# Safety Built Right in:

## Exploring the occupational health and safety potential of BIM-based platforms throughout the building life cycle

Catherine Trask & Madeleine Hoeft

# As Part of  a Bigger Project

An Introduction by

Principal Investigator

**Jörgen Eklund**

# Presentation Authors

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# Topics

- Background & Study Aims
- Approach and Methods
- Published Research- what is possible?
- Current Practice – and how to move towards possibilities
- Principles for moving forward

# The path to today…


- Autumn 2020: had a meeting to discuss the study scope and goals
- Autumn and winter: Conducted a review of published literature
- Spring: workshops with industry practitioners from with experience from different life cycle stages
- Summer: analyzed and synthesized data, developed conclusions, wrote report
- August 2021: Submitted a research paper manuscript

# Project Objectives

1. What are the potentials for lifecycle OHS management with a BIM-based digital platform, as described by the peer-reviewed scientific literature?
2. What characterizes current BIM-based OHS practices in a Swedish context?

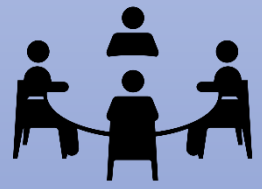
# Approach & Methods

# Mixed methods: 2 approaches

**Literature Review**

What is the ***state of the art*** for BIM in safety?

**Workshops with Industry Practitioners**



What is the ***current practice*** for BIM in safety?

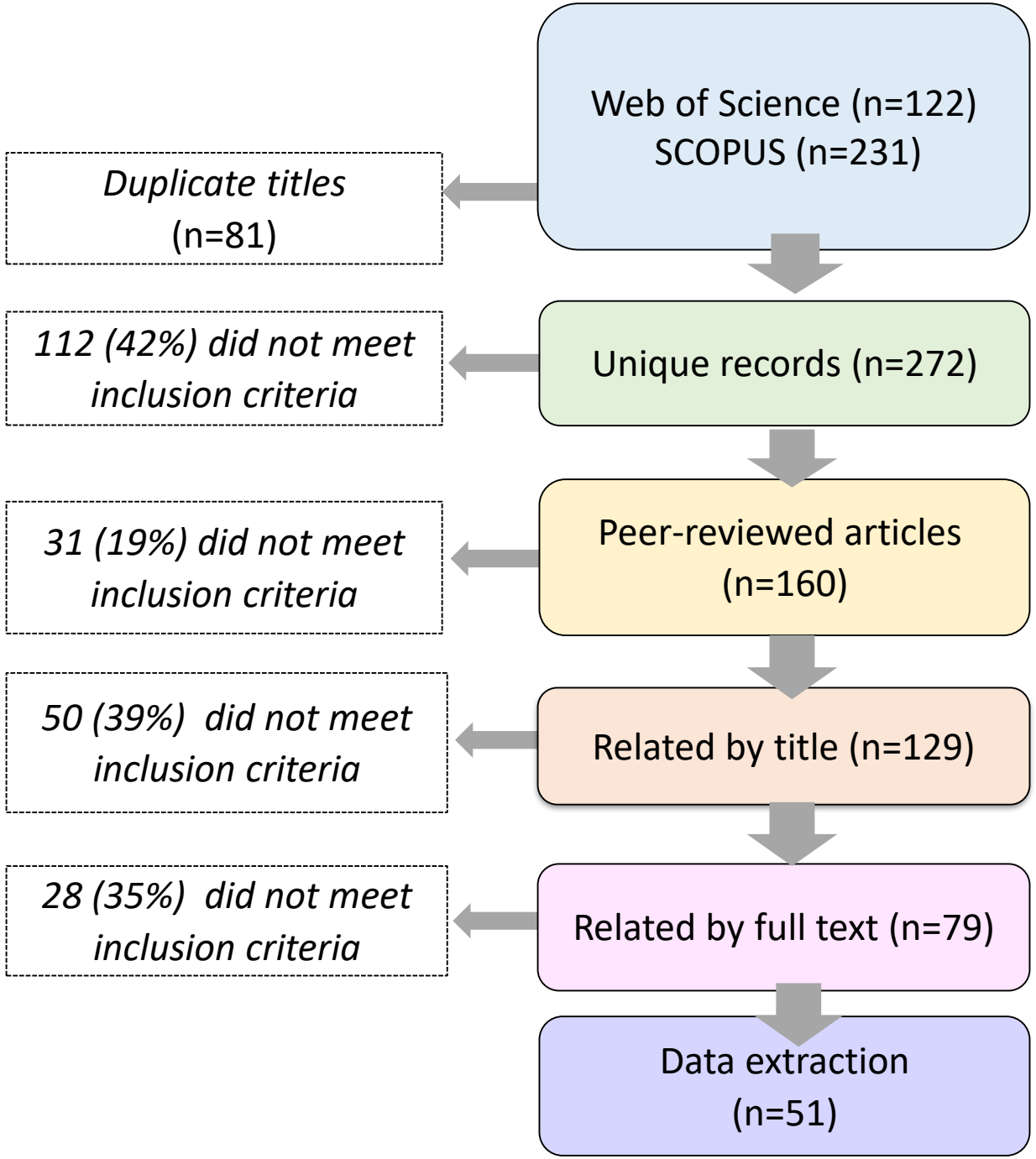
**Principles for the Way Forward**

What is needed to help overcome the challenges of implementation and make workplaces safer?

# Literature Review

We wanted research papers with:

- Reports of application of BIM with safety as a primary or secondary benefit
- Actual testing of methods or development of methods
- Applications were permanent buildings, excluded infrastructure (roads, bridges, dams)
- Any stage of life cycle
- Any methodology



# Data Extraction

| Category | Description of Extracted Information |
|---|---|
| **Basic study information** | - Country of study<br>- Type of building |
| **Solution characteristics** | - Data sources<br>- BIM applications<br>- Linked technologies<br>- Type of hazard addressed<br>- Type of solution |
| **Stakeholder integration** | - Responsibilities for solution<br>- Beneficiaries of solution |
| **Lifecycle integration** | - Life cycle stages<br>- Links between stages |
| **Impact and adoption** | - Facilitating factors for adoption<br>- Barriers/weaknesses of solution |

# Focus Groups

- A series of 2-hour online workshops with industry practitioners:
  - Architects
  - Contractors and sub-contractors
  - Developers
  - Health and Safety Managers
  - 67% men, 33% women
- Supplementay interviews

# Focus Groups

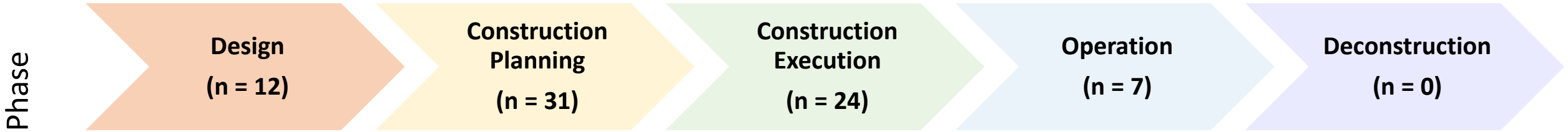
## Question Topics

1. Please describe your use cases for BIM to enhance health and safety. What actors were involved and what were the main information sources?
2. Which factors supported the implementation of the use cases?
3. What are the main challenges to implementing BIM for safety benefits?
4. How could these barriers be overcome?
5. How (else) could BIM & digital twins be used for safety in future applications?

