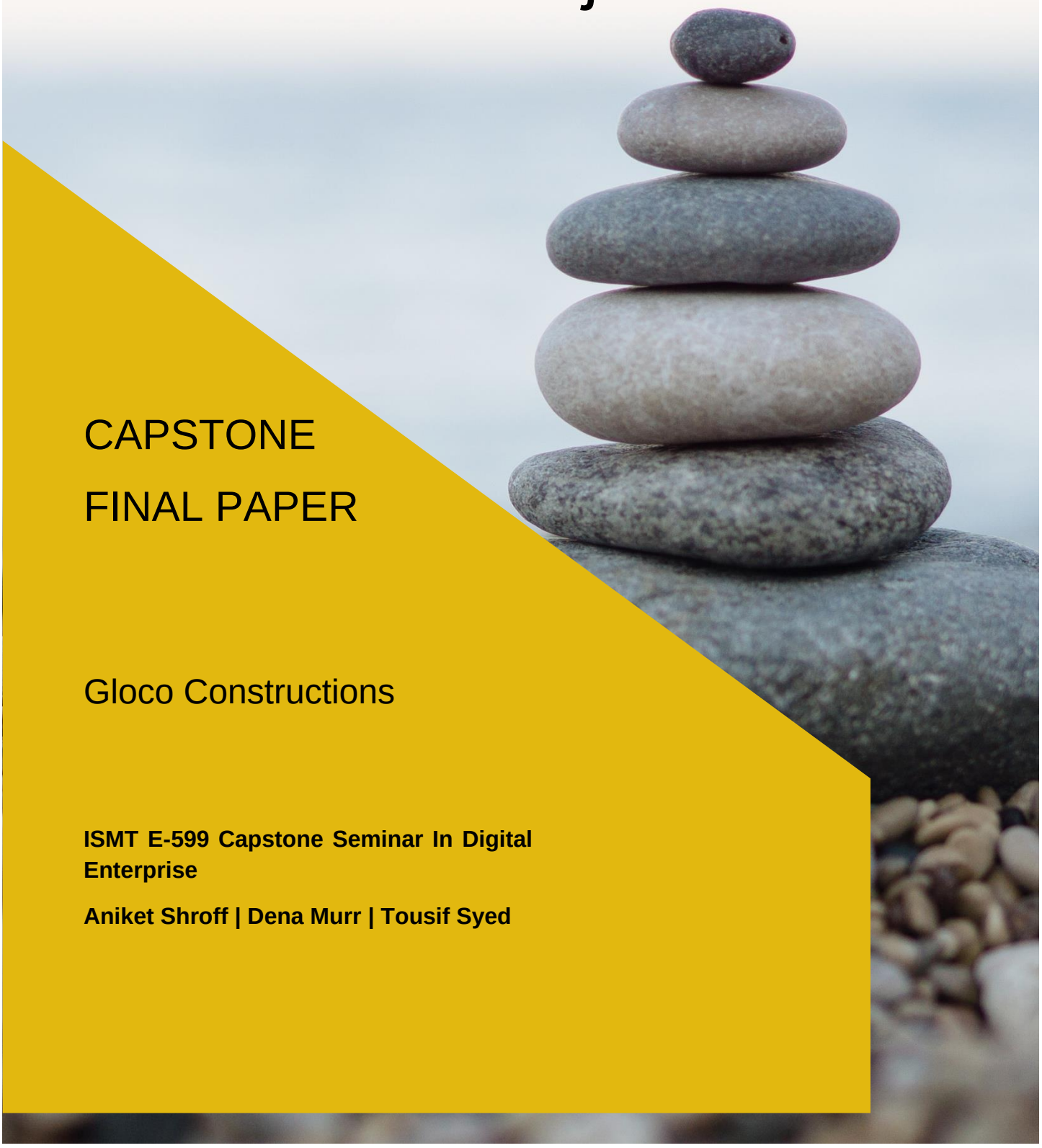
Remote Quality Control and Progress Monitoring of Construction Projects



CAPSTONE

FINAL PAPER

Gloco Constructions

ISMT E-599 Capstone Seminar In Digital Enterprise

Aniket Shroff | Dena Murr | Tousif Syed

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Common Terms

Term	Description
Reality capture	Process of documenting a construction project by manually or automatically pinning images or video frames against a floor plan to create virtual documentation of a building or structure
Reality mapping	Transforms standard and 360 photos and videos into a multidimensional, measurable, as-built version of a job site (without needing to upload a floor plan as a starting point)
Orthophotos	Computer-generated images that combine the characteristics of a photograph with the geometric qualities of a map. They remove distortions caused by camera tilts and terrain relief
Photogrammetry	Science of making measurements from photographs. The input to photogrammetry is photographs, and the output is typically a map, a drawing, a measurement, or a 3D model of some real-world object or scene.
Digital Twin	Highly accurate virtual replicas of physical assets that reflect real-time data
Reconstruct	AI-powered remote quality control and progress monitoring SaaS
BIM	Building Information Model is an intelligent, 3D model-based tool that provides a digital representation of a facility's physical & functional aspects.
Point Cloud	Set of data points in a 3D coordinate system—commonly known as the XYZ axes

EXECUTIVE SUMMARY

Introduction

Gloco Construction is building a new state-of-the-art commercial complex in the downtown area of Boston, USA that will have multiple high-rise office buildings, retail spaces, and a large underground parking facility. The expected duration of the project is 48 months, with a budget of around $200 million. The buildings will be designed to offer modern office spaces with advanced amenities and will have an underground parking facility to accommodate employees and visitors, enhancing convenience and accessibility. Appendix 1: Project Card provides further information on start date, stakeholders, expected end date, delivery method etc.

Key Challenges

Gloco, however, has been facing significant challenges in their current manual progress tracking and reporting processes. Gloco construction process involves paperwork, meetings and progress documentation by supervisors manually walking a site and taking notes, often shared via WhatsApp. Issues with lost or misplaced documents, up to date information such as new or minor changes are not effectively communicated to relevant teams, info, or changes, with relevant parties, insufficient and delayed inspections miss poor quality work leading to problems later that need to be completely redone. Project delays lead to delayed payments which leads to subcontractor disputes that become legal issues and so on. This costs Gloco millions of dollars and hurts Gloco's reputation as a Construction Company leader. To address these issues and maintain their growth and reputation, Gloco plans to adopt automated remote quality control and monitoring technologies.

Technology Provider

Skyline Sync LLC (Skyline) specializes in technology facilitation for large scale construction projects helping construction companies digitalize their construction sites with advanced technology, to ensure projects are executed efficiently and effectively. Skyline's solution provides a suite of advanced digital tools that facilitate real-time monitoring, project management, and remote site inspections. By partnering with Skyline, Gloco aims to mitigate their common issues of delays and cost overruns so that they can maintain their reputation and deliver projects on schedule and within budget.

Implementing this digital transformation will cost $860,000 and is expected to save Gloco $3.7m from cost delays and legal fees (on a $200m construction project), providing a high return on investment.

Business Goals

- Streamline Project Execution: Implement digital tools to streamline project management and oversight, ensuring that all construction projects are completed within their scheduled timelines.
- Enhance Project Transparency: Utilize advanced monitoring technology to provide real-time updates and detailed reports on project progress to all stakeholders. This transparency will improve trust and satisfaction among clients, enhancing Gloco Construction’s reputation for reliability and quality.
- Cost Efficiency: Deploy advanced technologies to improve resource utilization and reduce waste, resulting in significant cost savings across all projects. This will enhance profitability and allow Gloco Construction to offer more competitive pricing, further strengthening its market position.

Expected Outcomes

- Reduce project delays, saving $3,700,000.
- Decrease related costs through more efficient resource management and timely problem resolution as described in the ‘Business Justification’ section.

Provide more precise and faster updates, enabling project managers to react quickly to issues or necessary alterations on-site.

Scope Limitations

Skyline is a technology enabler that assists construction companies with digitalizing their construction site monitoring. Skyline will assist Gloco in project planning, setup and monitoring remotely. Gloco is expected to provide its own BIM, which Skyline will integrate into Reconstruct's software. This will enable the software to create a digital twin of the construction site. The primary responsibility for deploying and managing drones/lasers/cameras will be Gloco's responsibility. Gloco has indicated it would like to integrate the following monitoring devices:

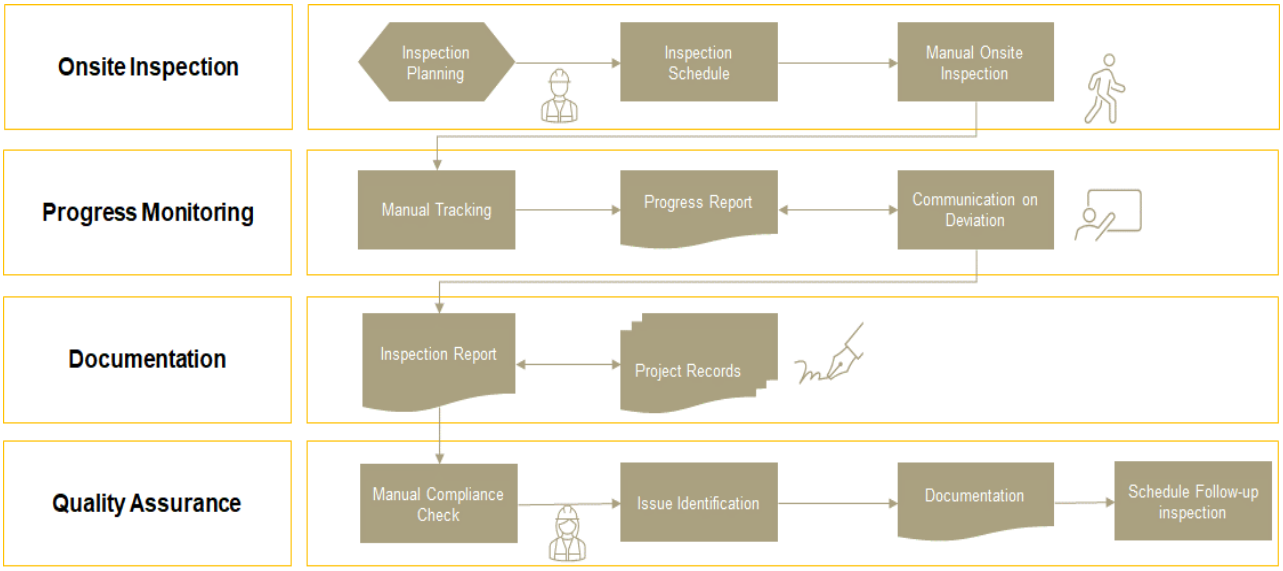
- Insta360 (1)
- DJI Mavic 2 Pro (1)
- Matterport Pro3 (1)
- Faro Focus (1)
- Sensera systems solar cameras (3)

Skyline will assist with construction site data capture and integration with Reconstruct. Skyline will also provide training for the staff on using Reconstruct. And finally, Skyline will ensure that the project schedules and existing construction data are integrated into Reconstruct allowing Gloco to have an accurate account of the progress being made.

BUSINESS REQUIREMENTS

As-is Construction Monitoring process

The existing construction monitoring process at Gloco is manually driven as shown in Figure: As-Is Construction Monitoring Process and therefore, easily susceptible to errors, mistakes, and delays.



The As-Is process for construction monitoring includes the following tasks and activities:

Task Number	Task Name	Activity
1	Onsite Inspection	Inspection planning is done by the Site Supervisor and Project Managers. Inspections are scheduled for manual onsite inspections at pre-determined stages of construction.
2	Progress Monitoring	The inspection observations in task 1 'Onsite Inspection' are manually tracked using Microsoft Excel and a progress report is prepared in MS Word using a standard template. All deviations from the standard building prints are then communicated over phone or physical meetings to responsible people.
3	Documentation	Preparation of inspection reports are combined with feedback from stakeholders and manually filed in the project records
4	Quality Assurance (QA)	Issues are identified are documented and a schedule for a following inspection is prepared and shared with stakeholders.

Key challenges:

S. No.	Challenge	Description
1	Manual Processes	The reliance on manual methods for tracking and documentation can lead to errors, omissions, and inefficiencies.
2	Communication Gaps	Coordination among various teams and stakeholders can be challenging, potentially leading to delays in issue resolution
3	Consistency	Ensuring consistent quality across all phases of construction can be difficult without standardized procedures and tools
4	Cost and Time	Frequent site visits and manual inspections increase operational costs and extend project timelines

To Be Construction Monitoring Process

Gloco would like to improve site inspections and remotely monitor their construction projects. By implementing technology that will capture videos, pictures and even digital scans of the construction progress each week, Reconstruct software will provide Gloco with a real time digital twin of the current state, allowing Gloco to be able to streamline inspections, improve quality control, and improve communication with stakeholders.

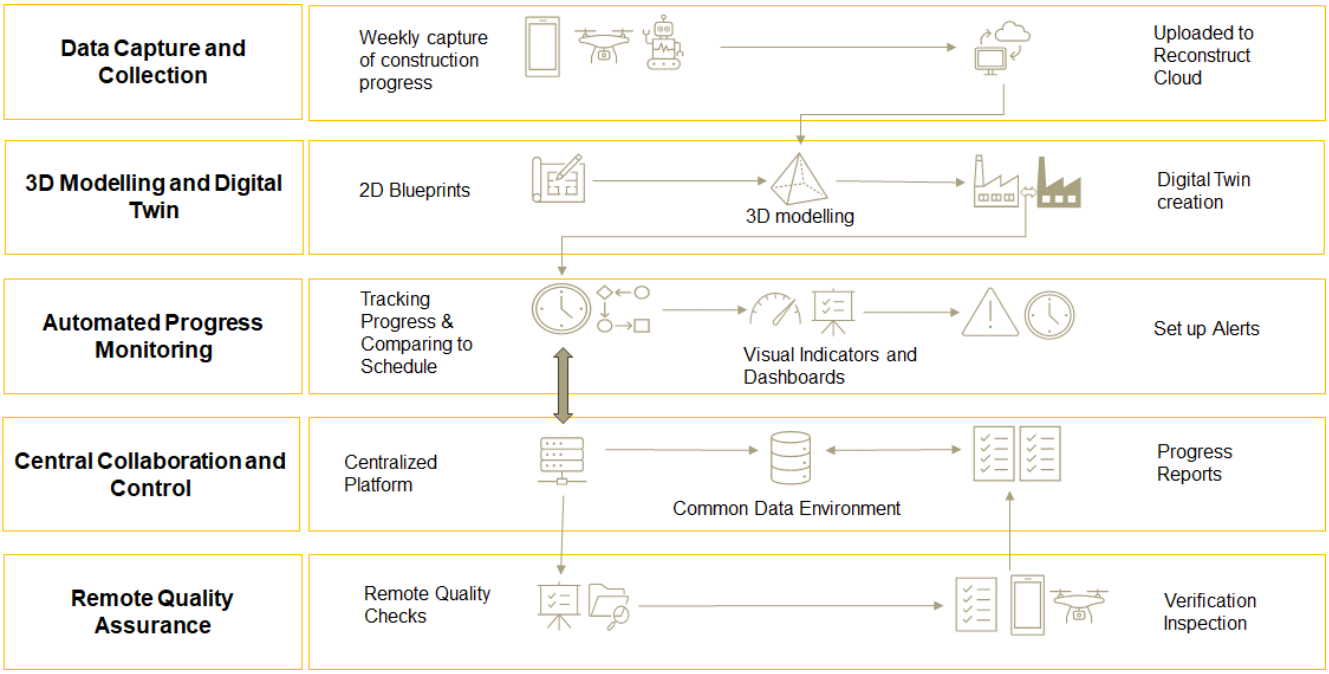


Figure: To-Be Construction Monitoring Process

Gloco wants to use advanced reality capture, digital twin technology, and real-time data integration to enhance the construction monitoring process. This approach will streamline inspections, improve quality control, and enable efficient communication among all stakeholders.

Task Number	Task Name	Activity
1	Data Capture and Collection	The activity includes weekly reality capture using smartphones, 360 cameras, drones, and laser scanners to capture detailed images and videos of the construction site. The captured data is stored in Gloco's database and then uploaded to Reconstruct's cloud platform, eliminating the need for manual data handling. Note: The solution can perform real-time data capture, however, considering the project size, schedule, data requirements the solution is planned for weekly data capture.
2	3D Modelling and Digital Twin	Gloco prepares digital 2D Floor Plans/ blueprints that provide a detailed view of the site layout. Then a 3D model is developed using Gloco's existing Building Information Model (BIM) software. The BIM is uploaded into Reconstruct which uses this to create a 3D digital twin of the construction site.
3	Automated Progress Monitoring	Each week, video, images, and scans are captured of the site and uploaded into Reconstruct. These changes are then displayed on the digital twin, providing a real time view of the construction progress. The tracking is done by indicating areas of interest within the digital twin and using that and the project schedule to track the status of various construction activities and milestones.

Task Number	Task Name	Activity
4	Central Collaboration and Control	The Reconstruct SaaS acts as a centralized platform for all stakeholders, including contractors, subcontractors, and clients, which allows for a single source of truth. The captured data, inspection evidence, and reports within the Reconstruct platform are maintained as per Gloco's standard data governance and security policies for future reference and compliance audits.
5	Automated Quality Assurance	Because the digital twin of the current construction site is accurate, measurements can be determined from the digital twin. If these measurements contrast with the BIM measurements, the system will detect and issue, promptly notifying stakeholders as soon as they happen.

Business Architecture

Gloco's planned business architecture for the remote construction monitoring project using Reconstruct is designed to align the strategic objectives and the architectural principles. The architecture encompasses business objectives, business processes, key business capabilities, technology components, stakeholders, and performance metrics as shown in Figure: Gloco's Business Architecture. This structured approach ensures a comprehensive and integrated framework for effective construction project management.

