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

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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
<table>
<thead>
<tr>
<th>Category</th>
<th>Description of Extracted Information</th>
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<tbody>
<tr>
<td>Basic study information</td>
<td>- Country of study</td>
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<td>- Type of building</td>
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<td>Solution characteristics</td>
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<td>- BIM applications</td>
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<td>- Linked technologies</td>
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<td>- Type of hazard addressed</td>
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<td>Stakeholder integration</td>
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<td>- Beneficiaries of solution</td>
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<td>Lifecycle integration</td>
<td>- Life cycle stages</td>
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<td>- Links between stages</td>
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<td>Impact and adoption</td>
<td>- Facilitating factors for adoption</td>
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<td>- Barriers/weaknesses of solution</td>
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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

• Supplementary 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 (n = 12)
- Construction Planning (n = 31)
- Construction Execution (n = 24)
- Operation (n = 7)
- Deconstruction (n = 0)
Design

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

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

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

No use cases found in published research
Within the published research literature:

1. What **hazards** are targeted?
2. What kind of **solutions** does BIM contribute to?
<table>
<thead>
<tr>
<th>Hazards</th>
<th>Rule-Based Checking &amp; Design Validation (n = 8)</th>
<th>Site Layout &amp; Task Planning (4)</th>
<th>Equipment &amp; Temporary Structures (1)</th>
<th>Safety Training (1)</th>
<th>Use of Robotics (1)</th>
<th>Monitoring (3)</th>
<th>Learning &amp; Documentation (1)</th>
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<td>Falling (n = 4)</td>
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<td>Caught-In/Between (1)</td>
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<td>Intrusion/Near-Miss (0)</td>
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<td>Health Damages (2)</td>
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<td>Fires/Explosions (3)</td>
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Within the published research literature:

1. What do researchers identify as **barriers** and **facilitators** for each type of solution?
Barriers and Facilitators – Literature Review

**Facilitators**
- Access to as-built information \( D_{1} \)
- Software interoperability \( T_{1} \)
- Use of established BIM software \( T_{2} \)
- Access for many stakeholders \( T_{3} \)
- Low implementation costs \( B_{1} \)
- Integrated project teams \( B_{2} \)
- Use of established standards \( I_{1} \)
- Regulatory obligations \( I_{2} \)
- High user-friendliness \( T_{4} \)
- Use of additional technologies \( T_{5} \)
- Complementary IT infrastructure \( T_{6} \)
- Extension of BIM use cases \( B_{3} \)
- Innovation mindset \( P_{1} \)

**Solution Type**
- Checking & Validation
- Learning & Documentation
- Safety Training
- Site Layout & Task Planning
- Equipment & Temp. Structures
- Real-Time Monitoring
- Task Performance by Robots

**Barriers**
- \( B_{1} \) High degree of manual work
- \( B_{2} \) Lack of evaluation metrics
- \( P_{1} \) Limited training transferability
- \( P_{2} \) Lack of technical skills
- \( D_{1} \) Static information in BIM
- \( D_{2} \) Limited input data
- \( T_{1} \) Technological immaturity
- \( T_{2} \) Limited scope of hazard recognition
- \( T_{3} \) Limited depth of hazard recognition
- \( D_{3} \) Human intervention needed
- \( I_{1} \) Regulatory boundaries
- \( B_{3} \) Increased upfront resources needed
- \( P_{3} \) Staff resistance to change
- \( P_{4} \) Integrity concerns
- \( T_{4} \) Needs complementary infrastructure
- \( T_{5} \) Limited user friendliness
- \( D_{4} \) High quality requirements for BIM
- \( B_{4} \) Isolated use cases
- \( B_{5} \) Need for organizational changes

**Legend**
- \( T \) = Technology
- \( D \) = Data & Information
- \( I \) = Industry & Governance
- \( B \) = Business & Organization
- \( P \) = People & Communication
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
- Technology
- Data & Information
- Industry & Governance
- Business & Organization
- People & Communication

Lifecycle Stage
- Design
- Construction
- Operation
- Deconstruction

Barriers
- Technology
- Data & Information
- Industry & Governance
- Business & Organization
- People & Communication
Barriers and Facilitators – Workshop Discussions

<table>
<thead>
<tr>
<th>Lifecycle Stage</th>
<th>Facilitators</th>
<th>Barriers</th>
</tr>
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<tbody>
<tr>
<td><strong>Design</strong></td>
<td>Frequent testbeds B1</td>
<td>D1 Limited data transferability</td>
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<td>Client support B2</td>
<td>P1 Communication gaps</td>
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<td></td>
<td>Lifecycle knowledge P1</td>
<td>B1 Lack of resources</td>
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<td>Clear communication P2</td>
<td>B2 Lack of lifecycle perspective</td>
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<td>Realistic virtual representations T1</td>
<td>B3 Time pressure</td>
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<td>Regulatory predictability I1</td>
<td>B4 Low prioritization</td>
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<td></td>
<td>Integrated project teams B3</td>
<td>P2 Lack of technical skills</td>
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<td>Access for many stakeholders T2</td>
<td>B5 Lack of implementation road map</td>
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<td>Early investments in safety B4</td>
<td>B6 Lack of evaluation metrics</td>
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<td>Top-level prioritization B5</td>
<td>B7 Scattered responsibilities</td>
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<td>Sense of pride and inclusion P3</td>
<td>B8 Lack of client support</td>
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<td></td>
<td>Public sharing of best practices P4</td>
<td>I1 Regulatory boundaries</td>
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<td></td>
<td>Building of inhouse skill pool P5</td>
<td>I2 Risk aversion of actors</td>
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<td>Clear transformation road map B6</td>
<td>I3 Different levels of adoption</td>
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<td>Adjustment of evaluation metrics B7</td>
<td>I4 Fragmented industry nature</td>
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<td></td>
<td>Flexible database structures D1</td>
<td>T2 Limited scalability of solutions</td>
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<td></td>
<td>Data crowdsourcing and sharing D2</td>
<td>D2 Lack of clear requirement definitions</td>
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<td>Information consistency D3</td>
<td>D3 Lack of input data</td>
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<td>Lifecycle data perspective D4</td>
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<td>Data transferability D5</td>
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</table>

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

Find more details in the Published journal article:


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