# Results

# Use Cases: How can BIM Contribute to Safety?

# What lifecycle stages were represented in published research?



# Design

- “Design for Safety”
- “Prevention through Design”
- Design optimizations
- Identification of clashes & spatial conflicts
- Knowledge library for safety review, ‘rule checking’

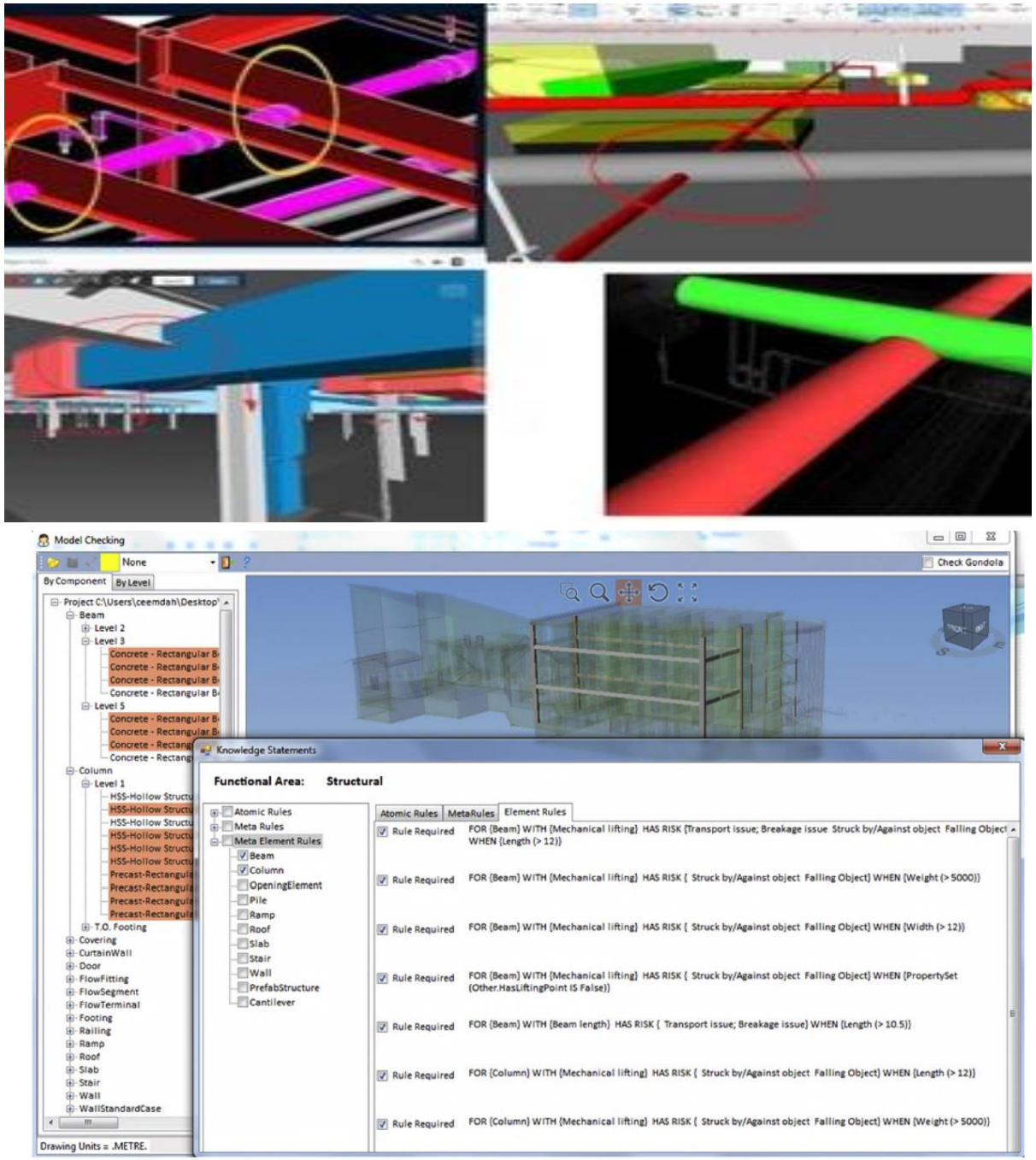



Fig. 17. Risk review with Meta element rule for beam and column.

# Design

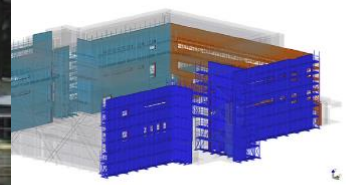
- “Design for Safety”
- “Prevention through Design”
- Design optimizations
- Occupant accessibility
- Design for manufacturing & industrial construction (off-site)

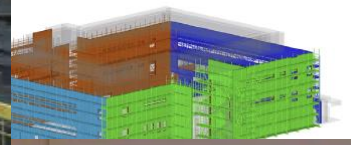

Kit of parts of tilt-up panel by BIM platform.

