PREVU3D

Planning, scanning and delivery of reality capture data

WHITE PAPER

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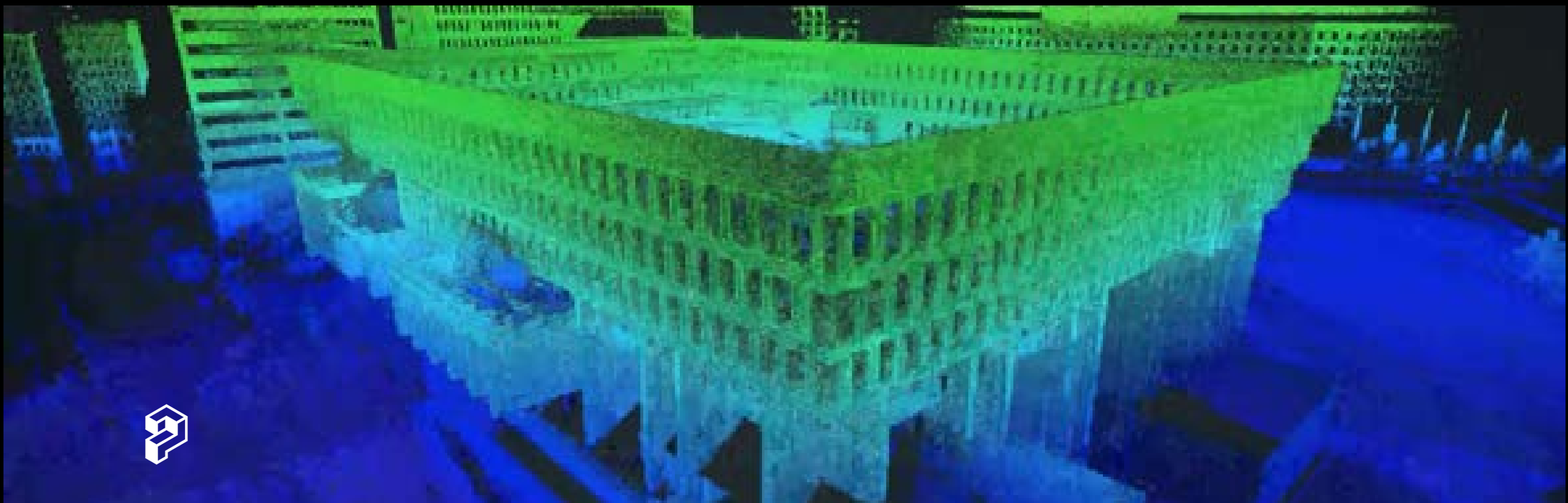


Executive Summary

While 3D scanning has been around for several years, creating photorealistic meshes for digital twins is still in its infancy. This white paper covers planning, scanning and delivery of reality capture data.

BIMstream has been providing some of the best product demo datasets for Prevu3D.

"We're constantly seeking to leverage the latest technology and solutions. Prevu3D software is an innovative visualization tool that enables us to provide value beyond our conventional digital twin deliverables.

Peter Garran
BIMstream Founder

The field of reality capture is filled with a range of technologies that offer distinct capabilities and uses for engineers, project managers, and operations professionals, with even greater potential for various industries as these tools continue to advance.

Reality capture coupled with digital twin software provides several benefits to industrial sectors. In AEC industries, it reduces costs, saves time, provides accurate as-built documentation, and improves team collaboration. Digital twin technology can simulate and predict outcomes, enhancing manufacturing design quality and minimizing project risks.

For real estate, digital twin platforms enable remote property viewing, improving customer experience and accelerating sales.

In critical infrastructure sectors like power plants and oil rigs, digital twins can monitor and optimize operations in real time, preventing costly downtime and reducing safety risks.

Reality capture and digital twin technology empower companies to unlock actionable insights and make data-driven decisions, leading to improved productivity, efficiency, and sustainability.

Planning the reality capture process

Planning a reality capture process involves several steps to ensure the successful implementation of the technology. Key steps to consider:

1 **Define project goals and objectives:**
Clearly define the purpose of the reality capture process.

2 **Select the appropriate reality capture method:**
Choose the most suitable method for capturing the required data.