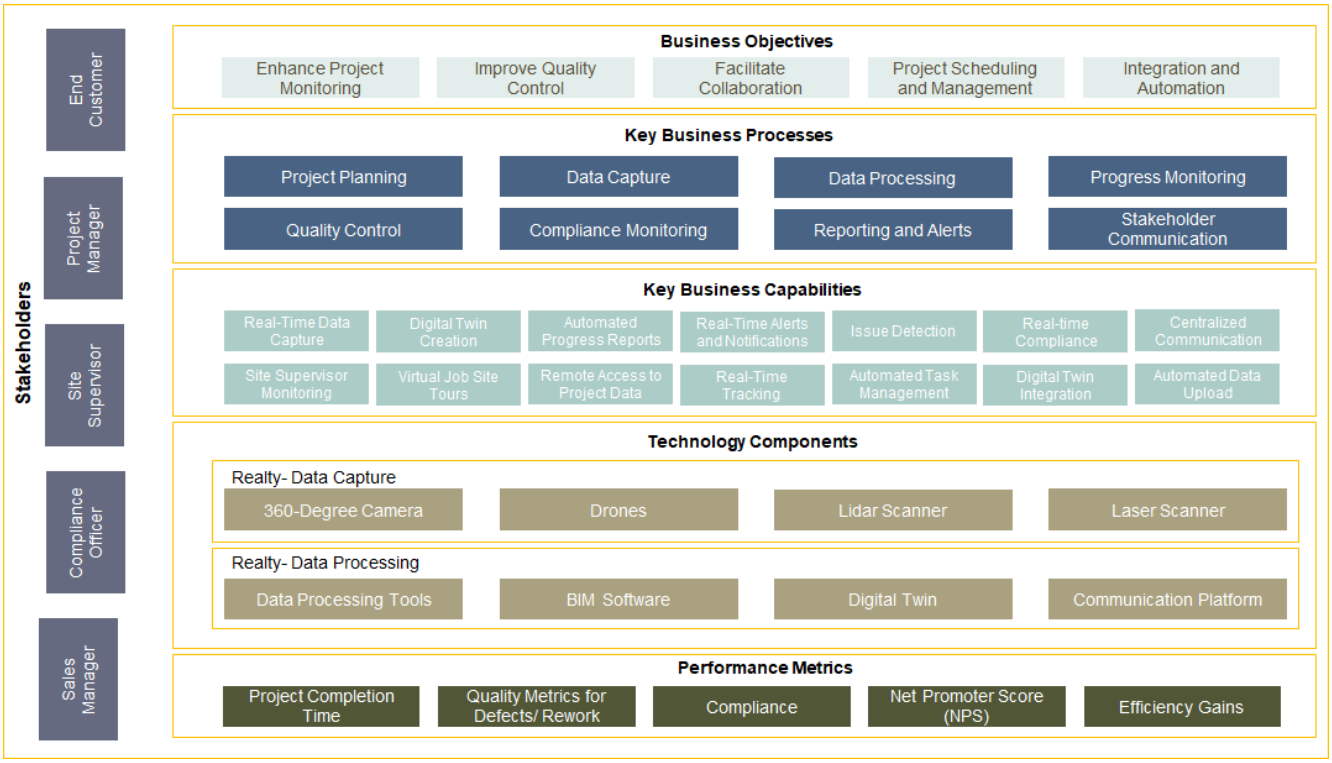


Figure: Gloco's Business Architecture

Business Objectives

The business objectives are based on the themes defined in Appendix 3: Themes, Epics and Features. The business objectives include enhancing project monitoring to improve visibility and oversight of construction projects, improving quality control to maintain high standards through continuous monitoring and precise measurements, facilitating collaboration to enhance communication and cooperation among stakeholders, optimizing project timelines and resource allocation for efficient execution through project scheduling and management and finally, automating processes to integrate data for improved efficiency and effectiveness.

Key Business Processes

The architecture outlines essential processes to support the business capabilities. The processes include project planning using a Building Information Model (BIM) for detailed project plans, data capture utilizing drones, 360-degree cameras, lidar scanners, and laser scanners to capture the construction progress, and using Reconstruct software to create an accurate digital twin using the 3D models integrated with the BIM. Progress monitoring involves tracking project progress weekly, while quality control includes verifying that measurements are correct and using the digital twin to verify that the progress being made matches the BIM. Compliance monitoring ensures adherence to safety and building codes, and reporting and alerts involve generating automated progress reports and setting up alerts to be notified when there are issues or delays. Stakeholder communication is facilitated through the Reconstruct website, which acts as a centralized platform where all communication can take place, ensuring a single source of truth.

Key Business Capabilities and User Stories

To achieve the business objectives, the architecture focuses on 14 key business capabilities derived from the features defined in Appendix 3: Themes, Epics and Features section of this report. The business capabilities include real-time data capture for continuous site data collection using advanced technologies, digital twin creation for developing dynamic digital representations of construction sites, and automated progress reports for generating regular updates on project status. The architecture also emphasizes real-time alerts and notifications for immediate issue detection, issue detection and documentation, compliance monitoring, and centralized communication for effective stakeholder collaboration. Additional capabilities include site supervisor monitoring, virtual job site tours, remote access to project data, real-time tracking of construction schedules, automated task management, digital twin integration with other project management tools, and automated data upload and processing.

The use stories table in Appendix 4: Use Stories and Acceptance Criteria provides a detailed overview of the key use cases required for the successful implementation of the Reconstruct platform in Gloco's construction monitoring project. Each use case has a clear acceptance criterion, ensuring that the delivered features meet the expected standards for accuracy, timeliness, and integration. The structured approach ensures coverage of all project aspects and facilitates improved project monitoring, enhanced compliance, and efficient communication among stakeholders.

Technology Components

Architecture utilizes advanced technologies to support key processes. Data capture technologies include 360-degree cameras such as Insta360, drones such as DJI Mavic 2 Pro, lidar scanners like Matterport Pro3, and laser scanners such as Faro Focus. The BIM software (Autodesk360) is used for creating and managing the BIM models. Reconstruct will take all the videos, photos, scanning data and integrate it to create a dynamic digital representation of the construction site, a digital twin. Additionally, Reconstruct also provides a communication platform to facilitate real-time collaboration and data sharing among stakeholders.

Stakeholders

The architecture identifies key stakeholders involved in the project. Project managers oversee project progress and resource management, while site supervisors monitor daily construction activities and manage on-site resources. Compliance officers ensure regulatory compliance, and sales managers provide clients with updates and ensure client satisfaction. Clients receive regular updates on project progress and quality, ensuring transparency and trust in the construction process.

Performance Metrics

To measure the success of the implementation, the architecture includes performance metrics. These metrics track project completion time to ensure adherence to schedules, quality metrics for accuracy and rework to maintain high standards, and compliance to ensure adherence to regulatory requirements.

Functional Requirements

The following table provides the functional requirements mapped to the features:

Feature	Functional Requirement
F1. Data Capture	Integrates with 360 cameras and drones to capture images and videos.
	Upload captured data to the Reconstruct portal with geo-tags and timestamps.
F2. Digital Twin Creation	Create and update a 3D digital twin in the Reconstruct portal using real-time data uploads.
F3. Automated Progress Reports	Generate automated progress reports at defined intervals.
	Reports shall include updates on milestones, status, and any issues detected.
F4. Alerts and Notifications	Generate and send alerts for any detected issues or delays, defined by Gloco.
	Alerts shall include detailed information and suggested corrective actions.
F5. Issue Detection and Documentation	Allow documentation of issues directly within the digital twin.
	Documentation can include photos, descriptions, and geolocation data.
F6. Compliance Monitoring	Integrate compliance data and display it on the monitoring dashboard.
	Automatically flag non-compliance issues and generate compliance reports.
F7. Centralized Communication Platform	Provide a centralized platform for all communications and real-time collaboration between users.
	Support messaging, file sharing, and discussion threads.
F8. Site Supervisor Monitoring	Display progress data from all active sites on a dashboard for site supervisors.
	Alert supervisors about any delays or deviations from the planned schedule.
F9. Virtual Job Site Tours	Sales managers with logins can generate and send progress reports including visual data.
	Portal is a secure portal to view their project status updates.
F10. Remote Access	Everything can be remotely accessed via web and mobile interfaces.
F11. Real-Time Schedule Tracking	Visualize schedule adherence and highlight delays.
	Updates shall be accessible to all stakeholders.
F12. Automated Task Management	Automate task assignments and tracking.
	Provide notifications for upcoming and overdue tasks.
F13. Digital Twin Integration	Integrate with tools like Autodesk (BIM), compliance software, project management etc. for a virtual site model.
	Integration tools shall overlay physical and digital data for comparison.
F14. Automated Data Upload and Processing	F26. The system shall automate the upload and processing of reality capture data.
	F28. Processed data shall be available ensuring confidentiality and integrity.

Non-functional Requirements

Category	Non-Functional Requirement
Performance	The system shall process and upload data.
	The digital twin shall display the most current data uploaded.
	The system shall support concurrent access by at least 100 users without performance degradation.
Scalability	The system shall handle large-scale projects with up to 1,000,000 square feet of monitored area.

Category	Non-Functional Requirement
	The system shall support the integration of additional sensors and data sources without requiring major architectural changes.
	The system shall be able to scale horizontally to accommodate increased data processing and storage needs.
Reliability	The system shall have an uptime of 99.9%, ensuring minimal downtime and high availability.
	The system shall provide automatic data backup every 24 hours to prevent data loss.
	The system shall include failover mechanisms to ensure continuous operation in case of hardware or software failures.
	The system shall support multi-factor authentication (MFA) for all user accounts.
	The system shall comply with industry-standard security protocols such as ISO 27001, SOC 2 Type II, PCI DSS, NIST etc.
Usability	Users shall be trained in how to use Reconstruct in a train-the-trainer framework.
	The system shall provide comprehensive user documentation and training materials.
	The system shall support multiple languages, including English and Spanish.
Maintainability	The system shall be designed with modular architecture to facilitate easy updates and maintenance.
	The system shall include automated testing tools to ensure stability and functionality after updates.
	The system shall provide detailed logging and monitoring to assist in diagnosing and resolving issues quickly.
Compatibility	The system shall be compatible with the latest versions of major web browsers (Chrome, Firefox, Safari, Edge).
	The system shall support integration with popular project management tools such as Oracle Aconex, Autodesk BIM 360 etc.
	The system shall be accessible via desktop and mobile devices, including iOS and Android platforms.
Compliance	The system shall comply with GDPR for data protection and privacy.
	The system shall meet OSHA standards for safety compliance documentation.
	The system shall adhere to local building codes and regulations for all supported regions.
Availability	The system shall be accessible 24/7, with planned maintenance windows not exceeding 4 hours per month.
	The system shall provide users with advance notice of at least 48 hours before any planned downtime.
Disaster Recovery	The system shall have a disaster recovery plan that ensures full data recovery within 12 hours of a major incident.
	The system shall conduct regular disaster recovery drills at least twice a year to ensure preparedness.
Interoperability	The system shall integrate with all major construction management software such as oracle and Autodesk. This enables seamless integration into the existing work environment of multiple companies.

Business Benefit Justification

Cost Breakdown

Category	Details	Amount
Cost Breakdown		
Initial Costs		$860,000
Software Licensing	Reconstruct (2 years)	$160,000
Installation and Integration	Setup of equipment* and software, including initial data migration and system configuration.	$330,000
Site Specialist	6 months of Skyline Site Engineer.	$130,000
Training	Training for site managers and staff on new systems	$240,000

Return on Investment (ROI)

Cost Savings		
Reduced Project Delays	1% reduction in delays, saving 2 months on a 48-month project ($2 million on a $200 million project)	$2,000,000
Reduction in Legal Fees	.9% reduction in legal fees due to timely payments ($1,700,000 on a 4-yr project)	$1,700,000
Total Savings	Sum of cost savings ($3.7m for a 4-year project)	$3,700,000
Operational Savings		
Efficiency Gains	15% increase in operational efficiency	Qualitative
Cost Overruns	8% reduction in incidents leading to budget overruns	Qualitative
ROI Calculation		
Total Initial Investment		$860,000
Net Savings		$2,840,000
Monthly Savings	$3,700,000 / 48 months	$77,000
ROI	2,840,000 / 860,000 * 100	330%
Break-even Point	Within the first 11 months of project completion	11 months

*Gloco equipment is comprised of Insta360 (1), DJI Mavic 2 Pro (1), Matterport Pro3 (1), Faro Focus (1), Sensera systems solar cameras (3)

Implementing Reconstruct construction monitoring system with the help of Skyline provides a significant upfront investment but promises substantial long-term benefits. The total initial investment includes 2 years of software licensing, installation, integration, and 6 months of a Skyline Site Engineer. The financial assessment highlights immediate and operational savings that justify the investment. With a reduction in project delays, Gloco can save approximately $3,700,000 million on a $200 million project by avoiding the legal fees that result from delayed projects. These savings amount to $77,000 per month. The anticipated best case of solution's break-even point is within the first 11 months of project completion, with an anticipated ROI of approximately 330%. In summary, the financial benefits and operational efficiencies offered by this construction monitoring system not only justify the initial investment but also provide a competitive advantage through enhanced project management capabilities and client satisfaction.

TECHNICAL SOLUTION

Software Solution

Skyline Sync is working with Reconstruct Inc's technology stack to implement the remote construction monitoring solution for Gloco. Reconstruct provides a software solution that can allow remote monitoring through a digital twin that replicates the real world. Reconstruct's software solution includes the following essential components that enable it to create a digital twin.

Technical Architecture

The technical architecture for the remote construction monitoring project using Reconstruct is designed to integrate advanced data capture technologies with cloud-based platforms for data processing, storage, and analysis.

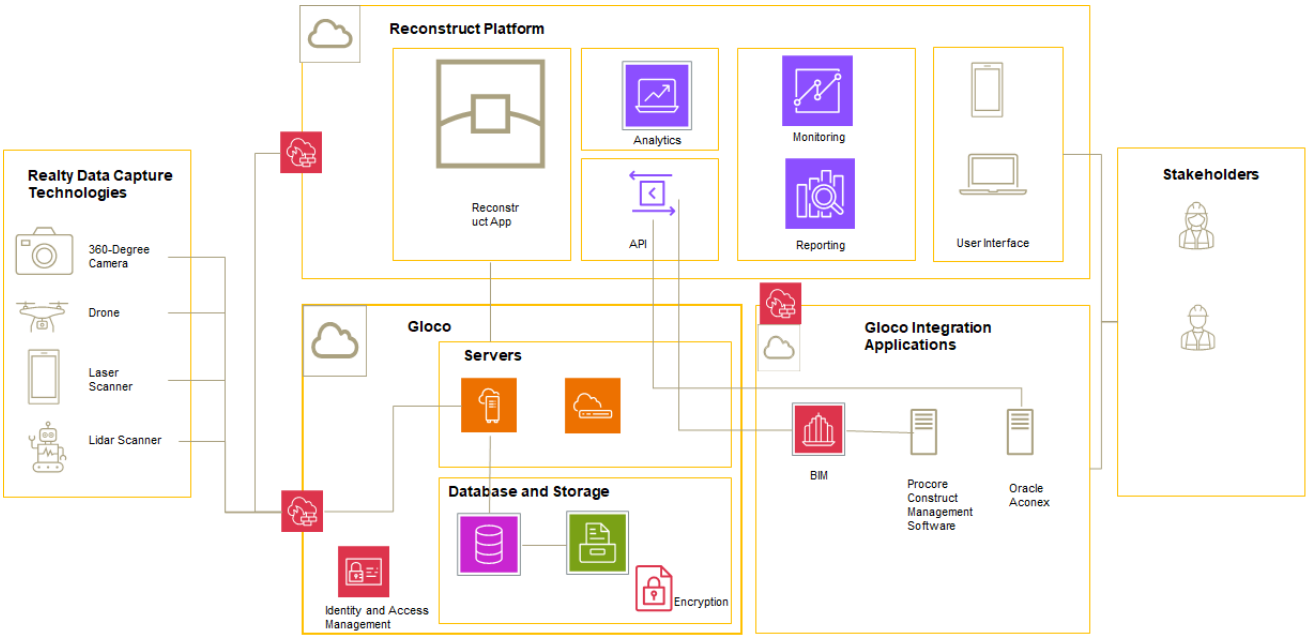


Figure: Technical Architecture

Reality Data Capture Technologies

The architecture employs various advanced data capture technologies to gather site data. Please refer to the data flow diagram later in the section to see the flow of jpg, video and E57 data.

Technology	Description	
Insta360	Small camera (weighs 35 grams) that that can be mounted or worn and used to capture panoramic images and videos of the construction site, providing comprehensive visual data	
DJI Mavic 2 Pro	Consumer drone that captures high-resolution aerial images and videos, offering an overview of the site from different angles	
Matterport Pro3	Lidar camera for fast, accurate, high-resolution indoor/outdoor reality capture	

Faro Focus	3D Laser Scanner for capturing accurate measurements of buildings and complex environments	
Sensera Solar Camera	Fixed position cameras for every kind of weather, visual documentation, remote progress monitoring, collaboration, risk/safety, and security	

Gloco will be responsible for providing the data feed from the data capture technologies. The data will be ingested in many formats for use in the Reconstruct web application software. The images will have GPS (Global Positioning System), and INS (Inertial Navigation System) data embedded in each capture. Further, the data will include distance between objects in space along with the GPS coordinate data when creating the 3D digital twin in the Reconstruct software. Furthermore, Reconstruct supports E57 file format which is a compact vendor-neutral format for storing point clouds, images and other data produced by 3D image systems such as laser scanners. In addition, E57 enables quick sharing and easier interoperability. This will be the main file format for sharing captured data.

