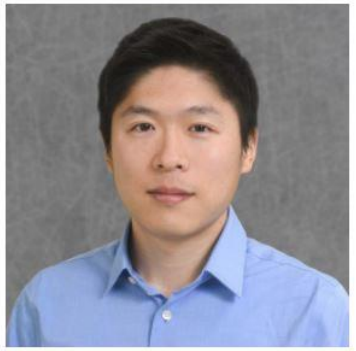
Mihai A. Diaconeasa, Assistant Professor

Nam Dinh, Professor



Kevin Han, Assistant Professor

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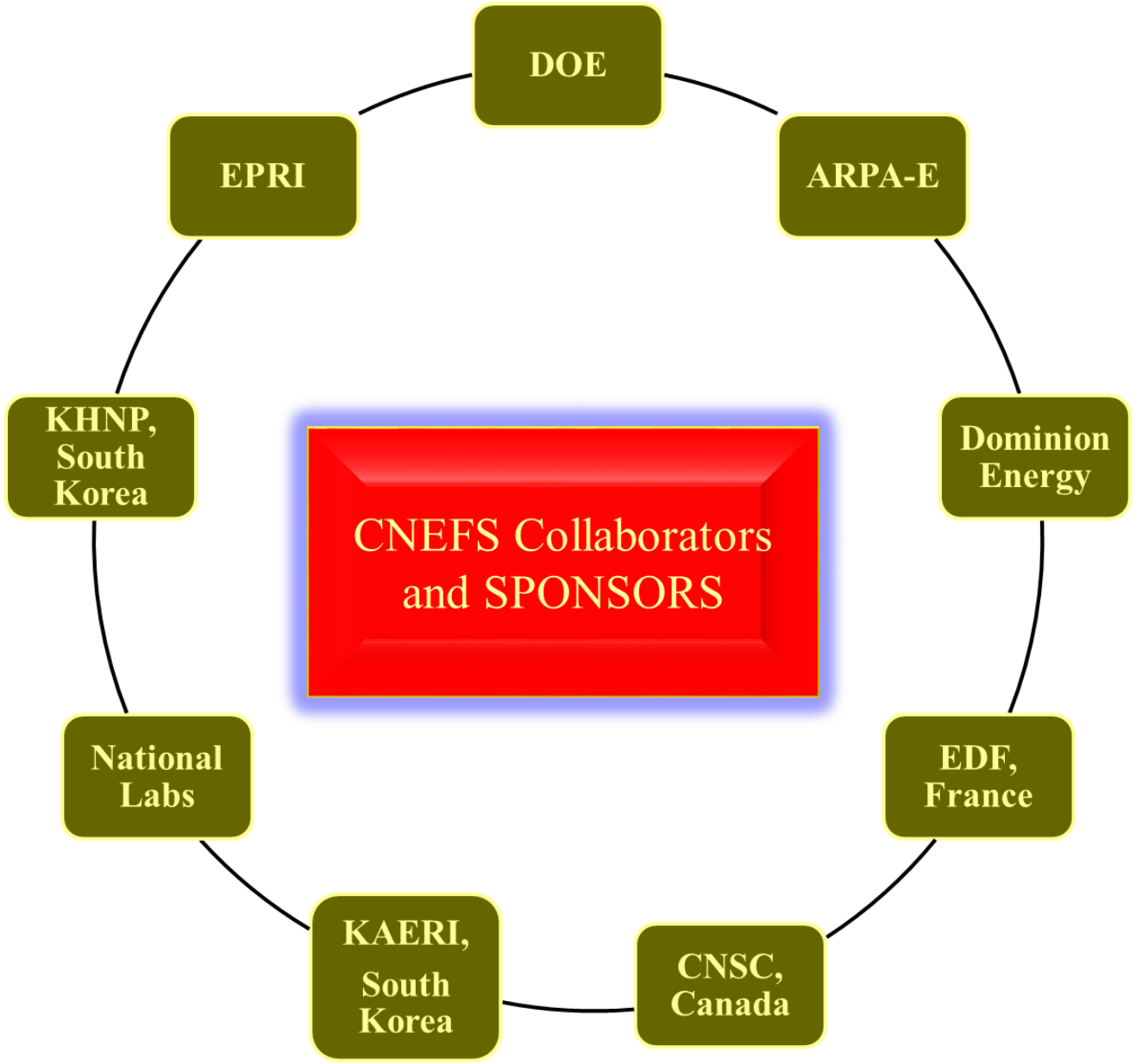
Jim Rispoli, Professor of Practice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KAERI, South Korea
National Labs
KHNP, South Korea
EPRI
CNEFS Collaborators and SPONSORS

Facilitated by Support From

- VTR Project at INL
  - Digital Engineering for Integrated Design and Construction
  - *Chris Ritter, Lee Nelson and Digital Engineering team at INL*
- ARPA-E
  - Development of Construction Performance Modeling & Simulation
  - *Rachel Slaybaugh and rest of ARPA-E team*

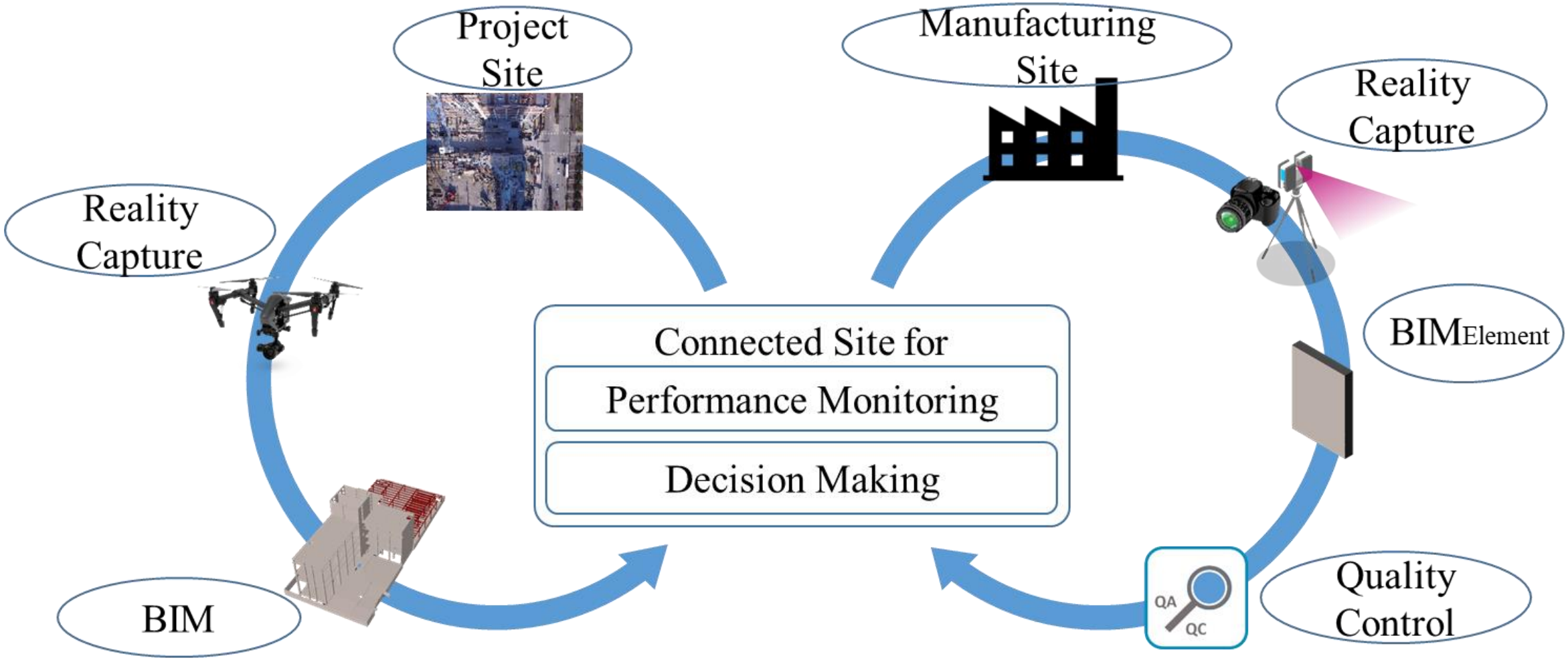
What happened at VC Summers…

- Construction plans and schedules not reflective of on-site reality.
- Project management integration was poor. Approvals of changes through paperwork between construction supervisors, inspectors, decision makers, regulators, and owners.
- Lack of communication and information flow at all levels. Very slow pace and lack of understanding of the real issue at all stages.
- Design changes not showing up in EPC or in construction drawings.
- Mismatch in as-design and as-built.
- Lack of real-time info for oversight.