3 **Determine the equipment and software requirements:**
Identify the hardware and software tools needed to carry out the reality capture process effectively.

4 **Conduct a site assessment:**
Evaluate the site and identify any potential challenges or limitations that may affect the reality capture process.

5 **Plan the scanning positions:**
Determine the strategic locations for the scans to achieve comprehensive coverage of the site or assets.

Exploring scanning techniques

The two main reality capture techniques are Terrestrial and Mobile Laser Scanning. We'll introduce them both and present common applications for capturing indoor environments before diving deeper into these technologies and their pros and cons.

Terrestrial Laser Scanning

The industry standard for laser scanning usually requires tripod-based terrestrial laser scanners capable of achieving 2mm accuracy. While the data obtained from a terrestrial laser scan is of the highest quality that can be achieved through Prevu3D, the capture time and effort involved are much higher than that of a mobile LiDAR scanner.

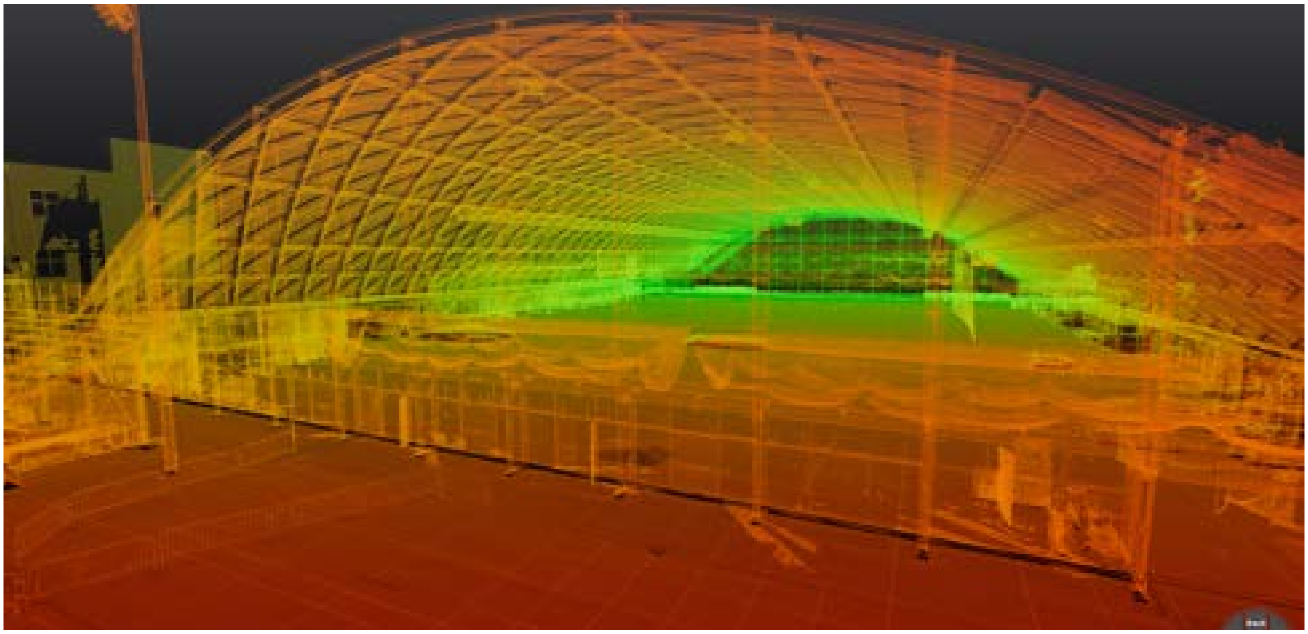
Mobile SLAM Laser Scanning

Providers use mobile Simultaneous Localization And Mapping (SLAM) laser scanners for an accelerated capture process. Mobile SLAM scanners continuously add data into one large scan as the operator moves throughout a space. This allows surveyors to capture large amounts of building space in hours rather than days, as terrestrial laser scanning often requires. While capturing with a mobile laser scanner is much quicker, some finer assets and features in certain spaces are captured with less definition than in a terrestrial scan.