The technical process of data capture and processing is provided in Appendix 9: Technical Details of Data Capture and Processing

3D Modelling

Gloco's 2D drawings and BIM models are used to create an as-planned model, incorporating project budget and schedule. The reality data capture is measured against the as-planned model which becomes the benchmark for construction monitoring**.** Gloco's BIM model solution provides a completed 3D architectural drawing of the building that is going to be built in Boston.

The BIM model will be created in Autodesk 360 software and will include the exact specification, building material, 2D plans and 3D plans of the building. The BIM model will be in an .obj file format or an .ifc file format for ingestion into the Reconstruct software solution. .ifc file format is developed by buildingSMART®. IFC provides an interoperability solution between different software applications. Reconstruct and Autodesk utilize this file format for easier transition of data. The Reconstruct platform and Autodesk BIM 360 platform will be integrated bidirectionally. Single sign-on will be used for accessing Gloco's BIM Model and the data will be automatically pulled into Reconstructs platform.

Reconstruct Platform

The Reconstruct platform serves as the central hub for creating and managing digital twins, providing real-time monitoring, and delivering analytics. Initial data filtering and noise reduction are performed using the Reconstruct app to ensure data quality. The platform integrates data from various sources to create dynamic digital representations of the construction site, known as digital twins. Please refer to Appendix 14: Reconstruct Platform Product Description for more details.

Capture App by Reconstruct

While workers can capture photos and videos without an app, Reconstruct has an app to make the data transfer a little easier since the data can be directly uploaded to Reconstruct. It also lets users do things like selecting a 2D floor map first and adding video to that specific location.

Please note that the details on Reconstruct's technology working and architecture are not publicly available and therefore, we have researched similar technologies that provide insight into how Reconstruct works. These technologies have been provided as a reference in Appendix 12: Additional Technology Recommendations.

Integration Applications

The architecture integrates various applications to enhance project management and collaboration. Reconstruct can integrate with multiple industry standard software. The main software for integration in construction monitoring is Autodesk 360 and Reconstruct provides ready APIs for integration.

- BIM Software: Tools such as Autodesk 360 are used for creating and managing detailed project models.
- Procore Construction Management Software: This software manages construction schedules and time management.
- Oracle Aconex: Ensures compliance and centralized document management.
- Database: Reconstruct back-end API integrates with Amazon AWS Dynamo DB or a NoSQL server environment.

Security

Robust security measures ensure data integrity and protection throughout the architecture:

- Identity and Access Management: Secure access controls ensure that only authorized personnel can access sensitive data.
- Encryption: Data is encrypted during transmission and storage to protect against unauthorized access and breaches. To limit the amount of data stored and processed the data capture will be performed only once a week. Further, the data will be stored in Amazon S3 storage services to ensure scalability and availability.

Vendor Selection

Reconstruct's software solution was selected for this project because Reconstruct is an industry leader and all in one solution for construction monitoring. The software solution is integrated with Autodesk 360, making it easy for Gloco to upload the BIM file from Autodesk. It also integrates with Procore which is Gloco's software for project management.

Reconstruct is the only solution that supports all forms of reality capture data. It can take any sort of data captured from IoT devices and integrate them together into an accurate digital twin. There is no pre-processing of the data required by Reconstruct making data collection and management simple and straightforward. Reconstruct is also the only platform that creates floor plans from videos. This means workers can simply walk through the site with any device (phone, camera etc) and upload it to Reconstruct which can turn it in to a 360-photo tour, 3D model, and map of the site.

Reconstruct's digital twins provide an accurate picture of the construction site at any given point in time, enabling remote monitoring and thus saving construction companies millions of dollars in errors. Furthermore, the back-end integration of Reconstruct and Amazon Dynamo DB offers scalability. Therefore, a large volume of drone photography could be stored for processing on the Dynamo DB. Finally, Reconstruct is a cloud-based solution which provides 99.99% uptime. This enables continuous around-the-clock monitoring of the construction sites.

During vendor selection we identified a cutting-edge technology that used Neural Radiance Fields (NeRF) rather than photogrammetry in creating digital twins; however, there are no vendors that currently provide NeRF for creating digital twins in the construction space. NeRF is a newer AI technology that uses a cutting-edge machine learning model to encode color and opacity at every point and orientation in the 3D scene (reconstructinc.com). NeRF is going to be the future of digital twin solution as photogrammetry has holes for bad geometry in texture fewer glossy surfaces. NeRF is in its infancy of development; hence, has scalability and measurability issues. However, future models might be using this AI technology in the construction monitoring industry and Reconstruct is considering using NeRF in future software development versions.

Architecture Integration with Existing Systems Landscape

The new remote construction monitoring solution using Reconstruct will be integrated into Gloco's existing systems landscape as an "Enhancement Project." The enhancement will augment the current systems with

advanced capabilities without replacing the existing infrastructure. The integration focuses on enhancing the functionality and efficiency of current processes by leveraging Reconstruct's advanced technology stack. The product description for Reconstruct software is provided in Appendix 14: Reconstruct Platform Product Description

Enhancement	Existing Systems	Enhanced Solution Fit	Responsibility
BIM Integration	Gloco's BIM solution (Autodesk 360) provides comprehensive 3D architectural drawings, specifications, and 2D/3D plans.	Reconstruct supports bidirectional integration with Autodesk 360, allowing smooth data exchange and automatic ingestion of BIM models in .obj or .ifc formats for digital twin creation.	Skyline: Integration with BIM
Automated Data Capture Integration with Advanced Technologies (Weekly)	Traditional data capture with mobile phone camera and manual inspections.	Enhances data capture capabilities with 360-degree cameras, drones, lidar scanners, and laser scanners for real-time site data, essential for creating accurate digital twins.	Gloco: Procurement and installation of advanced data capture technologies. Skyline: Integration
Enhanced Data Processing and Storage	Basic local servers or cloud storage solutions.	Utilizes cloud-based storage (AWS) for scalability and reliability, with Amazon Dynamo DB handling large volumes of data.	Gloco: Procure Cloud Services Skyline: Integration
Automated Monitoring and Reporting	Monitoring and reporting rely on manual processes and periodic updates.	Provides monitoring and automated reporting tools, with advanced analytics for continuous updates, anomaly detection, and outcome prediction. Please refer to the section Functional and Non-Functional Requirements for more details	Skyline
Collaboration and Communication Enhancement	Traditional communication methods (email, phone, on-site meetings).	Enhances collaboration with tools integrated into the Reconstruct platform, ensuring easy data sharing and access via Oracle Aconex, promoting transparency and efficient decision-making.	Skyline
Security and Compliance	Basic or fragmented security measures.	Ensures robust security with identity and access management, encryption, and compliance with data handling standards, aligning with Gloco's security and compliance needs.	Skyline

Deployment Model

Reconstruct is a cloud-based application requiring no on-premises installation. The app is hosted through AWS Cloud and is delivered through the web application www.reconstructinc.com. The software is SAAS based software and is charged based on consumption. This enables smaller construction companies to utilize the software without investing in heavy on-premises infrastructure. The only investment required to optimally run the software are as follows:

- Internet Speed: Internet speed is important to transfer the data from the devices to the database. However, when network speeds are not optimal, the devices can connect through 5G, 4G or 3G networks using cell towers. An internet speed of at least 30 Mbps for simple projects and 1Gbps for ultra-complex projects.
- Laptop Memory: The recommended laptop memory is 16 Gb as some datasets are saved on the computer when the web application is being used.
- Graphics Card: A dedicated graphics card is also recommended for seamless use.
- Browser: Firefox or chrome browsers are the preferred browser to use when logging into the Reconstruct app. Chrome is not preferred when using a windows-based computer as the data limitation per tab is 4Gb.

System Metrics

- Availability: The software will have a 99.999% uptime as its hosted-on AWS cloud and the SLA provided by AWS is 99.999%
- User Access: The software has no limitations on the numbers of users. The system has managed more than 300 users on large-scale construction projects.
- Site Monitoring Size: The software does not have a limitation on the number of square feet it can monitor. Reconstruct recently measured an 89,500 sqft (about the area of a Manhattan city block) powerplant site.
- Image and Video Size: Reconstruct integrates with Amazon Dynamo DB and Amazon S3 storage for storing images and videos. Amazon Dynamo DB is used for metadata storage rather than large files which will be stored in S3. Alerts are set for database administrator in case the data captured exceeds 100 GB during the weekly data capture.

Data Design and Management

The data involved in a construction project includes heterogeneous data such as contracts, blueprints, schedules, images, videos, scans, reports etc. In this section the formats involved in a construction monitoring project and the data architecture and workflow are discussed.

Overview

The data design and management for the construction monitoring project includes a comprehensive approach to capturing and integrating various data objects essential for effective site project monitoring. The key data objects include 360-Degree Images/Videos, Aerial Images/Videos, Laser Scans, Lidar Scans, BIM Models, Point Cloud Models (PCM), Mesh Models, Geolocation Data, Reality Capture Data, Processed Data, Analytics Data, Compliance Data, Reporting Data, Integration Data, User Interaction Data. Real-time data capture utilizes 360-degree images, videos, drone footage, and laser scans, all tagged with geo-location and timestamps, to provide an accurate and up-to-date view of the construction site. These inputs feed into the digital twin creation process, which integrates real-time updates, BIM models, point cloud, and Lidar data to create dynamic 3D models.

The data format table in Appendix 10: Data Formats provides an overview of the various data objects utilized in the construction monitoring project, along with their descriptions and formats. It includes 360-degree images/videos captured using 360-degree cameras, aerial images/videos from drones, and detailed point cloud data from laser and lidar scans, all of which contribute to creating a holistic view of the construction site. BIM models and point cloud models (PCM) represent the 3D architectural drawings and models of the building, while mesh models add texture for photorealistic representations. Geolocation data embeds GPS and INS information, providing spatial context. Please refer to ‘Appendix 5: Data Objects’ for details on expected data objects as part of the construction monitoring project. Also, for data formats please refer to ‘Appendix 10: Data Formats’ for details of file extensions.

Data Components, Layers and Data flow

Key Data Components:

***Common Data Environment (CDE)**:* Data is organized, centralized, and made accessible through the CDE, which Reconstruct hosts via a cloud and acts as a single source of truth. The CDE acts as a secure repository where all stakeholders can access, update, and contribute to the data. It enforces data consistency and version control while promoting collaboration.

Data Integration: The Digital Twin serves as a nexus for data integration. The digital twin aggregates data from diverse sources, including point clouds, spreadsheets, BIMs, IoT sensors, GIS data, and more. This aggregation process ensures that a holistic view of the asset is created by combining spatial, design, operational, and environmental data.

Machine Learning and AI Integration: Reconstruct's software uses machine learning to be able to identify objects, to determine which materials are in the picture. The software also enables predictive analytics, anomaly detection, and optimization.

Digital Twin as Data Visualization Hub: Reconstruct converts the data into a visual representation of the construction site. Users can explore 3D models, interactive dashboards, and other visual elements. Because all required data is in one place, comments and updates are visible to everyone immediately, enabling better communication and faster decision-making.

As you can see from the diagram below, all the data processing is done by Reconstruct. Its ability to take any type of file (jpg, OB7, E57) and pull specific info out (like data points, GPS, object recognition) and integrate it all together to provide an accurate model of the construction site is a game-changer in construction project management. This seamless integration of various data types ensures that stakeholders have a reliable and comprehensive view of the site, facilitating better decision-making and efficient project execution.

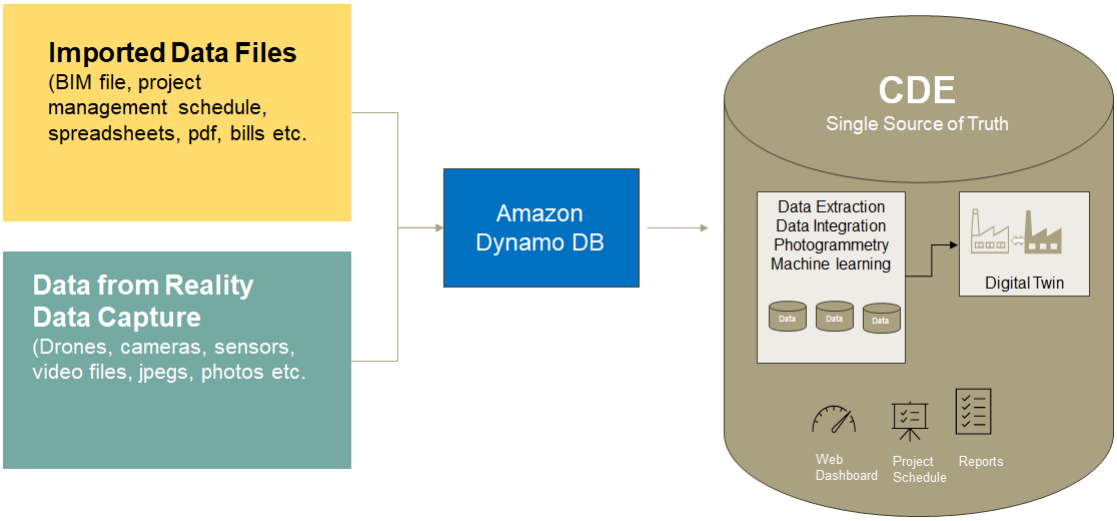


Figure: Key Data Components

The data is acquired, transmitted, processed, and presented at different levels as shown in the table below:

Layer	Description
Data Acquisition	Capturing dynamic data from the physical environment using 360-degree cameras, drones, laser scanners, and lidar scanners.
Data Transmission	Processing and transporting raw data from the data acquisition layer using WLAN, Wi-Fi, Bluetooth, 5G, 4G and other network technologies.

Data Processing	Reconstruct filters data for noise reduction, and transformation of raw data into usable formats. This includes point cloud generation, object recognition, and 3D model creation.
Digital Modelling	Integrating data from the environment and BIM data through data fusion techniques to create accurate digital twins.
Analytics and Monitoring	Applying advanced analytics to monitor construction progress, detect anomalies, and predict outcomes. Continuous real-time monitoring of the construction site.
Service	Providing the virtual representation of the data in the form of a digital twin. Includes visualizations, reporting, and alerting functionalities.

Further, the data flow diagram for key data items and flow at various levels is shown in the Figure: Data Flow Diagram below:

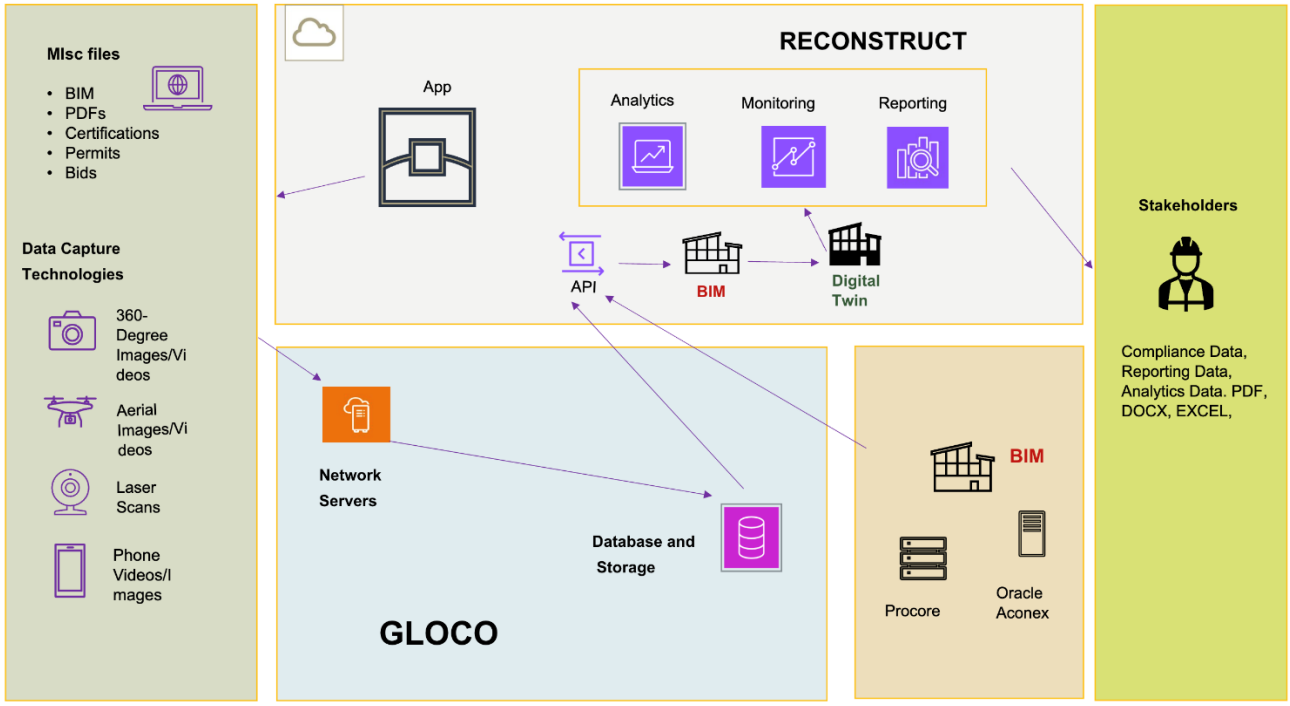


Figure: Data Flow Diagram

The different types of data that are stored, processed, transmitted, and presented across different components of the architecture is shown in the following table:

Item	Data
Database	Image/Video Data, 3D Model Data, Progress Report Data, Alert Data, Issue Data, Compliance Data, Monitoring Data, Integration Data, Access Logs
Storage	Raw and Processed Images/Videos, 3D Models and Meshes, Backup and Archive Data,
Data Presented on Websites/ Mobile App	Real-Time Monitoring Dashboards, Progress Reports, Compliance Reports,
Transactions	Alerts, Task Assignment, Data exchanged between Reconstruct and other integrated systems

IMPLEMENTATION PLAN

Solution Delivery Roadmap

The implementation plan for Gloco's remote construction monitoring project is structured in a phased manner to ensure a smooth transition to an advanced, integrated platform using Reconstruct's technology stack. The implementation plan encompasses a) high-level roadmap, b) implementation plan details, c) data migration considerations and d) transition plan. The structured approach is divided into four stages: Design, Develop, Test, and Deploy, each with specific phases, deliverables, and timelines. Further, Skyline will provide 6 months of post implementation support.