What We Do…

- Provide near real-time on-site & off-site progress/quality monitoring
- Improve communication of **performance and changes** among all stakeholders through integrated digital modeling
  - Project management integration & streamlined decision making for changes
- Model performance (as-built) against construction plan (as-design)
  - No mismatch in as-design and as-built
- Improve interoperability between design software and BIM
  - Design changes showing in EPC and in construction drawings

Holistic Approach to Performance Management at Project Site and Off- Site Facilities

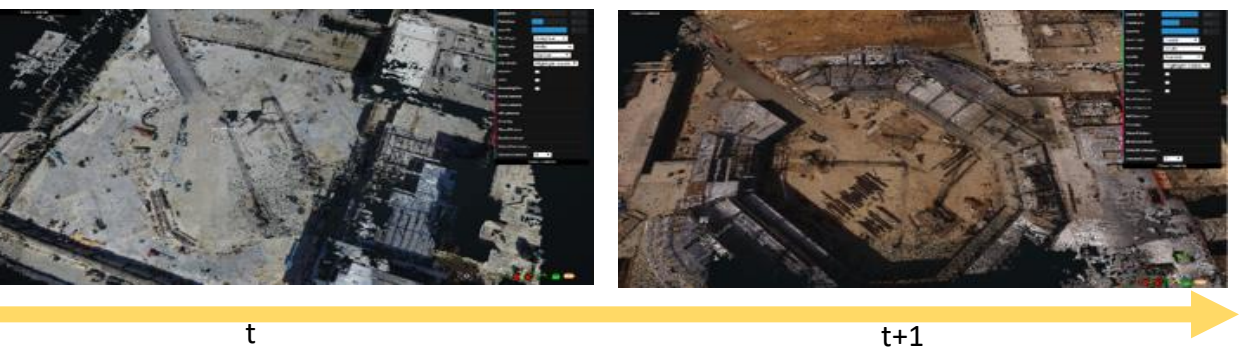


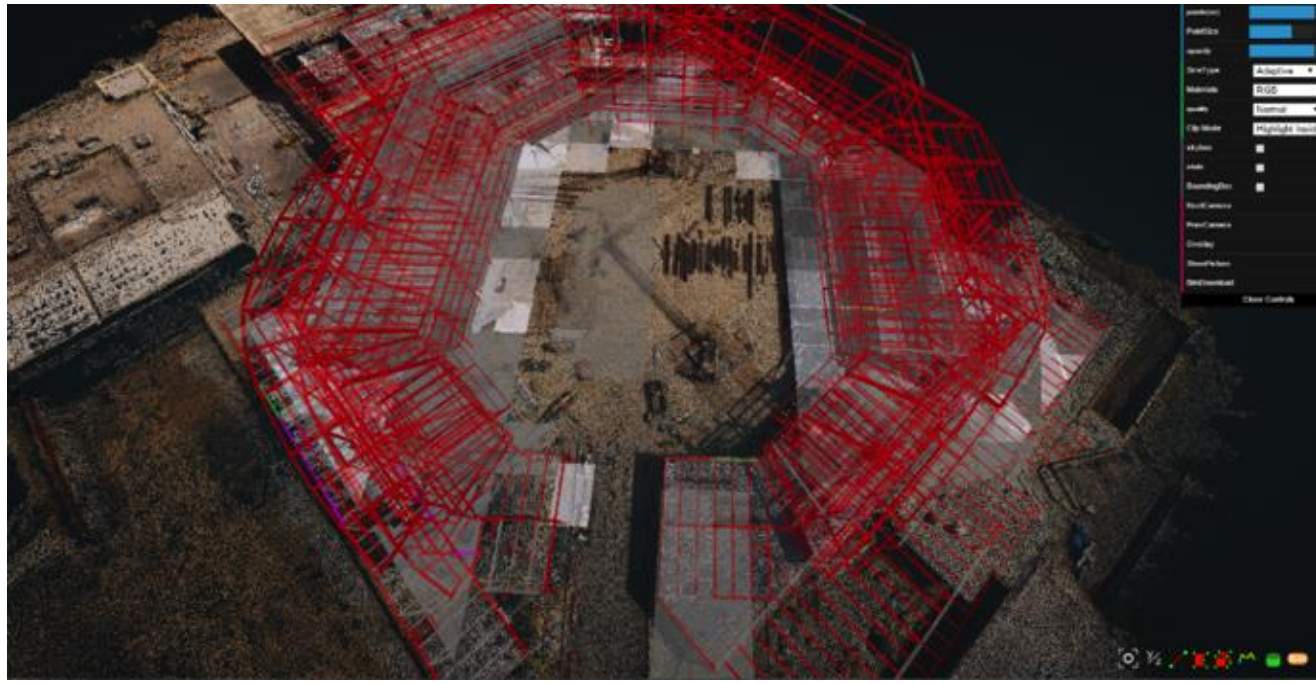
Virtual QA/QC and Workflow

- NQA-1 standards for key components that require visual inspection
- Quality assessment method that ensures compatibility of modular components
- Workflow, standards, and quality of digital information exchange for CPMS

