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The Future of Intelligent Construction
From BinformationM to AIntelligence

Digital Twins • Agentic AI • Digital Master Builder

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Director | Built Environment Technology Application (BETA) Research Lab

Founding President | Built Environment Technology Application (BE Tech Alliance)

NWCCC Construction Technology Program | November 5, 2026

About the Speaker — Background and Experience



Hongtao Dang, Ph.D., P.E.

Assistant Professor
Director, BETA Research Lab

- Ph.D., Construction Engineering and Management, Iowa State Univ.
- Professional Engineer (P.E.)
- School of Design and Construction Washington State University
- Research: AI, BIM/VDC, Digital Twins, Construction Technology

Background

Bridge Engineer and Estimator
Bridge Engineering Center



Structural Engineer and Manager
Stanley Consultants, Inc.



Director of Engineering and Construction
Base4 International, Inc.



2016
Professional Engineer
Licensed Professional Engineer (P.E.) in Iowa

2011, B.S.
Bachelor of Science
Civil Engineering
Iowa State University & Lanzhou Transportation University

2014, M.S.
Master of Science
Structural Engineering
Iowa State University

2019, Ph.D.
Doctor of Philosophy
Construction Engineering and Management
Iowa State University



2019
Assistant Professor
Tenure-Track Assistant Professor, Central Washington University

2022
Assistant Professor
Tenure-Track Assistant Professor, School of Design and Construction, Washington State University



BIM/VDC
Professor

2005 2010 2015 2020 2025

A career bridging industry practice, engineering leadership, and construction technology research and education.

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Objectives and Agenda

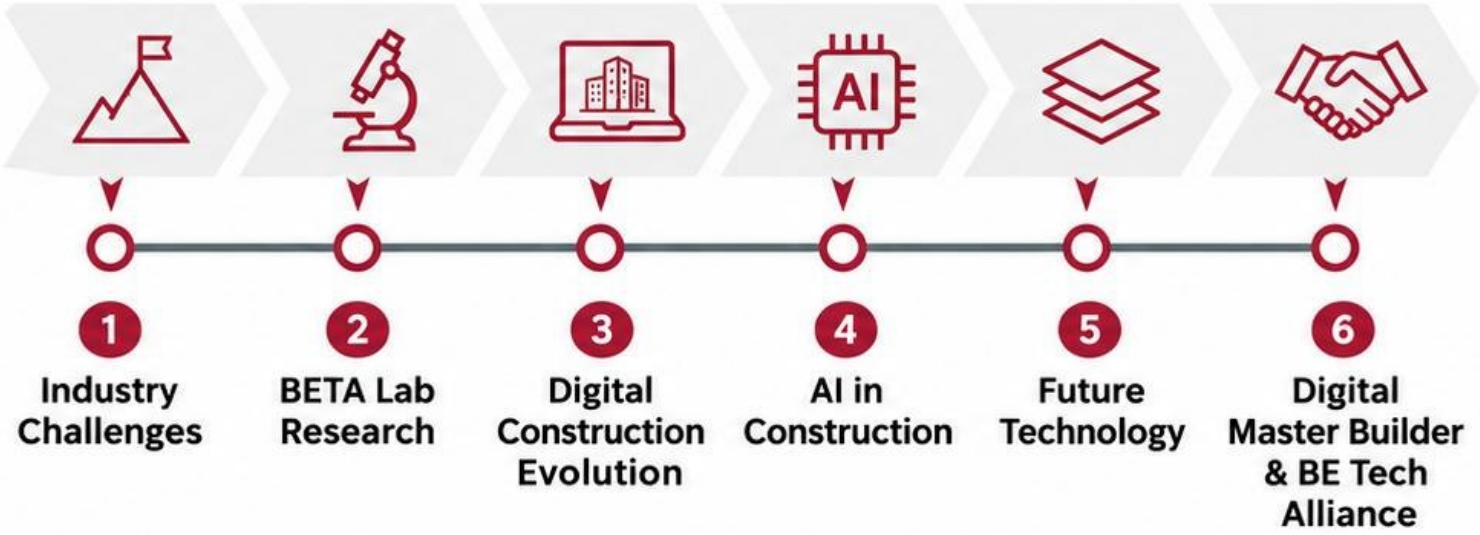
What this presentation will cover

Digital Twins • Agentic AI • Digital Master Builder

Objectives

- Understand major construction technology trends
- Explore BETA Lab research and applications
- Examine AI and agentic AI in construction
- Discuss future workforce and industry transformation

Agenda

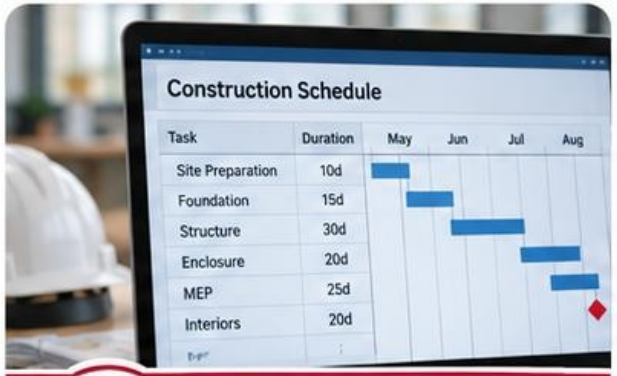


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Construction's Next Productivity Challenge

How do we turn construction information into better project outcomes?

Digital Twins • Agentic AI • Digital Master Builder



Schedule Uncertainty

Complex projects remain hard to predict.



Cost Pressures

Teams face rising costs and tighter margins.



Workforce Challenges

Skilled labor and digital talent are limited.



Fragmented Information

Data lives across disconnected systems.