Roadmap

The high-level roadmap provides a visual representation of the project timeline, outlining key milestones from project initiation to full deployment and ongoing support. The post-implementation support is provided by Skyline in Phase D2: Post Implementation Support and Maintenance for a period of 6 months. The High-Level Roadmap ensures that all stakeholders understand the project's progression and critical checkpoints.

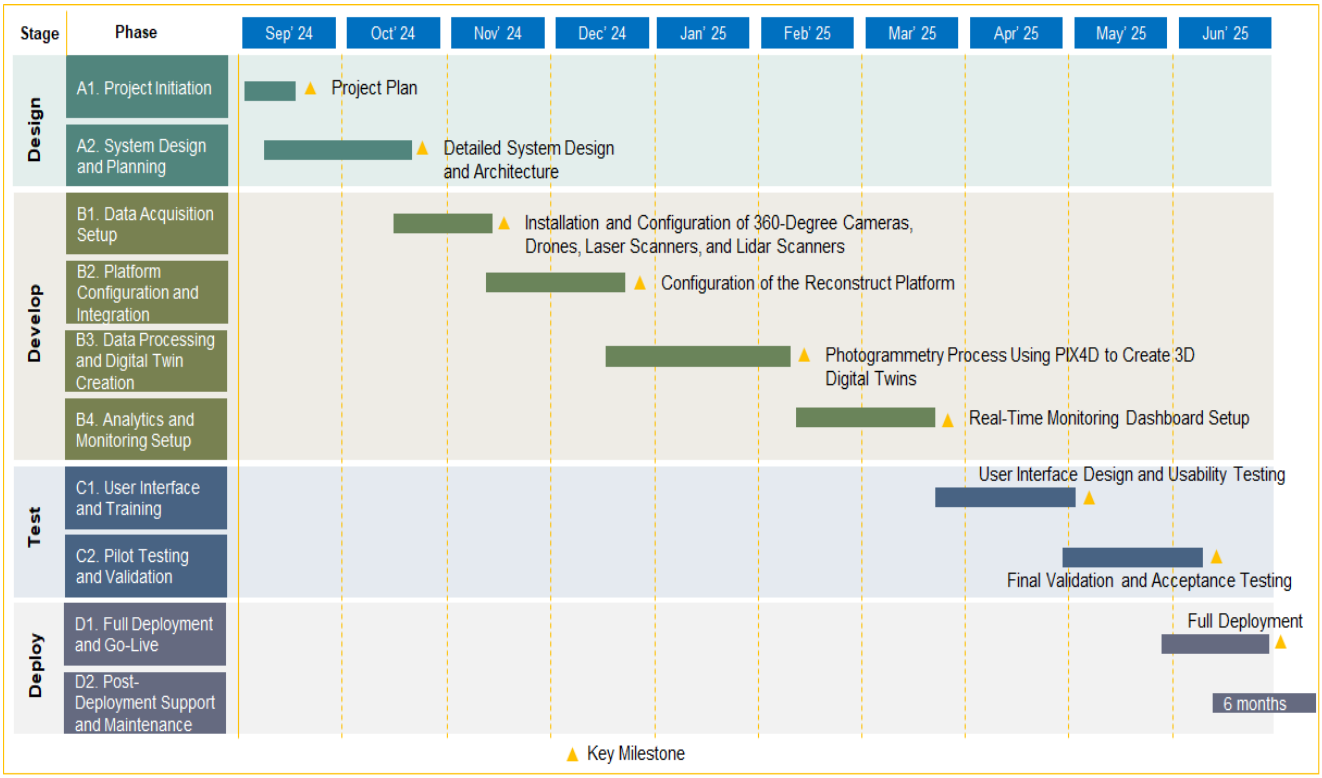


Figure: High-Level Roadmap

The implementation plan is segmented into four stages of software development life-cycle framework 'A. Design', 'B. Develop', 'C. Test' and 'D. Deploy'. The four stages are further divided into phases and deliverables as shown in the table below:

Implementation Framework	Implementation Phase	Key Deliverables	Timeline
A. Design	A1. Project Initiation	1. Project Charter for Gloco	2 - 3Weeks

Implementation Framework	Implementation Phase	Key Deliverables	Timeline
		2. Stakeholder Identification (Refer to 'Account provisioning, roles, and responsibilities' section) and Communication Plan 3. Initial Requirements Gathering and Analysis 4. Project Plan with Milestones and Timelines	
	A2. System Design and Planning	5. Detailed System Architecture Design 6. Data Flow Diagrams, Data Models and Migration Plan 7. Integration Plan with Existing Systems 8. Security and Compliance Plan 9. Procurement Plan for Hardware and Software	3 - 4 Weeks
B. Develop	B1. Data Acquisition Setup	10. Installation and Configuration of 360-Degree Cameras, Drones, Laser Scanners, and Lidar Scanners 11. Data Capture Standard Operating Procedures (SOPs) 12. Initial Test Data Captured and Validated 13. Training Materials and Sessions for Data Capture Personnel	2 - 3 Weeks
	B2. Platform Configuration and Integration	14. Configuration of the Reconstruct Platform 15. Integration with BIM (Autodesk 360), Procore, Oracle Aconex, Gloco Database 16. Customization of the Reconstruct Mobile App for On-Site Data Capture	4 - 5 Weeks
	B3. Data Processing and Digital Twin Creation	17. Setup of Reconstruct for Photogrammetry and Digital Twin Creation	3 - 4 Weeks
	B3. Analytics and Monitoring Setup	18. Configuration of Analytics Tools on the Reconstruct Platform 19. Real-Time Monitoring Dashboard Setup 20. Automated Reporting and Alerts Configuration 21. Compliance Monitoring and Reporting Setup	3 - 4 Weeks
C. Test	C1. User Interface and Training	22. Customization of Web Portals and Mobile Apps for Gloco 23. User Interface Design and Usability Testing 24. Training Sessions for Project Managers, Site Supervisors, Compliance Officer, and Sales Manager 25. Develop User Manuals and Quick Reference Guides	3 - 4 Weeks
	C2. Pilot Testing and Validation	26. Pilot Testing on a Selected Gloco Construction Site. Refer to Appendix 1: Project Card for site details [part 1 submission] 27. Refinement and Optimization of System Based on Pilot Feedback 28. Final Validation and Acceptance Testing	3 - 4 Weeks
D. Deploy	D1. Full Deployment and Go-Live	29. Full Deployment of the Reconstruct Platform 30. Go-Live Support and Monitoring 31. Post-Implementation Review and Adjustments	2 - 3 Weeks
	D2. Post-Deployment	32. Ongoing System Support and Maintenance Plan 33. Regular System Updates and Enhancements 34. Performance Monitoring and Optimization	6 months

Implementation Framework	Implementation Phase	Key Deliverables	Timeline
	Support and Maintenance	35. Continuous Training and Support for Users	

Data Migration Considerations

Data migration is a critical component of the implementation plan, to ensure that the data from Gloco to Reconstruct is accurately transferred and processed. The following table provides the data migration considerations at different stages of the implementation.

One of the reasons that Reconstruct was selected was because it can handle raw data from videos, pics etc. without needing to be pre-processed. This aids in the implementation process since data can go right from the database to Reconstruct without needed action.

Framework Phase	Implementation Phase	Data Migration Considerations	Responsibility
A. Design	A1. Project Initiation	*Backup Existing Data:* Ensure all existing data is backed up securely to prevent any data loss during migration.	*Gloco*
	A2. System Design and Planning	*Create Migration Plan:* Develop a detailed migration plan for data not captured with Reconstruct App. The migration plan should outline the steps, timelines, resources, and responsibilities. *Define Data Mapping:* Identify the data fields to be mapped to the Reconstruct Platform. The details of the data objects and data formats are provided in Appendix 5: Data Objects in the To-Be Process and Appendix 10: Data Formats [Part 2 Assignment Submission]	*Skyline*
B. Develop	B1. Data Acquisition Setup	*Validate Data:* Perform data validation checks to ensure the accuracy and integrity of the migrated data. Data validation includes comparing records, checking for completeness, and verifying data formats.	*Skyline*
C. Test	C2. Pilot Testing and Validation	*Integration Testing:* Test the integrations between the new system and the BIM, project schedule and data captured form site to ensure seamless data flow and interoperability	*Skyline*

Transition Plan to Reconstruct Platform

Retiring the old manual construction monitoring process at Gloco involves a structured transition plan to ensure a smooth shift to the new automated system provided by Reconstruct. The structured approach helps in validating the new system, gaining Gloco's confidence, and ensuring no disruption to ongoing projects. It is important to note that Gloco should continue to carry on its current operations until the implementation project is complete.

Phase	Activities	Details
Parallel Operation	Parallel Operations for 6-12 months	Gloco continues using manual construction monitoring while the Reconstruct system is used in parallel. The manual and automated

Phase	Activities	Details
		monitoring outputs are reviewed to ensure that Reconstruct meets all requirements before full transition.
Training and Support	User Training	Skyline will provide training for project managers, site supervisors, compliance officers, etc. on using and operating the Reconstruct platform. The framework is a train-the-trainer model.
	Support	Skyline will provide support for 6 months with a dedicated team to assist Gloco users with the Reconstruct system.
Reconstruct Digital Twin	Software Solution	Skyline will work with Gloco's architects to ensure BIM is integrated. Skyline will ensure that Reconstruct produces an up-to-date digital twin for Gloco.
Data Capture	Continuous Data	Skyline's Site Data Engineer will visit Gloco's construction site once per week to (on Fridays) to ensure data capture and data upload to Reconstruct (up to 6 months).
Gradual Phase-Out of Manual Processes	Step-by-Step Reduction	Gradually reduce reliance on manual processes by decreasing frequency of manual data collection by Gloco Personnel.
Final Transition	Final Validation	Skyline to conduct a final validation and acceptance test before the official cut over to ensure all stakeholders are satisfied.
	Official Cutover	Transition to Reconstruct system for all monitoring activities and Gloco announces retirement of manual process.

Operationalization

Currently, Gloco has a BIM model from Autodesk 360 to track project files that have the CAD drawings of the site that needs to be developed. Also, in the current situation, Gloco does not use drones and scanners to monitor site progress. Instead, the company uses manual reporting to report project progress. Moreover, the company has most of its scheduling done on the Procore software for scheduling and Oracle Aconex for compliance and collaboration.

The implementation of the Reconstruct software will enhance the operations of Gloco. To ensure a smooth transition to the new monitoring software a phased implementation of the Reconstruct Software is proposed in the Solution Roadmap section of this report. The implementation of the new software will create shifts in workflow, changes in job profiles, and reassignment of access rights. Further, the change will incorporate intense training on the new platform along with the change in cultural mindset.

Account provisioning, roles, and responsibilities

To lead a smooth transition of the systems, account provisioning roles and responsibilities need to be well defined. Gloco's existing BIM model has an active directory for all users that have access to the files. The people that have access to the BIM files in the existing environment are the site supervisor, the engineering department and the C level management team.

New users can be added to the active directory. Site workers would be given a user id and password to login on to the Reconstruct app to capture data from the site. Skyline will implement a user onboarding workflow and process with Gloco, which will ensure new users are added seamlessly and old employees are retired from the system. There would be multiple users in the active directory and the users' roles, responsibilities, and access in Gloco is defined in the table below:

Role	Responsibilities	Permissions to Assign
Gloco Civil Engineers Project Managers	▪ Complete the BIM Model in Autodesk 360. ▪ Ensure each drawing element is documented in the BIM file	▪ Edit and view rights to the BIM files ▪ Edit and view rights to reconstructs BIM file data source
Gloco Site Supervisor Project Managers	▪ Visits site to ensure videos are captured by team members ▪ Update construction notes to the Reconstruct software ▪ Ensure construction is on schedule with Reconstruct	▪ View rights to the BIM files ▪ Edit and view rights to the notes add on module on Reconstruct ▪ View rights to Reconstruct scheduling system ▪ View rights to video uploaded content ▪ View Digital Twin
Gloco C Level Management Project Managers	▪ View projection completion status with the 3D digital twin ▪ View cost control dashboard ▪ Ability to view detailed videos	▪ View rights for Reconstructs 3D model. ▪ View rights to Reconstruct scheduling system ▪ View rights to video content, ▪ Edit rights available upon additional sign on
Gloco Construction Worker et al.	▪ Weekly tasks of uploading images and videos using Construct app.	▪ Uploading rights on Reconstruct App ▪ Ability to view 2D maps of recorded locations on the site. ▪ Further rights given by Gloco.
Skyline Sync Data Engineer	▪ Monitor API Integration of the Amazon database and Reconstruct ▪ Visit onsite to ensure data capture ▪ Check weekly updates of data from AWS server to Reconstructs Server.	▪ Access to AWS database owned by Gloco ▪ Access to Reconstruct back-end data source feed with Gloco's user admin.
Gloco Cloud Engineer	▪ Ensure health and encryption of AWS datacenter. ▪ Ensure API availability and connection with Reconstruct ▪ Create different database buckets for varying video feeds from the drones and lidar sensors. ▪ Manage the data capture of construction site.	▪ Access to AWS account ▪ Access to Reconstruct back-end data source feed with Gloco's user admin.
Reconstruct Account Manager	▪ Ensure data connection between the Amazon Dynamo DB and Reconstruct ▪ Ensure Reconstruct App data is being fed in the right manner ▪ Highlight datapoints that might be required to be captured to avoid data leakage.	▪ Access to Reconstruct admin console ▪ Access to Reconstruct App admin console

Role	Responsibilities	Permissions to Assign
	▪ Assist with user right creation and access issues ▪ Ensure Digital Twin is accurate and accessible to users	
Gloco User Admin Manager	▪ Has super admin rights to assign users and remove them once they stop working ▪ Ensure monthly audits of active directory	▪ Access to admin console of Reconstruct for assigning user rights.

Data Management

The data will be owned and controlled by Gloco. Gloco will ensure that each device (drone, lidar scanning device etc.), is connected to its Amazon DB and has its own bucket. Skyline Data Engineer and Gloco Data Engineer will install the Reconstruct API for data transferring. Each Friday, for the first 6 months, Skyline Site Specialist will visit the construction site to oversee data capture and ensure the data is being uploaded to Reconstruct. Then Gloco's cloud engineer will assume the task.

Data Governance

Data compliancy and privacy is important when recording open public spaces and will follow Gloco's cybersecurity policies. There are terms and conditions that each Reconstruct app user must sign before using the app. The signed waiver releases Reconstruct from any liability regarding data capture.

The terms and conditions of Reconstruct are provided in Appendix 13: Terms and Conditions. The terms clearly highlight that the hardware, user passwords and data transmitted over internet is the responsibility of the User (Gloco). Reconstruct does not take any liability for data that is in transit or in the hardware operated by Gloco. The terms and condition also illustrate that the data's intellectual property is owned by Gloco and upon termination of the contract Reconstruct will have the data available for retrieval for a period of 3 months. Furthermore, Reconstruct takes responsibility to maintain data security up to industry standards.

Service Desk

Gloco has its own service desk. The image illustrates the service desk structure, which includes three main components: Gloco Users, Gloco Service Desk, and Third-Party Support from Skyline and Reconstruct. The Gloco users can be any users provided in the section 'Account provisioning, roles, and responsibilities' of this report. The Gloco Service Desk creates a ticket with Skyline Technical support for incident resolution. The Skyline Technical support can reach out to Reconstruct product support in case of new unknown problems.

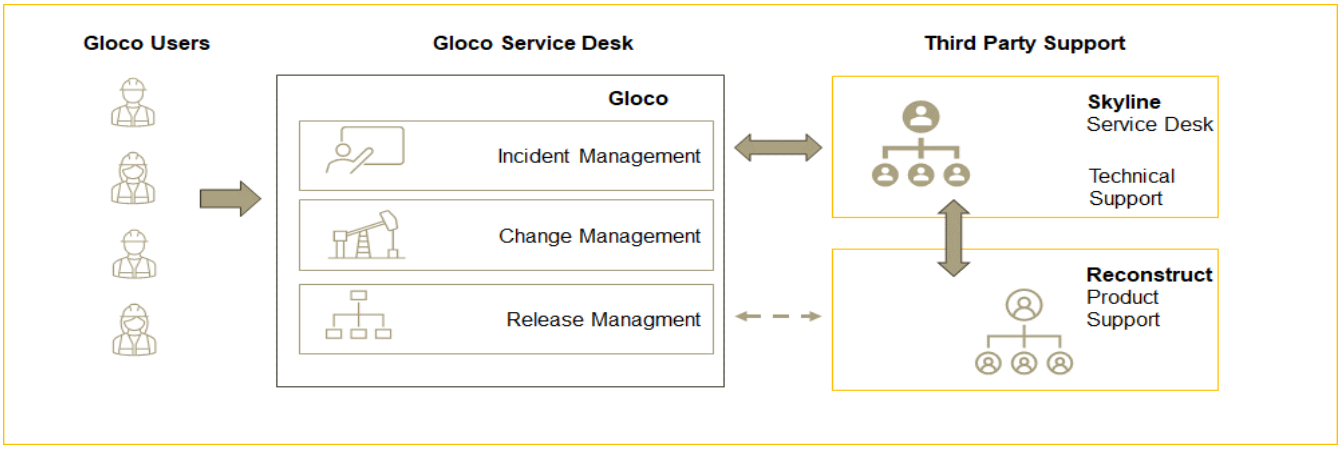


Figure: Service Desk

Incident Management Process

Gloco's service desk involves 3 layers of service depending on the severity of the issue. Service level 3 is targeted for the important issues that can cause major disruption to system use while service level 1 is for minor system issues and service level 2 is for advanced software related issues. The incident management process is based on the ITIL (Information Technology Infrastructure Library) framework.

