

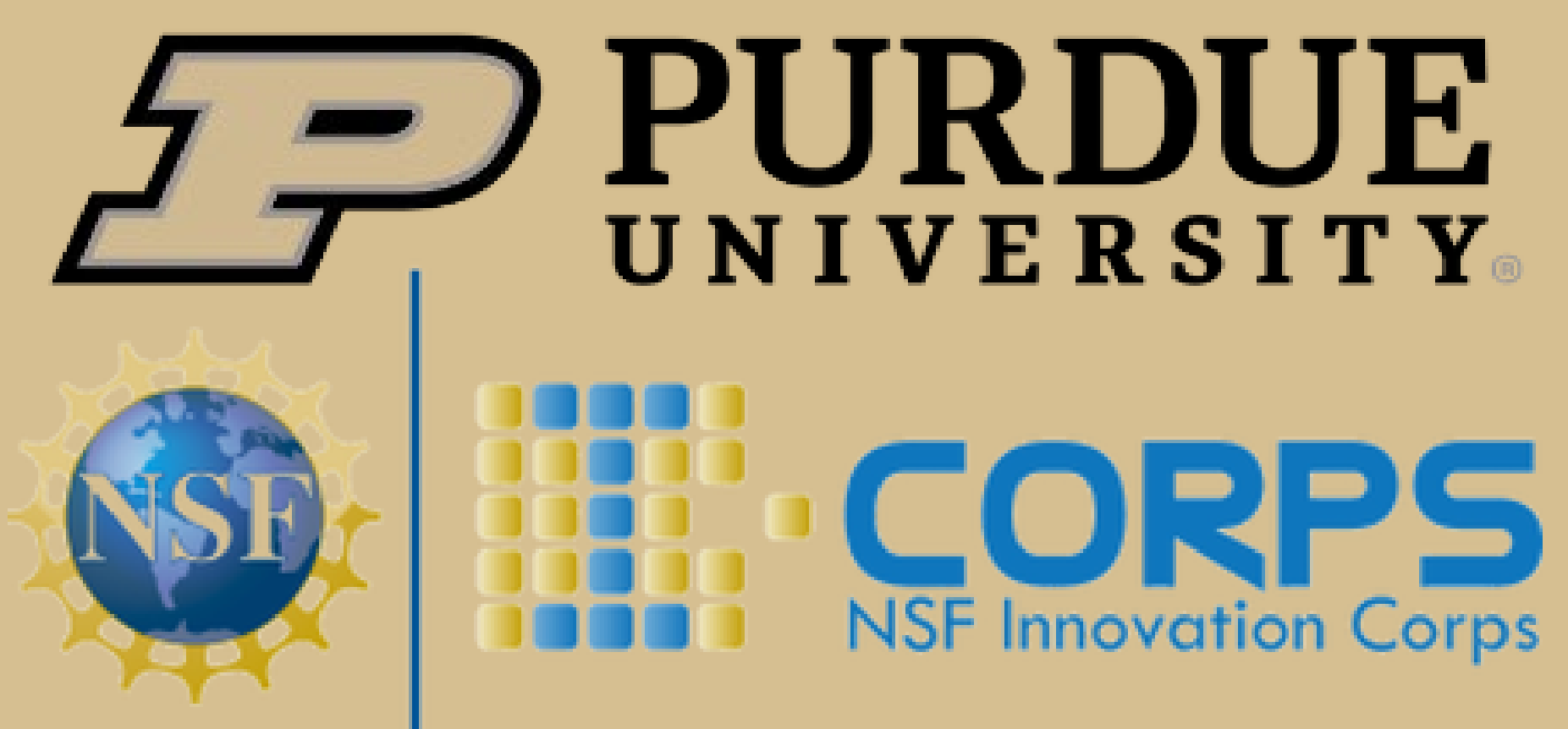
Integrating Digital Twins, Artificial Intelligence, and Large Language Models for Building Maintenance