Depending on the application and intended use of the 3D model, certain customers may opt for the slower, more detailed terrestrial scan, while others may prefer the quicker mobile scan capture. This choice could be due to various reasons such as budget, impact on operations associated with reality capture, intended use and accuracy requirements.

One example of a quicker mobile scan being a more effective solution is in the refit/reconfiguration of a manufacturing space. In this application, the client may prioritize the overall dimensions of machinery or production lines over intricate details. Using Digital Twin software like Prevu3D, the client can crop out, move, or delete machinery to find the most efficient configuration. Prevu3D also allows for the import of new equipment models for configuration and CAD clash detection assessments.

In this situation, where overall dimensions are the primary concern, faster mobile laser scan capture can be highly cost effective.



Laser Scanner Point Cloud: image sourced from BIMstream's Prevu3D dataset.

In some cases, there may be mixed requirements between various spaces. In these instances, combining terrestrial and mobile laser scanning may be the most effective solution. An example of this could be a large factory with attached offices or warehouse spaces that do not require the highest detail but attached to them are manufacturing/production lines where more detail is needed. In many of these scenarios, the higher detail requirement might only cover 25% of the space. To efficiently capture this type of space, in terms of both time and cost, we would employ a combination of terrestrial scanners to cover areas with a higher detail requirement and our SLAM device to capture the balance.

Terrestrial Laser Scanning (TLS)

Technology explanation

Terrestrial scanning, also known as terrestrial laser scanning (TLS) or ground-based LiDAR scanning, is a technology used to capture highly detailed and accurate three-dimensional (3D) data of objects or environments. It's commonly employed in various fields, including surveying, engineering, architecture, construction, archaeology, geology, and forestry. Terrestrial scanning relies on laser technology to create a precise point cloud, a collection of millions or even billions of 3D points in space.

Occlusion

Occlusion refers to the obstruction or blocking of the line of sight to certain objects or features within a scan area. In indoor industrial sites, occlusion can occur due to complex layouts, equipment, machinery, and other structures obstructing the view of certain areas or surfaces. TLS, known for their high accuracy, are prone to experiencing more occlusion challenges compared to SLAM devices. This is because TLS requires multiple positions and viewpoints to capture every detail in complex environments. The need for a comprehensive scan from various angles and positions significantly reduces the square footage that can be captured in a single day. While TLS scanners provide precise measurements, the time-consuming and resource-intensive nature of capturing all possible viewpoints in occluded areas makes them less practical in certain situations. This is why SLAM devices, which utilize a real-time simultaneous localization and mapping approach, are often preferred. SLAM devices can capture data more efficiently and navigate through occluded areas, providing a viable alternative when occlusion is a concern.

The scanner positioned on the left side resulted in partial equipment reconstruction. A scan on the right side is essential to avoid occlusion and achieve complete accuracy.

Registration

Registration, or the alignment of scan data, is a crucial step performed after capturing data on-site. It involves merging and aligning individual scans to create a comprehensive and accurate 3D representation of the environment. This process is typically conducted manually or semi-manually, requiring careful adjustments and manipulation of the scans to ensure proper alignment. Due to its time-intensive nature, registration can be slower, resulting in higher costs. However, this step is essential to achieve a seamless and accurate point cloud model that accurately represents the captured space.

Here's how terrestrial scanning typically works:

1. **Laser Emission**
Terrestrial laser scanners emit laser beams from a fixed or rotating instrument in various directions. These beams are directed towards the object or scene being scanned.

2. **Laser Reflection**
When the laser beams encounter surfaces, they bounce back to the scanner's sensors. The time it takes for the laser beam to return to the scanner is measured, allowing the device to calculate the distance to the object's surface.

3. **Point Cloud Generation**
The collected distance measurements are converted into 3D coordinates (x, y, z) to create a point cloud. Each point in the point cloud represents a scanned location on the object or surface.

4. **Multiple Scans**
To create a comprehensive 3D model, the scanner captures data from different positions and angles. This may involve setting up the scanner in various locations or using a rotating head to cover a wide field of view.

5. **Data Processing**
The point cloud data is processed and registered to create a unified 3D model of the scanned area or object. This processing may include tasks such as noise elimination, alignment of overlapping scans, and color information application if the scanner has a built-in camera.