# Planning & Construction

- Workspace visualizations
- Safety training
- Automated scaffolding planning
- Pre-installed temporary support







# Planning & Construction

- 4D site layout simulation
- Fire safety equipment planning
- Detection of unsafe behaviour & intrusions
- Use of on-site robotics

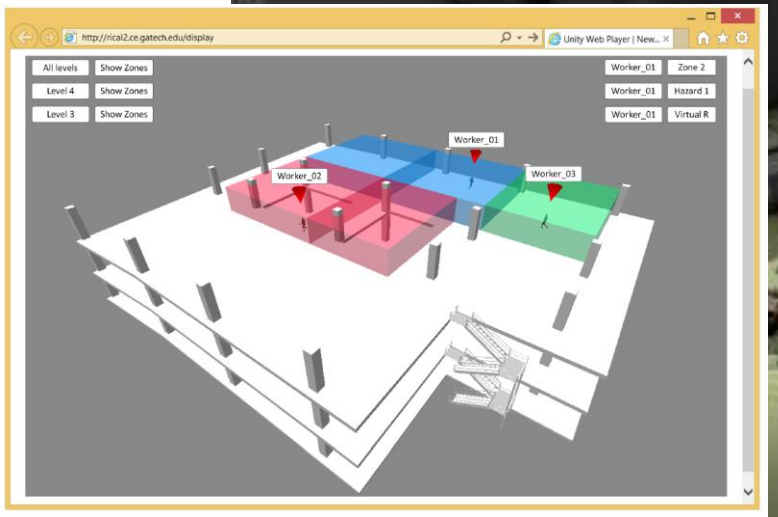



Fig. 12. Cloud-enabled remote monitoring user interface



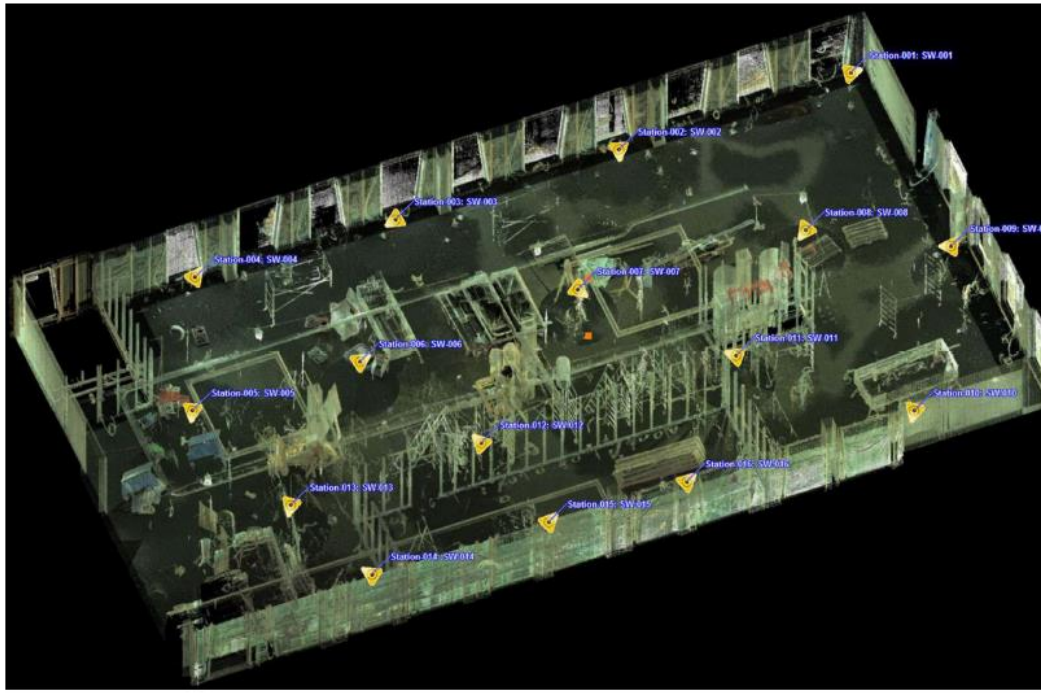


Fig. 4. Three-dimensional scan of Zone 2 robotically drilled, Level 02 House of Archives.

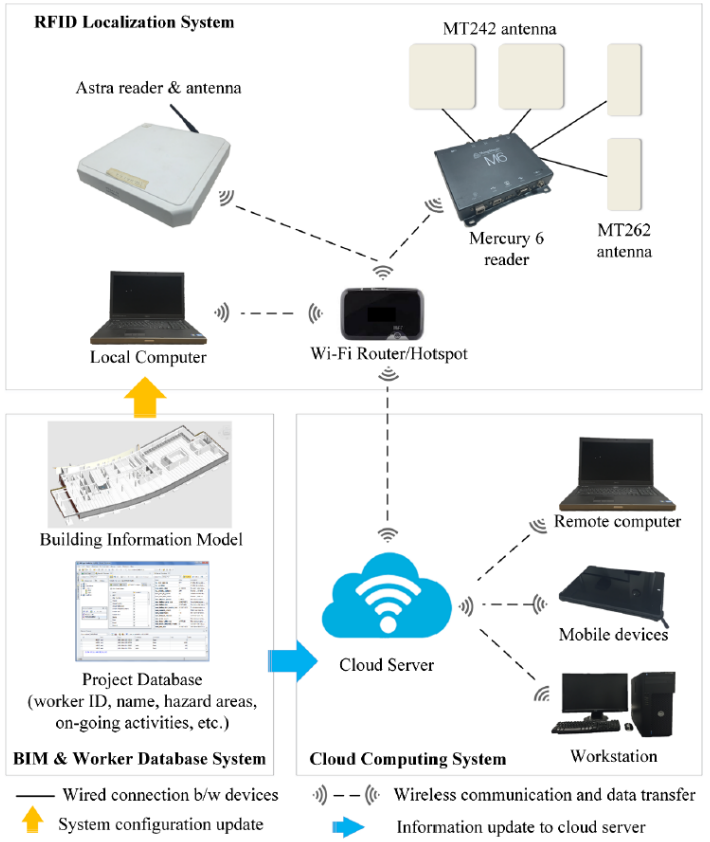
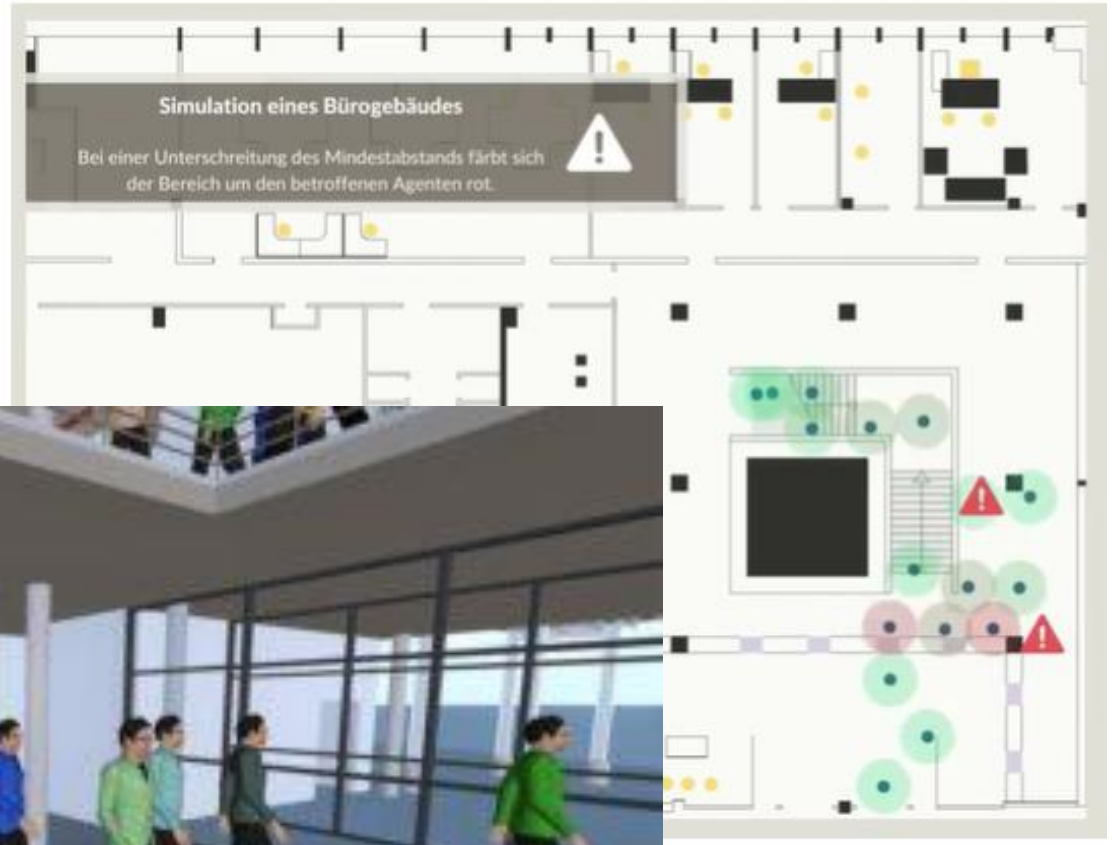