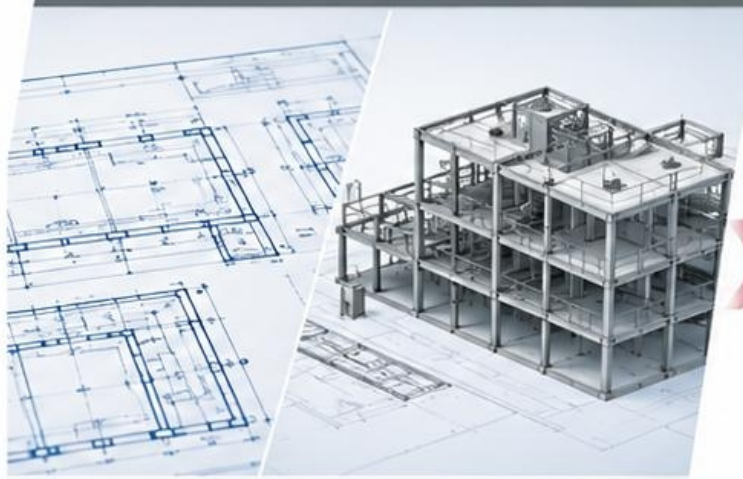
The challenge is not more software — it is better-connected information and decisions.

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From Digitization to Intelligence

Digital Construction



CAD | BIM | VDC

Connected Construction



IDD | Digital Twins

Intelligent Construction



AI | Agents | Automation

Built on digital data, connected through integration, and enhanced by AI intelligence.

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Built Environment Technology Application (BETA) Research Lab



BETA Lab

Our Mission

Develop and apply emerging technologies to solve real-world challenges in the built environment through research, innovation, and industry collaboration.

Research Frontiers



AI and Spatial Intelligence

Agentic AI, computer vision, and spatial reasoning



Digital Twins and Digital Delivery

Integrated delivery, model-based workflows, and lifecycle applications



Human–Technology Interaction and Safety

Workforce support, safety analytics, and technology adoption



Automation, Robotics, and Reality Capture

UAV, LiDAR, 3D scanning, and construction automation

Industry Collaboration | Applied Research | Workforce Development | Real-World Impact

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Integrated Digital Delivery (IDD)

Connecting people, processes, and data across the project lifecycle

Architecture / Design Information



- BIM design model
- Spatial/functional requirements
- Architecture systems (e.g., envelope, interior)

Structural Engineering



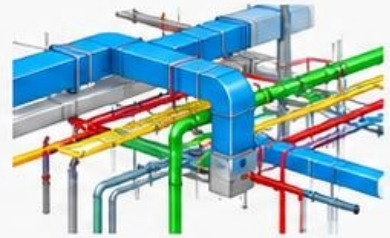
- Structural BIM model
- Framing, foundations, connections
- Code and performance requirements



Coordinated Federated Digital Model

(Integrated Project Delivery Environment)

MEP / Systems Coordination



- MEP BIM models (HVAC, plumbing, electrical)
- Systems coordination (clash resolution)
- Constructability and installation planning

Construction Management / Schedule / Field Workflows



- 4D schedule (time) linked to BIM
- Field workflows (e.g., RFIs, issues, progress)
- Construction planning and execution

Benefits

- ✓ Better coordination
- ✓ Improved interoperability
- ✓ Lifecycle information continuity

BIM is the foundation. Integration creates value.

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Digital Twins and Reality Capture

From physical project conditions to decision-ready digital information



1 Physical Project
Field conditions and construction status

2 Reality Capture
UAVs, photogrammetry, LiDAR, imagery

3 Digital Twin
Connected digital representation and project information

4 Decision Support
Progress assessment, comparison, and monitoring

The value is not just capturing data — it is turning field observations into useful information.

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Evaluating the Value of Advanced Surveying and Mapping



A Structured ROI Evaluation Framework

Seven ROI Categories

- Productivity & Efficiency
- Safety Risk Reduction
- Data Quality & Accuracy
- Workflow & Coordination
- Lifecycle & Asset Management
- Cost Impacts (Implementation & Operation)
- Organizational & Strategic Value

Overall Assessment

- ☑ Identify and compare technology options
- ☑ Evaluate benefits and costs
- ☑ Assess implementation considerations
- ☑ Provide ROI-based recommendations

Providing a practical, ROI-based framework for transportation agencies and the construction industry.

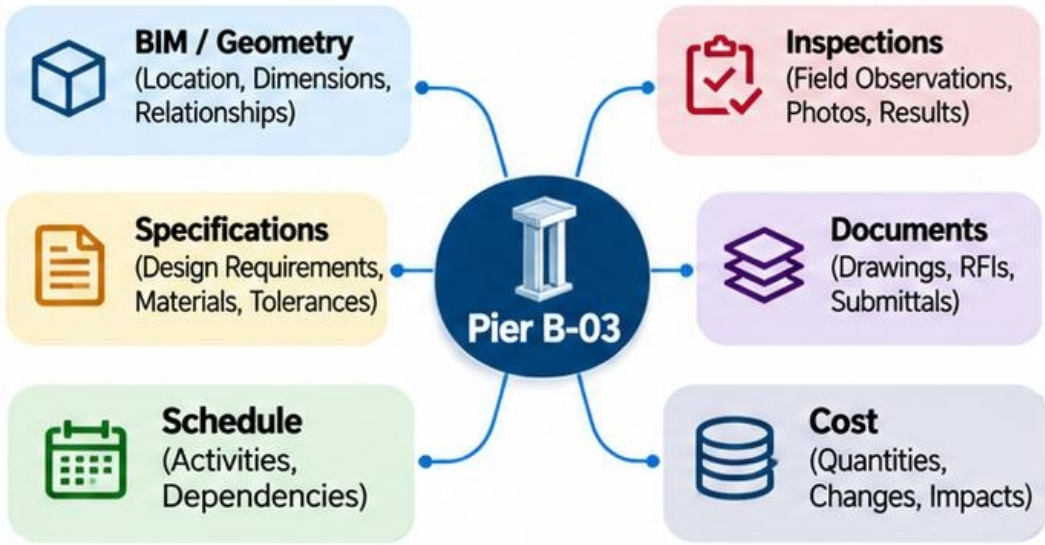
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Agentic AI and Spatial Intelligence Research



Spatial Construction Knowledge Graph



Agentic AI Workflow

1. Retrieve
Collect related model, document, and field information

2. Analyze
Interpret spatial and technical context

3. Reason
Identify issues, assess options, and evaluate impacts

4. Recommend
Provide actionable, evidence-based suggestions

Research Focus

- **Multimodal Information**
- **Spatial Reasoning**
- **Agentic Workflows**
- **Decision Support**

Integrating geometric, technical, and project information to enable context-aware, AI-assisted infrastructure decisions.

