BIM for Corporate Real Estate Data Visualization from Disparate Systems

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Abstract. Corporate Real Estate (CRE) management has several functional components, which are often owned by different departments and stored on different data management systems. A Building Information Modelling (BIM) centralized software framework is an efficient way to document, manage, share, analyze and present information used in CRE management operations and provide a single source of truth to allow evidence-based decision-making regarding individual buildings as well as property portfolios. This paper explores previous examples from the literature and presents a case study whereby BIM models were created for two existing small commercial offices to display information related to corporate real estate management, facility management and space use, building operations and maintenance, and thermal comfort and complaint tracking. These case studies demonstrate the data visualization benefits of this tool within this context and its potential for scaling to the portfolio level, as information in each of these models can be interfaced with its associated centralized data management system.

Keywords: Building Information Modeling · Corporate real estate · Lease management · Facilities management · Multi-system data visualization

1 Introduction

Building Information Modeling is effectively a database of building information, both geometric and non-geometric, with a 3D interactive graphical user interface (GUI) that allows user navigation and access to this data within an object-based virtual environment. As has been noted by some authors [1], it is often difficult for facilities managers to switch between text-based data from their Facility Management systems and the physical nature of either drawings or the built environment. Because of its information-rich and graphical nature, BIM provides a promising platform to merge these two types of data to support CRE activities.

BIM is commonly used for the design and construction of buildings, and substantial research has been published regarding data management in these contexts (e.g. [2–4]). Applications to facilities and asset management and real estate are topics of current research [5–9]; for a comprehensive review of BIM applications for existing buildings, the reader is further referred to [10].

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At the core of the traditional approach to BIM FM model development is the creation of an as-built model, and the subsequent addition of operations data and information to this model. This process of adding additional information to a BIM model results in the creation of multi-dimensional models, (referred to as “4D”, “5D”, etc.), which has proven to be a highly efficient way of documenting all aspects of a building through its life cycle [6]. Unfortunately, the creation of as-built BIM models has proved to be a barrier to adoption of BIM in FM, particularly for existing buildings due to the resource cost [10] and similarly, the constant update of such BIM models has proved a further hindrance to adoption [11]. Previous research aimed to minimize these barriers by using a simplified BIM model for data visualization [9]. That model was developed incrementally and iteratively to incorporate use cases driven by the stakeholders, and was focused on an institutional (university campus) context.

The purpose of this paper is to demonstrate how this simplified BIM model provides an efficient platform for data visualization for Corporate Real Estate (CRE) applications and presents two case study examples where BIM models were created for existing commercial offices of a financial services company (referred to herein as “FinCo”). In these examples, information related to CRE management, facility management and space use, building operations and maintenance, and thermal comfort/complaint tracking are displayed in a common user interface. Because these functions tend to be contained in organizational “silos”, the associated data is typically not readily available across departments. The use of BIM to store a read-only copy of this data thus provides benefit to those individuals requiring data from multiple systems to support organizational decision-making. In this paper, these individuals will be referred to as end-users and are seen as the primary drivers of the information content of the platform. Note that FinCo does not conduct their own construction activities, but rather hires this out to third parties (as is common for corporate tenants) and thus this element is beyond the scope of the case studies. For a recent case study where this is not the case, the reader is encouraged to refer to [12].

2 Context

The ability to create simplified visual representations of data is a key benefit of BIM within the facilities management context. These representations allow end-users a simpler but more comprehensive means of understanding the relationships between building elements and processes, which is required to resolve maintenance and operations functions by building experts [7]. Critical to the CRE context are two key elements of BIM: the ability for multiple users to interface with the same model simultaneously, and the ability to interface multiple data systems with a single model. This data integration allows a simplified and efficient means of inputting and disseminating information across different software through BIM plug-ins and API scripts [5, 7, 13], and the use of a single model, particularly one that could be accessed within an Augmented Reality context on a mobile device (as proposed conceptually in [1]) further increases its potential use as a core facilities management tool.

The research presented herein recognizes the current research on data integration with existing FM software, database functions in BIM for asset management (i.e. inventory and building condition assessment), and the use of 3D representation as a means of visual analysis and navigation [6, 7, 14, 15], and builds on it by demonstrating how such use cases could be implemented using this simplified BIM model approach, reducing the barrier to adoption noted previously.

