Revolutionizing Industrial Digital Twins: Autonomous Building Information Collection

## Enhancing Efficiency and Accuracy Through Automated Data Collection and Integration

May 16, 2023

Lead: Gregory Porter

Drafted by: Luis Henriquez and Gary Innerarity

# Executive Summary

This document explores the development of Digital Twins through automated data collection and integration. The authors identify the current methods used in Building Information Management/Modeling (BIM) collection, as well as data sources and types, and discuss the purpose of data in developing a Digital Twin. They also outline the minimal data needed for a Digital Twin, the challenges and constraints of automated data collection, and their goals for the project. The document is organized into four parts: Planning, Scheduling, Framing, and Repeat. Ultimately, the goal is to lower the barrier to entry for Digital Twins and digital thread products while maintaining standards for accuracies by reducing human intervention during processing.

Contents

[Enhancing Efficiency and Accuracy Through Automated Data Collection and Integration 1](#_Toc135124794)

[Executive Summary 2](#_Toc135124795)

[**Part I – Planning** 4](#_Toc135124796)

[What is BIM? 4](#_Toc135124797)

[What are the current methods used in BIM collection? 4](#_Toc135124798)

[**Data Sources** 4](#_Toc135124799)

[**Data Types** 5](#_Toc135124800)

[Purpose of Data 7](#_Toc135124801)

[***Minimal* Data Needed for a Digital Twin** 7](#_Toc135124802)

[**Best Method to Collect the Baseline Data** 7](#_Toc135124803)

[Challenges & Constraints 8](#_Toc135124804)

[Capabilities 8](#_Toc135124805)

[Goals 8](#_Toc135124806)

[**Part II - Approvals** 10](#_Toc135124807)

[Workflows 10](#_Toc135124808)

[Raw documentation 10](#_Toc135124809)

[Systems as a Service 10](#_Toc135124810)

[Physical Collection 10](#_Toc135124811)

[**Laser Scanning** 10](#_Toc135124812)

[**Photogrammetry** 10](#_Toc135124813)

[**Part III - Framing** 11](#_Toc135124814)

[Artificial Intelligence, Deep Learning, Machine Learning 11](#_Toc135124815)

[**Part IV - Do it again** 12](#_Toc135124816)

[Resources**:** 13](#_Toc135124817)

# **Part I – Planning**

In developing a Digital Twin, it’s key that we develop a method to lower the barriers to entry for our customers. Speeding up the process but maintaining accuracies. Once the scope and Level of Detail is agreed on, the key information that we need should be collected up front, when possible, outlining the *source of data*[[1]](#endnote-1) that is currently owned by the client(s). Any information that is not provided as fact from the client will need to be collected – as outlined in this document.

## What is BIM?

An acronym for Building Information Modeling/Management. In brief, it's a digital model that multiple tenants utilize to collaborate on the successful delivery of a building, or construction project. Other industries are utilizing Building Information Models to correctly anticipate the delivery of assemblies and collaborate with contracted vendors digitally. The primary difference with a digital twin, as a digital model, is that they can be used to break barriers with multi-tenant facilities and multi-tenant production lines.

## What are the current methods used in BIM collection?

It's currently the industry method to utilize tools like laser scanners, photogrammetry, handwritten documentation, electrical panel schematics, and any other form of diagram previously developed by Architects, construction teams and manufacturers for these orchestrations. Here are a few examples in list form:

### **Data Sources**

* Schematics
* System Manuals
* Issues/Tasks associated with an area/component.
* Measurements
  + Laser Scanning
  + Measuring Tape
  + Disto Single Point measurements
  + Calipers
* System Meta Data
  + Material Type
  + Dimension Information
  + Install Date
  + End of Life/Expected Life Expectancy
  + Requirent Specification (torque Levels, Lubrication types, etc..)
* Blueprints
* CAD (2d/3D)
* Excel sheets of asset metadata
* Hand drawn layouts
* Software as a Service platforms
  + SysQue
  + Autodesk Construction Cloud
  + Revit
  + Procore
  + Inventor
* Experience/Human memory
* As-Built not documented

### **Data Types**

* Wiring
  + Type
  + Suppler and Installer
    - Install date
    - Expected Life / End of Life
    - Warranty
  + Wire Gauge
  + Age
  + Path Tracing
  + Circuit Type
  + Material
  + Sheathing
    - Type
    - Girth
  + Watts/Volts
    - Current
    - Max
  + Length
* Plumbing
  + Type
  + Purpose
  + Material
  + PSI
    - Current
    - Max
  + Length
  + Girth (inner, outer)
  + life cycle
    - Install date
    - Expected Life / End of Life
* Flooring
  + Type
  + Installer
  + Life Cycle
    - Install Date
    - Expected Life / End of Life
  + Finish
  + Fillers (sub-floor moisture barriers)
  + Capacity
  + Scratch resistant ratings
* Walls
  + Material
  + Insulation Type
  + Installer
* Lights
  + Material
  + Life Cycle
    - Install Date
    - Green Rating
    - Expected Life / End of Life
    - Consumables (bulb refresh cycle)
  + Installer
    - Warranty
* HVAC
  + Duct Types
  + Unit Types
    - Consumable Types
      * Filters
      * Freon
  + Unit Locations
  + Capacity
  + Power Consumption
    - Expected
    - Observed
  + Service History
  + Installation Date
  + Life Cycle
    - Expected Life / End of Life
* Windows
  + Life Cycle
    - Expected Life / End of Life
    - Installation Date
  + Type
    - Thickness
    - Ratings
    - Air Gap Type
* Fire Suppression
  + Type
  + Life Cycle
    - Expected Life / End of Life
    - Installation Date
    - Vendor
      * Warranty
      * Prior Service History
* Compliance
  + Signage
    - Type (ADA, Fire Exits, Health)
    - Locations
    - Regulated (t/f)
* IT
  + Type (Intercom, Wireless, Network, Surveillance, Door Access)

## Purpose of Data

The time to collect and the Data itself can be completely wasted if there is not a use case. The scope of this paper is to identify data types correlated to a facility’s structure that has a direct impact in the initial ingestion cycle of a new site to develop the ground plans of a digital twin. With that information, we can attempt to create automated pipelines to take the ingested *data sources* and convert it into *data types* autonomously. Ultimately lowering the barrier to entry for a digital twin and digital thread product while maintaining standards for accuracies.

