The hidden engine of project success: Best practices for managing large 3D models and 2D documentation in infrastructure projects

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ABSTRACT: Managing large 3D models and 2D documentation effectively is essential to enable efficient delivery of complex infrastructure projects. The scale and complexity of modern projects introduce challenges such as maintaining consistency, minimising errors, and supporting collaboration across multidisciplinary teams. This paper presents best practices for handling extensive digital models and the associated documentation, focusing on optimising workflows and improving outcomes. Key topics include file performance, version control, data structuring, documentation standards, cloud-based collaboration, and practical approaches to resolving interoperability issues. The role of automation in streamlining tasks and improving model reliability is also explored. In addition, the paper highlights the human factors that influence Building Information Modelling (BIM) success, such as leadership, team trust, and mindset. By implementing these strategies, organisations can achieve greater accuracy, efficiency, and coordination, leading to better project delivery and long-term value in infrastructure development.

1 INTRODUCTION

Across the globe, infrastructure projects are expanding in scale, ambition, and complexity. From underground tunnels and high-speed railways to massive bridges and utility networks, the physical assets we design and build increasingly rely on equally complex digital models. At the heart of these digital twins are 3D models and 2D documentation, which are crucial tools for design, coordination, procurement, construction, and operations. However, managing these models effectively is a daunting task that can either accelerate success or derail entire projects.

Why do some teams consistently deliver accurate, timely models while others struggle with bloated files, version conflicts, and coordination nightmares? What separates high-performing digital engineering teams from those drowning in technical debt and miscommunication? The answers lie not in software licenses or flashy presentations but in the less glamorous terrain of workflows, standards, habits, culture, and leadership.

Because "BIM" is such a broad and often misunderstood term, it's essential to clarify its meaning at the outset of any project. In this paper, BIM refers not only to the 3D model itself, but to the structured processes, data standards, and collaborative workflows that support the full lifecycle of an asset—from concept design through to construction, operation, and maintenance. This definition ensures that when we discuss BIM in the following sections, we are referring to a coordinated approach that integrates people, processes, and technology toward shared project goals.

This paper is for every engineer, modeler, BIM manager, and project leader who has opened a 2GB file only to watch it crash. For every project that's lost hours chasing missing parameters, redrawing clumsy details, or untangling corrupted links. It offers a practical, experience-based roadmap grounded in real project environments, shaped by lessons learned through both success and failure. The goal is to provide clear, actionable strategies that support more resilient and efficient digital delivery across teams and disciplines.

Managing large 3D models and 2D documentation is not just a technical issue, it's a collaborative discipline. It's about anticipating complexity, managing performance and aligning teams with the bigger picture. This paper outlines not only what can go wrong but more importantly, what to do about it. We unpack the pitfalls and bottlenecks that plague projects and provide real-world solutions that can be applied immediately.

If you're prepared to rethink your digital approach, enhance productivity, and future-proof project delivery, this paper offers a pathway forward. It's not merely about improving models—it's about achieving better outcomes, building stronger teams, and ultimately delivering superior infrastructure for the communities we serve.
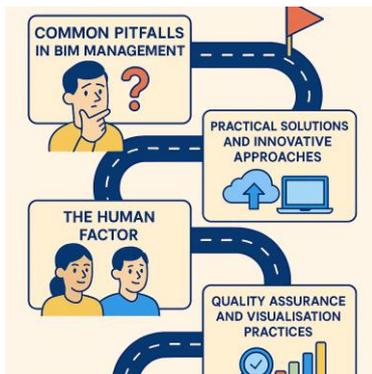

Figure 1. Visual overview of the paper's purpose.

2 COMMON PITFALLS IN BIM MANAGEMENT

While BIM offers powerful capabilities, it is not immune to pitfalls that often emerge across infrastructure projects. These challenges, if not identified and addressed early can ripple through project phases, compounding into costly delays, coordination breakdowns and missed opportunities for optimisation. Many of these pitfalls are not purely technical but rooted in implementation, communication, and human behavior.