The Evolution of Digital Construction

CAD



Digital drawings and documentation

BIM



Object-based 3D models with project information

VDC



Model-based coordination, planning, and constructability

IDD



Integrated people, processes, and data across the lifecycle

Digital Twins



A living digital representation linked to the physical asset

AI-Enabled Construction



Data-driven, intelligent decisions and autonomous workflows

A continuous evolution from digital representation to connected, data-driven, and intelligent construction.

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The Construction Software Ecosystem

Design and BIM

AUTODESK

- Building and infrastructure design
- BIM modeling and documentation
- Design collaboration

Digital Twins and Operations

Bentley®

- Digital twin development
- Asset and facility management
- Lifecycle performance and operations

Document Review

Bluebeam®

- PDF markup and review
- Plan verification and QA/QC
- Design and construction submittals



Construction Project (BIM / VDC)

Coordination and VDC

Revizto®

- Multi-discipline model coordination
- Clash detection and issue tracking
- Virtual design and construction (VDC)

Project Management

Procore®

- Project planning and scheduling
- Cost, RFIs, and submittals
- Field management and reporting

Surveying and Reality Capture

Trimble®

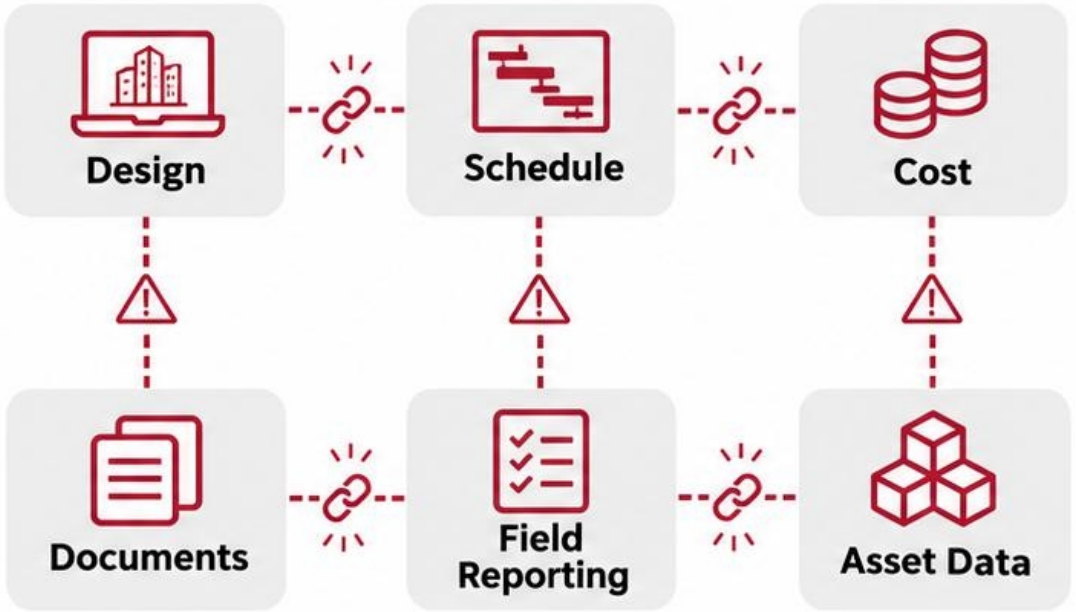
- Surveying and site layout
- Drone, laser scanning, and photogrammetry
- As-built data and model updates

An integrated software ecosystem for the entire construction lifecycle

The Interoperability Challenge

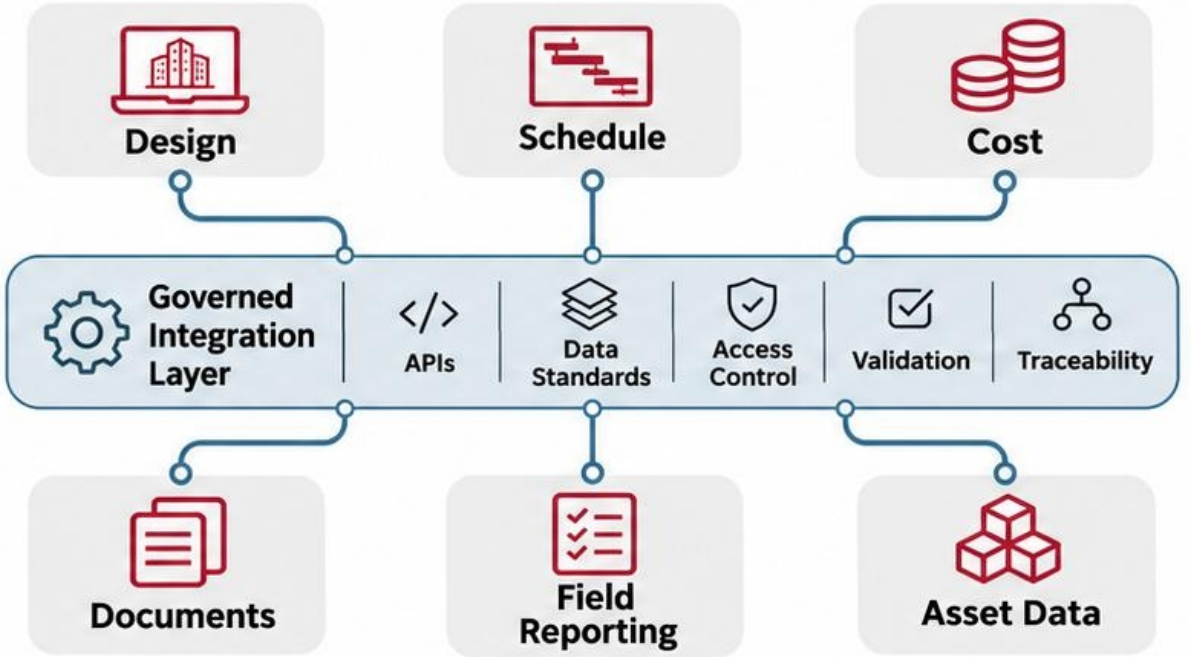
The problem is not simply technology availability; it is connecting data across organizations and systems.