### ***Minimal* Data Needed for a Digital Twin**

* Floors, Walls, Ceilings with threshold/clearance (height, length, width) information
* HVAC, Plumbing, Electrical
* Data Systems (IT systems (door access, wireless, infrastructure), IoT devices)

### **Best Method to Collect the Baseline Data**

Aside from what a customer may provide during the scoping phase; laser scanning with 360 photo/video captures, supplemented with high resolution photos.

## Challenges & Constraints

Private/Secure facilities with sensitive access requirements can pose a challenge when attempting to clear photographic equipment and laser scanning access. In the same line, having enough time in the space to collect adequate information with minimal interruption to facility production and collection methods.

With laser scanning and photogrammetry, the collector is limited to field of view. Getting adequate capture (overlap) of an object can take extensive time coupled with the complexities of height and tight spacing. There are some tools that assist in making this easier, but the facility would have to approve the use of robotic equipment such as remotely controlled robots, drones, and lifts.

Capturing and delivering a high quality 3D mesh from photogrammetry is an ongoing challenge. No internal capability.

NeRF technology was recently released, utilizing generative AI to convert photos to "fill the gaps" for generating a 3D mesh. No internal capability.

AI for object segmentation has been around, but no good workflow has been developed. Object segmentation is useful for providing modelers with a singular object out of the gate to work with rather than attempting to segment billions of points for an object they may need. No internal capability.

AI for text extraction from 360 and still images/video for asset identification and tracking. Correlating the extracted text with what is expected or previously gathered in a data catalog is not an internal capability.

Lack of a data catalog for CAD/Modeling to easily find all the necessary data they need when modeling. All photos, scans, videos should be searchable by meta data and image detection could be developed to find ‘similar’ photos of an object preventing the need for re-capture. Something along the lines of Google image search where you can upload a reference image and it'll populate where that source is from, and high confidence matches of other photos.

## Capabilities

Sev1Tech currently has these capabilities:

* Measure in 3D and 2D
* 360 Video/Singles
* Photograph Singles
* Manually Document
* Manually Map threaded connections between API’s and documents.
* 3D Model on top of point clouds and free hand

## Goals

Automate Building Information Collection allowing the human to verify and assign, rather than click, wait, align.

This may mean automating the scan to mesh process so the computer can calculate and process by area/room rather than attempting to generate the entire building at once, leaving the need to align by human workers.

Increase time to visualization. 24 hour MVP turn around on an office space.

Lower the cost of entry for the initial ingestion cycle when onboarding a new client site.

Optimized for low touch collection, reducing the needs for clearances, training, tethering, etc… Allowing for these techniques to be used in annual site reviews for asset verification and tracking.

Integrate with information management platforms. An example of this would be NetBox. If a survey crew captures a site with B12 patch port in a room, NetBox api should tell our system that B12 feeds back to the main distribution frame in building B on rack #1, U3-U5 with switch Meraki 225-48P last managed by Technician #1. It should also be able to highlight a path going back to that location in a digital twin, following the visible conduit and "generating" a path through the non-visible conduit using ‘known’ paths and ‘OSPF’ for the most “likely” path. This provided information should also calculate the anticipated length of the runs, if not calculated in the switch or cable management platform (netbox).

Auto calculate identified objects: # of exit signs, # of visible fire extinguishers, # of fire strobes, # of suppressions outlets etc... for building compliance and planning. These items should be visible, therefore, automatically collected using traditional photo/video.

# **Part II - Scheduling**

## Raw documentation

What can the client provide? Do they have a record of sub-systems, installation dates, and types of materials as-built?

## Systems as a Service

What systems are they currently utilizing to manage materials, installations, and any sub-system activity? Is there an API? Does it provide granular use of metadata and tracking?

## Physical Collection

What collection methods are approved? Will these collection methods work to maximize exposure but reduce exposure time?

### **Laser Scanning**

Distance requirements, length of time to capture.

### **Photogrammetry**

#### 360 Photogrammetry

Distance requirements, how far is too far?

#### Drone Photogrammetry

Distance requirements, how close can we get? Is there enough clearance? Do we need a certified drone operator?

#### Still Image Photogrammetry

Can we get enough angles? When would NeRF kick in? What's "enough"?

# **Part III - Framing**

## Artificial Intelligence, Deep Learning, Machine Learning

How do we build the data catalog? How do we get the information to CAD when they want it? How do we notify them of an identified object that wasn't previously identified?

# **Part IV - Repeat**

How do we verify year over year? How do we Frame, Erect, and Reference faster? How do we scale horizontally without extending time? How do we handle live content streams?

Resources**:**

<https://constructible.trimble.com/construction-industry/what-is-bim-building-information-modeling>

1. Source of Data – Building Plans, CAD Drawings, Wiring Schematics, Historical Work Orders and any additional from property changes. [↑](#endnote-ref-1)