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# Developing a BIM-Based Asset Management Framework for Urban Infrastructures

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## ABSTRACT

Infrastructure asset management needs extensive data collection to create a comprehensive inventory record that consolidates pertinent asset details, encompassing their operational and maintenance activities in an integrated manner. Conventionally, the initial assessment involves a laborious, tedious, and expensive random walkthrough visual inspection. With the advancements in assets management as a result of ongoing digital transformation, it is believed that laser scanning can be a game changer in easing visual inspection and digital inventory development if deployed in the infrastructures' asset management. Using a case study of a station from the Bus Rapid Transit (BRT) Peshawar, this study explores the use of laser scanning as an alternative to manual inspection, employing Scan-to-BIM for asset management of infrastructures. The station's façade details at two different time intervals were laser-scanned to view the parametric details and geometrical features of its components and their physical condition in a virtual environment. Following validation of the scanned data through field inspection for accuracy and reliability, the data was utilized to develop semantic 3D models of the station with realistic geometries and dimensions. These models represent the as-is state of the assets covering the temporal geometrical changes in the form of added, deducted, or degraded elements as highlighted from the comparison of the successive models. Consequently, an intelligent and efficient 3D inventory and geometrical change detection system emerged, offering a viable substitute for traditional inventorying and data collection techniques. Thus, the study adds a new dimension to the application of laser scanning in asset management through its utilization for change detection and deformation tracking of the geometrical façades of the infrastructures in addition to the data acquisition for inventory development.

**KEYWORDS:** Building Information Modelling, Visual Inspection, Scan-to-BIM, Façade changes, Laser scanning

## 1 INTRODUCTION

Infrastructure assets undergo physical and functional changes throughout their lifecycle due to aging, fatigue, and alterations in both physical and functional attributes (1,2). Conducting asset inspections is essential to collect accurate and relevant data, which is then organized through database management tools for condition assessment and performance evaluation using statistical

algorithms and empirical techniques (3). Statistical techniques like Bayesian network methods and Markov chains are used in different asset management models and deterioration modeling practices to examine asset conditions (4,5). Data for the analysis is collected through direct and indirect inspections, visual check-ups, sensors, and non-destructive testing (NDT) by encompassing empirical and laboratory-based tools (6–8). The application of scanners and moving cameras and CCTV-based condition inspections are examples of visual inspection techniques(9). To examine texture, breaks, pitting, and cracks, non-destructive evaluation (NDE) techniques include radio frequency-based identification, sound reflection, vibrations, and laser-based surveys (7). Postprocessing evaluation is a complex process as it incorporates complicated mathematical models (10). Building Information Modelling (BIM) has been adopted to improve collaboration and efficiency in the process as it integrates asset inspection and inventorying for faster condition tracking and attribute harmonization (11). Accurate real-time facility demonstrations are made possible by the integration of BIM with a variety of sensors (12). Laser scanners have lately been proven effective and precise substitutes for measuring horizontal and vertical displacement in place of traditionally used joint meters and total stations (13).
The asset management of Bus Rapid Transits (BRTs) illustrates that existing endeavors generally address operational issues, ignoring geometrical deformations unless they are directly related to functioning problems. The current inspection mechanism of BRT Peshawar relies on the qualitative detection of problems that are visible to the naked eye in walk-through inspections and lacks a systematic approach to gathering asset information and quantifying geometrical changes. This manual method of tracking certain assets and recording their geometrical state is labor-intensive, expensive, time-consuming, and tedious. To replace the manual method with a more dependable and practical one, an integrated inspection setup for BRTs is required. By blending laser scanning and the Scan-to-BIM method for asset inspection, inventorying, degradation tracking, and operation and maintenance, this study seeks to provide a comprehensive asset management framework for BRTs. Laser scanning has proved to be a reliable and practical technique for gathering data to develop a virtual inventory of the BRT station that is sensitive to deterioration and is replicable in different infrastructures.

## 2 METHODOLOGY

For a more lucid representation, the methodology is broken down into four discrete stages spanning from gathering data to change detection as described below.

### 2.1 Assets Digitization (Scan-to-BIM)

FARO laser scanner was used to scan the BRT station's surface to collect façade details via laser reflections. The data for the BRT station (BS24) was collected in sixteen segments taking around three hours total, including the time needed to move scene targets and assemble equipment across the standpoints and the resulting scan was saved as a point cloud data. The raw data gathered from scans at various viewpoints was aligned within a common coordinate system to produce a realistic three-dimensional picture of the station through processing in FARO's SCENE software. The data was exported in a .RCP format for point cloud visualization and 3D modeling in Autodesk tools. The model geometries were analyzed in Autodesk Recap, and 3D models of components were built in Autodesk Revit. The Recap dimensioning tool was used to take the dimensional readings of the components after some field validations as shown in Figure 1. The Revit model was developed parallel with the measurements and analysis done in Recap which can be shared with various users for collaboration.