Terrestrial Laser Scanning (TLS)

Pros

Terrestrial scanning efficiently captures detailed 3D data over large areas or complex structures. It's particularly valuable in situations where precision and accuracy are critical.

High Accuracy and Detail:
Terrestrial laser scanners are known for their high accuracy and ability to capture intricate details. They emit laser beams that measure distances to objects in the environment with exceptional precision. By combining multiple scans from different positions, a comprehensive and highly accurate 3D representation can be created.

Large Scanning Range:
Terrestrial laser scanners have a large scanning range, allowing them to capture data from both nearby and distant objects. The range is typically several tens of meters, making them suitable for scanning large-scale environments, making them suitable for scanning large assets and complex environments such as industrial sites.

Cons

Fixed Position:
Terrestrial laser scanners remain stationary during the scanning process. They are set up at a fixed location, and the scanner's laser beams sweep across the environment to capture data from multiple viewpoints. Terrestrial scanners require a direct line of sight to the objects being scanned.

Obstacles such as objects or other structures can block the scanner's view and limit its effectiveness. This often leads to some occluded areas if not enough scans are taken.

SLAM Scanning

Technology explanation

SLAM, which stands for Simultaneous Localization and Mapping, is a technology used in robotics, computer vision and more recently in 3D scanning applications to enable a device, such as a robot or a camera, to map its environment while simultaneously determining its position. In essence, SLAM allows a device to create a map of an unknown environment and keep track of its location within that map in real time. SLAM uses various sensors, such as cameras, LiDAR (Light Detection and Ranging), and IMU (Inertial Measurement Unit), to collect data about the surroundings. The device then processes this data to build a map of the environment and estimate its pose (position and orientation) within that map. This is a complex computational task that involves solving a set of equations to reconcile the incoming sensor data with the existing map and the device's movement.

Here's how SLAM scanning typically works:

1

Gathering Data
The SLAM scanner starts by using its sensors, such as cameras and laser scanners, to collect information about the world around it. This includes tasks like measuring distances to objects and capturing images.

2

Identifying Features
If it's a visual SLAM system, it looks for unique points in the images that can be used as reference points.

3

Getting Started
Initially, the system tries to determine its location and gain an understanding of the surroundings. It may have a rough estimate of its position.

4

Guessing Movements
The scanner estimates how it has moved since the last check. This involves measuring turns or distances traveled.

5

Matching Data
It tries to determine which parts of the currently collected data match what it already knows from before.