What begins as a minor oversight, like inconsistent model structuring, unclear roles or lack of process ownership can grow into significant project risks if left unmanaged. Recognising these issues in their early stages allows teams to apply targeted solutions before they escalate. It also helps build a culture of accountability, where lessons are captured, shared, and embedded into future practice.

The sections that follow explore some of the most common pitfalls encountered across BIM-enabled projects. Alongside each challenge, practical insights are offered to demonstrate their real-world consequences and provide a foundation for more resilient, efficient digital delivery.

Figure 2. A summary of typical challenges in BIM management.

2.1 *Lack of strategy*

Many BIM initiatives falter due to the absence of a clear strategic direction. Too often, BIM is treated as a standalone technical tool or a software deployment exercise rather than a core component of the project's delivery strategy. However, BIM's true value emerges when it is directly aligned with overarching business objectives, such as cost efficiency, risk reduction, sustainability targets or improved asset performance.

A well-defined BIM strategy should begin by answering some key questions: What problems are we solving with BIM? How will success be measured? How does BIM contribute to the broader project and organisational goals? The answers to these questions should be translated into clear, measurable Key Performance Indicators (KPIs) that can be tracked over the lifecycle of a project.

Another critical step at this stage is to identify the required software, integration points, and potential limitations early in the project. Understanding how platforms will interact and resolving compatibility issues upfront helps prevent costly delays and workflow disruptions later in the lifecycle.

Without this alignment, BIM risks becoming a siloed effort, technically impressive but disconnected from the real project value. This leads to fragmented implementation, reduced team buy-in and missed opportunities for integration with procurement, construction and asset management systems.

Firms that approach BIM as a strategic enabler rather than a side initiative see markedly better outcomes. For example, organisations that connect BIM outputs to functions like cost estimation, construction phasing and risk forecasting often report stronger stakeholder confidence, improved project visibility and increased access to funding or internal investment. In these cases, BIM is no longer just a modelling exercise; it becomes a driver of performance and a tool for informed decision-making across the project's lifecycle.

2.2 *Neglecting people and change management*

BIM is 80% about people and only 20% about technology. Yet, many initiatives focus too much on tools and not enough on engaging the people using them. Resistance often arises when teams are informed, but not involved, and when changes are imposed rather than introduced through dialogue and collaboration.

Effective BIM leaders prioritise clear communication and ensure that all stakeholders understand not only what is changing but why it matters to them. Involving team members early will build ownership and reduce resistance.

Investing in internal champion team members who advocate for BIM and guide others through challenges can improve adoption significantly. Pairing this with peer mentoring and structured onboarding helps teams adapt more quickly and confidently.

Digital transformation is as much about mindset as it is about tools. Without attention to change management, even the best systems can struggle to deliver their full value.

2.3 *Overengineering processes*

Overcomplicated workflows, excessive documentation and poorly written Digital Engineering Management Plan (DEMP) hinder rather than help.

Best practices favour clarity and simplicity, designing processes that are intuitive, repeatable and scalable. Teams that document fewer but clearer protocols experience fewer coordination errors and faster onboarding.

2.4 *Failing to demonstrate ROI*

A critical oversight is the failure to link BIM efforts to tangible outcomes such as cost savings, risk reduction and productivity gains. Business leaders require a clear value proposition to support and expand BIM initiatives. Projects that align BIM reporting with project KPIs, such as earned value management or safety compliance, gain broader organisational support.

2.5 *Underestimating risk management*

Overlooking small risks, such as outdated software, duplicate elements or insufficient training, can lead to major disruptions in project timelines and budgets. To manage these risks effectively, BIM leaders should create digital risk registers, enforce strict version control and conduct regular audits of models and documentation. These practices help teams detect and resolve issues early, reducing the chance of costly rework or delays. Proactive risk management isn't just about avoiding problems, it plays a vital role in ensuring smooth, successful project delivery.