Disconnected Information Systems



Data silos, manual handoffs, and inconsistent information.

Connected Project Information Network

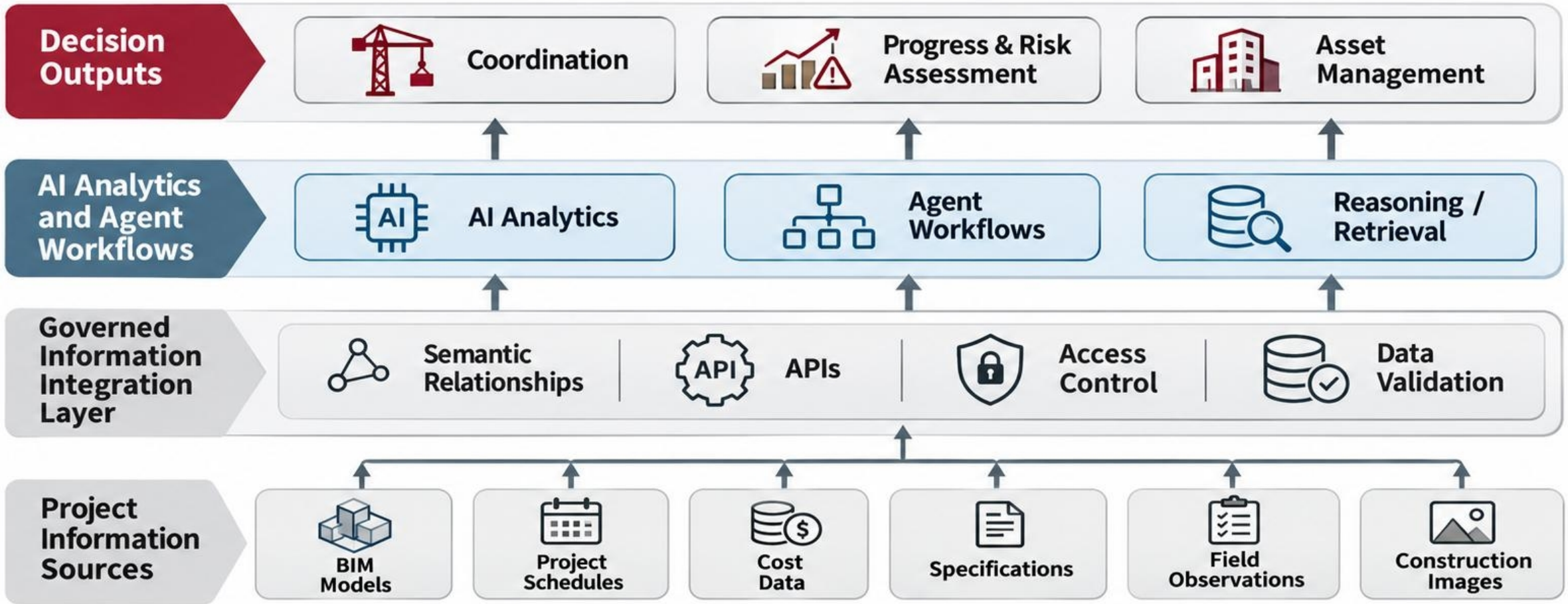


Integrated data flows, governed exchange, and better decision support.

Interoperability turns disconnected project data into coordinated, decision-ready information.

Toward Connected Construction Intelligence

Integrating project data to support AI-assisted construction decisions



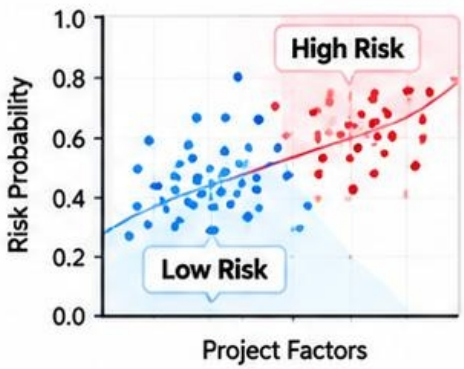
Connected data turns project information into decision-ready intelligence.

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Understanding AI in Construction

Machine Learning (ML)



Learn patterns from data to predict outcomes and risks.

Application:

- Safety risk prediction
- Cost and schedule forecasting
- Productivity analysis

Computer Vision (CV)

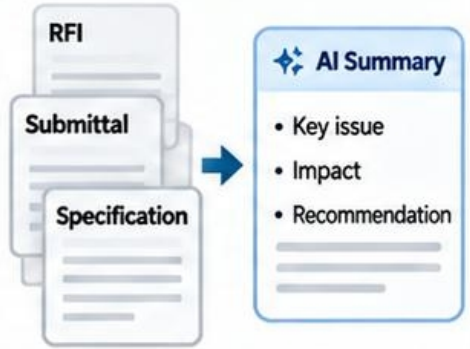


Analyze images and video to detect, classify, and measure construction objects and activities.

Application:

- Worker and equipment detection
- Progress monitoring
- Safety hazard identification

Generative AI (GenAI)

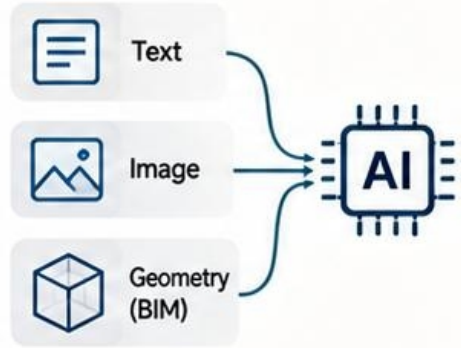


Generate, summarize, and extract knowledge from project documents and text.