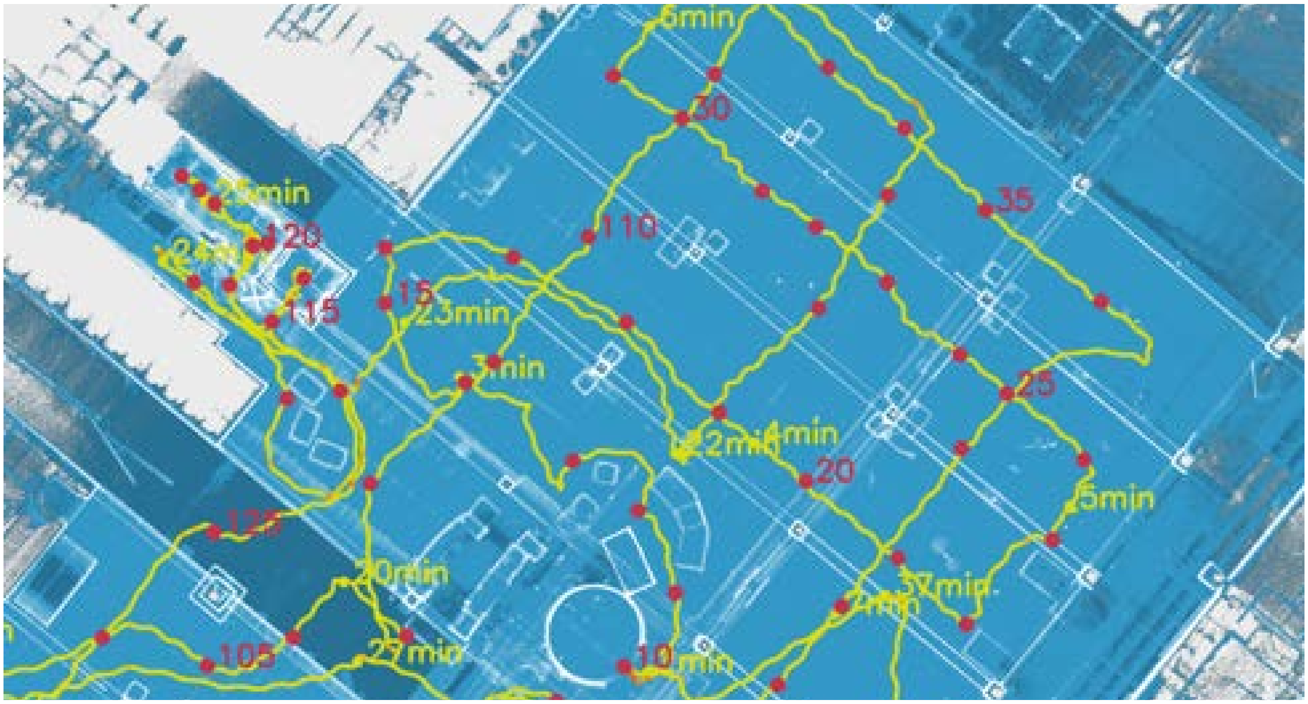
6

Creating a Map
As it collects new data and finds matches, it builds a map of the environment. This map can be in the form of a collection of points or a grid.

7

Loop Closure (Recommended)
This is usually crucial during a scan. Over time, the device may experience some drift and accumulate errors. Loop closure involves revisiting the same location to mitigate these errors.

Here’s an example of a scanning path including loop closure



Above, we can see the yellow line describing the device's position. The scanning provider did well by creating those "box" patterns and overlapping the trajectory. Those loops will help the algorithm tie the model back together and reduce the drift.

Usually, all the processes described above are a black box and proprietary to the device constructor. It's more user-friendly to capture data using a SLAM device because the complexity is hidden from the user.

SLAM Scanning

Pros

SLAM scanning is highly efficient for capturing large areas. It's particularly valuable when a good overview is required or access is time-limited on site.

Mobility:
SLAM scanners are typically mobile and can be mounted on robots, drones, or handheld devices. They move through the environment to capture data in real -time while simultaneously estimating their position.

Speed:
Devices used for space capture are typically fast, but it's crucial to minimize environmental changes during scanning. Time-limited access can pose challenges in certain cases. This is where SLAM can be a better option than TLS (Terrestrial Laser Scanning) due to its faster acquisition time. With fully automatic processing, customers can benefit from a cost-effective solution that doesn't require any assistance.

User-Friendly:
These hardware devices are recent on the market and we can clearly see the different approach to the user experience compared to traditional terrestrial scanners. They are easier to control, but you still need a good experience to get the best results.

Cons

Accuracy:
Those devices might be fast, but there's a small cost on the quality of the point cloud. Since the device is actively moving, it has less "occluded area," but there's a bit more noise in the data overall.

The point spacing or definition is also reduced compared to TLS, resulting in the possibility of smaller details being left behind. It's important to note that SLAM devices may not efficiently capture elements that are under 1 inch in most cases.

Drift:
Since the device tracks its position using anchor points in the space, it tends to accumulate errors over time. If you have a space with few assets or a similar pattern, the devices can also lose their tracking position—for instance, a rooftop without mechanical equipment, a long white hallway, or a cedar hedge.

Reality capture the foundational data layer of Prevu3D Digital Twins

By collecting data about the physical world using sensors like laser scanners, we can gather measurements, images, coordinates, and other sensory information that accurately represent the real-world environment. This data is often stored in point cloud files, which can be challenging to work with and require expertise to clean up and manage. However, once processed into 3D mesh models, the datasets become more accessible and provide a visually immersive experience.

By transforming reality capture datasets into mesh models, we can create virtual replicas known as digital twins. These digital twins are dynamic and static representations of physical assets, systems, and environments that enable users to navigate in real time. They integrate data from various sources like CAD and BIM to provide a comprehensive and accurate digital replica of the physical entity.