3 PRACTICAL SOLUTIONS AND INNOVATIVE APPROACHES

In response to the challenges described earlier, this section offers hands-on strategies drawn from real-world implementation across major infrastructure programs. These practices aim to empower teams with clear, scalable and efficient methodologies that foster collaboration and reduce rework. Examples and case-driven evidence accompany the approaches to provide clarity and guidance.

Figure 3. Practical solutions and innovative approaches.

3.1 *Streamlining workflows*

Efficiency comes from smart systems, not complex ones. Automation scripts, standardised templates and the intelligent use of software features can eliminate redundant tasks. For example, scripts in Revit or Dynamo can reduce modelling time by up to 80%, and templates prevent manual data entry errors. Grasshopper in Rhino enables rule-based geometry generation, making it ideal for infrastructure elements like tunnels or bridges (Saminfar 2023).

Sometimes, laziness sparks innovation. When experts look for shortcuts, they often create better templates, workflows and automation. Taking time to step back and rethink can lead to sharper insights and priorities, turning "lazy" moments into long-term efficiency.

3.2 *Embracing cloud-based collaboration*

Performance issues, such as slow Revit files, often stem from legacy server setups. Moving central files to cloud platforms like Autodesk Construction Cloud or BIM 360 can reduce syncing times, enhance cross-team collaboration and prevent costly delays. Cloud-based workflows also facilitate version control, access logging and rollback in case of corruption.

To make BIM teamwork less stressful, teams should start with purpose, clarity and passion. Purpose gives direction. Clarity ensures alignment. Passion drives innovation.

3.3 *Clarifying documentation standards*

The 2D documentation must align with the 3D models, follow clear CAD standards and support regulatory compliance. The use of view templates, sheet sets and revision tracking contributes to consistency, traceability and review readiness. Developing discipline-specific drawing lists and checklists ensures standardisation across teams and packages.

Better documentation is not just about compliance; it's also about clarity. Clarity reduces rework, speeds approvals and improves team morale.

3.4 *Overcoming IFC and interoperability challenge*

Interoperability issues are often blamed on file formats like industry foundation classes (IFC). However, the root cause is often outdated workflows and a resistance to process evolution. A mindset shift, focused on structure, clarity and discipline, is critical.
Improving user habits and investing in user training can dramatically improve outcomes.

The Architecture, Engineering, and Construction (AEC) industry has evolved from a black-and-white picture into a rich, colourful digital canvas, thanks to BIM. Today, roles like BIM coordinators, computational designers and data analysts are reshaping how we work, bringing diversity and innovation to the forefront.

4 THE HUMAN FACTOR

While tools, platforms and standards form the visible structure of digital engineering, the true engine of successful BIM implementation lies in its people. The human factor is often underestimated, but it is what transforms good systems into great outcomes. Technology alone cannot resolve communication breakdowns, unclear responsibilities, or a lack of trust. For large-scale infrastructure projects, the ability of teams to collaborate effectively, adapt to change and uphold shared values is just as critical as the models they produce.

This section explores the core human elements that underpin digital delivery: trust, mindset and leadership. High-performing BIM teams are built on open communication, mutual respect and a shared understanding of purpose. Team members are more likely to contribute their best when they feel heard, supported and empowered to grow.

Fostering the right culture takes more than motivation, it requires intention. Leaders must set the tone by aligning teams early, promoting accountability, simplifying complexity and encouraging continuous learning. When the human side of digital delivery is strong, technical challenges become easier to solve and innovation becomes a natural outcome.

In short, the strength of BIM systems will always reflect the strength of people.

Figure 4. The human factor.

4.1 *Building trust in teams*

The foundation of collaboration is trust, not tools, software, or individual skillsets. In high-performing BIM environments, trust is what allows technical systems to function effectively across disciplines. Teams thrive when members consistently deliver on their commitments, acknowledge mistakes without blame and maintain open, respectful communication. Without this foundation, even the most advanced digital platforms and workflows can fall apart under pressure.

Trust empowers individuals to speak up when something isn't working, to challenge ideas constructively and to support one another through tight deadlines and complex problems. It enables faster resolution of issues, smoother coordination across disciplines and greater innovation because people feel safe to test ideas and propose improvements.