Application:

- RFI and submittal analysis
- Specification Q&A
- Meeting and report summaries

Multimodal AI

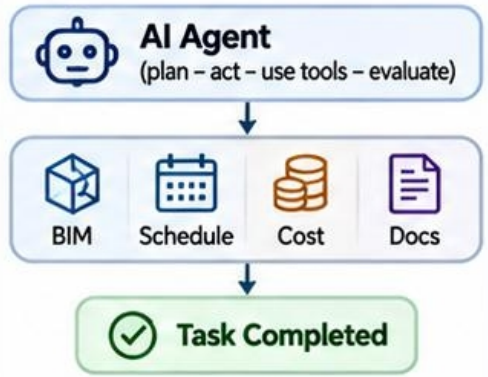


Integrate and reason across multiple data types (text, images, models, etc.) for richer insights.

Application:

- Compare “as-designed” vs. “as-built”
- Model-based issue detection
- Context-aware decision support

Agentic AI



Autonomously plan, use tools, perform multi-step tasks, and deliver results.

Application:

- Automate project coordination
- Identify and resolve clashes
- Track progress and take follow-up actions

From data to insight to action — AI for a safer, smarter, and more productive construction industry.

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AI Across the Construction Lifecycle

1 Planning

- Site analysis and feasibility assessment
- Cost, schedule, and risk forecasting
- Scenario and what-if analysis

2 Design

- Generative and parametric design
- Code and constructability checking
- Design alternatives and optimization

3 Procurement

- Demand forecasting and quantity takeoff
- Supplier and risk analysis
- Material delivery and logistics optimization

4 Construction

- Progress tracking (vision, drone, scan)
- Safety risk identification and alerting
- Quality assurance and as-built updates

5 Commissioning

- AI-assisted system testing
- Automated issue detection
- Digital handover and as-built verification

6 Operations

- Predictive maintenance
- Energy and performance optimization
- Asset lifecycle management



AI-enabled, data-connected, and lifecycle-optimized project delivery.

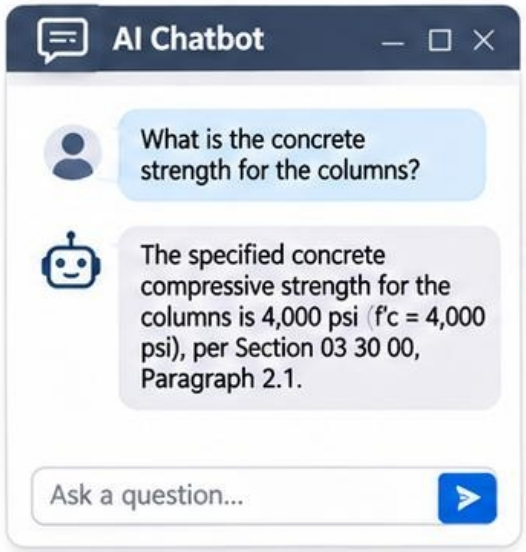
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From AI Assistants to Agentic Workflows

1 Chatbot

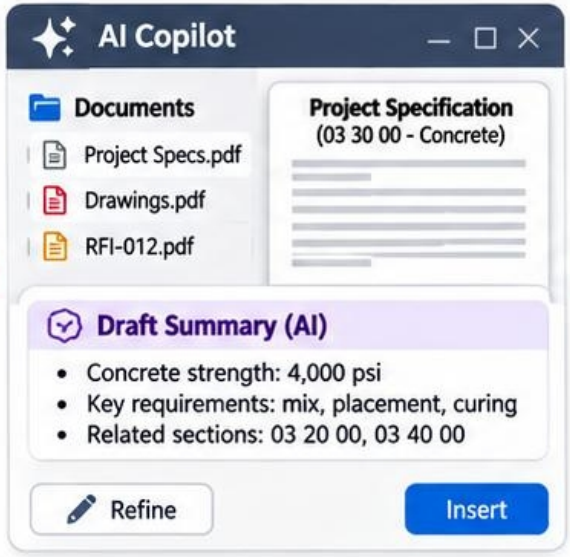
Answer questions and provide information.



- Conversational Q&A
- Retrieve basic project information
- Explain codes, specs, and terms

2 AI Copilot

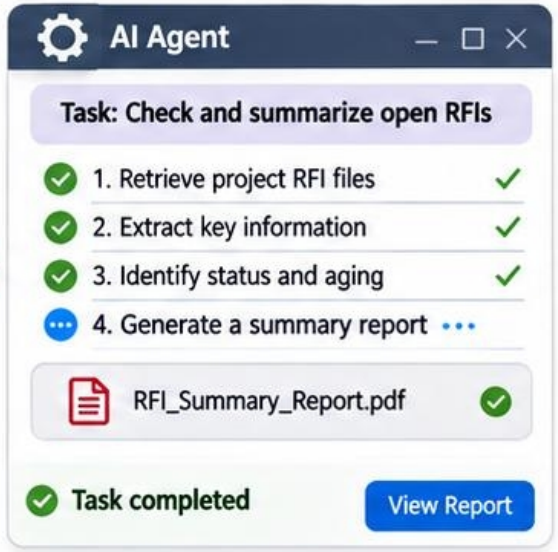
Work with you to analyze content and generate drafts.



- Understand and analyze project documents
- Summarize key requirements
- Draft RFIs, reports, or meeting notes

3 AI Agent

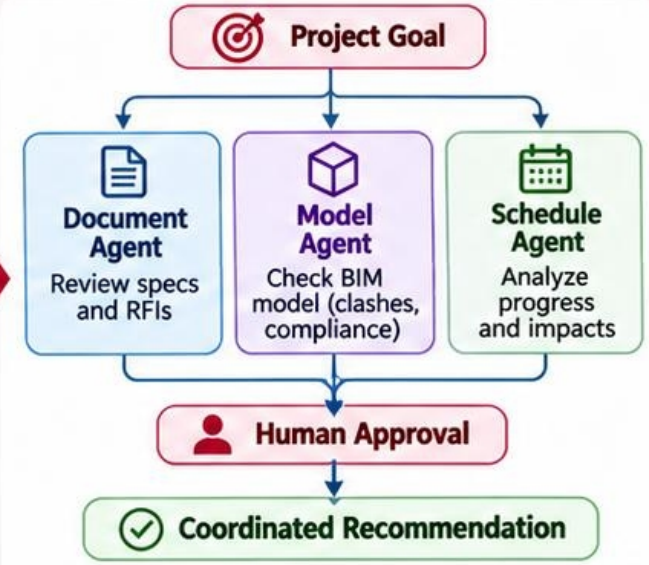
Autonomously perform a defined, multi-step task.