3 Case Studies

To explore the range of applications within the Corporate Real Estate (CRE) context, two case studies were undertaken in cooperation with FinCo, a large tenant occupying over 150 small facilities and five large office towers across Canada. Each considered a single small retail office and together they represented the archetypes representative of FinCo's small office portfolio, namely tower (Facility A) and walk-up (strip mall; Facility B) occupancies. For each case study, a BIM model was created based on available data and supplemented by site surveys and meetings with CRE leasing, sustainability, and data management system staff. The detailed creation of these models is further discussed in Sect. 3.1 while the use case development and interfaces with existing systems are discussed in Sects. 3.2 and 3.3, respectively.

Previous research on a similar project in the institutional sector [9] informed the BIM model development process for this research. Based on that experience, three key concepts were drivers for this methodology:

1. The effort/reward relationship must be balanced to make BIM model development both financially feasible as well as useful
2. Data must be added incrementally based on end-user needs to maximize the benefit of the model to the user and engage buy-in
3. Existing data management systems are not to be replaced by the BIM model; rather, the BIM model pulls data from multiple systems using API scripts and allows this "central" model to act as an information portal for all systems, eliminating the need for additional data management and maintenance of the model.

3.1 Building the BIM Model

The three dimensional models were created in Autodesk Revit™ and produced from the as-built CAD drawings of the facilities provided by FinCo. Because these were limited to FinCo-occupied spaces, the remainder of the building was modeled with minimal detail to show the location of the leased space but no other details (Fig. 1).

Base Geometry and Equipment. 2D architectural drawings were provided by FinCo and these were used to create the floor plans and base geometry (wall, door and window locations, etc.). To minimize effort in modeling, data not relevant to the CRE systems was not modeled in detail but were included as assigned attributes, e.g. partition types and fire ratings, and captured either in notes, tags, schedules or as parameters thereby providing pertinent information without having to expend effort to create a full "as-built" detailed model. This reduced the total data content of the model significantly and optimized the model.

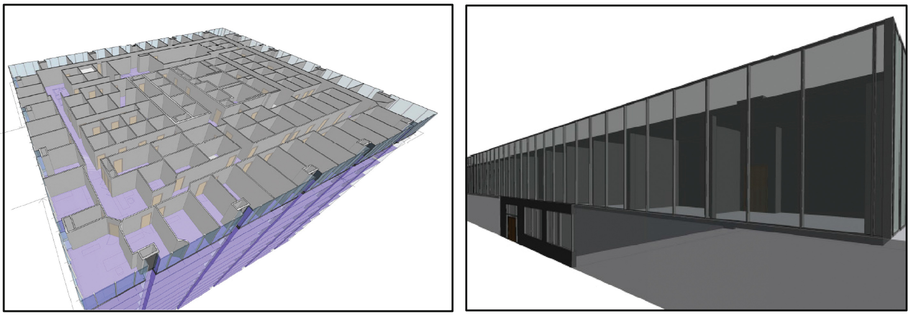

Fig. 1. 3D modeled in Revit views of the FinCo facilities used in study illustrating the base geometry elements to construct the BIM models. Facility A (left) shows a top view into the occupied floor and Facility B (right) shows the front façade.

Because FinCo either outsources maintenance (in walk-up units) or it is provided by the landlord (tower units), detailed construction and operation information for equipment is less important than details indicating who to contact in case of equipment failure. As a result, only the primary equipment was modeled using manufacturer "families" (data-rich objects containing equipment construction and performance data) and was enhanced with information more relevant to facility management systems, as discussed in Sect. 4.3. The detailed design of the air distribution systems were considered minimally relevant for the end-user and were thus not modeled as data-rich objects; they were included as reference, however, in the form of a 2D drawing overlay on the ceiling, as shown in Fig. 2. This allows system information to be readily accessible while minimizing effort and model size. In addition to this system data, detailed architectural elements such as stairs and handrails were also displayed using the 2D overlay. This reduced the expended effort for such elements that offer no significant value to the corporate system database.

Fig. 2. Partial reflected ceiling plan of Facility A showing base geometry with overlaid 2D CAD data shown in grey.

3.2 Use Case Development

To ensure the relevance and value of this research to the end-users, the study was carried out in collaboration with representatives of various departments including facilities management, space planning and real estate management. This is the iterative process (Fig. 3) by which through a dialogue with FinCo, the most critical data would be added to the model in essentially what is a process of layering information onto the model. This process would commence with the creation of the level of data being the basic geometry, walls and openings which define space, followed by other components which FinCo would identify as significant for the company to garner information pertinent for management of the facilities.