Integrated Information Models for Production Control

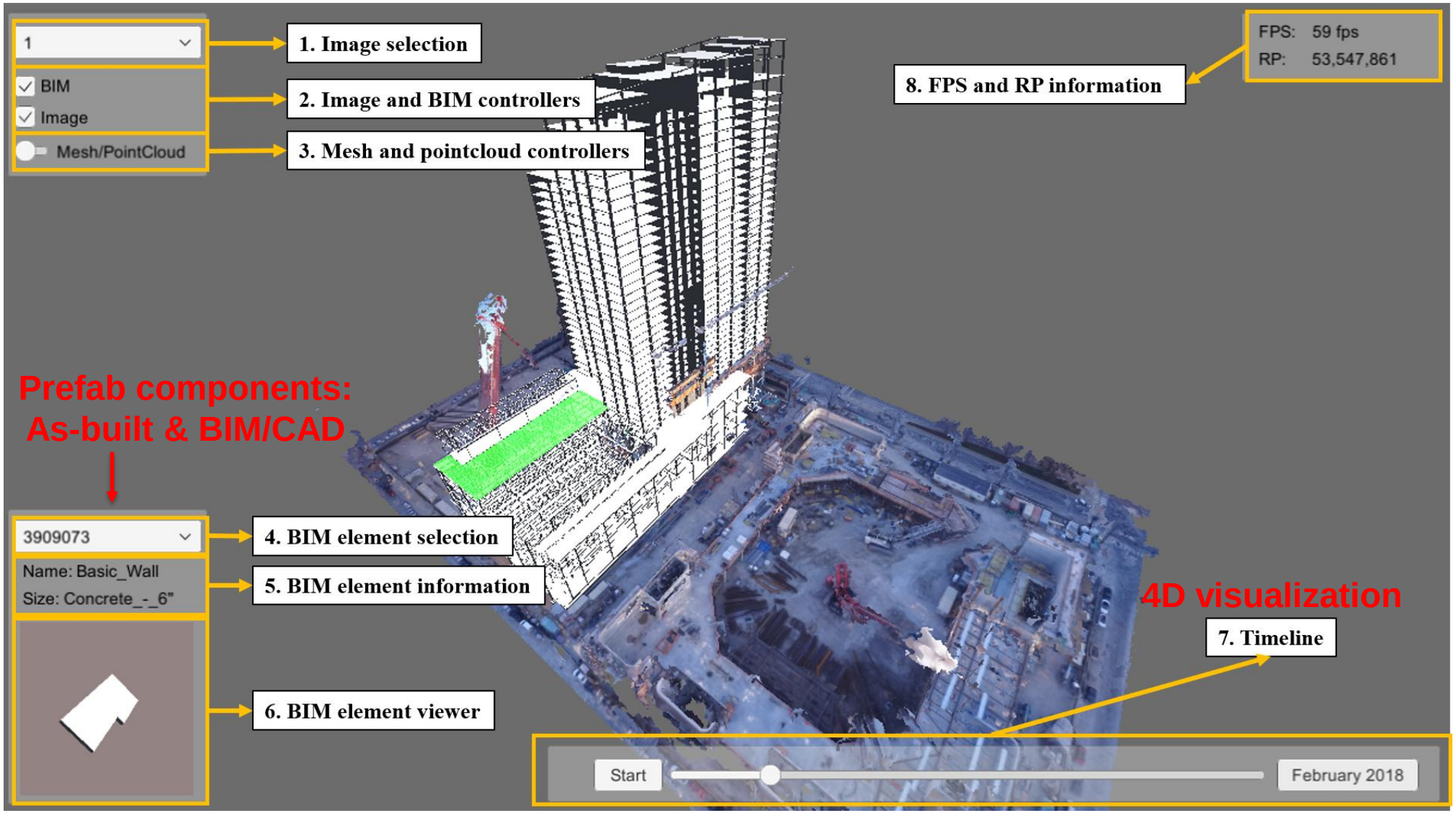
- As-built Documentation
- Performance Monitoring (Progress, Safety, and Quality)
- Contractor Hand-Over



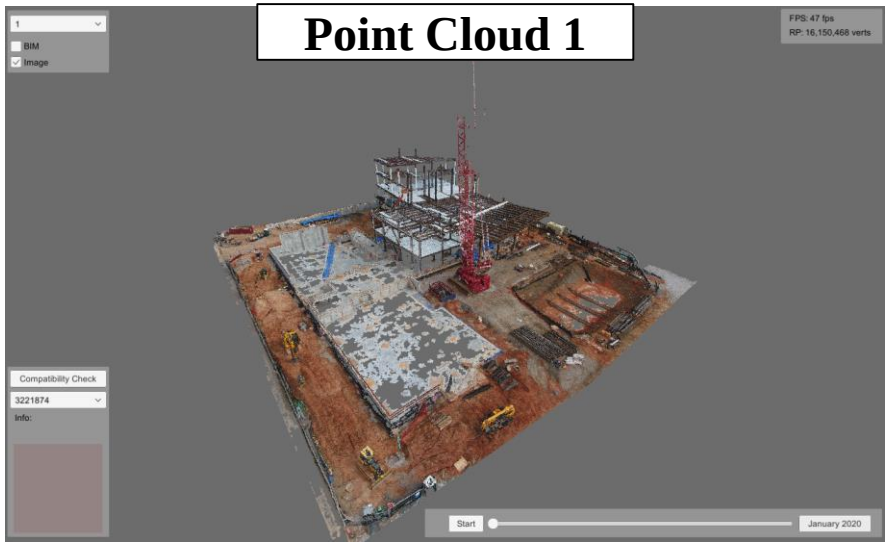


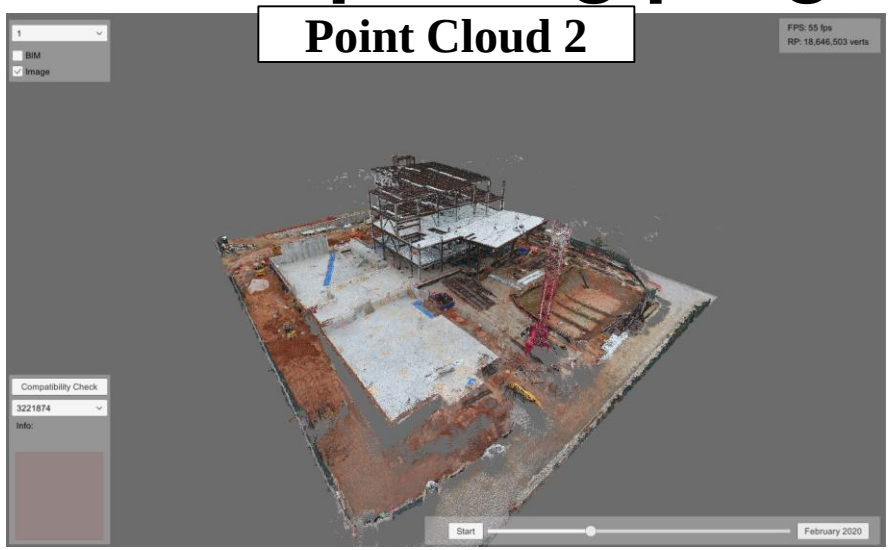
Virtual Comparison: 4D As-built Model (Progress) vs 4D BIM (Plan)

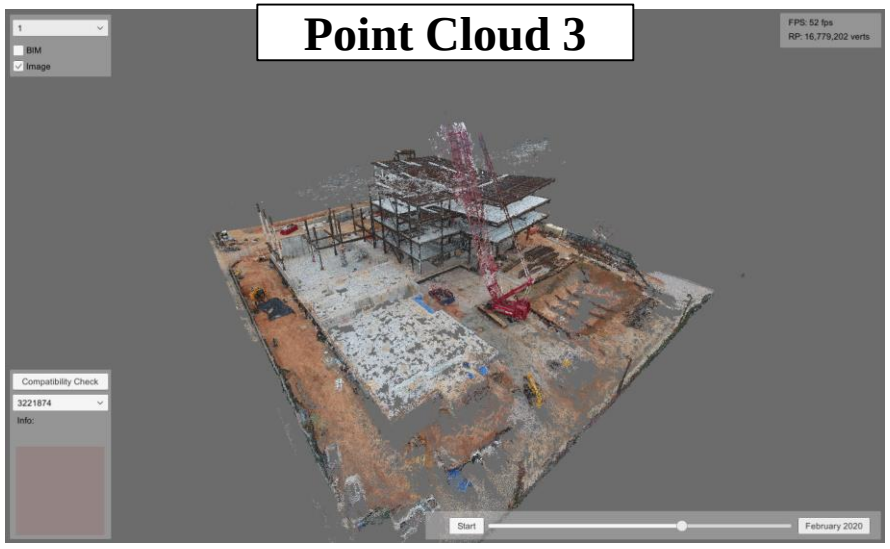
Prototype – Virtual Environment for Performance Monitoring