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BACKGROUND

The built environment accounts for approximately 45% of global carbon emissions and major energy consumption levels. In addition, building maintenance activities comprise almost 75% of the operating costs in the whole building life cycle. Emerging technologies, such as digital twins and artificial intelligence (AI), offer promising solutions for synthesizing big data from various building systems that enable predictive analytics and scenario simulations for critical systems, such as mechanical and electrical infrastructure, which directly influence building performance and energy efficiency. **The primary objective of this project is to leverage digital twin technology by integrating diverse data sources, including building automation, controls, sensors, actuators, metering, and maintenance management systems, with AI. This integration aims to predict potential failures and defects while providing risk scenario simulations. Additionally, the project explores the incorporation of Large Language Models (LLMs) to develop a "maintenance chatbot," enhancing real-time information access and decision-making support for maintenance personnel.**

METHODOLOGY

Literature Review

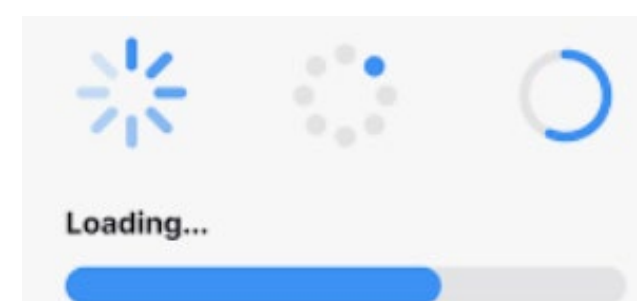
Synthesis of current **studies** with the focus on identifying:

- ✓ Challenges and benefits of DT & AI & LLM for building maintenance
- ✓ Hardware, software, system needs
- ✓ Trends in industry regarding the proposed technology