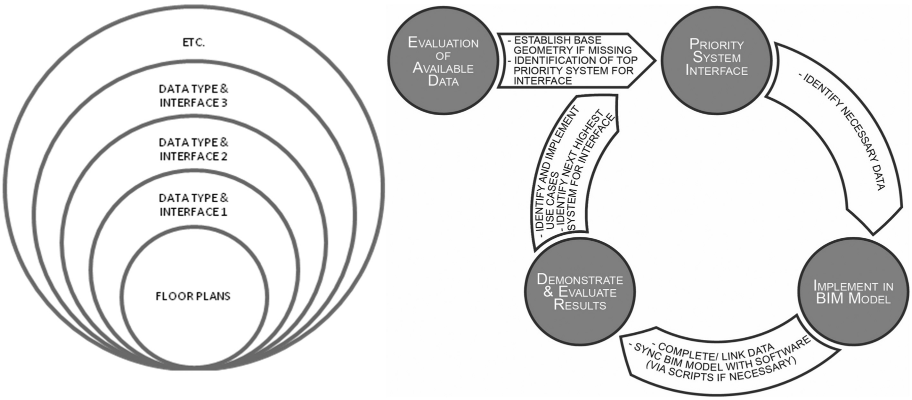

Fig. 3. Incremental data increase *(left)* and iterative process to identify, implement and evaluate use cases based on critical management needs *(right)* [9].

3.3 External Software and Data Manipulation

The BIM model is linked to multiple facility management systems as indicated conceptually in Fig. 4. Each interface is either defined as a “PUSH” interface (where data is pushed from the BIM model to the central data management systems to update geometric information) or a “PULL” interface, where this data is pulled from the central systems for visualization at the site level.

Input Information (PULL): Using the base model outlined above various analysis and reports are able to be generated from data stored in existing CMMS software being used by FinCo. Information stored in work orders or maintenance logs can be associated with the digital space or component. In the models used for FinCo one of the variables which was explored was comfort and occupant complaints. Within the models the rooms were provided with a complaint parameter that would be linked to the data provided from the complaint log. By linking the external log data to the model each log entry would be pulled into the model once synchronized via a program plug-in. In this way the floor plans can be automatically colour coded to indicate either the type of complaint logged or the frequency of complaints within the room.

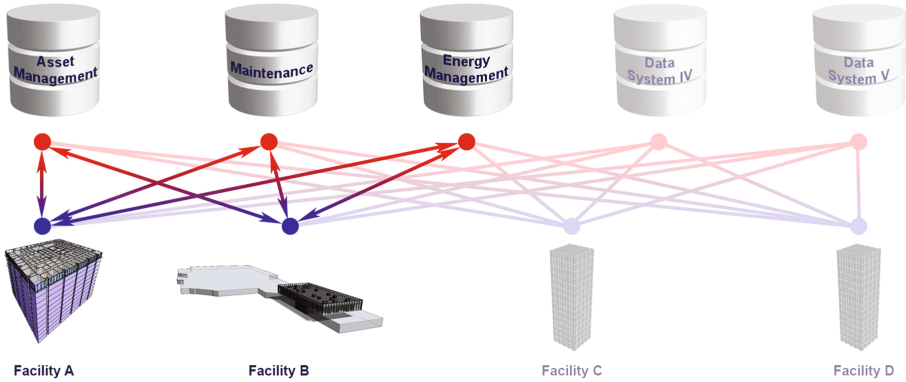

Fig. 4. Each facility BIM model interfaces with the full range of corporate data management systems, allowing the visualization of all data relevant to that facility from a range of systems as well as the potential to update all systems based on renovations or changes in space leased at the facility. (Color figure online)

Output Information (PUSH): In addition to data being parametrically manipulated to visually illustrate differing conditions and properties of various spaces and components, specific information was also directly identified in customized tags. By adding information to tags, component information is provided within the context of its location within the building. In the study models the mechanical roof top units were tagged with custom tags. It was important to FinCo to have information such as the service contractor contact information, service dates, warrantee status and manufacturer and model information easily identified within their physical context.