- Plan and execute a sequence of steps
- Use project data and tools (e.g., files, models)
- Deliver a defined output (e.g., a report)

4 Multi-Agent System

Coordinate multiple specialized agents to solve complex, end-to-end tasks.



- Multiple agents with specialized roles
- Share information and coordinate tasks
- Human-in-the-loop for oversight and approval
- Tackle complex, cross-functional workflows

Q&A Support → **Task Assistance** → **Autonomous Execution** → ***Collaborative, Goal-Driven Project Intelligence***

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Agentic AI for RFIs and Submittals

1 RFI Received

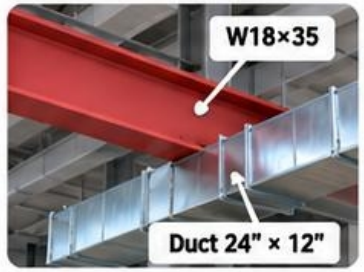
RFI No.: RFI-0247

Subject: Beam and Duct Interference

Question:

The MEP duct (24" × 12") appears to conflict with structural steel beam W18×35 at Grid B-4 (Elev. 12'-0").

Please confirm the required resolution (e.g., duct reroute, beam modification, or other).

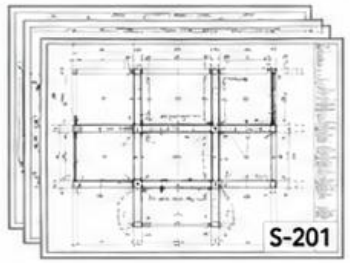


2 Retrieve Documents

Document Agent

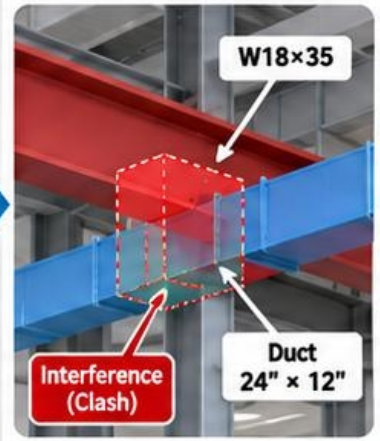
Retrieve relevant files...

- S-201 Structural Plan
- M-301 Ductwork Plan
- Structural Details
- Mechanical Specs (Section 23 31 00)



3 Check BIM Context

Model Analysis Agent



- Check model geometry
- Identify interference
- Locate in 3D and drawings
- Extract key dimensions and clearances

4 Analyze Requirements

Requirements Analysis Agent

Design Requirements
Required clearances (Section 23 31 00)

Structural Impact
Beam modification not allowed

MEP Options
Reroute or reduce duct size (code-compliant)

Constructability
Space and access for rerouting

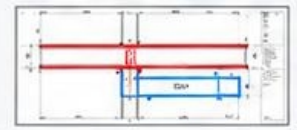
5 Draft Response

Drafting Agent

Proposed RFI Response (Draft)

Based on the structural drawings, mechanical plans, and project specifications (Section 23 31 00), the W18×35 beam shall remain as designed.
Please reroute the 24" × 12" duct below the beam with a minimum 1" clearance, as shown in the attached sketch. Updated duct layout is required for approval.

Attachment:
RFI-0247_Sketch.pdf



6 Human Approval

Engineer / PM Review (Human)



- ☐ Review technical accuracy
- ☐ Confirm code and project compliance
- ☐ Check constructability and impacts

Approve & Issue RFI Response

A multi-agent workflow that coordinates project data, analyzes requirements, and prepares RFI/submittal responses with human oversight.

Conceptual Workflow
(Not Fully Autonomous)

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AI-Enabled Construction Progress Monitoring

1 UAV Image Collection



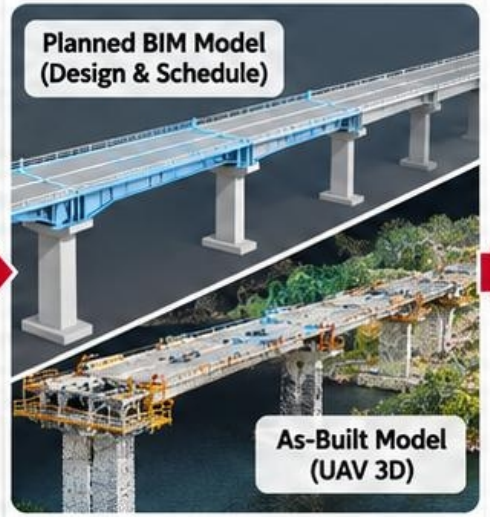
- Capture high-resolution aerial images
- Cover the entire construction area
- Provide time-stamped, geo-referenced data

2 3D Reconstruction



- Process UAV images (photogrammetry)
- Generate 3D point cloud and mesh model
- Reconstruct the as-built condition

3 Align with BIM Model



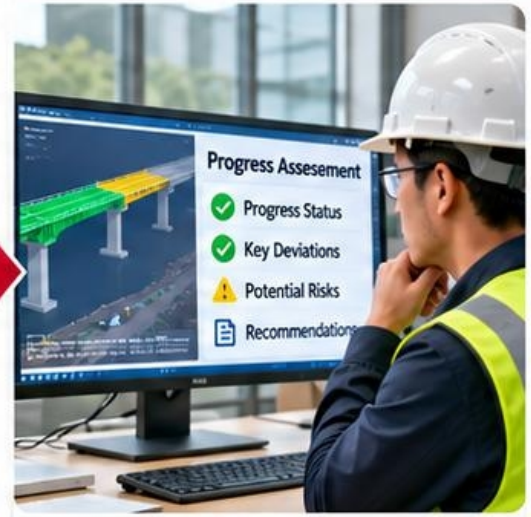
- Integrate as-built 3D model with BIM
- Register and align geometry (coordinate and elevation)
- Map construction elements (e.g., piers, girders, deck)

4 AI-Assisted Progress Analysis



- Compare as-built vs. planned (BIM + schedule)
- Identify progress status and deviations
- Highlight potential risks (e.g., delays, missing work)

5 Human Validation



- Engineer reviews AI results and evidence
- Validate progress and findings
- Provide professional judgment and final confirmation

From field data to actionable progress insights for smarter, more proactive project control.