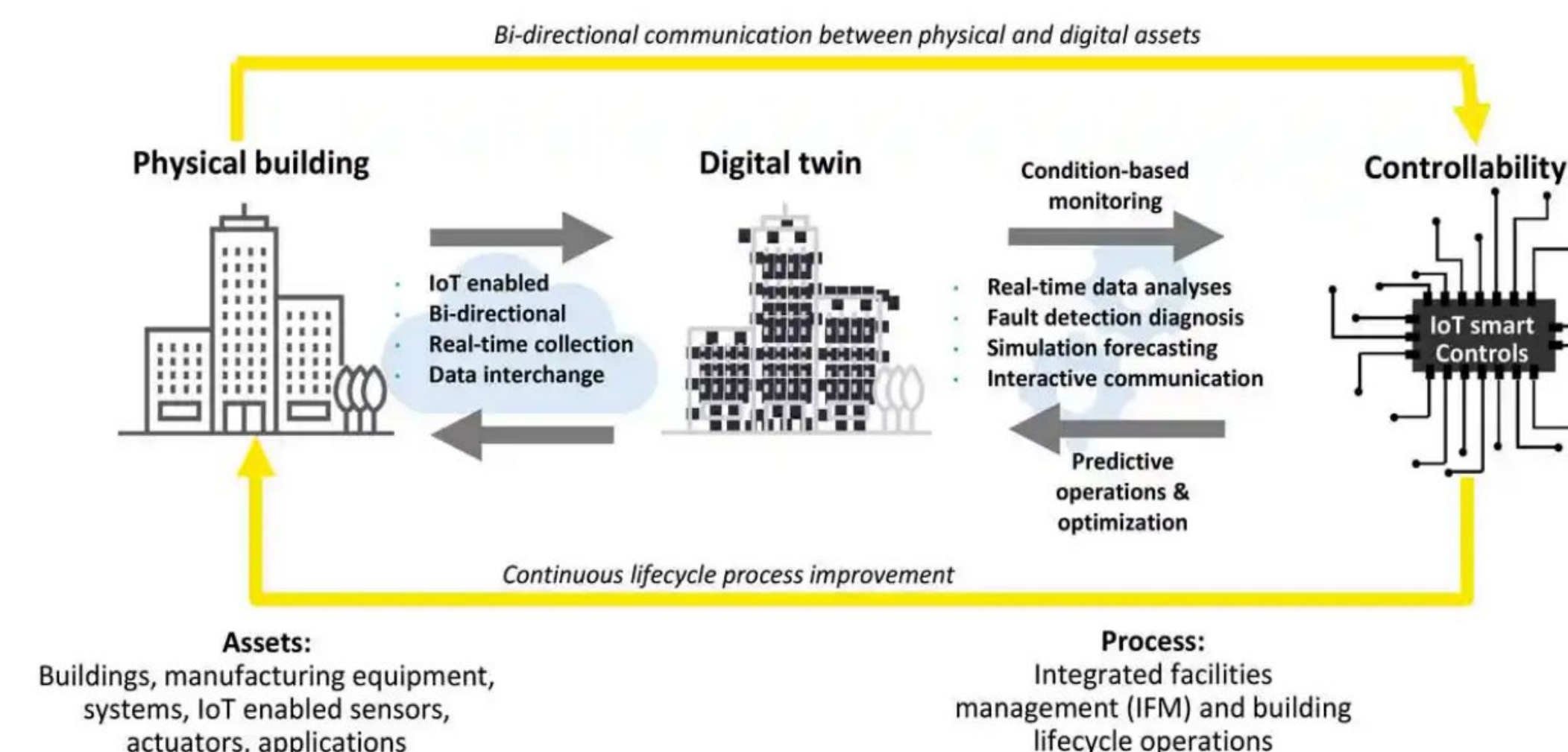
Interviews with Industry Practitioners

- ✓ **Interviews** with **over 100 industry practitioners** in construction, facilities and technology management areas.
- ✓ The interviews were completed through **National Science Foundation I-Corps Lean Startup experiential training program** (7 weeks) in summer 2024.
- ✓ The purpose of the interviews and the training program was to discover the **commercialization potential** of the proposed technology with **innovation** and **entrepreneurial** focus.

Proof-of-Concept and Start-up Development



Proof-of-Concept Development is in progress...



Representative example of a proof-of-concept. Lukesh et al. (2024). Digital twin: the Age of Aquarius in Construction and Real Estate. Retrieved from <<https://www.constructionplacements.com/digital-twin-the-age-of-aquarius-in-construction-and-real-estate/>>

There are several commercial platforms available that serve a similar purpose. What unique value or differentiating features would the proposed technology offer compared to these existing solutions?

- ✓ LLM integration for enhancing decision making
- ✓ Modules for decarbonization and CO2 emissions tracking
- ✓ Open data architecture and agnostic compatibility
- ✓ Tracing cascading effects of faults
- ✓ Life cycle cost and ROI analysis
- ✓ Gamification and technician training

RESULTS

Critical Challenges of utilizing the proposed technology in building maintenance management

- ✓ Gaps in the information transfer from design & construction to building operations stage
- ✓ Lack of proper design and construction documentation of existing built environment
- ✓ Lack of BIM models and/or as built drawings for existing building
- ✓ Additional cost to reorganize and recreate the missing documentation
- ✓ Need for additional personnel to properly operate the technology and data management
- ✓ Justification of benefits and the Return of Investment (ROI) of the technology

CONCLUSION and NEXT STEPS

- ✓ FM organizations need to effectively justify the necessity and benefits of the proposed technology to their executive leadership.
- ✓ Demonstrating an approximate return on investment (ROI) is critical to strengthen the business case.
- ✓ Any potential technology should ensure interoperability with the existing systems in place.

What is next?

- ✓ **Large Language Models** have a significant potential to be utilized in the proposed technology as a **"maintenance chatbot"**.
- ✓ Investigating the **insurance** aspect of utilizing advanced technology as a tool to justify the **ROI** or **cost savings**.
- ✓ Partnerships with industry and targeting SBIR grants.
- ✓ Start-up development and more...

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