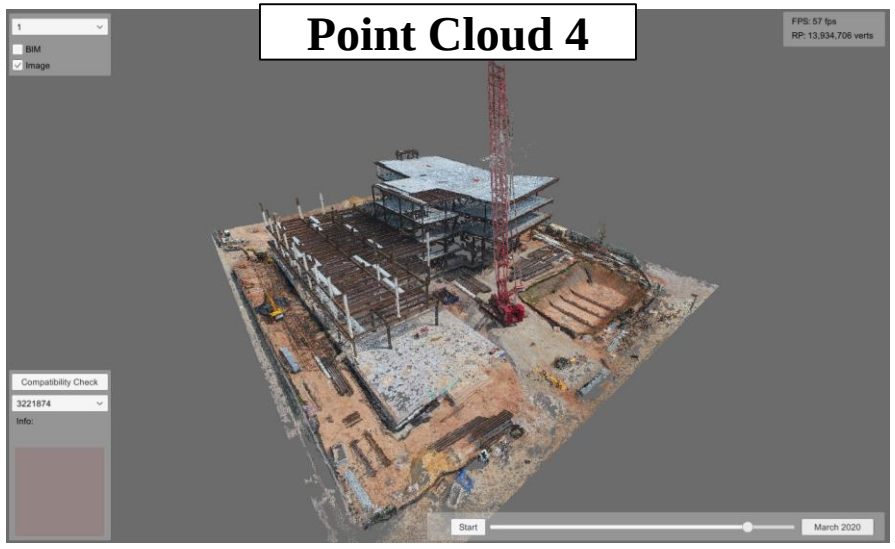


Prototype – 4D as-built model for capturing progress

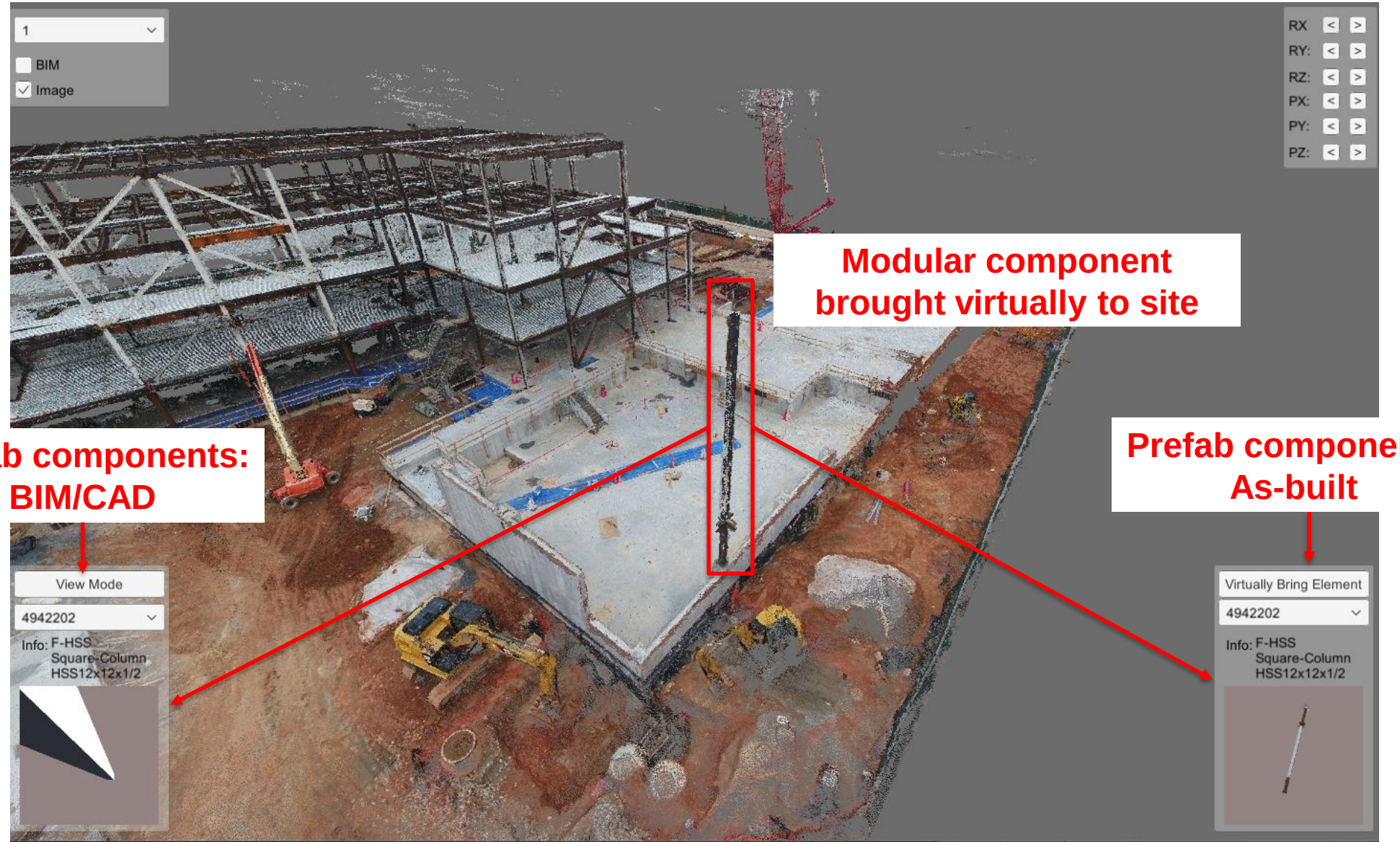






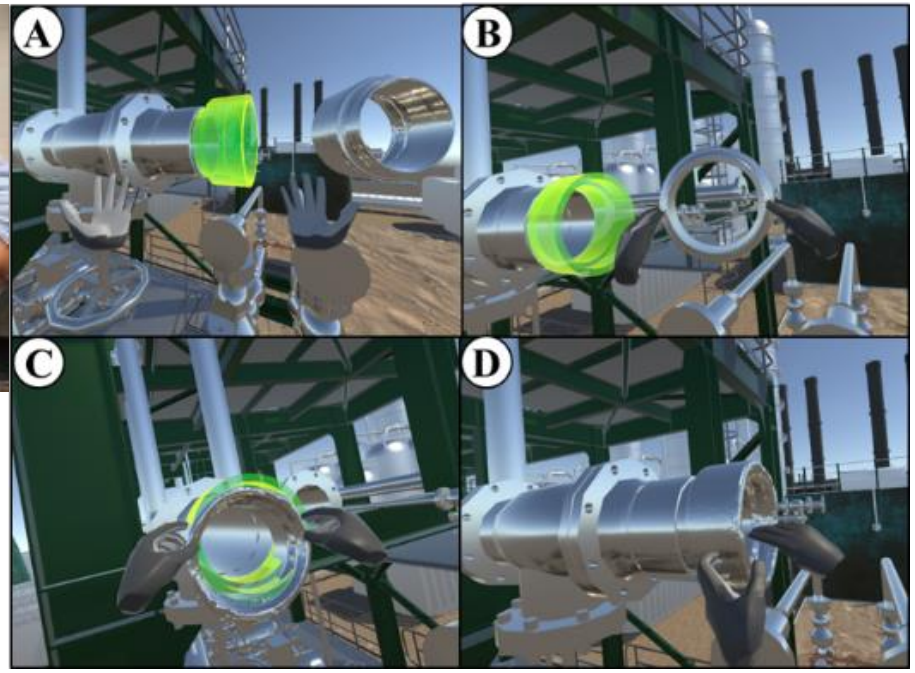


Prototype – Virtually bring modular component to assess

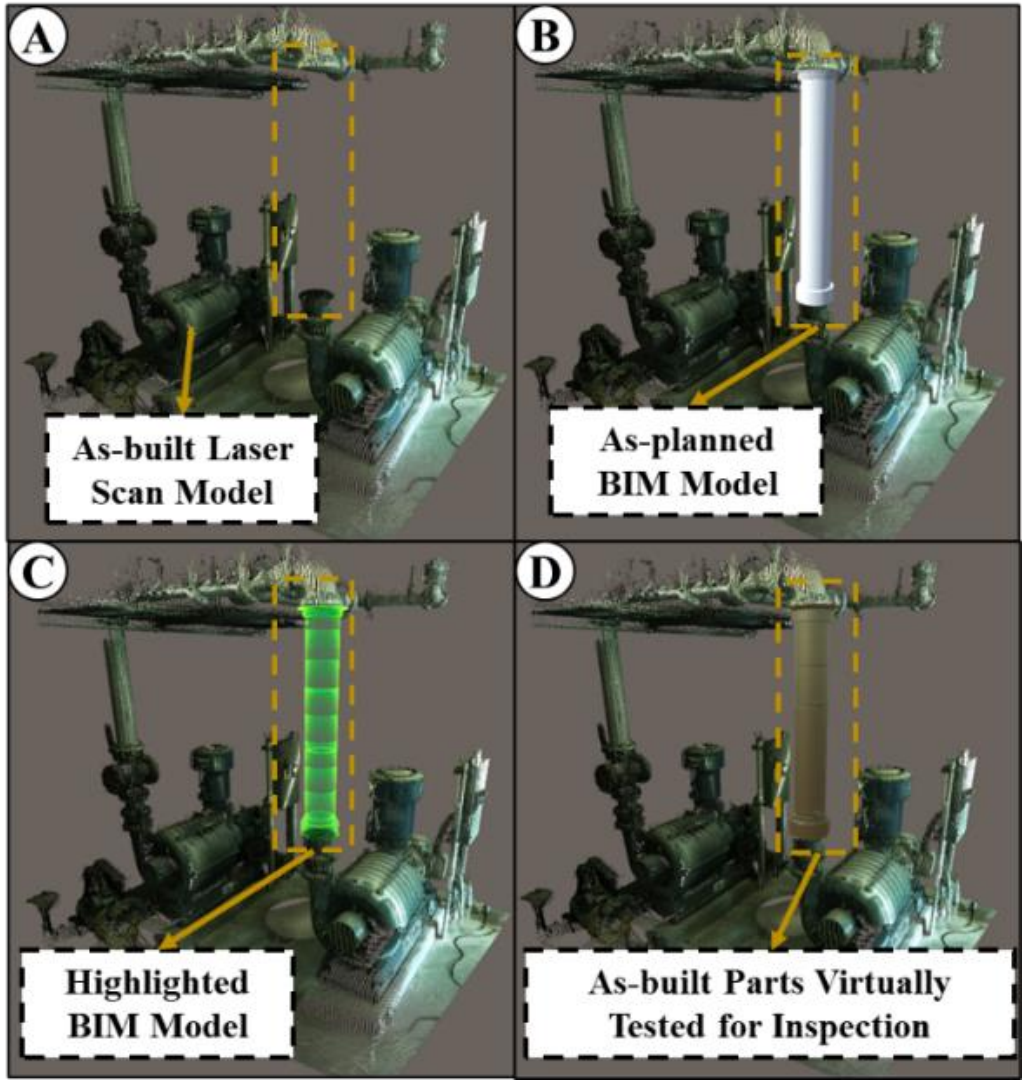