Data within the model can also be pushed into other software as an input. Data derived from the components or the geometry (e.g. example room areas) is used within FinCo's existing CMMS. FinCo's current software utilizes polylined CAD drawings to generate areas needed to allocate space within the facility and further across its extensive portfolio. As Revit inherently produces this information based on the modeled geometry, it can be automatically pushed into their current software once synchronized with any proposed layout produced in Revit. As Revit can produce multiple iterations, this increases the information the external software is able to receive and compare to ensure the best possible scenario is achieved.

Figure 5 illustrates both the PUSH and PULL data interfaces within each BIM model.

4 Results and Discussion

Three case studies were considered in this research: space management, complaints visualization, and equipment maintenance. These are described in Sects. 4.1, 4.2 and 4.3. Section 4.4 discusses how these case studies combined can contribute to more effective evidence-based decision-making.

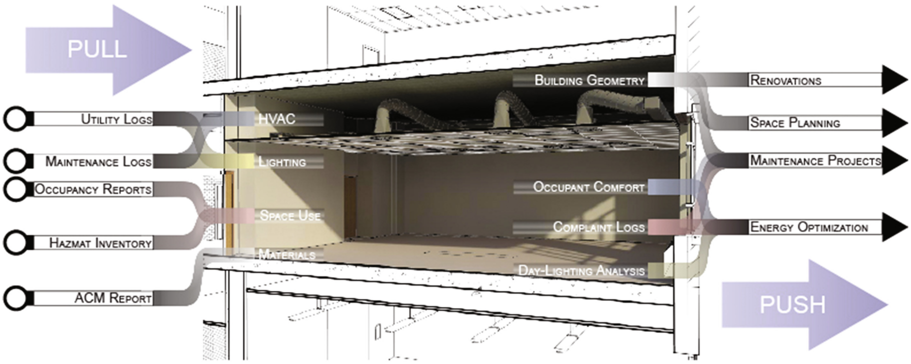

Fig. 5. Types of information that can be pulled into and pushed from the BIM by interaction with external software [9].

4.1 Space Utilization

A significant amount of effort is expended by FinCo on managing space use. FinCo's current software has the capacity to group/classify space based on variables the company assigns (Fig. 6). This serves as a powerful tool which has been customized to assist in the space allocation process of various individual spaces, group spaces, department spaces, etc., by comparing spatial needs against actual physical space. The software is capable of interpreting other variables which are essential to occupancy usage. Safety is an example of one parameter used within the software. It is able to identify where offices held by special safety personnel are required to be within the facility. BIM can be set up in a similar fashion by tagging each space with multiple space properties such as occupant type, space classification, department or fire evacuation zone. However it would be more efficient to utilize their existing software setup and pull these data points from the central facility management system (FM Interact, which is Revit-compatible) into the BIM model. This would take advantage of the existing software capabilities and BIM's ability to manipulate the layout which the space management software is not able to. This would be a powerful tool for proposing space changes during renovations for example. If the BIM model is updated to reflect the revised layout, this data transfer can be reversed, updating the room areas in the central system without undertaking the manual polyline-generation exercise that is now required for updating the data.

4.2 Comfort Complaints

Four key types of comfort complaints had been noted through site surveys and discussions with FinCo staff: thermal comfort (hot), thermal comfort (cold), air quality (odor and/or lack of fresh air), and acoustics (excessive noise and/or vibration).

In cases where thermal comfort has been historically identified as a problem in a specific area of the building this can be tracked through a running counter of complaints associated with each space type and thus assist in the diagnosis of the problem.

Fig. 6. Sample space management output from BIM model. (Color figure online)

By visualizing the extent of the area affected and how often individual spaces within that area log complaints, patterns of proximity to the building envelope, identification of a zone being served by a particular mechanical unit or an issue with the mechanical distribution system within the area may become apparent to maintenance staff reviewing the complaint log in conjunction with this contextual colour coded overlay (Fig. 7).

4.3 Maintenance and Operations

At Facility B, FinCo is responsible for managing their site systems and equipment. The company identified the management of the maintenance and operations records of recently installed roof top units as critical to its facilities management operations. The determined best method to document the units was using the manufacturer created Revit family. The model provided detailed visual representation and operational data with little effort. Unit variables were input into the family to reflect as built specifications. Pertinent data for the units was displayed in two ways: as 2D/3D drawings or in schedule format. The drawings gave the units their contextual locations within the facility. The units were identified with custom tags containing the unit name, make and model as well as the contracted maintenance representative information, latest service date and warrantee status. The information included in this tag was that deemed most important for quick reference required by FinCo. Additional information was available in drawing views. The detailed properties and unit capacities are visible through the BIM user interface. The schedules contain all operational and service information available on the units. External documentation such as manuals and service reports were available for the units by way of hyperlinks from the schedule (Fig. 8).