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Trustworthy AI and Human Oversight



Reliability

Consistent and accurate outputs with verifiable evidence.

Data Security

Controlled access to project data and compliance with policies.

Explainability

Transparent reasoning with source documents and traceable logic.

Accountability

Record of decisions, actions, and responsible parties.

Human Oversight

Final review and approval by qualified professionals (e.g., P.E., PM).

AI as a decision support tool — transparent, verifiable, and always under human oversight.

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Six Emerging Construction Technology Trends

1. Agentic AI



2. Spatial Intelligence



3. Intelligent Digital Twins



4. Robotics



5. Extended Reality



6. Connected Data



Integrated, intelligent, and interoperable technologies for a safer, smarter, and more resilient built environment.

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Construction Technology Roadmap: 2026–2035

Horizon 1 — 2026 – 2028

Near-Term: Adoption and Pilots

Deploy AI and digital tools in targeted workflows to deliver measurable value.

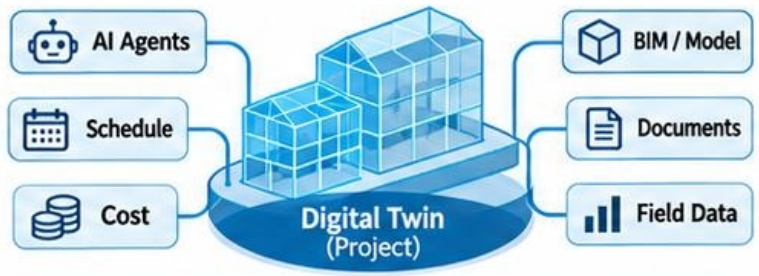


- AI assistants for RFIs, submittals, and document review
- Connected project information (BIM, schedule, cost, documents)
- UAV/vision-based progress monitoring pilots
- Project-level data governance and human oversight

Horizon 2 — 2028 – 2031

Medium-Term: Scaled Integration

Integrate data, models, and AI agents across the project lifecycle for coordinated decision-making.



- Project-level digital twins with multi-source data
- Multi-agent workflows (e.g., design–cost–schedule coordination)
- Broader deployment across projects and portfolios
- Standardized data exchange and interoperability

Horizon 3 — 2031 – 2035

Longer-Term: Intelligent Systems

Toward more intelligent, adaptive, and increasingly autonomous construction systems.



- Robotics and automation for key construction tasks (e.g., modular assembly, material handling)
- Agentic systems for end-to-end project orchestration
- Lifecycle digital twins for assets and infrastructure systems
- Predictive, adaptive, and intelligent infrastructure management

AI Assistance & Workflow Automation → **Integrated Digital Twins & Agent Collaboration** → **Autonomous Operations & Intelligent Infrastructure**

A phased roadmap from adoption to integration to intelligent, increasingly autonomous construction.

Note: *This roadmap is a strategic scenario to guide planning and investment, not a guaranteed forecast.*

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What Should Contractors and Owners Do Now?

1 Identify a High-Value Problem

Project Issue Register

ID	Issue / Challenge	Impact	Priority
I-001	RFI turnaround time is long	High	H
I-002	Progress tracking is manual	Med	M
I-003	Design coordination conflicts	High	H
I-004	Cost variance visibility	Med	M

- Focus on measurable pain points (e.g., RFIs, coordination, progress, cost)
- Align with project and business objectives
- Select a problem with clear stakeholders and expected benefits

2 Assess Data Readiness

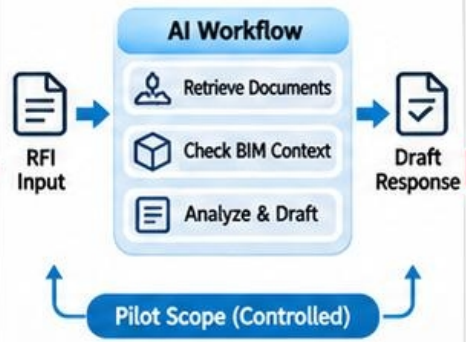
Data Readiness Checklist

- [x] **BIM / design models** (current and structured)
- [x] **Project schedule** (activities, dates, WBS)
- [x] **Cost data** (budget, actuals, coding)
- [ ] **Project documents** (RFIs, submittals, specs)
- [ ] **Field data** (photos, scans, sensors)

- Inventory available data and systems
- Check data quality, completeness, and format
- Address gaps (e.g., standardization, access)
- Ensure data security and permissions

3 Launch a Controlled Pilot

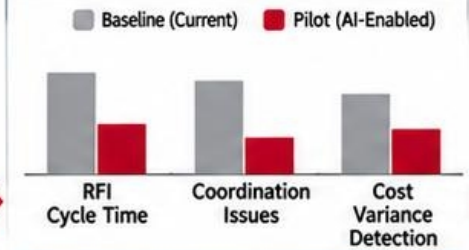
Pilot Workflow (Example: RFI)



- Define a limited pilot (scope, team, and duration)
- Use real project data and existing workflows
- Set clear success criteria (e.g., time, quality, adoption)
- Engage end users and collect feedback

4 Measure Business Value

ROI Assessment (Pilot Results)



Metric	Change
RFI cycle time	↓ (e.g., –XX%)
Coordination issues	↓ (e.g., –XX%)
Cost variance detection	↑ (e.g., +XX%)

- Compare pilot results with baseline performance
- Evaluate ROI (time, cost, quality, risk)
- Document lessons learned and practical value
- Decide go / no-go for broader adoption

5 Scale with Governance

Implementation Governance

- **People & Roles** (ownership, responsibilities)
- **Standards & Processes** (data, workflows, QA/QC)
- **Technology & Integration** (BIM, schedule, cost, ERP)
- **Data Governance & Security** (access, privacy, compliance)
- **Change Management** (training, adoption, support)