VR for Virtually Managing QA/QC in Supply Chain

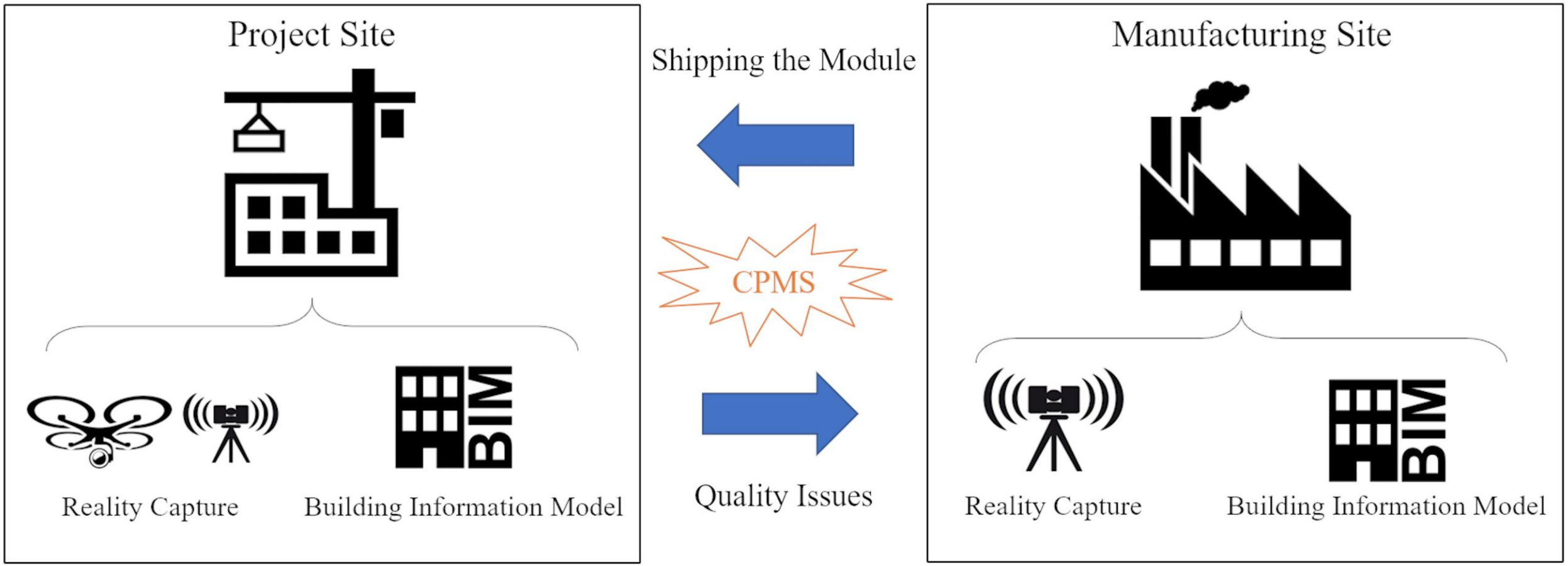
Manual Virtual Inspection



Automatic Virtual Inspection



Construction Performance Modeling and Simulation

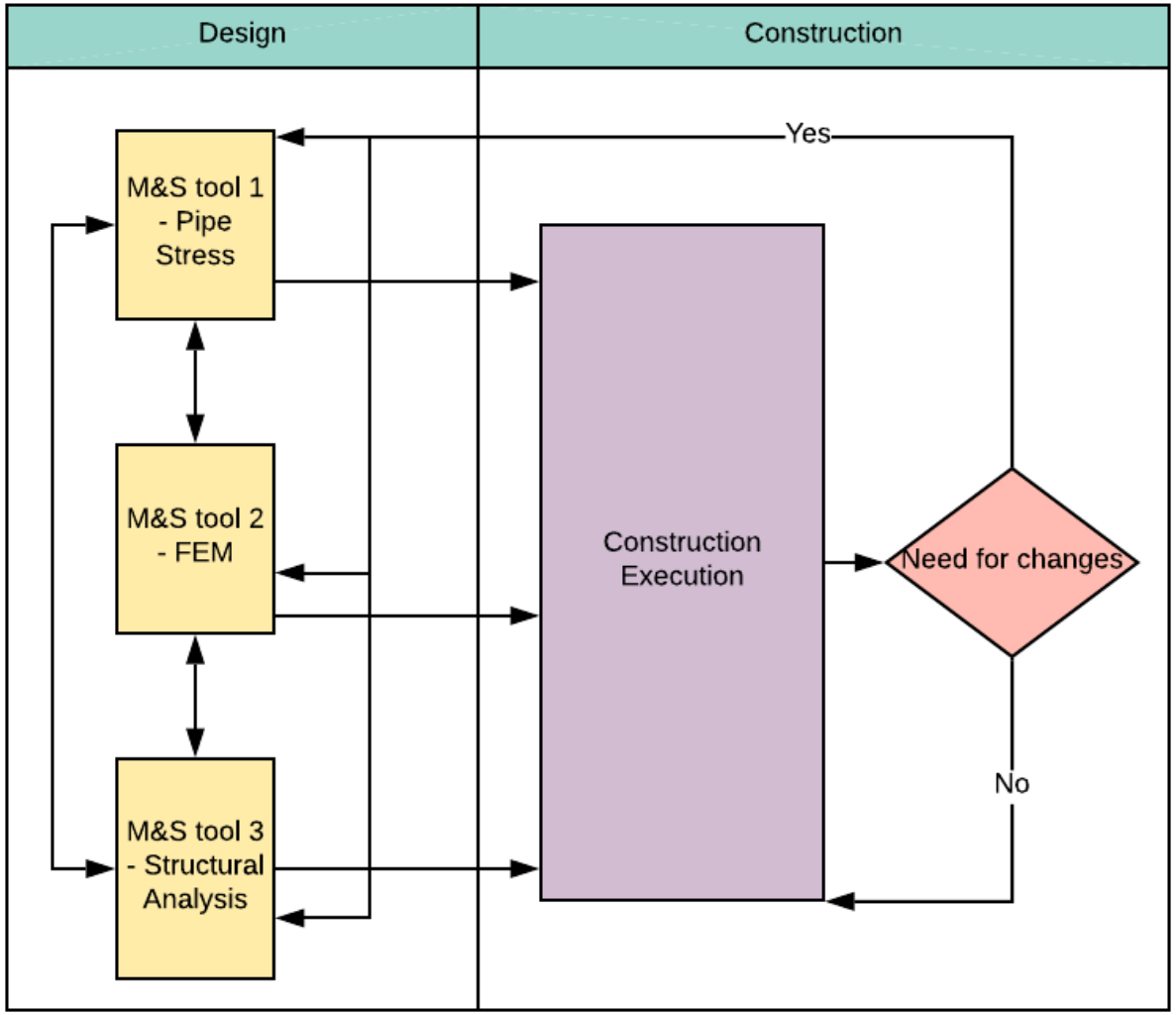


Risk-informed Approach to Increase Tolerance