High of BRT station railing in Recap scan

Field reading of BRT station railing

*Figure 1: Validation of railing height measurement*

### 2.2 Assets Identification and Attributes Assignment

The 3D model was enhanced with additional details for the parametric modeling through the identification and assignment of attributes. Beginning with asset identification in Recap, parameters were determined based on attributes in Recap's RGB interface. Asset attributes encompassed inventory details, geometrical specifications, and operational characteristics like upgrade status, condition, and observed issues. To facilitate defect recognition, assets were categorized into structural, mechanical, electrical, and miscellaneous components. Basic details like name, ID, description, fabrication, and categorization were promptly established while elaborating dimensions, coordinates, and asset conditions required additional investigations and measurements.

### 2.3 Integration of Schema and 3D model (adding attributes to model)

The characteristics and specifications of the assets were combined with the respective Revit model components to create an integrated inventory to make a realistic semantic illustration of the station's constituent parts. When incorporating the family to the model, some attributes were introduced as type parameters that allowed data entry for the full set of members while others as instance parameters that required human input in each instance. Since at least ten parameters were required per element to be manually inserted for every element, therefore, the data schedule for every element category was exported to Microsoft Excel to add the details conveniently to it and then reimporting it using the free DiRoots Sheetlink add-in.

### 2.4 Issues identification (Changes detection)

By examining point cloud data for both the scans in Autodesk Recap, geometrical deformations and faults in the BRT station were identified, and station element information was accordingly included in Revit models. The point cloud data from two different periods were opened in parallel windows, and element details were recorded correspondingly to record the changes. Hence, the changes and deformations were recorded in the three-dimensional model in the form of changes in the parametric asset attributes, placements, existence, and geometrical texture.

### 2.5 Field validation for accuracy and efficiency

The data collection and improvisation mentioned above were validated by comparing the accuracy and efficiency of the deployed tools with the manual inspection methods. For this reason, the BRT station was inspected manually through a walkthrough visit, and certain measurements were taken using measuring taps for cross-checking purposes. The naked-eye inspection of the station took around three hours and asset details were manually registered in a notebook whereas only a few elements were accessible for detailed manual inspection. Moreover, at least four individuals were hired for inspection each time in order to avoid operational interruption at the station.

## 3 RESULTS AND DISCUSSIONS

**Error! Reference source not found.** shows an inclusive BIM-based framework for asset management using laser scanning for asset inspection which has been deployed in this study.

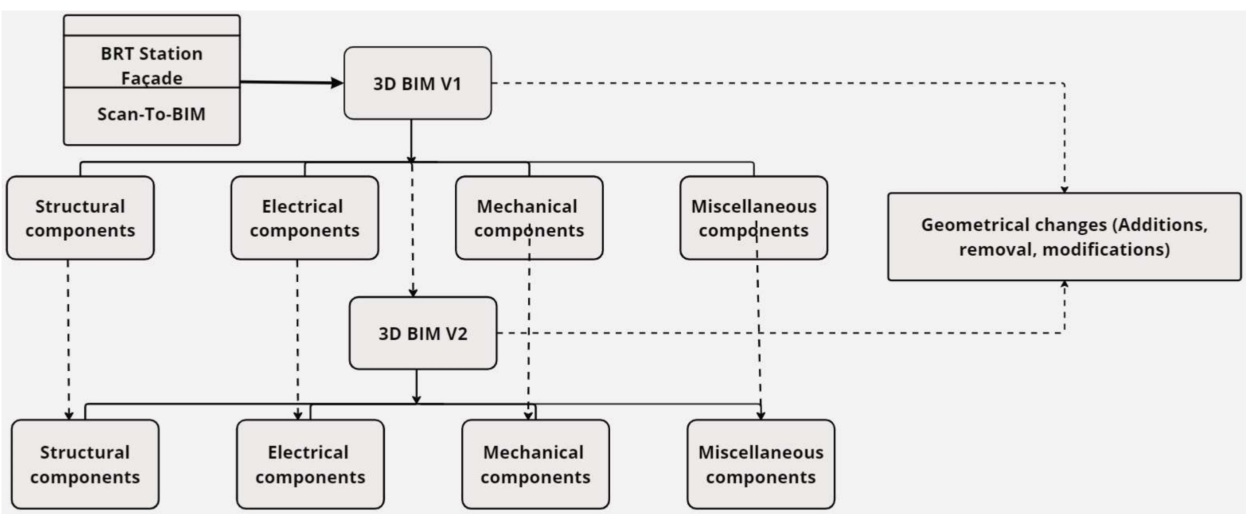


*Figure 2: BIM-Based asset inventorying and inspection*

The Scan-to-BIM has been proven to be useful in terms of low-cost, effective asset monitoring and degradation tracking. In addition to providing asset managers with a convenient and rich data source, the collaborative BIM model solved previous deficiencies in inventory construction, asset inspection, and geometrical change recognition of BRT station assets. Every component is assigned at least 10 semantic parameters using convenient nomenclature based on input from asset management experts, current asset management practices, and the existing literature for effective asset management. In addition to identifying the façade changes, the total element count changed from 2,451 in the first model to 2,456 elements in the later model since 5 new components were added to the station as noted during the second scan. A realistic inventory database shown in Figure 3 represents both the functional and physical characteristics of the assets.