- Expand to more projects and use cases
- Establish governance (standards, data, security, roles)
- Ensure workforce training and change management
- Continuously monitor, improve, and create long-term value

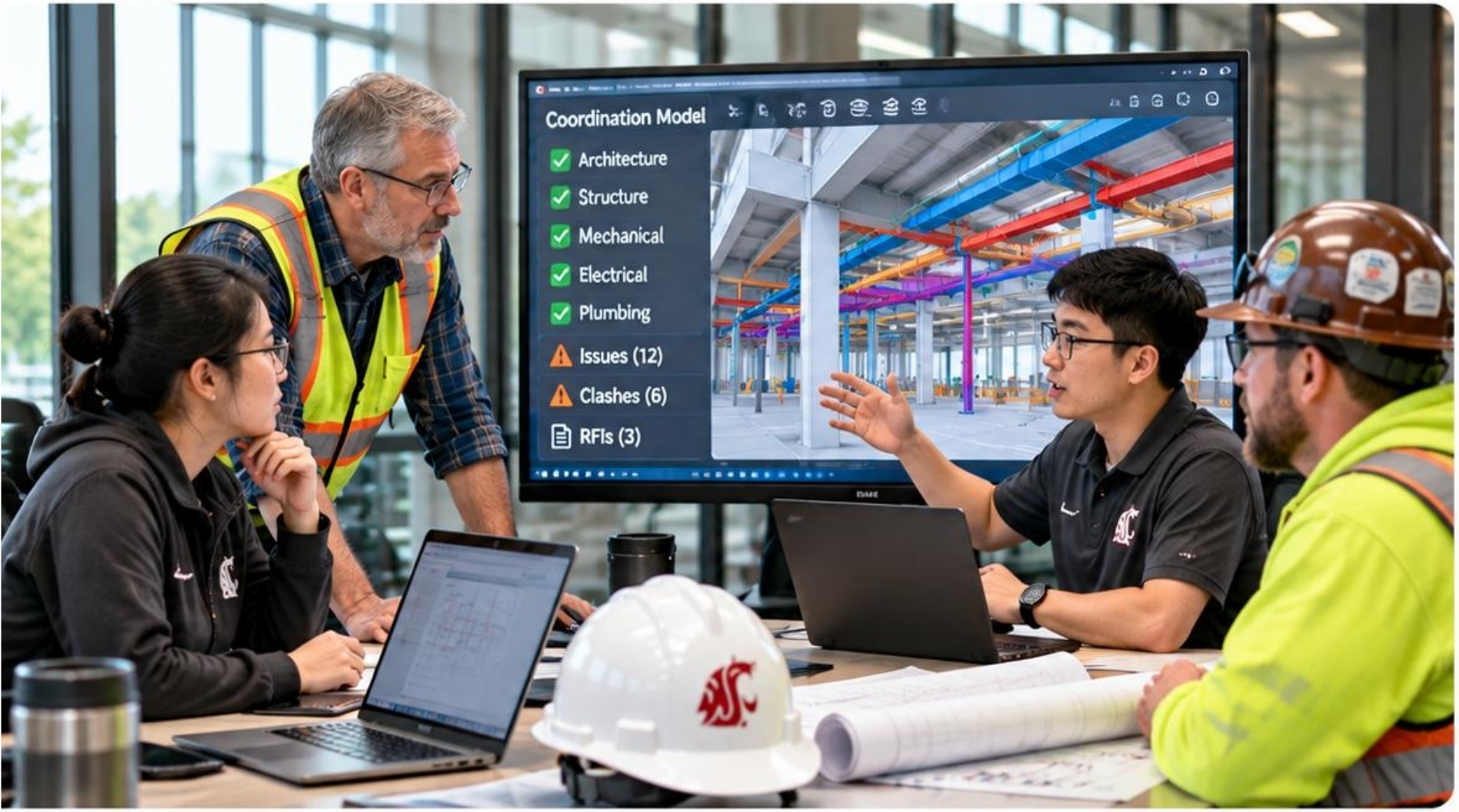
A practical, step-by-step path to realize value from AI and digital technologies in construction.

Project Implementation Roadmap

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BETA Research Lab

The Future Construction Workforce



Construction Expertise

Understand construction processes, methods, and field realities.

Digital Competency

Use BIM/VDC, digital tools, and data to improve project delivery.

AI Literacy

Apply AI responsibly, recognize opportunities and risks, and work with AI tools effectively.

Systems Thinking

See the big picture across design, construction, operations, and the asset lifecycle.

Leadership

Collaborate, communicate, and drive innovation and change in diverse teams.

Developing AI-ready, systems-oriented, and industry-leading construction professionals.

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The Rise of the Digital Master Builder

The Historical Master Builder

- Integrated design–build responsibility
- Holistic construction knowledge
- Architecture, engineering, and construction
- From concept to built reality





The Modern Integrated Project Delivery

- Collaborative, data-driven delivery
- BIM/VDC-enabled coordination
- Digital twins for lifecycle value
- AI-assisted workflows and decisions
- Integrated, multidisciplinary team



Digital Master Builder

The Professional Integrator

Six Core Competency Themes

- Construction Knowledge
- BIM/VDC
- Digital Twins
- AI
- Integration
- Leadership

Integrating construction expertise, digital systems, and leadership for the next generation of intelligent builders.

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BETA Research Lab

BE Tech Alliance: Bridging Research and Industry

University Research Laboratories



- Fundamental & applied research
- Technology validation
- Industry collaboration

Construction Owners



- Define industry needs
- Provide real-world use cases
- Evaluate and adopt proven solutions

General & Specialty Contractors



- Pilot and implement new technologies
- Provide field feedback
- Improve project delivery and productivity

Technology Providers



- Deliver and tailor innovative solutions
- Participate in technology pilots and evaluation
- Advance practical adoption in construction

Construction Professionals



- Engage in training and knowledge exchange
- Share field experience and best practices
- Build capacity for emerging technologies



Connecting research, industry, and workforce innovation for the future of construction.

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Building the Future Together

Digital delivery creates the foundation.

AI enables more intelligent decisions and workflows.

Digital Master Builders connect technology with construction expertise.



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