Prevu3D software connects real-world assets, data and people

Prevu3D software automatically converts massive point clouds into 3D mesh models for visualization and data analysis. The user-friendly platform enables easy access and management of reality capture data, accelerating engineering workflows. Engineers can quickly design, edit, and share layouts, speeding up decision-making and project delivery.

Prevu3D software is compatible with industry-leading scanning devices

NavVis Leica Geosystems FARO RIEGL

emesent Matterport™

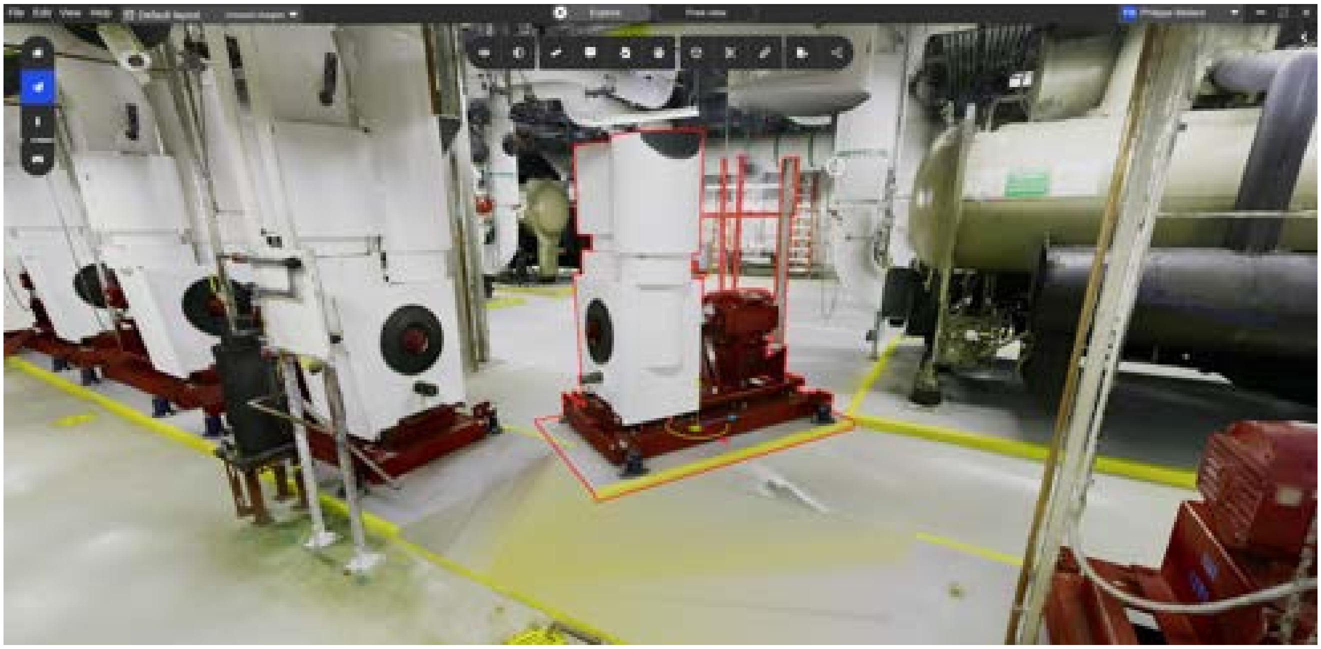
Through cloud processing, gaming technology, and AI, Prevu3D generates high-resolution, quality-textured 3D mesh models of real-world assets and environments. These environments are an editable and shareable visualization platform for all project stakeholders.