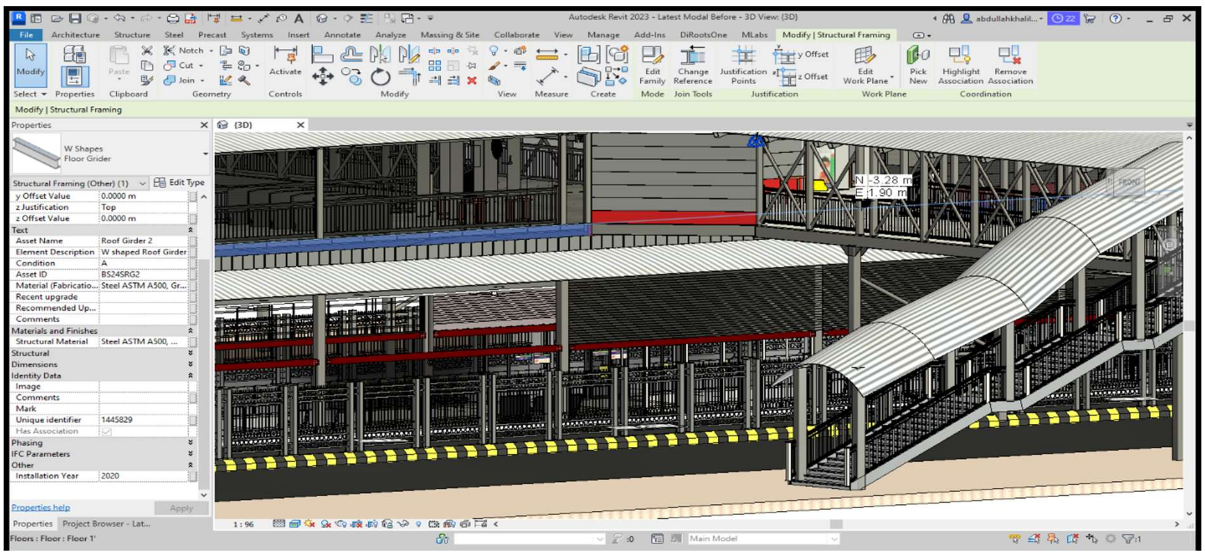


*Figure 3: Digital inventory of BS24 station*

By gathering information from a single source, the Scan-to-BIM guarantees a collaborative method that improves asset inventorying accuracy and convenience. With the ability for multiple users to access the database and 3D model and navigate asset-related details with ease, this method works well for users with different levels of CAD proficiency. Hence laser scanning has proved to be a reliable non-destructive direct asset inspection technique that is quicker than field-based visual inspection. The point cloud model is conveniently produced after two to three hours of data collection, allowing for a full virtual assessment without interfering with station operations. Geometrical degradations have been recorded during the second scan, and all these changes are introduced to the latest Revit model after quantification in Recap as discussed in the methodoly. This enables secondary investigation, revealing alterations or deformations in BIM models recorded across different periods. The validation suggests that errors are expected in reading, hence the scanning setup shall be chosen as appropriate to make sure no ghosting and obstruction effect disturb the point cloud pattern and each point of the façade is hit normally by the laser beam.

## 4 CONCLUSIONS

By including parametric features and geometric deterioration, the asset management process is improved by integrating laser scanning with building information modeling (BIM). Regarding inventorying and asset inspection, this method saves a lot of money, time, and effort. Through the Scan-to-BIM process, the framework created in this study offers asset managers an invaluable tool that enhances infrastructure asset management. Laser scanning has shown to be an accurate, efficient, and convenient way to inspect assets, taking the place of laborious walk-through inspections with unaided eyes. The final 3D inventory model makes asset information more realistic and makes it easier for stakeholders to navigate. Through the use of Revit models and point cloud data comparison, BIM models generated from the process help identify issues and detect changes.

Notwithstanding these benefits, obstacles including the need to create BIM models for a large number of elements, equipment costs, and staff skill levels may prevent BIM from being widely used in asset management. Companies might not have enough specialized staff; therefore, they would need to hire experts to digitize acquired data into BIM models. Greater precision deterioration models are made possible by early BIM application in new projects, which is advantageous during the maintenance and operation phases. Without the need for in-person site inspections, collaborative BIM-based inventory guarantees transparency in asset management and facilitates the harmonious tracking of outsourced activities by several service providers.

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