Service Level 1	Service Level 2	Service Level 3
▪ **Initial response to client issues** ▪ **Ticket logging** ▪ **Documentation of issue** ▪ **Basic monitoring and system resets**	▪ Advance issue resolution-related to data leakage or software glitches identified ▪ Training requirement for certain software complication ▪ Reporting and analysis of system ▪ Stakeholder Communication	▪ Managing adherence to SLA's ▪ Resource allocation to major outages ▪ Process Improvement or changes

Change and Release Management

The fast-paced changes in technology lead to the requirement for constant upgrades to the software. Gloco will be using the ITIL framework to define changes that happen to the software. In addition, the Reconstruct's software is cloud based and therefore most of the changes will be happening in package-based capabilities (PBC). The ITIL Framework for change management defines 3 types of changes:

Changes	Examples
Standard Changes (Preauthorized, low risk)	▪ Adding memory to storage ▪ Replacing hardware for the system ▪ Creating a new database instance
Normal Changes (General changes)	▪ Migrating to a new data center ▪ Performance improvement of Reconstruct
Emergency Changes (Major Incident)	▪ Server Outage ▪ Major security patch that requires immediate change ▪ Major data hacking requires immediate software upgrade.

* Gloco is responsible for keeping all its software and devices up to date and in working order.

Success Metrics

Digital construction site monitoring is a big project that has many moving pieces, however, Gloco will be able to realize the following benefits once the solution is up and running:

Sr. No.	Benefit	Description
1	Enhanced Efficiency	Automated data capture and processing reduce the time and effort required for manual inspections and documentation
2	Improved Quality Control	Remote issue detection and resolution ensure consistent quality across all project phases.
3	Better Communication	Centralized access and real-time updates improve coordination among all stakeholders
4	Cost and Time Savings	Reduced need for physical site visits and manual progress tracking results in significant cost and time savings

As Gloco sees an updated digital twin of its construction process at any given point in time, it will be able to realize the benefits from the implemented solution. The benefits will be quantifiable in terms of cost savings, revenue

growth, improved profit margins, and operational efficiency. In addition, there will be qualitative benefits in terms the ability to remotely monitor progress of a site, to be notified as soon as problems occur which will improve the planning and processes at Gloco and thus, the solution will pay it forward on the next project and the project after in continuation.

Quantitative Success Metrics

Metric	Description	Success Definition	Data Sources
Cost Savings	Reduction in legal fees due to timely payments and fewer disputes	$1,700,000	Financial records, legal expense reports
	Savings from reduced project delays	$2,000,000	Procore Project management software, risk logs/ project delayed reports
Revenue Growth	Increase in project completions and higher revenue	10-15% growth in annual revenue (after 2 years)	Financial statements, project completion reports
	Potential new business acquired due to improved reputation	Acquisition of new projects and clients	CRM systems, sales reports
Profit Margins	Improved profit margins through efficiency and cost savings	Increase in profit margins	Profit and loss statements, operational cost reports
Operational Efficiency	Reduced manual processes and faster task completion	10% improvement in operational efficiency	Procore Time Scheduling reports
Client Retention and Satisfaction	Enhanced customer experience through real-time monitoring and reporting	12% increase in customer satisfaction scores and retention rates	Customer satisfaction surveys, retention rate analysis

Qualitative Success Metrics

The qualitative metrics focus on the operational and implementation aspects of the project. They include system adoption, data accuracy, system availability, digital twin utilization, training effectiveness, report accessibility, and the usage of the Reconstruct software. The qualitative metrics are essential for ensuring that the digital transformation tools and processes are effectively integrated into the company's operations and are utilized as intended.

Metric	Description	Success Definition	Data Sources
Digital Twin Utilization	Successful creation and use of digital twin models	Digital twin available for all major projects	Autodesk 360, Reconstruct platform usage logs
Report Accessibility	Ability to generate and access reports in real-time	100% report generation without errors	Report generation logs, Reconstruct platform, user access logs
Data Accuracy	Accuracy of data captured and processed	Improvement from 80% to 98%	Data validation reports, Reconstruct platform analytics
Project Implementation Metrics	Adherence to project schedules and budget	Project completed on time and under budget	Budget reports from Procore software

Metric	Description	Success Definition	Data Sources
System Adoption	Adoption and usage of the Reconstruct software	Regular usage by Gloco staff	User activity logs, system usage reports, user feedback surveys
System Availability	Uptime percentage of the digital system	99.9% system uptime	System/ Server logs, uptime reports
Training and Onboarding	Effectiveness of user training and onboarding	90% satisfaction rate in user feedback	Training attendance records, user feedback surveys, onboarding completion logs

Business Benefit Realization Roadmap

The business benefit realization timeline for the project, as depicted in the image, outlines a structured progression of key milestones and expected benefits. The completion of data integration in Q4 2024 sets the foundation for the deployment of the Digital Twin Model in Q1 2025. By Q2 2025, the project moves towards remote site monitoring, enhancing oversight capabilities. The introduction of virtual walkthroughs with clients in Q3 2025 signifies an improvement in client engagement and transparency. As the system matures, significant benefits such as improved communication, faster quality checks, and a decrease in project delays are expected to be realized by Q4 2025. By Q1 2026, the project aims to have accrued savings of $3.7 million from project completions, showcasing a return on investment through enhanced operational efficiency and project management.

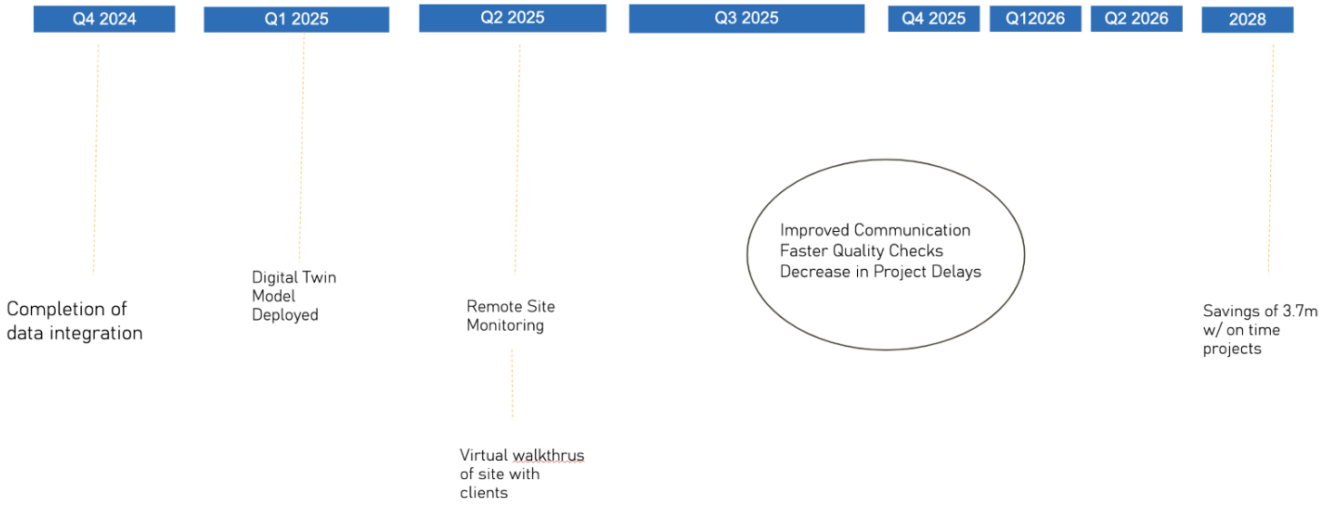


Figure: Business Benefit Realization Roadmap

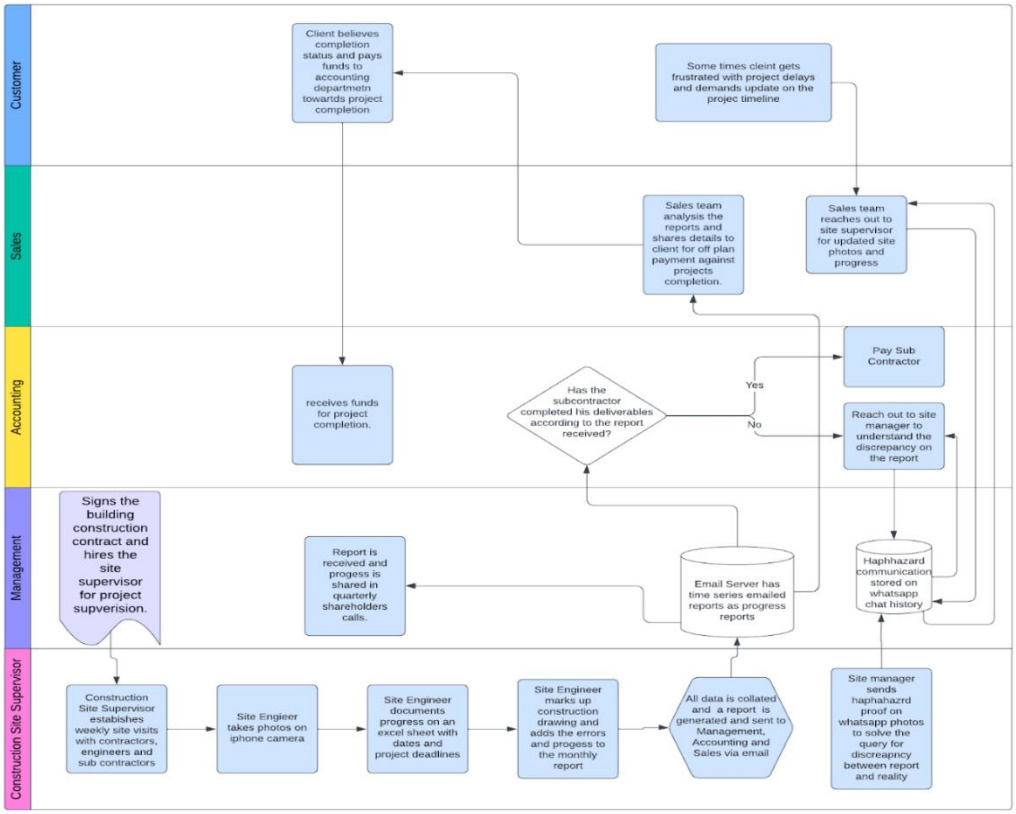
APPENDIX

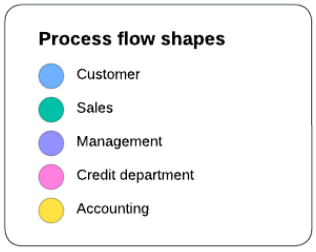
Appendix 1: Project Card

Item	Description
Name of the Construction Project	Downtown Commercial Complex
Start Date	August 1, 2024
Delivery Method	Design- Build
Size	500,000 square feet (about half the area of Chicago's Millennium Park)
Duration of Construction	48 months
Estimated Completion Time	July 31, 2028
Key Roles	
Primary Contractor	Gloco Constructions
Project Manager	John D
Site Supervisor	Jane S
Preferred Solution Provider	Skyline Sync
Regulatory Body	Boston Municipality
Preferred Technology Vendor	Reconstruct

Appendix 2: Current Process

Construction Monitoring Process Flow of Gloco





Detailed Description of the Process:

Contract Signing and Site Management:

Gloco Construction management signs a contract and assigns a site supervisor to manage the day-to-day construction progress.

The site contractor holds weekly progress meetings to document the site progress.

Progress Documentation:

The site manager documents progress on the site through photos and by completing forms regarding progress. Most photos are sourced from workers who share them through WhatsApp. The site manager conducts site walks

every few days to gather updates, but due to the size and time constraints, some areas may be neglected for weeks. Consequently, errors or issues may go unnoticed until much later.

Data Management:

Photos and progress updates are marked against a projected work schedule maintained on an Excel sheet. Progress reports are generated by comparing the expected progress to the actual progress. These reports are then shared with management, accounting, and sales departments. The accounting department uses these reports to approve costs and make payments to vendors. The sales department shares site progress with clients, while management monitors progress and provides updates to shareholders.

Challenges and Issues:

The current process often overlooks errors and omissions on the construction site due to its manual nature and infrequent reporting. Monthly reports create a lag in decision-making, leading to project delays and overlooked key decision inputs that could have mitigated issues earlier. Sub-contractor disagreements, payment delays, and site work halts are common problems.

Accounting and Payment Delays:

The accounting department requires complete reports from the site manager before signing off on payments. Delayed reports lead to delayed payments and dissatisfied subcontractors. This has resulted in mechanics, liens, and legal fees significantly higher than industry standards. Urgent and haphazard communications between the accounting department and site managers often lead to overpayments for substandard work.

Data Management Issues:

The company lacks a central data repository, making it difficult to access archived project approvals. Data is scattered across email servers and WhatsApp backups of various departments. Clients frequently complain about delays, and the sales department coordinates with the site supervisor through phone messages and photos, sharing this data with clients to demonstrate that delays are being addressed.

The sales department has adopted a practice of pitching projects with an upfront six-month delay expectation to manage client expectations.

Workflow Inefficiencies:

The existing workflow makes it challenging to establish a single source of truth. Emailed reports hinder the ability to track the latest ground situation accurately.

Discrepancies between field workers and management decision-makers contribute to a chaotic project environment with inconsistent information flow.

Appendix 3: Themes, Epic and Features of the solution

The themes, epic and features of the solution are provided in the table below:

Theme	Epic	Feature
T1. Monitoring and Reporting	E1. Implement Weekly Progress Monitoring	F1. Weekly Data Capture
		F2. Digital Twin Creation
	E2. Develop Automated Reporting Capabilities	F3. Automated Progress Reports
		F4. Real-Time Alerts and Notifications
T2. Quality Control and Compliance	E3. Enhance Quality Control Processes	F5. Issue Detection and Documentation via the Digital Twin
	E4. Ensure Regulatory Compliance	F6. Real-time Compliance Monitoring via the Digital Twin
T3. Stakeholder Communication and Collaboration	E5. Improve Communication Channels	F7. Single source of truth
		F8. Site Supervisor Monitoring
	E6. Facilitate Remote Collaboration	F9. Virtual Job Site Tours
		F10. Remote Access to Project Data
T4. Project Scheduling and Management	E7. Integrate Construction Scheduling Tools	F11. AI and Machine Learning software to use project schedule to determine if progress goals are being met
	E8. Optimize Resource Management	F12. Reconstruct can track the supplies listed in the BIM as well as worker hours, equipment etc
T5. Integration and Automation	E9. API Integration with Existing Tools	F13. Reconstruct is compatible with Autodesk and Procore
	E10. Automate Routine Tasks and Data Collection	F14. Automated Data Upload and Processing

Appendix 4: User Stories and Acceptance Criteria.

We identified four different users for the project namely Site Supervisor, Compliance officer, Project Manager (PM) and Sales Manager. The following table provides the mapping of features, user stories and acceptance criteria:

Feature	User Story	Acceptance Criteria
F1. Data Capture	U1. As a Site Supervisor, I want to use 360 cameras and drones to capture real-time images and videos, so that I can monitor construction progress.	Data from drones and 360 cameras can be viewed from Reconstruct portal.
F2. Digital Twin Creation	U2. As a Site Supervisor, I want to have a digital twin of the construction site, so that I can visualize the current state of the project remotely.	Given the upload of data, a 3D digital twin is created and accessible in the Reconstruct portal.
F3. Automated Progress Reports	U3. As a PM, I want to receive automated progress reports, so that I can stay updated on the project's status.	Reports regarding how much progress has been made, whether the job is still on schedule are automated in Reconstruct.
F4. Alerts and Notifications	U4. As a PM, I want to receive alerts for any delays or issues, so that I can take immediate corrective actions.	When an issue or delay is detected, an alert is generated and sent to relevant parties.

Feature	User Story	Acceptance Criteria
F5. Issue Detection and Documentation	U5. As a Site Supervisor, I want to document issues directly within the digital twin, so that I can ensure they are tracked and resolved promptly.	Given an issue is identified, when it is documented, then the issue is tagged within the digital twin.
F6. Compliance Monitoring	U6. As a compliance officer, I want to be able to monitor compliance with safety and building codes, so that any discrepancies can be identified and rectified immediately.	Reconstruct tracks compliance with standard compliance rules and the system flags non-compliance issues.
F7. Centralized Communication Platform	U7. As a PM, I want to use a centralized platform for all communications and collaboration, so that I can ensure all stakeholders are on the same page.	Users can add notes to Digital Twin, and these are shown to other relevant parties.
F8. Site Supervisor Monitoring	U8. As a site supervisor at Gloco, I want to have a dashboard that displays progress of all construction sites, so that I can quickly identify any areas falling behind schedule and address issues promptly.	The supervisor has a dashboard which provides an overall status of the progress by comparing digital twin to project schedule and BIM.
F9. Virtual Job Site Tours	U9. As a sales manager at Gloco, I want to provide remote clients with updates and visual progress reports, so that they feel assured of their investment and informed about the progress of their projects.	The sales manager can log in to Reconstruct and generate progress reports that include visual data (photos, videos) and optionally, clients can access a secure portal to view their project status updates.
F10. Remote Access to Project Data	U10. As a PM I want to access project data remotely, so that I can stay informed and involved from any location.	PM can log in to Reconstruct from any location and any device that can access the internet (phone, pc, iPad etc).
F11. Schedule Tracking	U11. As a Site Supervisor, I want to track the construction schedule, so that I can ensure the project stays on track.	Data captured from the site is uploaded to Reconstruct and compared to the project schedule, so that the system can determine whether progress is on track.
F12. Automated Task Management	U12. As a Site Supervisor, I want to automate task assignments and tracking, so that I can ensure tasks are completed on time and efficiently.	Site Supervisor can create automated tasks in Reconstruct.
F13. Digital Twin Integration	U13. As a Project Manager, I want to integrate Reconstruct with tools like Autodesk (BIM), compliance software etc., so that I can have a virtual representation of the site for better planning and management.	Reconstruct can upload the BIM from Autodesk360 and the schedule from Procore. Also, any changes made in Autodesk or Procore are shown in Reconstruct.
F14. Automated Data Upload and Processing	U14. As a Site Supervisor, I want to automate the upload and processing of reality capture data, so that I can reduce manual data handling and errors.	Data from capture tools (drones, phones etc) can be automatically uploaded to Reconstruct on a repeated basis.