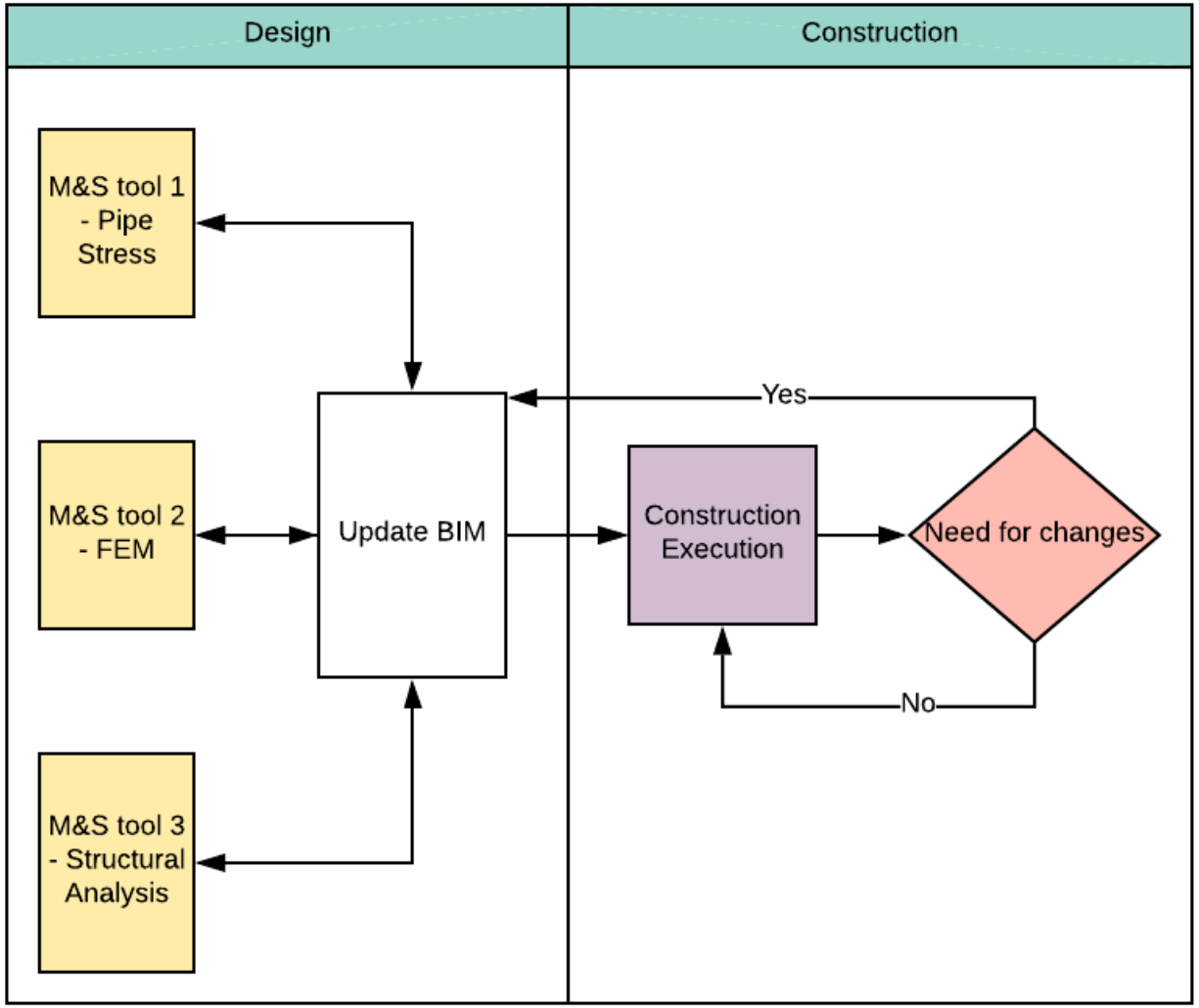
- Assessment of risk construction tolerance exceeds mechanical tolerance
- Update 4D BIM to reflect as-built condition
- Convert 4D BIM models into structural models
  - Automated approach currently under investigation
- Assess risk and determine acceptability of risk