Organize virtual assets

- Easily cut meshes to define and organize virtual assets
- Combine meshed assets with CAD metadata
- Use segmentation tools for quick asset identification

Design and edit layouts

- Rapidly design, edit and share layouts
- Animate assets to visualize movement and test trajectory
- Access real-time data and measurement



Navigate and explore

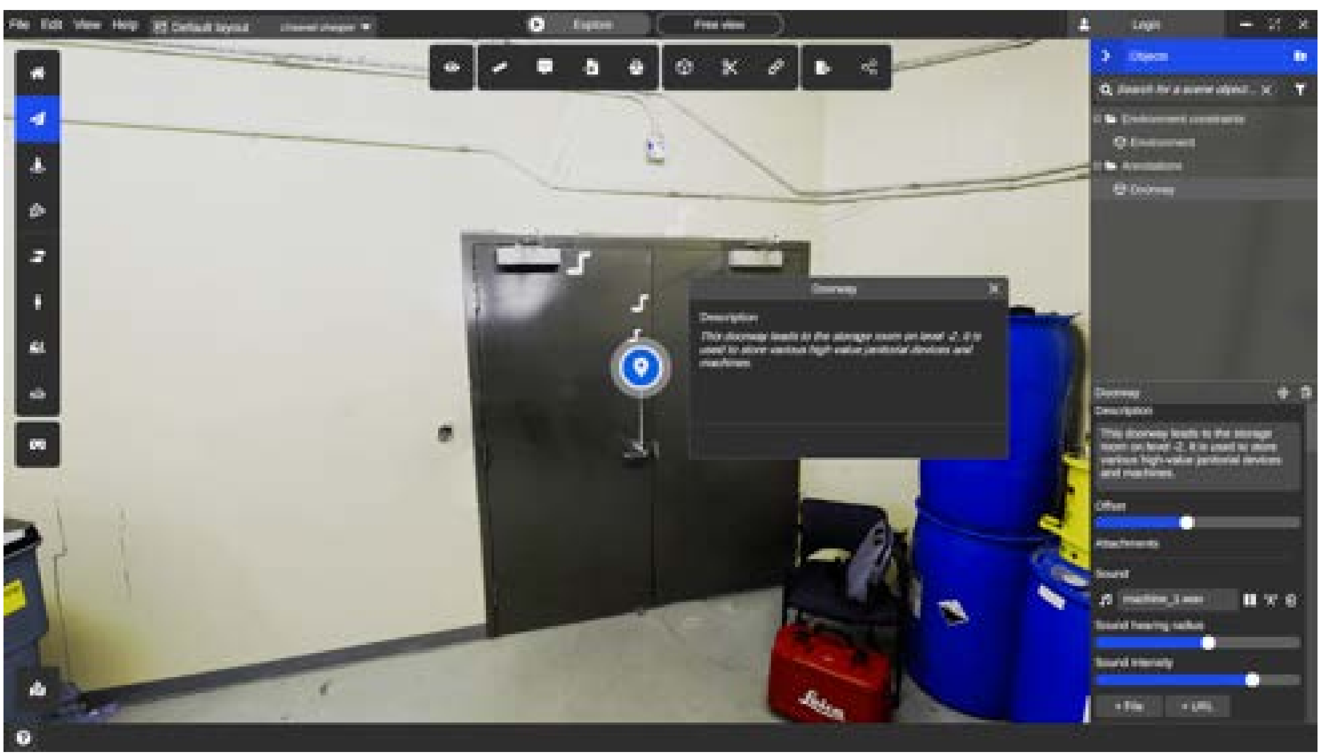
- Navigate through different modes for seamless exploration
- Zoom in to examine every detail and gain rich visual context
- Enhance analysis by evaluating circulation using avatars and vehicles

Reality capture for the industries of the future

Looking to the future of the industrial sector, it becomes evident that digital twins are gaining significant traction across all industries. The advantages of working in 3D are extensive, ranging from improved project visualization and efficient design engineering to streamlined collaboration and cost savings.

Prevu3D software provides a comprehensive platform that empowers companies to fully harness the potential of reality capture. It connects real-world assets, data, and people for top operational efficiency.

Embracing reality-capture technology means embracing its transformative potential.
For more information about Prevu3D's turnkey solutions, visit [the website](#).



Contributor

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Founder and CEO BIMstream

BIMstream is a family of architects, engineers, and creative technologists who combine bleeding-edge technology with world-class artistry to solve your toughest challenges. They've scanned, modeled, and delivered tens of millions of sq ft of accurate 3D data, designed robots to survey hazardous sites, rendered photo-realistic VR spaces, and more.

For more information, visit:
https://bimstream.com/

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