Strong BIM teams are neither shark tanks nor petting zoos. Shark tanks breed internal competition and defensiveness, while petting zoos prioritize comfort over progress. High-functioning teams strike a balance, value clarity, welcome healthy debate and align around a common purpose. This dynamic culture is essential to turning a collection of skilled individuals into a resilient, collaborative force capable of delivering complex infrastructure with confidence and consistency.

4.2 *Cultivating the right mindset*

BIM's success doesn't hinge on high-end workstations or fancy (expensive) software platforms. It's driven by a mindset of continuous improvement. At its core, successful digital delivery is not just technical; it's cultural. It begins with how teams think, how they learn and how they adapt.

Leaders play a crucial role in shaping this mindset. They must empower their teams to ask better questions, align early in the project lifecycle and communicate clearly across disciplines, whether it's between designers, contractors, operators or clients. True digital transformation happens when people shift from reactive to proactive, from siloed thinking to collective problem-solving.

Importantly, mindset influences longevity. Projects often span years and evolve over phases. A team's ability to maintain clarity, motivation and collaboration throughout that journey hinges on its willingness to learn, reflect and reset. Creating a culture of feedback, where lessons are captured, mistakes are discussed constructively and wins are shared, ensures long-term alignment and growth.

Each new year, a project phase or challenge presents an opportunity to reset, not just workflows, but attitudes. Replacing fear with curiosity, complaints with gratitude and blame with ownership fuels both professional and personal development. The most successful BIM teams understand that every technical breakthrough is rooted in a human one. A better BIM begins with a better mindset and that mindset begins with leadership.

4.3 *Leading by example*

Leadership in BIM is not just about mastering tools or managing models. It's about shaping how teams think, work and collaborate. A great BIM manager doesn't simply oversee digital workflows; they actively remove roadblocks, simplify processes and foster an environment where digital systems feel intuitive and supportive, not overwhelming or restrictive.

While the terms "manager" and "leader" are often used interchangeably, they represent different approaches. A manager primarily focuses on planning, organising, and ensuring tasks are completed to specification and on time — maintaining systems, schedules, and compliance. A leader, on the other hand, inspires, influences, and empowers people to exceed expectations. Managers tend to direct; leaders guide. In BIM, effective delivery benefits from both: the structure and accountability of good management, and the vision, adaptability, and trust-building of strong leadership.

True leadership means leading by example. That involves staying curious and adaptable as technologies evolve but also staying grounded in the human side of delivery. Great BIM leaders champion simplicity over sophistication. They streamline instead of stacking layers of complexity. They focus not on controlling every detail, but on creating systems and habits that empower others to work confidently and independently.

Crucially, impactful BIM leaders engage across the full spectrum of project functions, from design and engineering to procurement, construction and asset management. This cross-functional visibility enables them to align digital efforts with project strategy and client goals. They become connectors who help translate technical details into business value.

Importantly, transforming a team doesn't require massive budgets or high-profile consultants. What it does require is structure: clearly defined roles, regular and honest feedback and a commitment to continuous learning. When leaders communicate clearly, set expectations and model accountability, they build trust. And when that trust is combined with vision and support, good teams evolve into great ones, capable of delivering digital outcomes that are not only efficient, but meaningful.

5 QUALITY ASSURANCE AND VISUALISATION PRACTICES

5.1 *Implementing robust QA/QC workflows*

Quality assurance (QA) and quality control (QC) in digital delivery extends far beyond simply verifying that a model looks correct on screen. They involve a comprehensive approach to ensuring that the information within the model is reliable, consistent and aligned with project requirements. This includes validating data integrity, enforcing correct naming conventions and ensuring all elements adhere to agreed protocols, such as BEP (BIM Execution Plan) standards and client-specific documentation guidelines.

Tools like Navisworks and Revizto are commonly used to support QA/QC processes. These platforms offer robust features such as visual clash detection, issue tracking and rule-based compliance checks that help identify coordination conflicts and non-compliant elements early in the workflow. Leveraging these tools enables teams to catch and resolve issues before they escalate into costly on-site problems.