Appendix 5: Data Objects in the To-Be Process

The following table provides the data objects expected to be captured in the To-Be Process:

Sr. No.	Category	Data Object	Description
1	Data Capture	Image/Video Data	Geo-tags (latitude, longitude), Timestamps, Altitude (for drone data), Camera/device ID
2	Digital Twin Creation	3D Model Data	Real-time updates, BIM integration, Point cloud data, Lidar data
3	Automated Progress Reports	Progress Report Data	Milestones achieved, Current status vs. planned schedule, Issues detected and resolved, Resource utilization, Time-stamped progress records
4	Real-Time Alerts and Notifications	Alert Data	Type of alert (delay, issue, compliance breach), Time of alert, Detailed description, suggested corrective actions, Alert status (new, acknowledged, resolved)
5	Issue Detection and Documentation	Issue Data	Description, Photos and videos, Geolocation, Time of detection, assigned personnel, Status (open, in-progress, resolved), Resolution steps and comments
6	Compliance Monitoring	Compliance Data	Inspection results, Building code adherence, Audit trails, Non-compliance flags, Time-stamped records, Compliance reports
7	Centralized Communication Platform	Communication Data	Messages, Shared files, and documents, Timestamps, Participants, Discussion threads and history
8	Site Supervisor Monitoring	Monitoring Data	Real-time site progress, Schedule deviations, Site activity logs, Resource status, Alerts, and notifications
9	Virtual Job Site Tours	Tour Data	Visual data (photos, videos), Progress snapshots, Client access logs, Comments and feedback, Virtual tour sessions
10	Remote Access to Project Data	Access Logs	User login data, Time of access, Accessed data (reports, models, logs), User actions (view, download, comment)
11	Schedule Tracking	Schedule Data	Current vs. planned schedule, Delays and deviations, Task status, Updated timelines, Rescheduled tasks
12	Automated Task Management	Task Data	Task descriptions, assigned personnel, Start and due dates, Status (not started, in-progress, completed), Notifications (upcoming, overdue), Task dependencies
13	Digital Twin Integration	Integration Data	BIM data overlays, Compliance software data, Real-time updates, Comparison data
14	Automated Data Upload and Processing	Capture Data	Raw data (images, videos, scans), Processing logs, Validation results, Flagged issues, Processed data status

Appendix 6: Users

The user details are described in detail below:

User Type	Users Task	Users Activity
Site Supervisor	Real-time monitoring, Issue detection and documentation, task management	▪ Use 360 cameras and drones to capture site data ▪ Monitor real-time data on the dashboard ▪ Document issues directly within the digital twin ▪ Include photos, descriptions, and geolocation data ▪ Assign and track tasks ▪ Receive notifications for upcoming and overdue tasks
Compliance Officer	Real-Time Compliance Monitoring, Inspection and Reporting, Documentation	▪ Monitor compliance with safety and building codes in real-time ▪ Use the system to flag non-compliance issues ▪ Generate and export compliance reports ▪ Maintain records of compliance data and resolved issues
Project Manager	Project Monitoring and Reporting, Scheduling and Planning, Communication and Collaboration	▪ Receive automated progress reports, ▪ Set up real-time alerts for delays or issues, ▪ Track the construction schedule in real-time, Visualize schedule adherence and highlight delays ▪ Use a centralized platform for all communications ▪ Ensure all stakeholders are informed and aligned
Sales Manager	Client Communication and Reporting, Virtual Job Site Tours	▪ Generate and send progress reports to clients ▪ Include visual data (photos, videos) in reports ▪ Provide clients with remote updates and visual progress reports ▪ Ensure clients can access a secure portal for project status updates

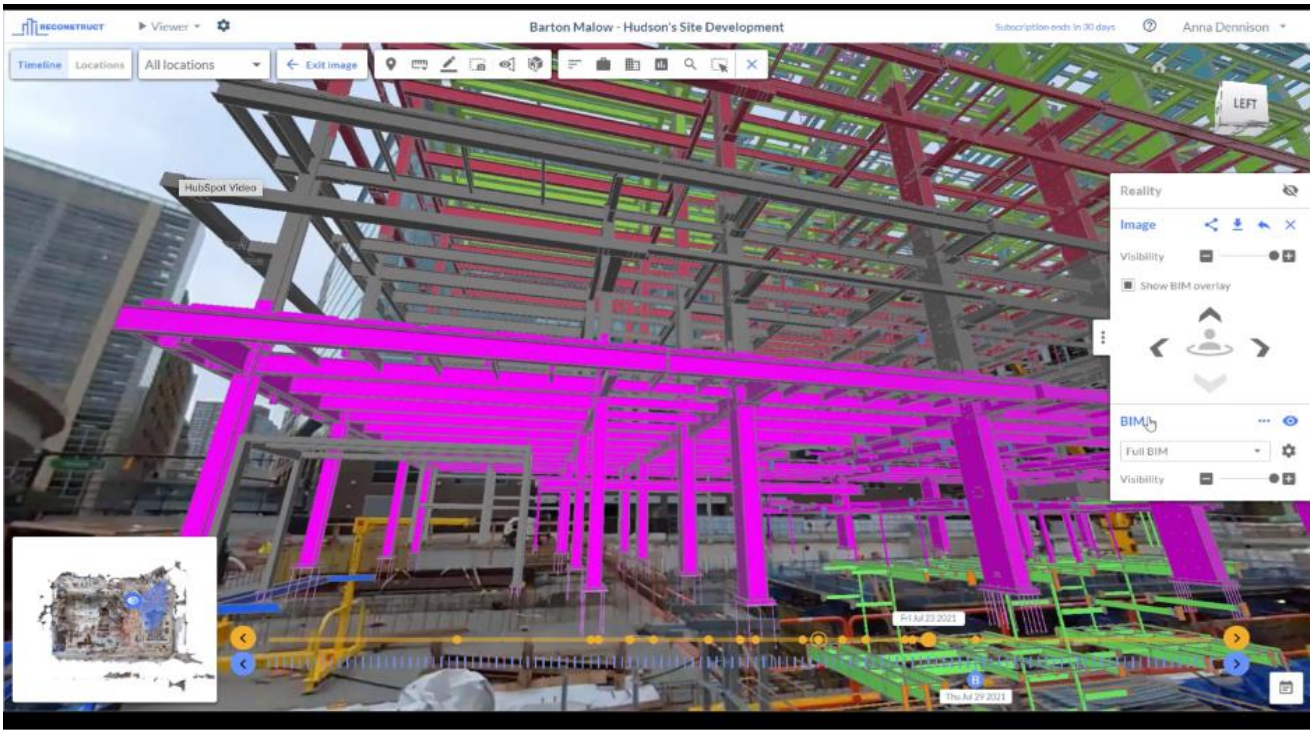
Appendix 7: Tools and Technology

The tools and technologies expected to be used for the project are provided below:

Area	Technology	Description	Scope for Gloco/ Skyline
Mobile Construction Technology	Mobile App Data Capture	Reconstruct's Capture app on Apple or Android devices to provides one way to record the progress on site.	Gloco
Drone Monitoring Services	DJI Mavic 2 Pro	Drone images and videos are uploaded with metadata including time, GPS positioning, and drone height. This assists AI software in reconstructing 3D locations and overlaying orthophotos on site maps.	Gloco
Lidar Monitoring Services	Matterport Pro3 Camera	Matterport Pro3 camera captures high precision measurements and uploads data directly to the Reconstruct portal. The software supports E57 file format for creating detailed 3D models of construction sites.	Gloco
Laser Scanning Services	Faro Focus Laser Scanners	Faro Focus laser scanners provide high precision scanning for quality control tests. Data from Faro Focus is integrated with Reconstruct to create digital twins of construction sites.	Gloco
Solar Site Monitoring Services	Sensera Systems Solar Cameras	Sensera cameras, mounted on cranes, capture time-lapse imagery. This data integrates with Reconstruct to generate 3D point clouds, mesh models, and 2D orthophotos with CAD overlays, ensuring continuous monitoring.	Gloco
BIM Overlay Services	Reconstruct Software, BIM Autodesk 360, Construction Cloud	Reconstruct enables video content to be superimposed on BIM drawings imported from Autodesk BIM 360 or Construction Cloud, allowing stakeholders to visualize real-world conditions over the virtual BIM 3D model.	Skyline/ Gloco
Construction Time Series	Reconstruct Software	Digital images and videos are tagged in a time series to track and visualize project progress over time, facilitating progress monitoring and ensuring timely completion.	Skyline
Construction Scheduling	Procore Construction Management Platform	Procore integrates with Reconstruct for construction schedule and time management, ensuring schedules are maintained and project tasks are organized for smooth execution.	Gloco
Compliance Overview	Reconstruct Software	Reconstruct nables centralized inspection and compliance information and review ensuring adherence to state, county, and federal building codes.	Skyline/Gloco
Virtual Job Site Tours	Reconstruct	Reconstruct Project Snapshot enables remote job site tours for stakeholders. Users can use Reconstruct to create a visual walk through and share a link with anyone, with no login required.	Gloco
API Integration with	Autodesk Platform	Forge API enables seamless data translation across multiple formats, allowing integration with	Gloco

Area	Technology	Description	Scope for Gloco/ Skyline
Construction Software	Services (Forge Model Derivative API)	tools like Autodesk Navisworks, Autodesk Revit, and other BIM solutions for centralized viewing and management within the Reconstruct portal.	

Appendix 8: Interfaces



Appendix 9: Technical Details of Data Capture and Processing

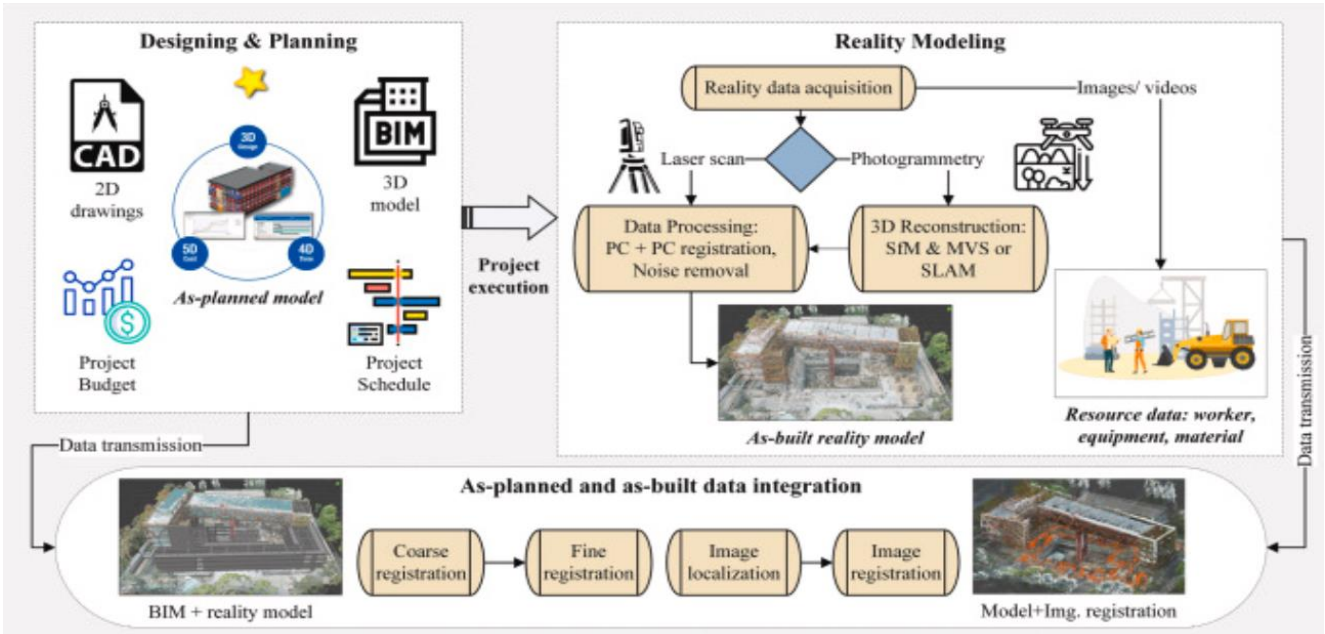


Figure: Reality Modelling

Source: Pal, A., Lin, J. J., Hsieh, S. H., & Golparvar-Fard, M. (2023).

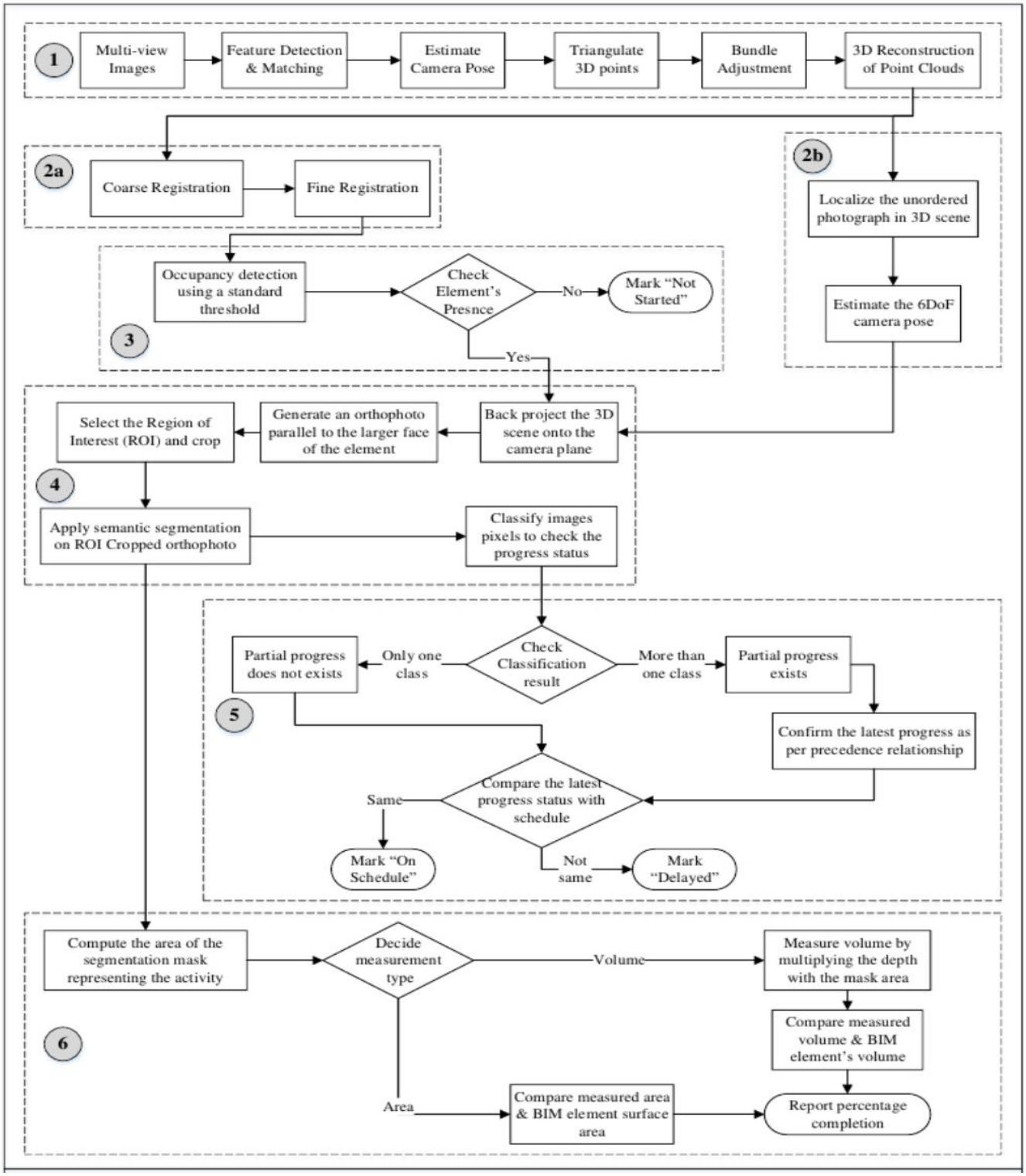


Figure: A Framework for Automated Daily Construction Progress Monitoring

Source: Pal, A, Lin J, & Hsieh, S. (2022).

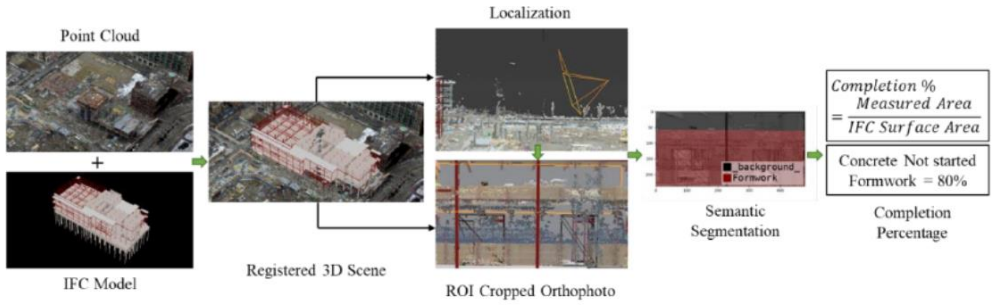


Figure C: Onsite Application Demonstration

Source: Pal, A, Lin J, & Hsieh, S. (2022).