Integrated Approach to Design and Construction

Problems in Practice

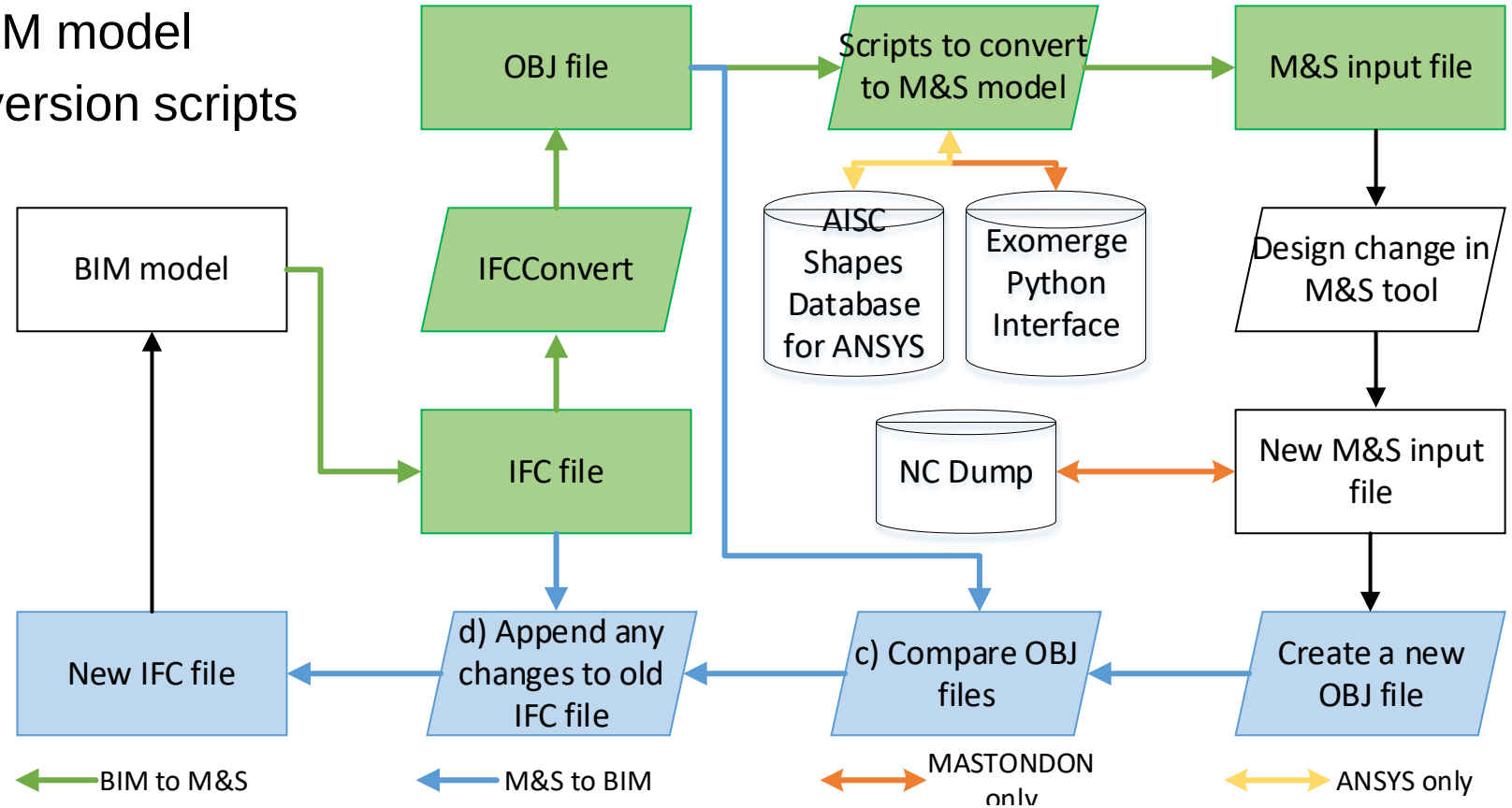


Our Approach

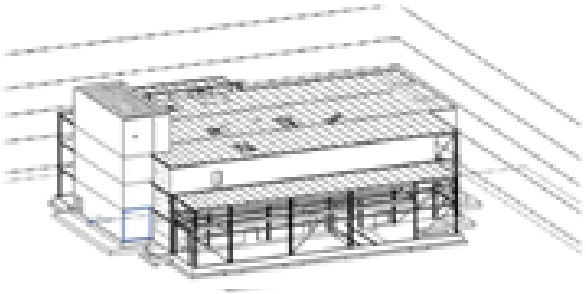


Interoperability between Design and BIM Software

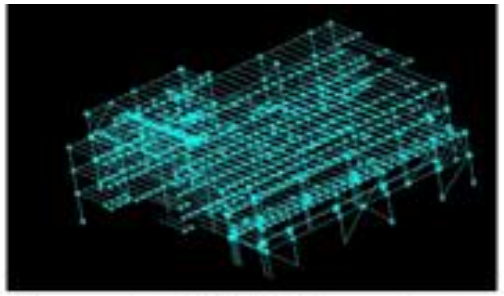
- Automated approach from BIM model (Revit and AVEVA E3D to FEM (ANSYS)
  - ANSYS Mechanical APDL is used for FEM tool
  - Revit 2020 used for BIM model
  - Python3 used for conversion scripts
  - IFC version 4