Instituting a structured QA/QC cycle at defined project milestones—such as design freeze, coordination review or pre-issue submission, ensures consistency and accountability across disciplines. Peer reviews, driven by checklists tailored to each project's scope, add a valuable layer of oversight. When combined with automation tools, such as Dynamo scripts or rule-based validation engines, these practices help reduce the time and risk associated with manual checking while increasing repeatability and confidence in the output.

Ultimately, incorporating tested QA/QC measures into the digital workflow is not just about compliance, it's about ensuring the final deliverables are technically sound, contractually aligned and ready for downstream use in procurement, construction and asset management. (Saminfar 2024).

5.2 *Visualisation for decision-making*

Model-based decision-making is significantly enhanced through the use of high-quality visualisation tools. These tools transform technical models into accessible, interactive experiences that support clearer communication and faster consensus-building. Renderings, animations, real-time simulations and VR walk-throughs help stakeholders, especially non-technical ones, understand design intent, identify spatial challenges and assess safety or sequencing risks that might otherwise be overlooked in traditional documentation.

Visualisation isn't just a presentation tool; it's a powerful decision-making aid. Platforms such as Twinmotion enable teams to generate immersive, real-time outputs that convey design, construction phasing and site logistics in a way that 2D drawings or even 3D models cannot. These tools bridge the gap between disciplines, allowing designers, contractors and clients to share a common visual language.

When applied early in the design process, visualisations are particularly valuable. They allow stakeholders to explore options, raise concerns and request adjustments while changes are still relatively easy and inexpensive to make. This proactive clarity reduces the likelihood of costly rework during construction and accelerates approval cycles by increasing stakeholder confidence and engagement.

By integrating visualisation into project workflows, teams can turn models into meaningful narratives that support better decisions, faster feedback loops and more aligned project outcomes.

6 CONCLUSION

BIM is not a magic button. It is a structured, strategic framework that, when implemented thoughtfully, enhances visibility into evolving design intent, which increases predictability in construction realities. It supports collaboration and accountability for stakeholders throughout the lifecycle of complex infrastructure projects. It is not just about 3D modeling or producing drawings. Rather, BIM is about integrating information, aligning teams and delivering coordinated, data-driven decisions that reduce risk and add value at every stage of a project.

As this paper outlined, managing large 3D models and 2D documentation effectively requires more than just technical expertise. It demands a well-defined strategy, clear standards, streamlined

workflows, and most importantly a focus on people. Projects often falter not because of technical limitations, but due to fragmented communication, uncoordinated models, or resistance to change. Addressing these challenges holistically is essential to move from reactive problem-solving to proactive delivery.

The practical solutions and lessons shared, such as embracing cloud collaboration, using scripting and automation, improving documentation protocols and fostering a culture of trust, are based on real-world experiences. These aren't theoretical ideals; they are tested strategies that have helped teams deliver major infrastructure outcomes on time, within budget and to a high standard of quality.

Moreover, the influence of the human factor cannot be overstated. Projects succeed when people are empowered, respected and aligned. By investing in leadership, communication and change management, organisations can ensure that their digital tools are supported by equally strong team dynamics. Trust, clarity and collaboration are not optional extras, they are the foundation upon which successful BIM implementation is built.

Ultimately, the path to success in managing large-scale digital models and documentation is not about having the latest tools but how those tools are used, by whom and within what context. In this sense, effective model and documentation management becomes the hidden engine of project success, quietly powering coordination, reducing risk and enabling smarter decisions from design through delivery.

By aligning digital practices with business goals, simplifying complexity, leveraging automation, securing data and fostering a supportive team culture, organisations can achieve more predictable outcomes, deliver higher-value projects and build better infrastructure for the communities they serve. The opportunity lies not just in managing models, but in mastering the systems, habits and mindsets that bring them to life.

ACKNOWLEDGMENTS

7 REFERENCES

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