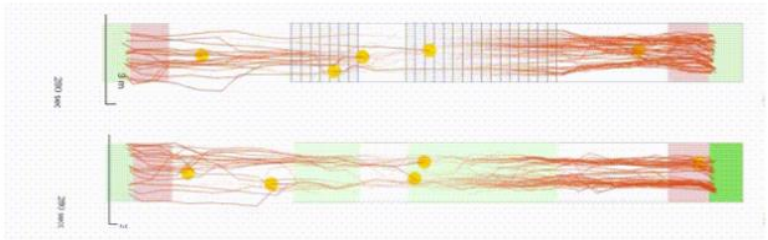

Fig. 1. Framework of the BIM and cloud-enabled RFID localization system

# Operation & Maintenance

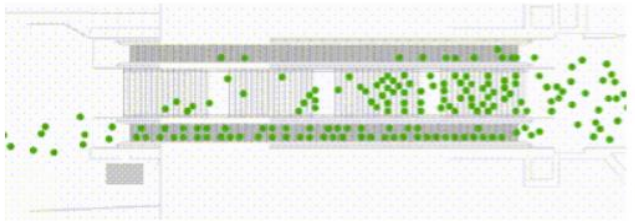
- Predictive maintenance
- Documentation & manuals
- Augmented Reality
- Remote control/ use of robotics
- Occupant/staff health (e.g., distancing)
- Emergency evacuation simulations




Modeled stairs vs. zigzag running on deceleration planes



Simulation of walking behaviour on fixed staircases and escalators

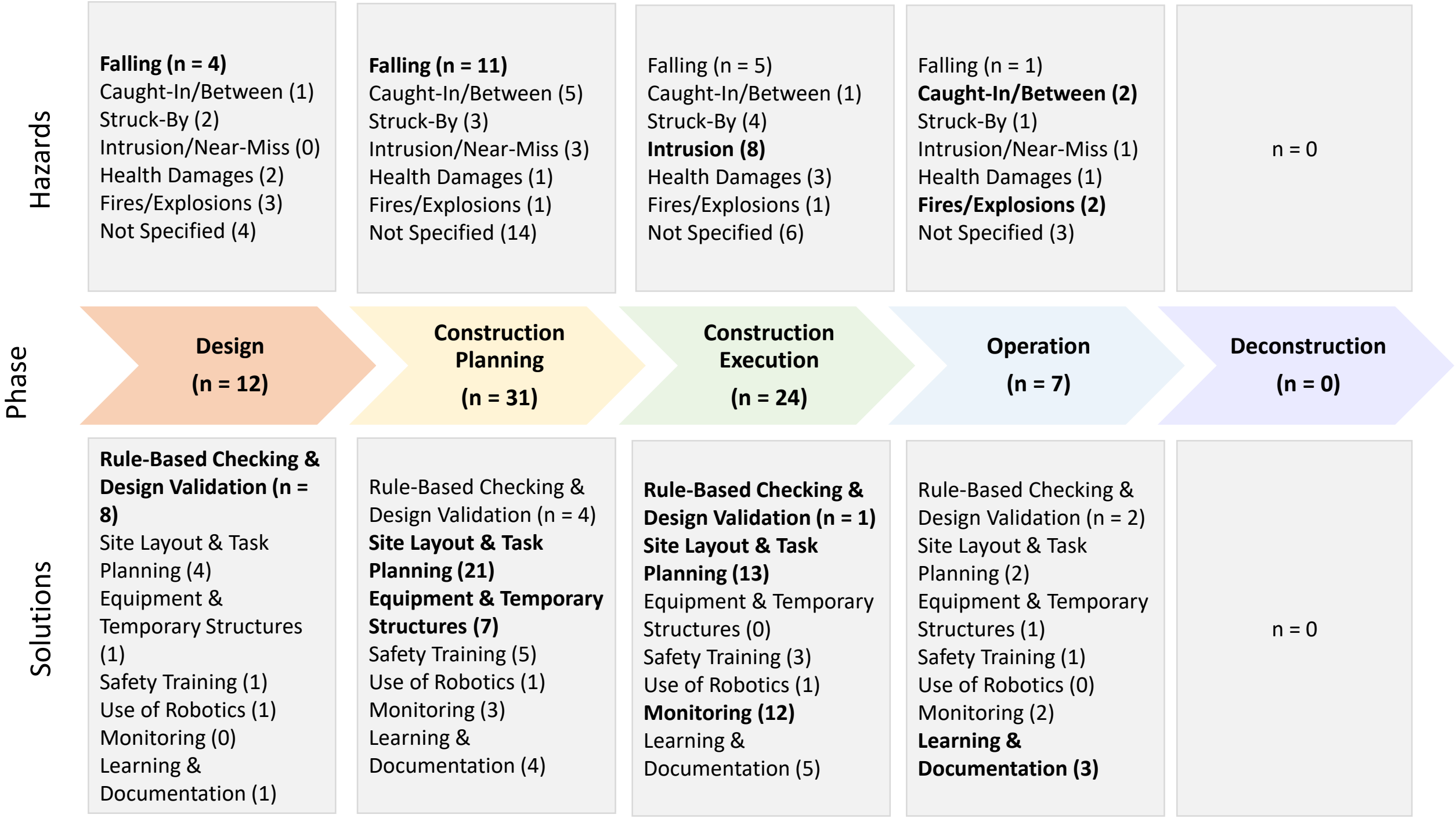


# Demolition & Renovation

No use cases found in published research

Within the published research literature:

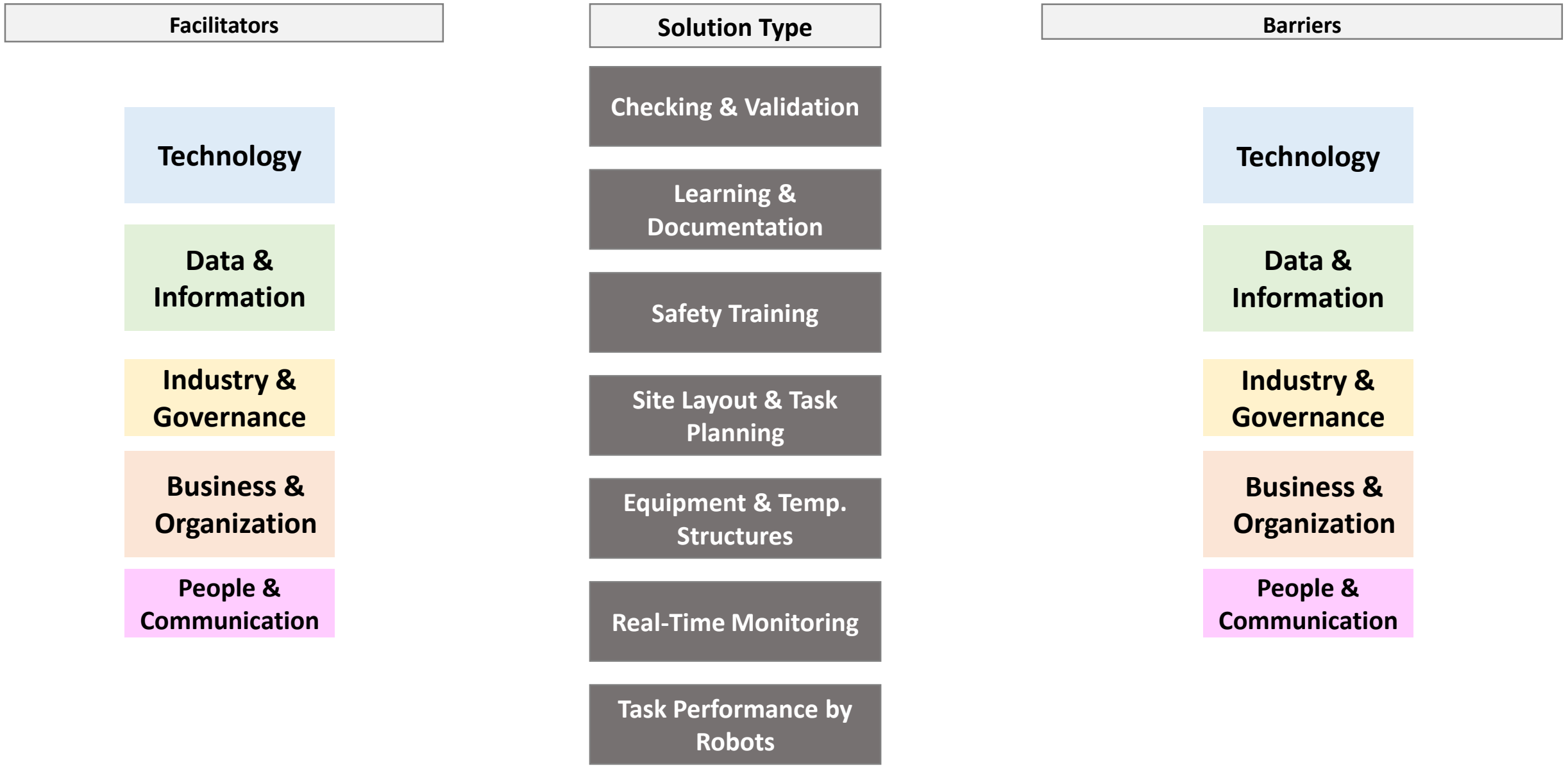
1. What **hazards** are targetted?
2. What kind  of **solutions** does BIM contribute to?


Hazards
**Falling (n = 4)**
Caught-In/Between (1)
Struck-By (2)
Intrusion/Near-Miss (0)
Health Damages (2)
Fires/Explosions (3)
Not Specified (4)
**Falling (n = 11)**
Caught-In/Between (5)
Struck-By (3)
Intrusion/Near-Miss (3)
Health Damages (1)
Fires/Explosions (1)
Not Specified (14)
Falling (n = 5)
Caught-In/Between (1)
Struck-By (4)
**Intrusion (8)**
Health Damages (3)
Fires/Explosions (1)
Not Specified (6)
Falling (n = 1)
**Caught-In/Between (2)**
Struck-By (1)
Intrusion/Near-Miss (1)
Health Damages (1)
**Fires/Explosions (2)**
Not Specified (3)
n = 0
Phase
**Design (n = 12)**
**Construction Planning (n = 31)**
**Construction Execution (n = 24)**
**Operation (n = 7)**
**Deconstruction (n = 0)**
Solutions
**Rule-Based Checking & Design Validation (n = 8)**
Site Layout & Task Planning (4)
Equipment & Temporary Structures (1)
Safety Training (1)
Use of Robotics (1)
Monitoring (0)
Learning & Documentation (1)
Rule-Based Checking & Design Validation (n = 4)
**Site Layout & Task Planning (21)**
**Equipment & Temporary Structures (7)**
Safety Training (5)
Use of Robotics (1)
Monitoring (3)
Learning & Documentation (4)
**Rule-Based Checking & Design Validation (n = 1)**
**Site Layout & Task Planning (13)**
Equipment & Temporary Structures (0)
Safety Training (3)
Use of Robotics (1)
**Monitoring (12)**
Learning & Documentation (5)
Rule-Based Checking & Design Validation (n = 2)
Site Layout & Task Planning (2)
Equipment & Temporary Structures (1)
Safety Training (1)
Use of Robotics (0)
Monitoring (2)
**Learning & Documentation (3)**
n = 0