Appendix 10: Data Formats

Data Object	Description	Format
360-Degree Images/Videos	Panoramic visual data captured using 360-degree cameras, providing a comprehensive view of the construction site.	JPG, MP4
Aerial Images/Videos	High-resolution images and videos captured by drones, offering an overhead perspective of the site.	JPG, MP4
Laser Scans	Detailed point cloud data captured by laser scanners, essential for quality control and flatness testing.	E57
Lidar Scans	3D point cloud data captured by Lidar scanners, used for creating detailed and accurate 3D models.	E57
BIM Models	3D architectural drawings and models of the building, including exact specifications and plans.	OBJ, IFC
Point Cloud Models (PCM)	3D models generated from photogrammetry or laser scanning, representing the physical site.	PCD, LAS, E57
Mesh Models	Textured 3D models created from PCMs, making them more photorealistic and suitable for AI object recognition.	OBJ, STL
Geolocation Data	GPS and INS data embedded in images and videos, providing spatial context and positioning information.	GPS, INS
Sensor Data	Data from various sensors, including environmental conditions and structural integrity measurements.	CSV, JSON
Reality Capture Data	Raw data from various capture technologies, including images, videos, and point clouds.	JPG, MP4, E57
Processed Data	Data after initial filtering, noise reduction, and registration, ready for further analysis and integration.	PCD, LAS, E57
Analytics Data	Insights and results generated from analyzing the captured and processed data, including progress status and anomaly detection.	JSON, CSV
Compliance Data	Information related to regulatory compliance, safety standards, and inspection reports.	PDF, DOCX
Reporting Data	Regular updates and detailed reports on project status, generated automatically by the system.	PDF, DOCX
Integration Data	Data is used to facilitate integration with other systems and tools, ensuring interoperability.	JSON, XML

User Interaction Data	Data related to user interactions with the system, including access logs and usage statistics.	CSV, JSONi

Appendix 11: Solution Demonstration

Reconstruct software integrates with BIM Autodesk 360 and can pull in files directly. Exhibit 1 illustrates how a user can upload a BIM file directly into the Reconstruct Application. Once the BIM and Reconstruct are integrated, a user can have a single sign on for both the applications. The second part of the software process involves capturing data. Exhibit 5 and 6 illustrate how the app allows a user to take photos and videos from the capture app developed by reconstruct. The content is then converted into 3D with Reconstructs AI capabilities. Data can also be ingested through API integration between Sensera cameras and AWS Dynamo DB.

Once the data capturing has started, the site inspector can ensure regular uploads of data on the application. This would enable a time series report to be generated by the system. Exhibit 9 illustrates the timeseries user interface for the user. The bottom scroller can be used to see how the site has developed over time. Furthermore, users would be able to compare reality to the 4D BIM Model provided by Gloco. Exhibit 7 illustrates the user interface where the existing site is overlayed on the BIM model. This assists in quickly identifying variance from the predicted site work. A simple toggle button can enable a user to switch between reality and a BIM overlay 3D site. Exhibit 11 shows a reality model and a BIM overlay side by side to illustrate the comparison and progress monitoring capabilities of the system. The user interface is decluttered and intuitive with a single toolbox on the right-hand side. The user can easily navigate the site remotely and see details that would have otherwise required frequent site visits.

The app also allows the user to easily measure angles or distances between different objects as illustrated in Exhibit 10. This can allow an engineer to provide changes and recommendations remotely.

There are other solutions such as scheduling and accounting that are not illustrated in the scope of this demonstration; however, they are key value addons to see if a project is on time and within budget. Exhibit 7 shows how the software tags on schedule and delayed project elements.

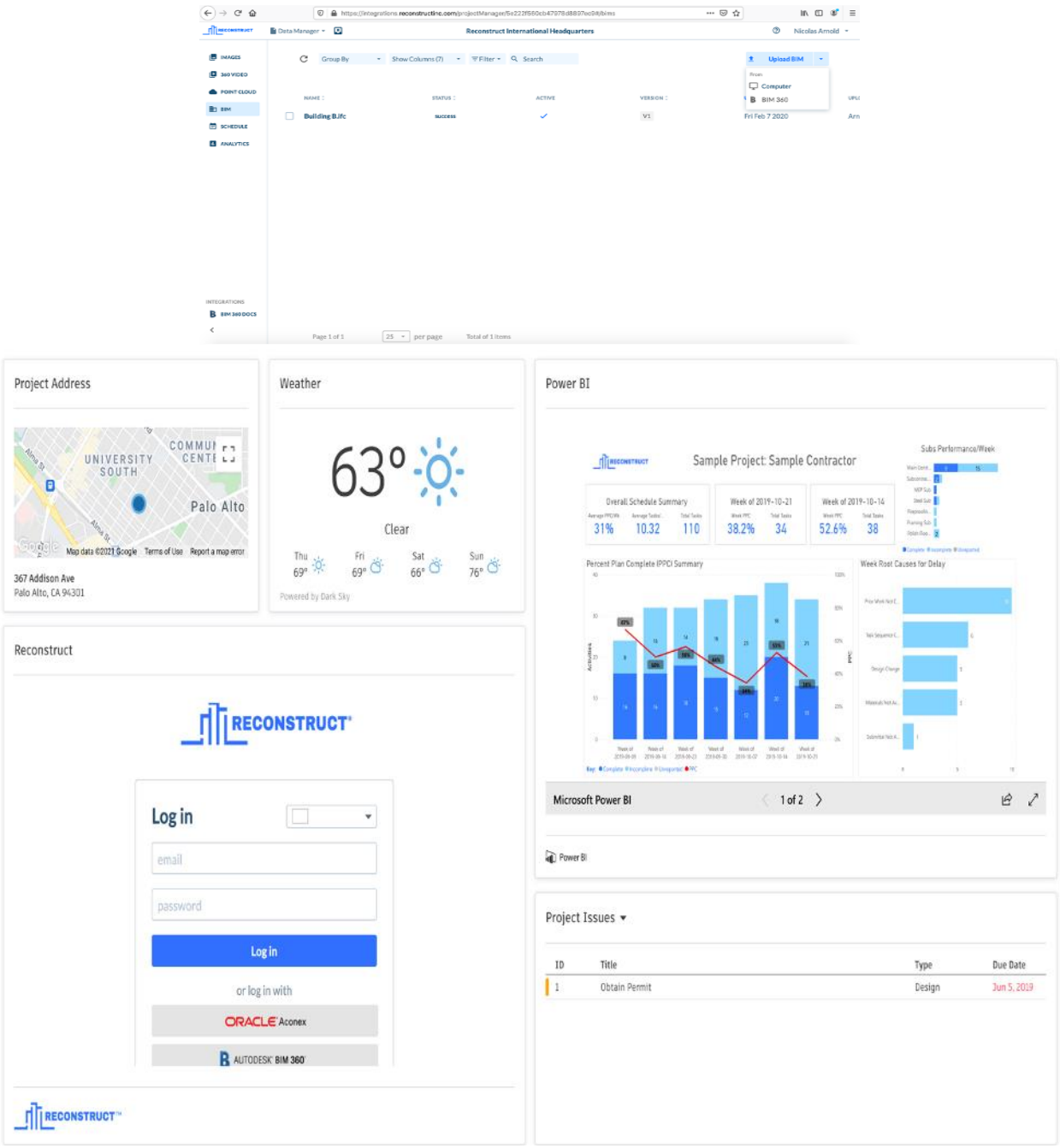


Exhibit 1: Single sign on and integration with Autodesk 360 (Autodesk Website)

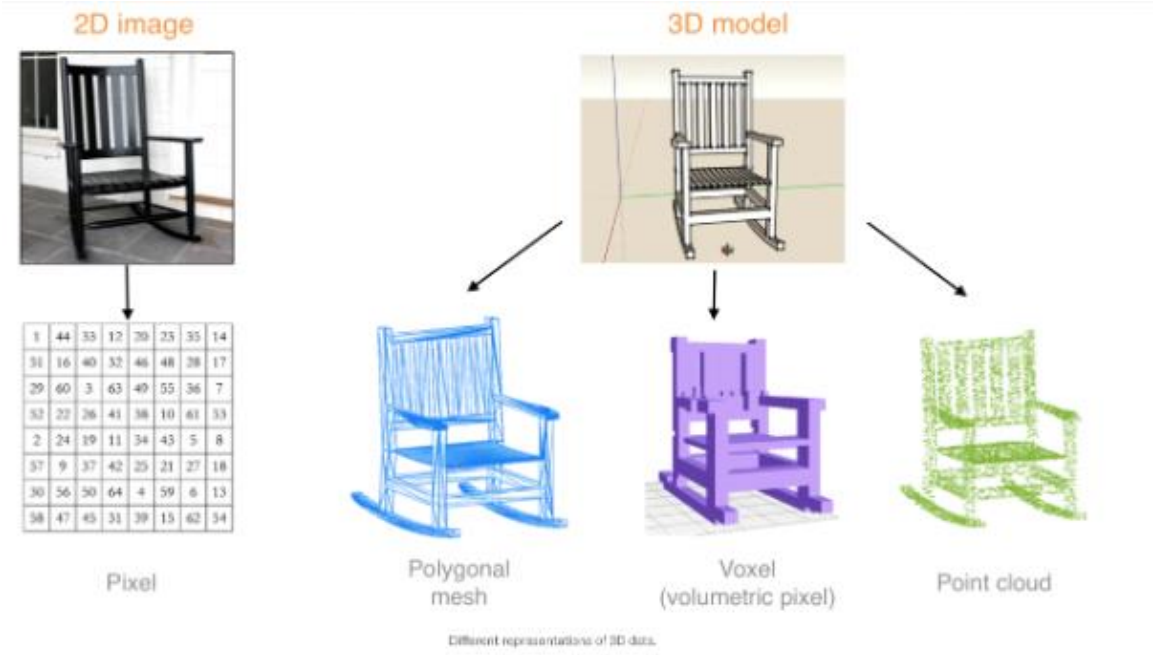


Exhibit 2: 2D to 3D Point Cloud Model (Dolhopolov page 1)

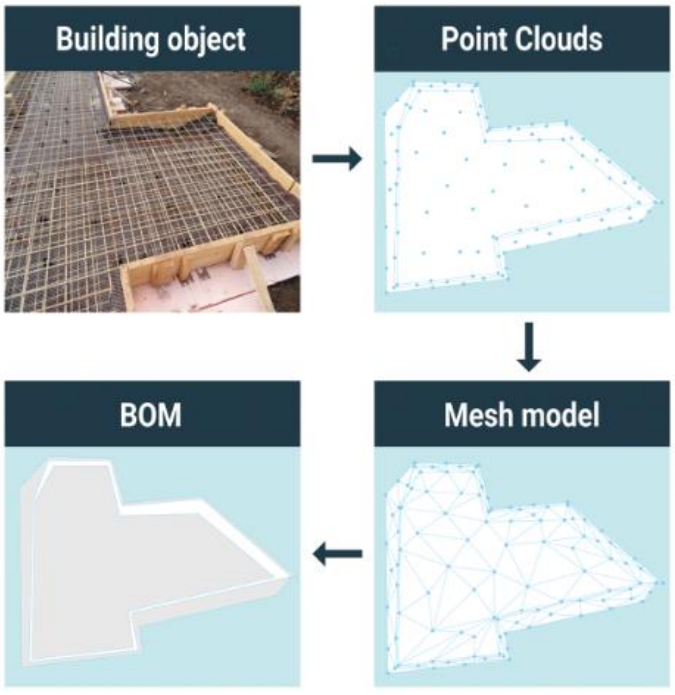


Figure 4. BOM construction using photo modeling and SfM for sample №5.

Exhibit 3: BOM construction from raw image. (Dolhopolov page 5)

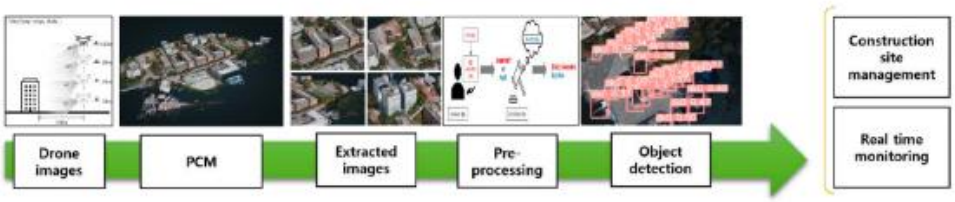


Figure 2. The proposed process of construction site digitalization.

Exhibit 4: Drone Image to Object Detection in 3D (Page 6 Choi)

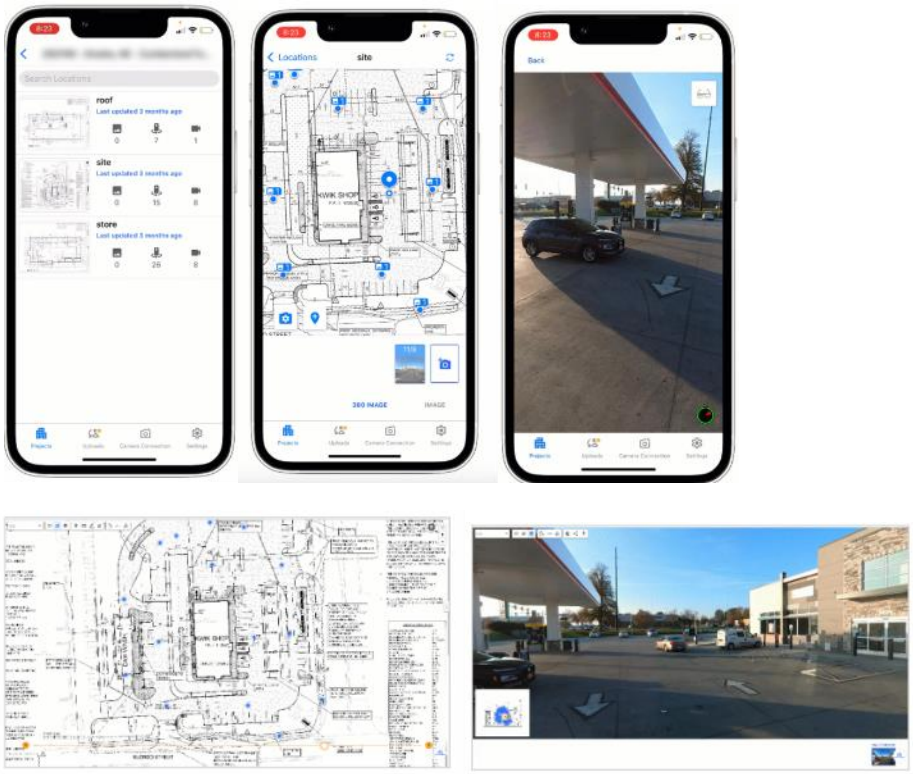


Exhibit 5: Capture App and Web App User Interface (Reconstructinc.com)

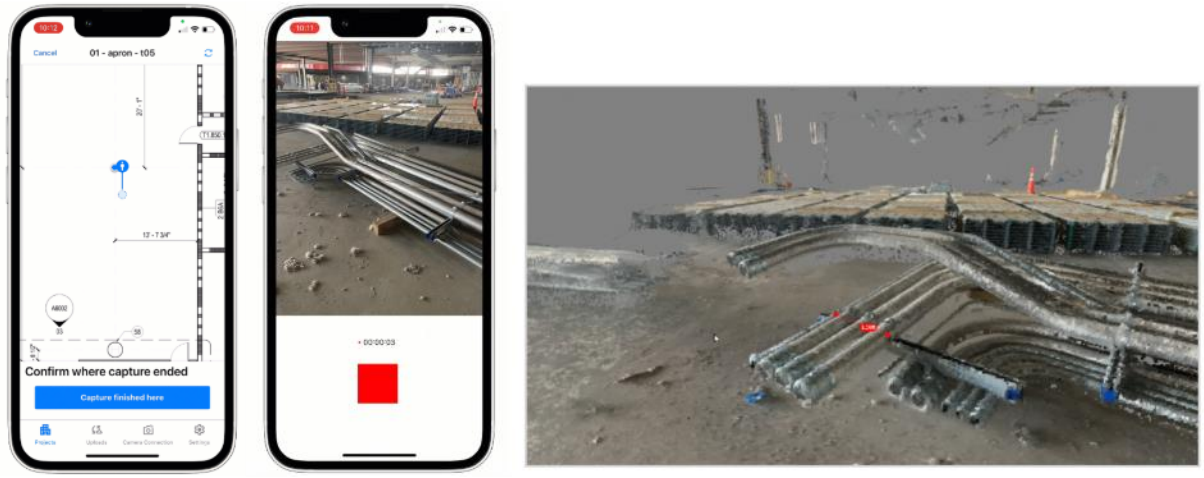


Exhibit 6: 3D object created from video. (reconstructinc.com)