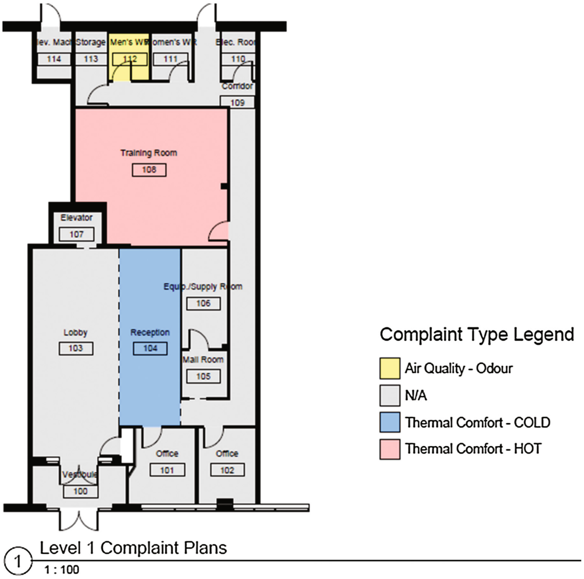

Fig. 7. Example of complaint overlay display to inform lease renewal decision-making. (Color figure online)

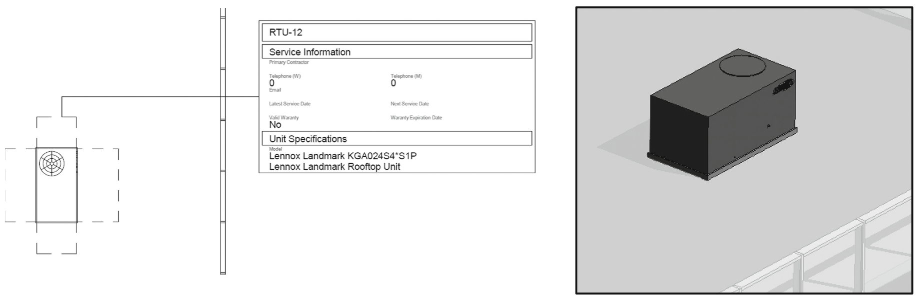

Fig. 8. Example of equipment and maintenance data visualization (rich data tag on left; 3D view to serve as reference on right)

4.4 Applications of Data Visualization in Corporate Real Estate

The value of readily available visual data for quick reference and analysis is evident in the examples above. This however is only one step beyond FinCo's current usage of their existing software. Where BIM can become an even more powerful tool for data analysis is through the flexibility with which a multiplicity of data can be integrated and captured in a single snapshot, within a Smart Cities context. This functionality can be used in energy analysis that not only takes into account detailed information provided in modeled components and systems that would typically be analyzed but also offers the capacity to overlay existing operations data, energy reports and payments from utility providers, occupancy usage, etc., onto that analysis. For example, consider the complaint log scenario described previously where there are recurring thermal comfort issues. In such a facility, the Sustainability Director would like to investigate measures by which to reduce the overall energy performance. The BIM model in this instance would be able to illustrate the heating and cooling loads through a contextual environmental analysis, the types of equipment and electrical loads within the individual space, complaints related to energy related components, typical office occupancies and billing records from the utility providers. These utility reports might indicate usage greater than expected from the loads produced by the components shown in the model. The difference that can be discerned from the overlaid information would be the highlighted thermal complaints indicating that in a large area of the facility the occupants are cold and supplement their temperature using small electric space heaters. By including all data in the visualization, information that may not typically be considered by a department can provide evidence to support improved decision-making.

Another application for consideration is lease renewal. Consider the scenario where the real estate team in the second facility has a need to modify the space. Using the BIM model for multi-system visualization, existing occupants, area requirements, existing room geometry, and existing structural and building service information can inform the basis for revision or renovation. By overlaying complaint information and work order logs on the facilities management and space data, issues related to thermal comfort or excessive noise could identify mechanical equipment in need of replacement as a condition of lease renewal, or could inform a reduced floorplate selection avoiding those areas where such historical complaints exist.