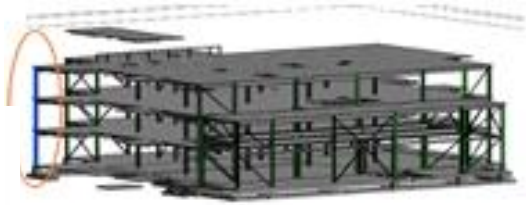
Structural Model & BIM



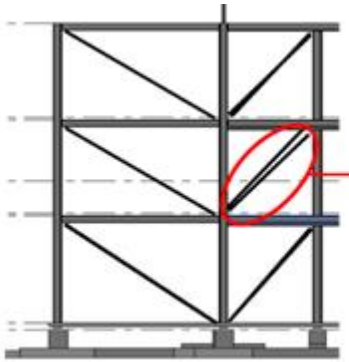
Original structure



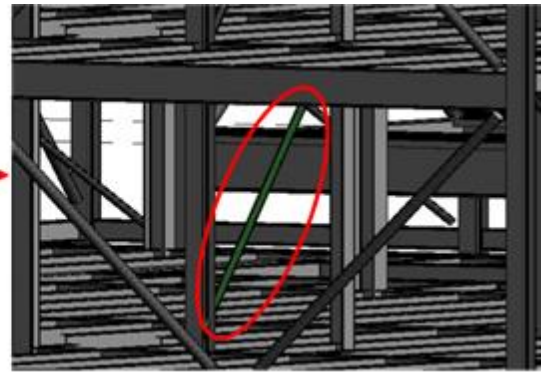
Converted ANSYS model

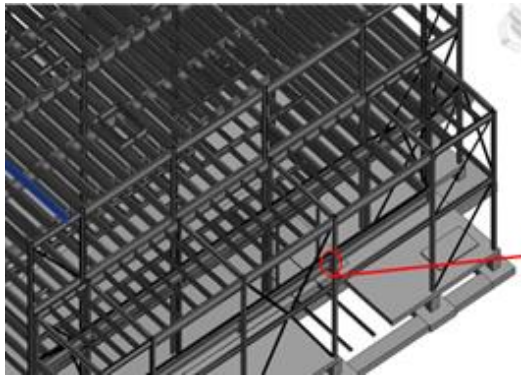


Changed and imported model

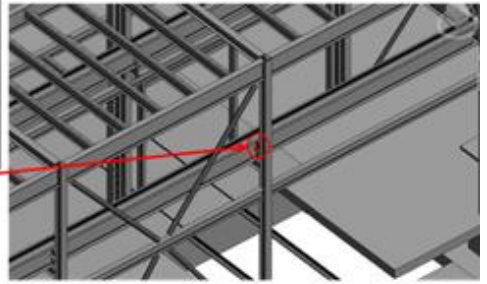


Length of brace has changed

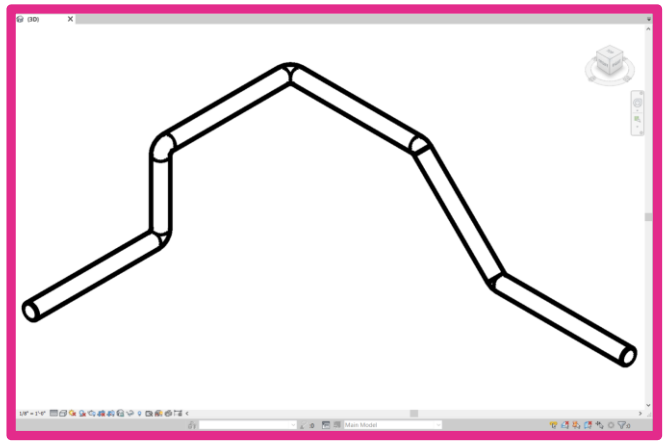




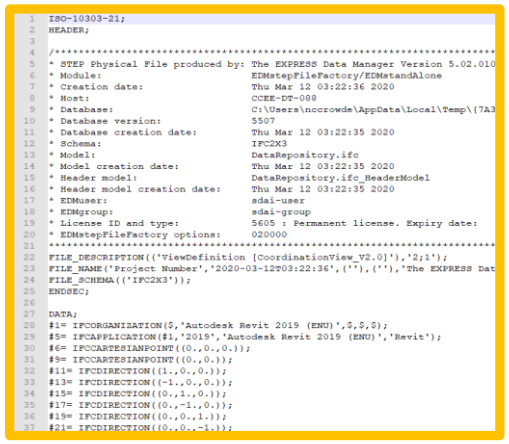
Element deleted from original model



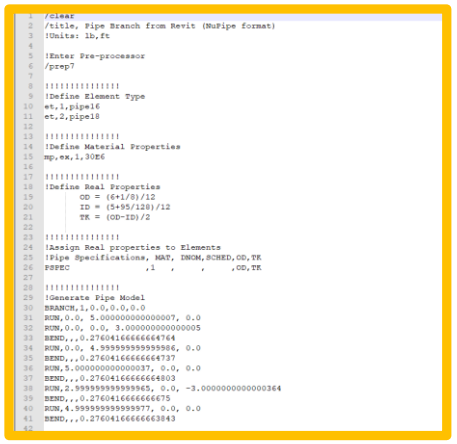
Piping Stress Model & BIM



BIM: Revit Piping

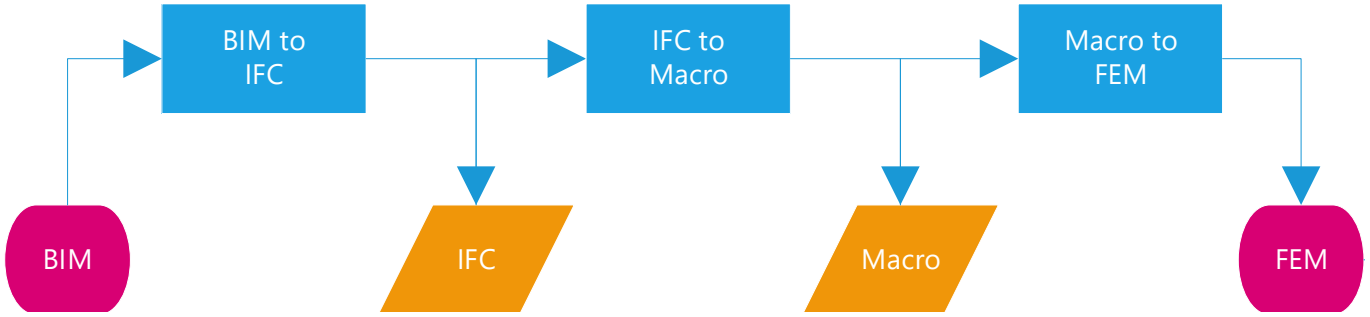


IFC File



FEM Macro

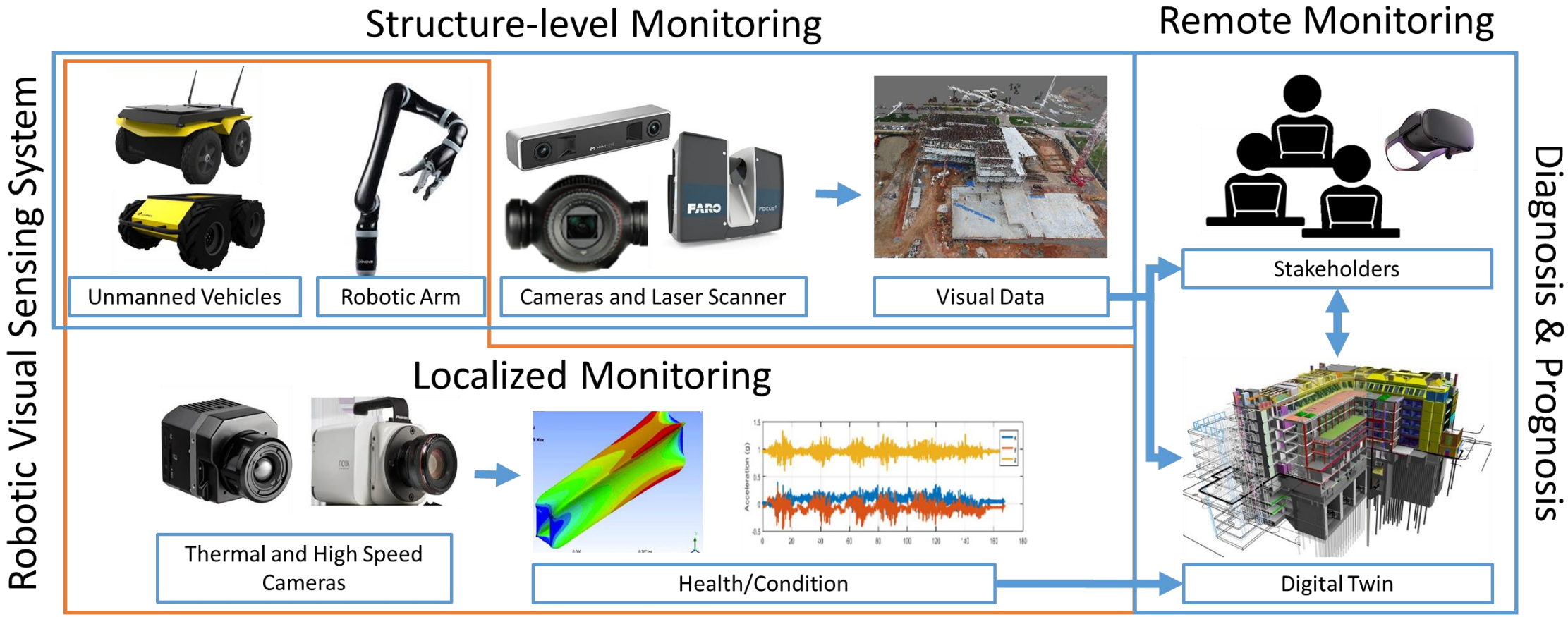
FEM: ANSYS Piping



- From BIM model to FEM analysis
- Completely automated file conversion and model generation

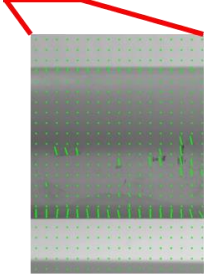
Visual Sensing Integration with Digital Twins

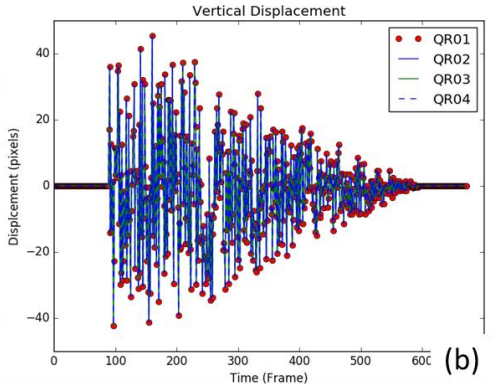
- Continuous monitoring during transportation using multi-sensory system & integration with “Construction” and “Design” models through DT

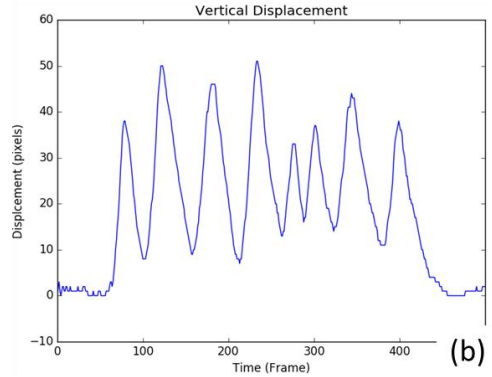


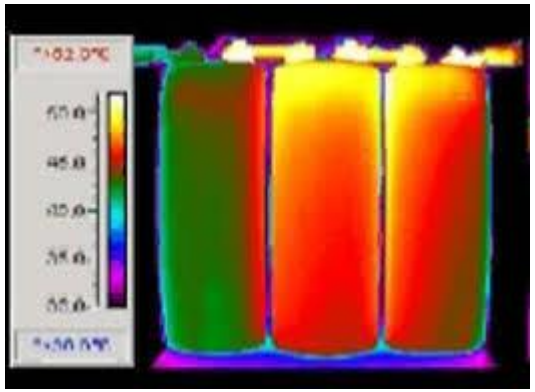
Continuous Monitoring during Transportation

- Target-based (and also target-less for less accuracy) sensing for vibration
- Automated object recognition to detect any movement
  - Integrated sensing system (high-speed and thermal cameras and accelerometers)









https://www.nrel.gov/docs/fy16osti/66960.pdf

Questions