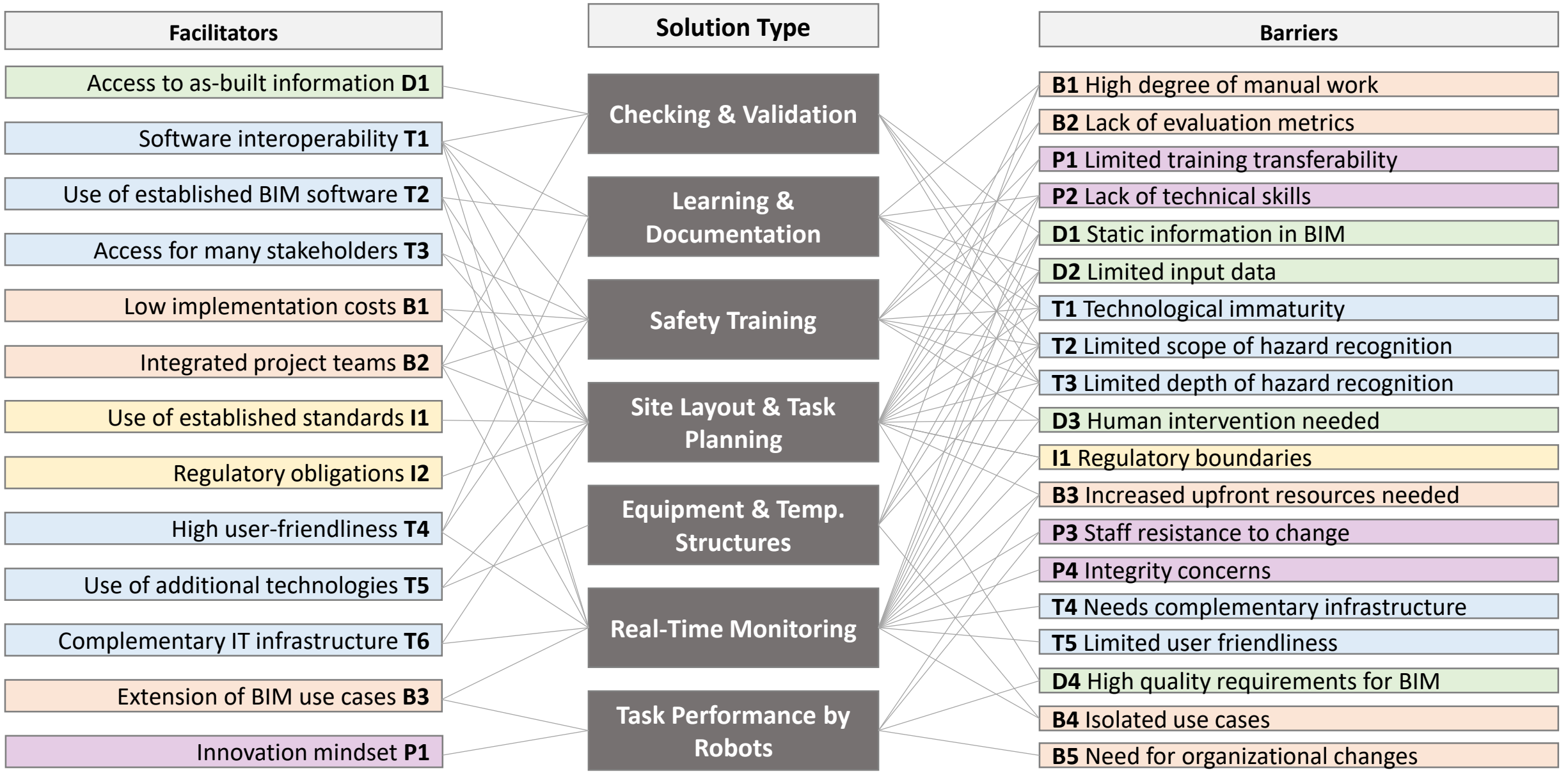
Within the published research literature:

1. What do researchers identify as **barriers** and **facilitators** for each type of solution?

# Barriers and Facilitators – Literature Review

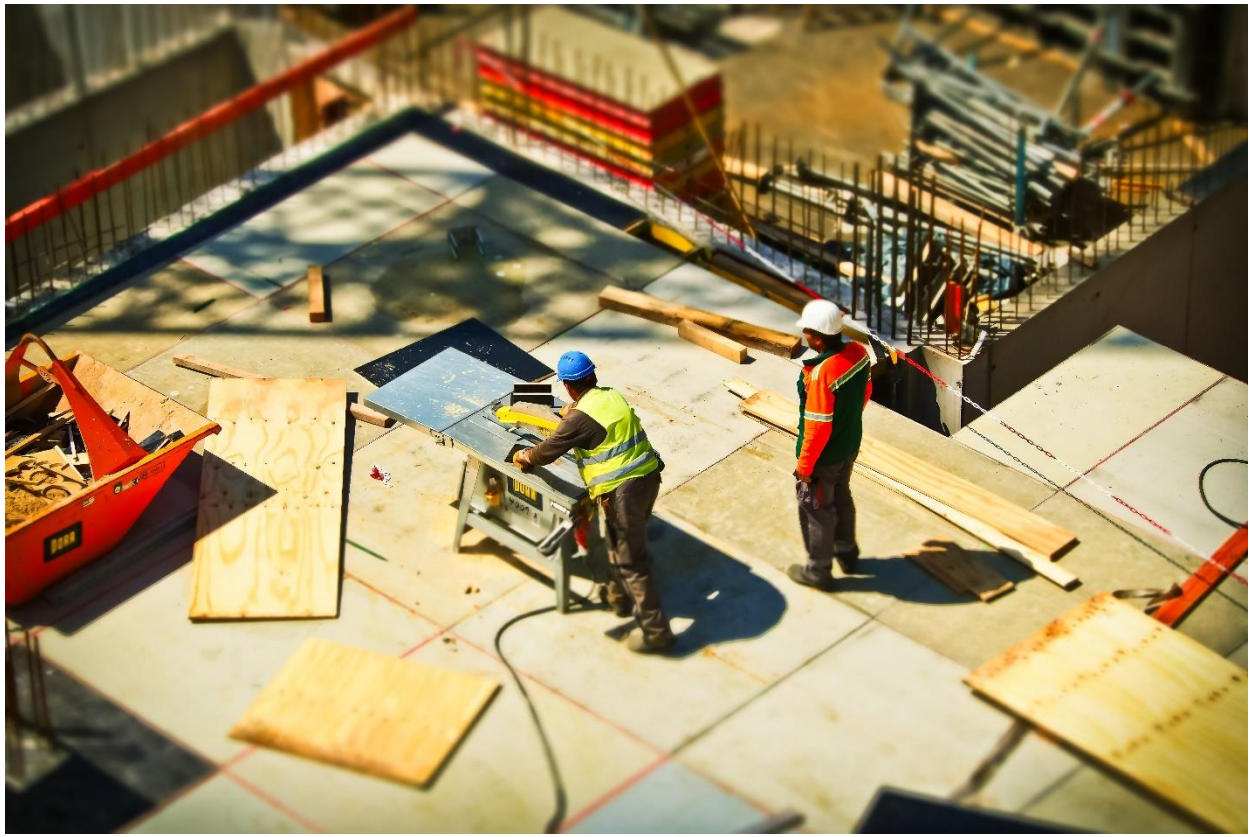


# Barriers and Facilitators – Literature Review



In actual current practice…

1. What do industry workshop participants identify as **barriers** and **facilitators** for their life cycle stage?

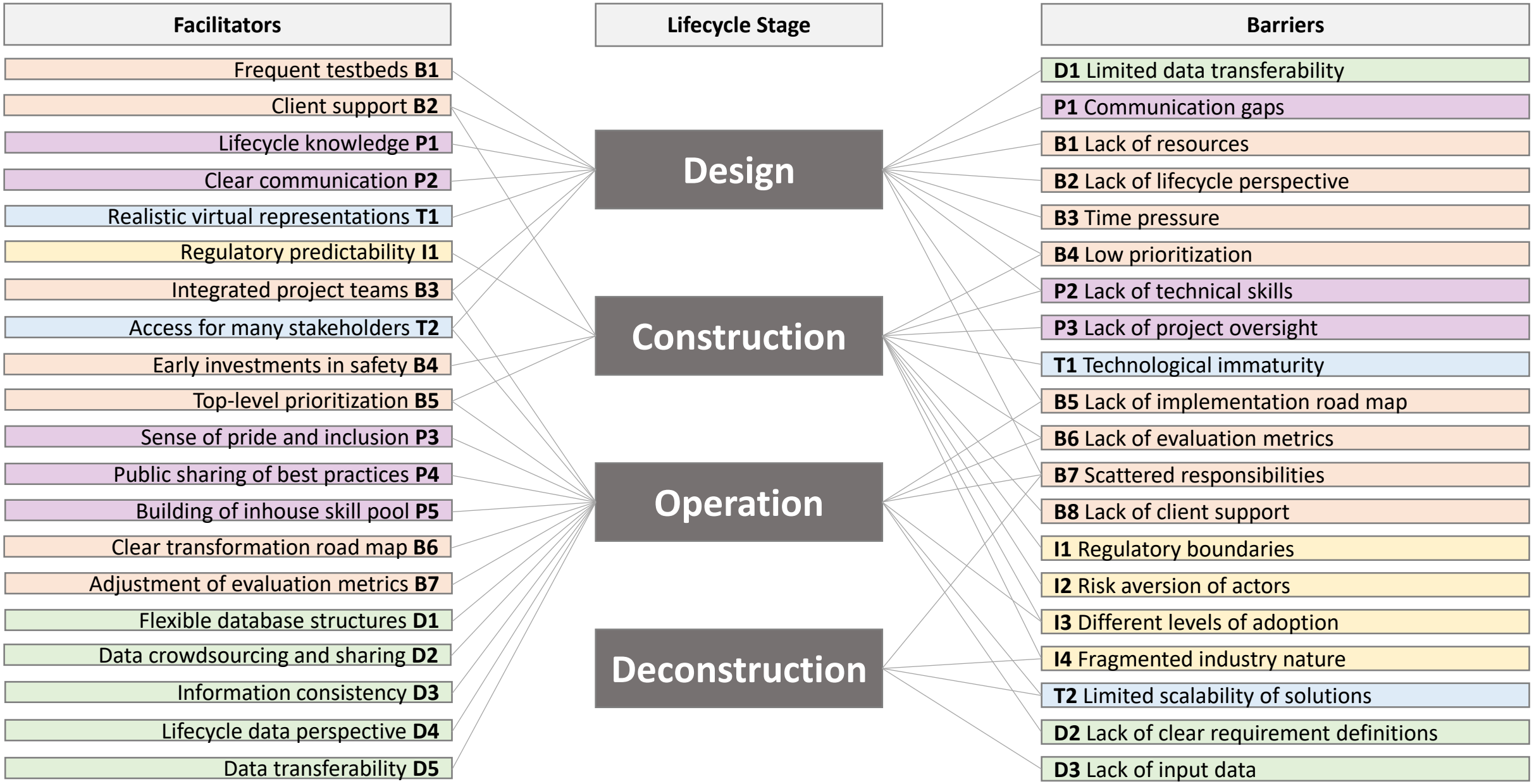


# Barriers and Facilitators – Workshop Discussions

| Facilitators | Lifecycle Stage | Barriers |
|---|---|---|
| Technology | Design | Technology |
| Data & Information | Construction | Data & Information |
| Industry & Governance | Operation | Industry & Governance |
| Business & Organization | Deconstruction | Business & Organization |
| People & Communication | | People & Communication |

T=Technology | D= Data & Information | I=Industry & Governance | B=Business & Organization | P=People & Communication

# Barriers and Facilitators – Workshop Discussions



# Where do we go from here?

**Principles for the Way Forward**

What is needed to help overcome the challenges of implementation and make workplaces safer?

| | |
|---|---|
| **Technology** | • Focus on user-friendliness<br>• Modular stake-holder integration<br>• Prioritize digital infrastructure<br>• Increase industrialization |
| **Data & Information** | • Establish a single source of truth<br>• Plan digitally “all the way through”<br>• Build a common data environment<br>• Ensure platform flexibility<br>• Share safety information |
| **Industry & Governance** | • Stronger academia & industry links<br>• Adjust regulatory requirements”<br>• Establish standards<br>• Scale solutions on industry level |
| **Business & Organization** | • Democratize safety<br>• Adopt feasible metrics<br>• Link safety and business goals<br>• Iterate in frequent testbeds<br>• Scale in the project |
| **People & Communication** | • Cultivate a safety mind-set<br>• Cultivate a digital mind-set<br>• Communicate success stories |