In accordance with the results of an industry survey [5], one of the issues faced within the process was a reluctance to introduce BIM as the core component among the collection existing facilities management software. The current software used by FinCo does offer the capacity to display simple 2D visualization of various data sets through custom queries. While the existing software is unable to overlay information to the extent proposed within a BIM central framework it is sufficient for FinCo's current operations. As a pilot it is difficult to ascertain the type of information that is critical for collection which would result in the most valuable use. This is a significant obstacle given the fact that the buildings being modeled have not undergone recent renovation and the availability of accurate documented information is very limited. What further complicated the collection of data was the current way in which various reports and logs were documented and stored. For example the existing documentation used for work orders is carried out using a Microsoft Excel spreadsheet document. The way in which work orders are documented consists of a minimal number separated values which include a date, an incident number, its status and a general description. The details which are necessary to assign as parameters to modeled elements are included in one unseparated value documented in the description. Simply put in order for the existing work order logs to be of value within the proposed BIM central framework the description must be further broken down into a format that can be pulled into the BIM model upon synchronization. Therefore to implement the BIM framework would necessitate a modification to some of the existing management protocols. Based on these issues, the effort that would be required to implement the framework to produce data may be considered questionable relative to the value of the BIM framework versus the existing software framework. While the type of data available will affect the feasibility of implementing the framework into existing building the issue is nonexistent with new or recently renovated facilities.

What is most significant about this approach to framework utilization is that it is meant to supplement existing software and procedures. By reusing the existing data and merely manipulating how it is presented a much greater depth of insight and analysis can be had. Further to this the BIM model is used to eliminate data entry overlap and make documentation more efficient and less prone to error [13]. While the possibilities of this application have been seen for these two test facilities, the potential for use for a complete portfolio of facilities would seem almost limitless. For example an energy analysis inventory on all facilities could become the primary selection criteria used to determine the priority sequence of capital renovation projects for all facilities. This would promote a more sustainably responsible corporation and lower overall energy operational costs. In this way the centralized software would allow a scaled approach for large scale data comparison across all properties similar to the data overlays generated within the individual BIM facility models. With this broad adaptation of the data provided by the BIM framework, an organization would be better equipped to manage its facilities to align with its overall goals as per [8].

5 Recommendations and Conclusions

The various FM and BIM software available each hosts a diverse selection of tools and capabilities for creating, storing, manipulating and presenting data. While these tools are powerful by themselves, the potential attainable through using the various systems together in an efficient workflow increases the processing and analyzing of information. Because multiple data sets can be overlaid into a single visual workspace, facilities managers and other operations personnel are able to consider multiple types of data simultaneously, increasing their capacities to analyze complex elements and processes by discerning relationships and patterns between the data which may be missed [7] and supports evidence-based decision-making in the portfolio. Herein lies the hidden value of BIM as the central hub within which a dialogue between existing FM software can be used as illustrated in the scenarios above.

In addition to the increased analytical capabilities, the BIM central framework offers greater efficiency in data sharing [13]. Because the BIM software acts as a pointer to the original data source, there is minimal data entry required to maintain the model, reducing known barriers to adoption of BIM in this context [11], and eliminating the risk of accidental data over-writes. Where calculations occur within the software, data entry is mostly eliminated. This significantly reduces the effort to maintain the BIM model and makes much greater use of the available data by maximizing information distribution efficiency.

The value of a BIM central platform is that it does not change the information or processes currently employed in facilities management but rather allows the visualization of multiple systems. This reduces the effort required to input data, while disseminating information effectively and increasing an organization's capacity for evidence-based decision-making. The ability to overlay and visualize different data sets using information-rich tags is necessary to understand how data is related and is essential in order to understand those relationships as data accumulates. Because of its intrinsic ability to combine data in this way, BIM is a powerful tool for data management. Looking from the building to the portfolio scale and beyond, these case studies have demonstrated the potential for BIM as a data visualization tool for real estate management.

Moving to the city - or Smart City - data increases exponentially, and this type of visualization approach provides insight for an owner with multiple sites to inform decision-making using large quantities of data. This ability to utilize simplified visual navigation and representation provides significant scaling potential as it would allow the visualization and synthesis of large amounts of information within complex networks. Additional case studies expanding this research to the portfolio scale would confirm this potential benefit and as such provides a promising avenue of further exploration.

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