# Interested in learning more?

*Find more details in the Published journal article:*

Hoeft, M.; Trask, C. Safety Built Right in: Exploring the Occupational Health and Safety Potential of BIM-Based Platforms throughout the Building Lifecycle. Sustainability 2022, 14.

https://www.mdpi.com/2071-1050/14/10/6104

sustainability

MDPI

*Article*

## Safety Built Right in: Exploring the Occupational Health and Safety Potential of BIM-Based Platforms throughout the Building Lifecycle

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**Abstract:** This article investigates the opportunities of using digital building platforms based on Building Information Modelling (BIM) to increase occupational health and safety (OHS) in building design, construction, operation and deconstruction. The data collection followed a mixed-method approach with a systematic mapping review and focus group discussions with industry practitioners from the Swedish construction and real estate industry. Use cases were identified from both venues, as were prevailing barriers, potential facilitators, best practices and future applications. The findings highlight OHS potentials of digital building platforms for Rule-Based Checking and Design Validation, Team Building and Communication, Site Layout and Task Planning, Real-Time Monitoring, Equipment and Temporary Structures, Robotic Task Performance and Learning and Documentation. A set of principles is proposed to promote a higher degree of lifecycle and stakeholder integration: (1) technology, (2) data and information, (3) business and organization, (4) people and communication and (5) industry structure and governance aspects.

**Keywords:** occupational health and safety; digital twin; building information modelling; building life cycle; construction safety; design for safety; construction management; facility management

**Citation:** Hoeft, M.; Trask, C. Safety Built Right in: Exploring the Occupational Health and Safety Potential of BIM-Based Platforms throughout the Building Lifecycle. *Sustainability* **2022**, *14*, x. https://doi.org/10.3390/xxxxx

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### 1. Introduction

The building sector has one of the highest rates of accidents and fatal injuries each year both in greenfield construction and maintenance works. In 2020, the construction

# Questions & Discussion

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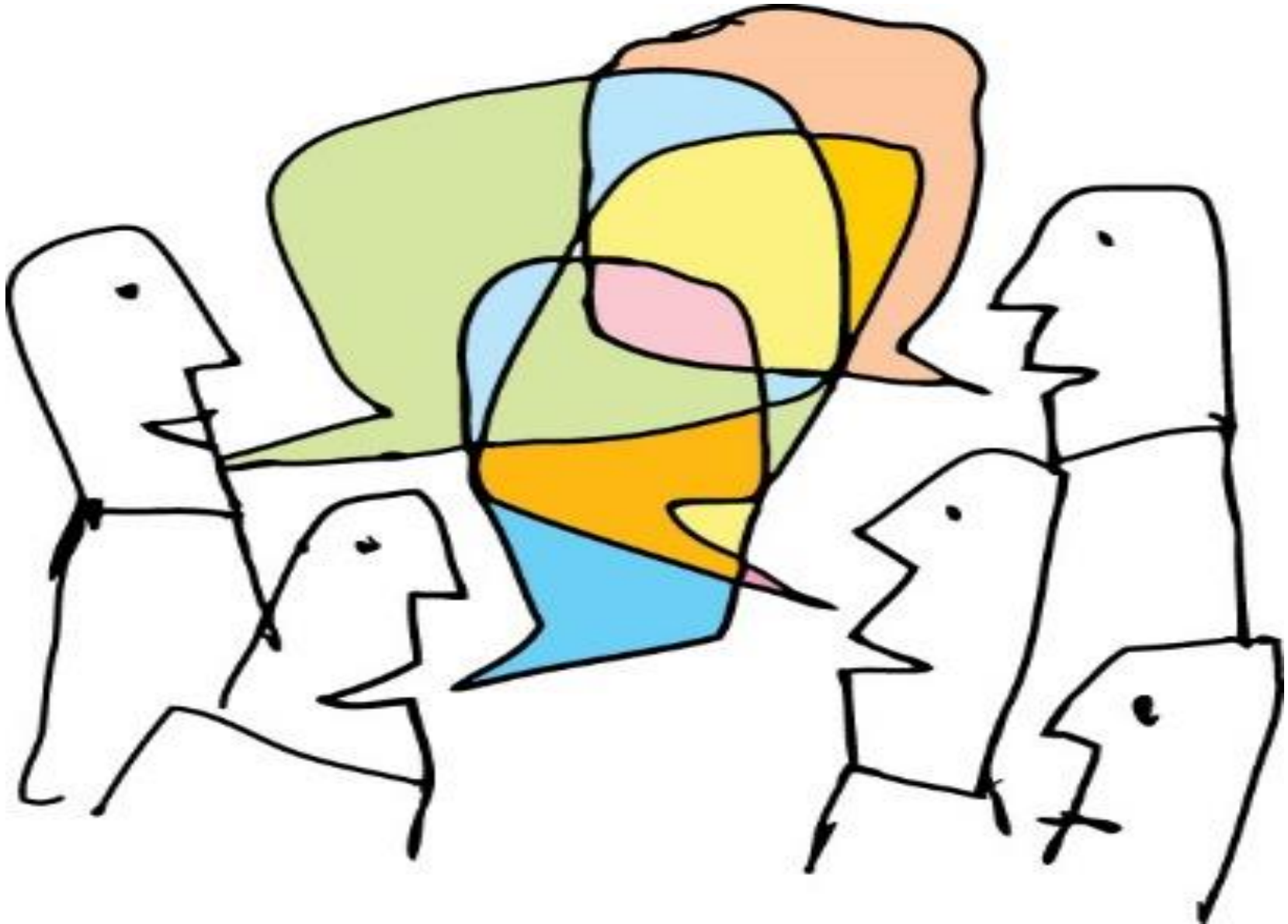

# Project Summary

This project investigates the opportunities of using digital building platforms based on Building Information Modelling (BIM) to increase occupational health and safety (OHS) in building design, construction, operation and deconstruction. The data collection followed a mixed-method approach with a systematic mapping review and focus group discussions with industry practitioners from the Swedish construction and real estate industry. Use cases are identified from both venues, as are prevailing barriers, potential facilitators, best practices and future applications. The findings highlight OHS potentials of digital building platforms for Rule-Based Checking & Design Validation, Team Building & Communication, Site Layout & Task Planning, Real-Time Monitoring, Equipment & Temporary Structures, Robotic Task Performance, and Learning & Documentation. A set of principles is proposed to promote a higher degree of lifecycle and stakeholder integration: (1) technology, (2) data and information, (3) business and organization, (4) people and communication and (5) industry structure and governance aspects.