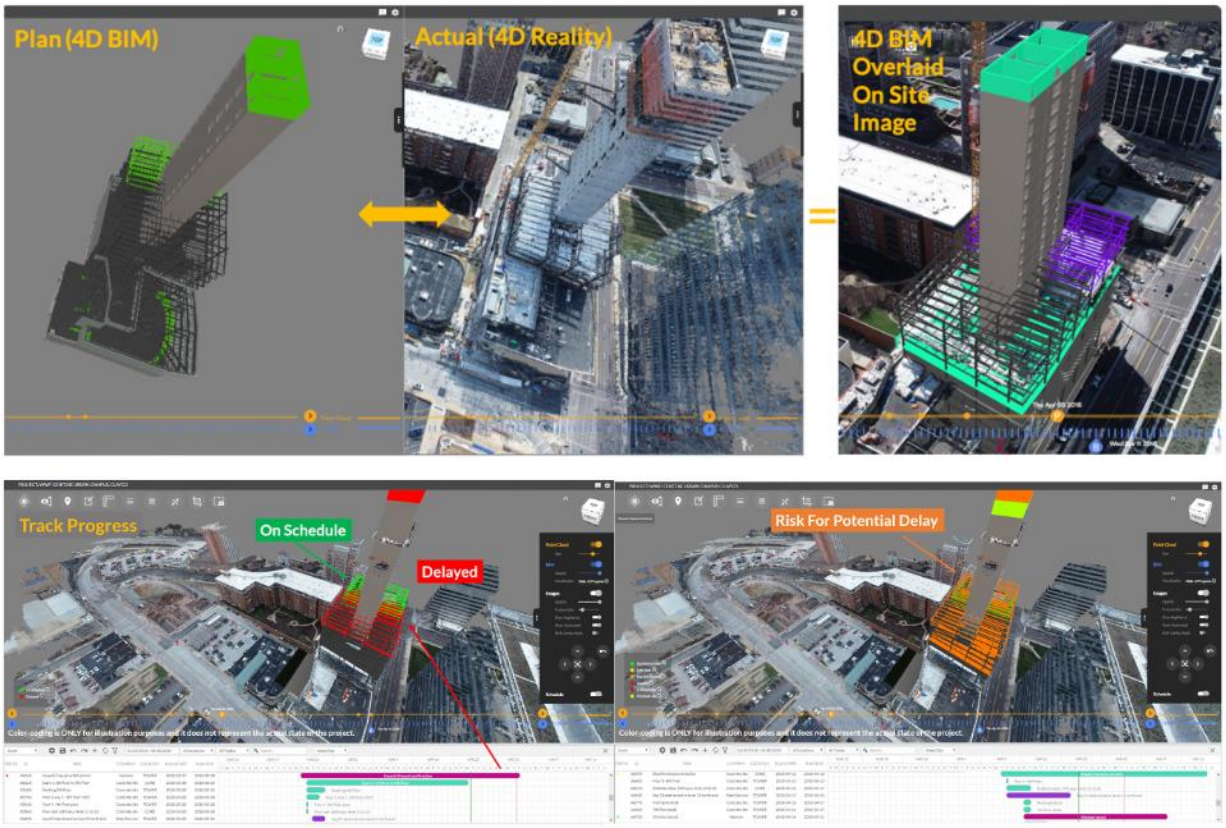


Exhibit 7: BIM Overlay(reconstructinc.com)

Exhibit 8: Application UI on iPad(reconstructinc.com)

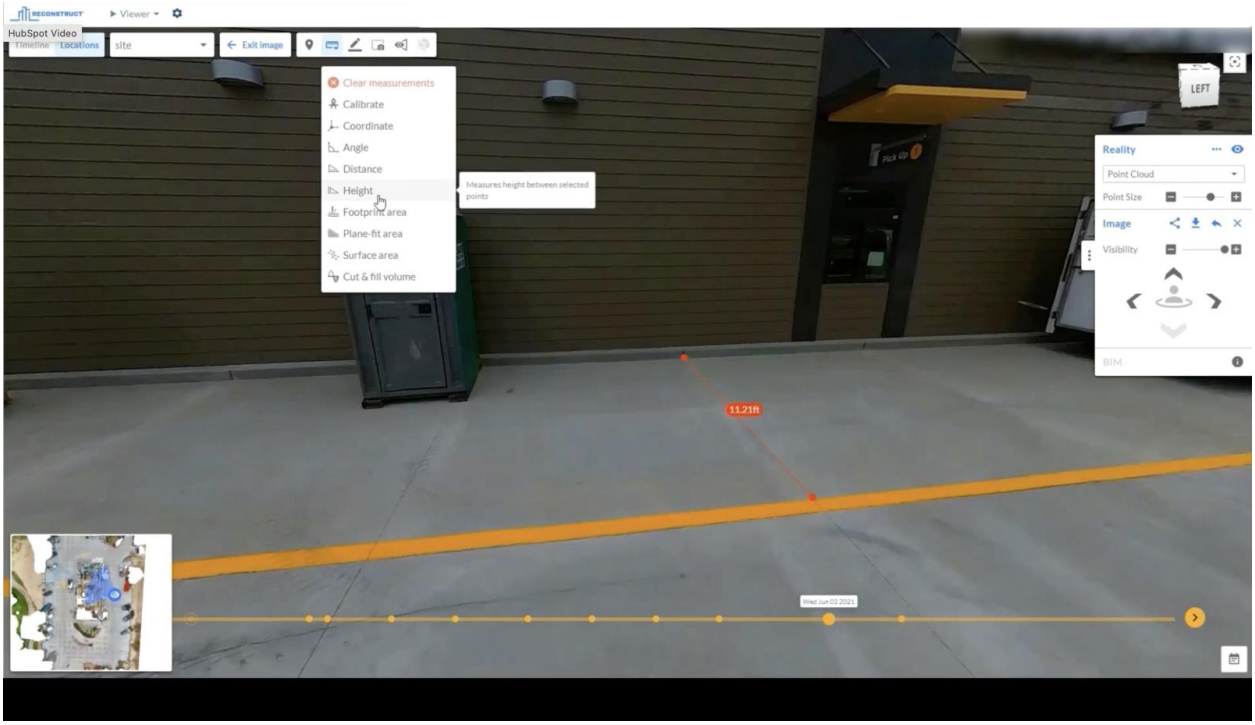


Exhibit 9: User Interface Time Series Illustration (Reconstructinc.com)

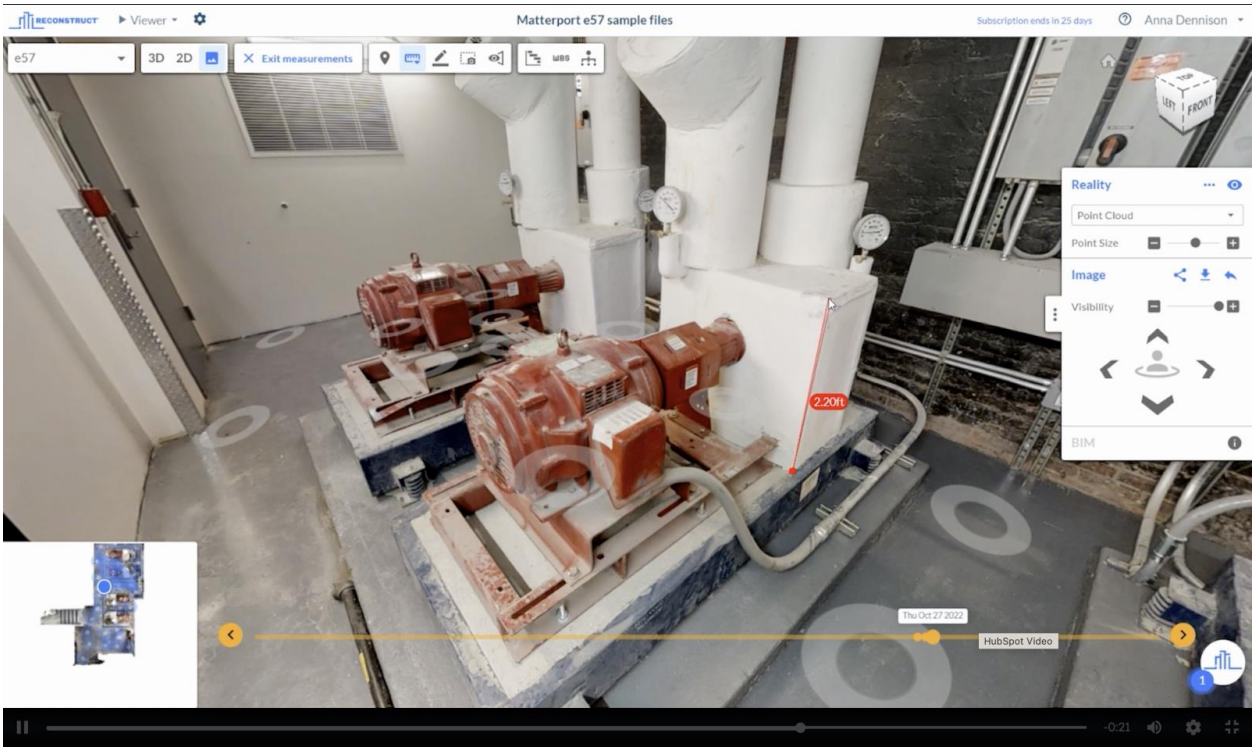
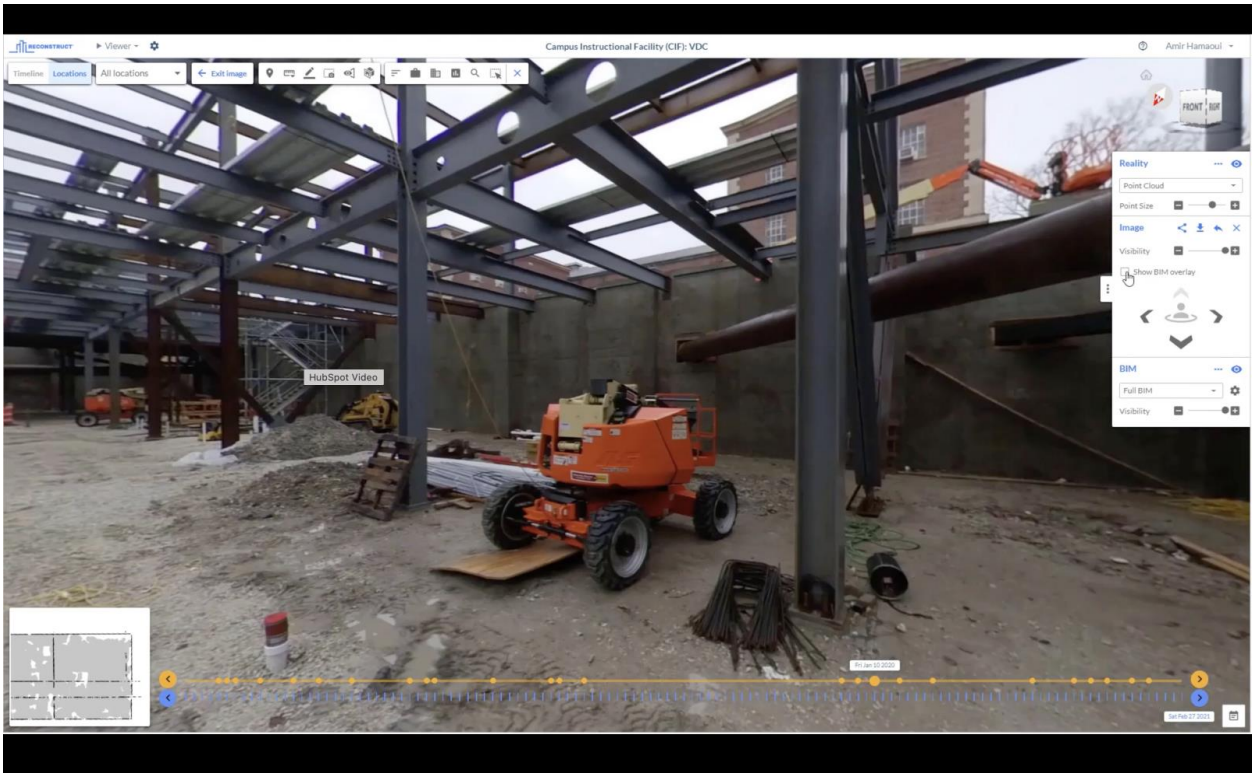


Exhibit 10: 3D Distance measurement and angle calculation (Reconstructinc.com)



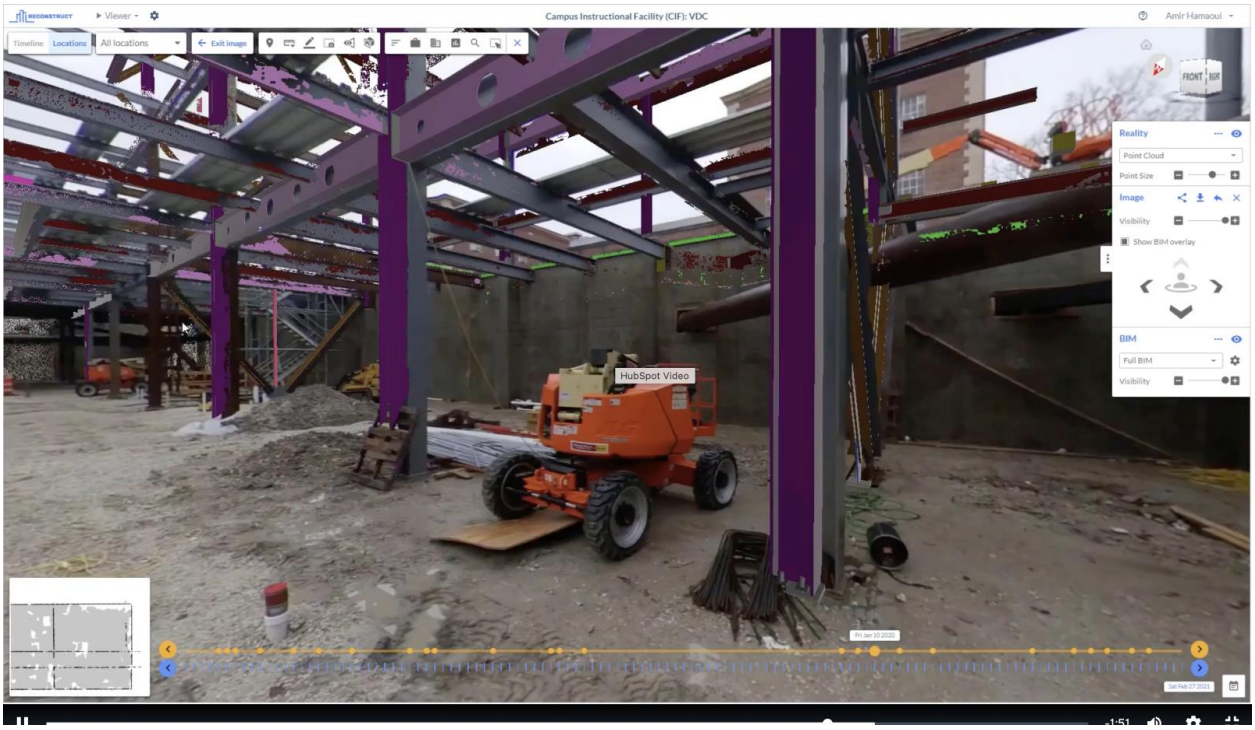


Exhibit 11: 3D BIM Overlay (Reconstructinc.com)

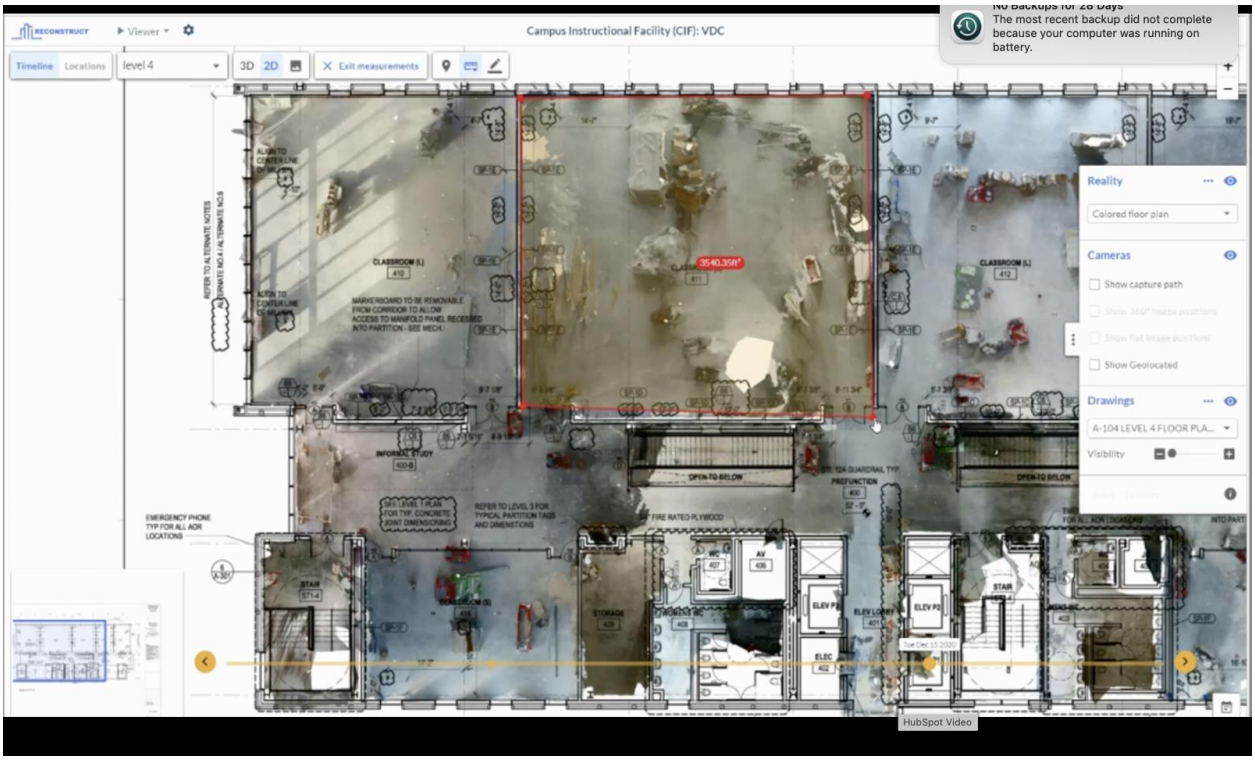


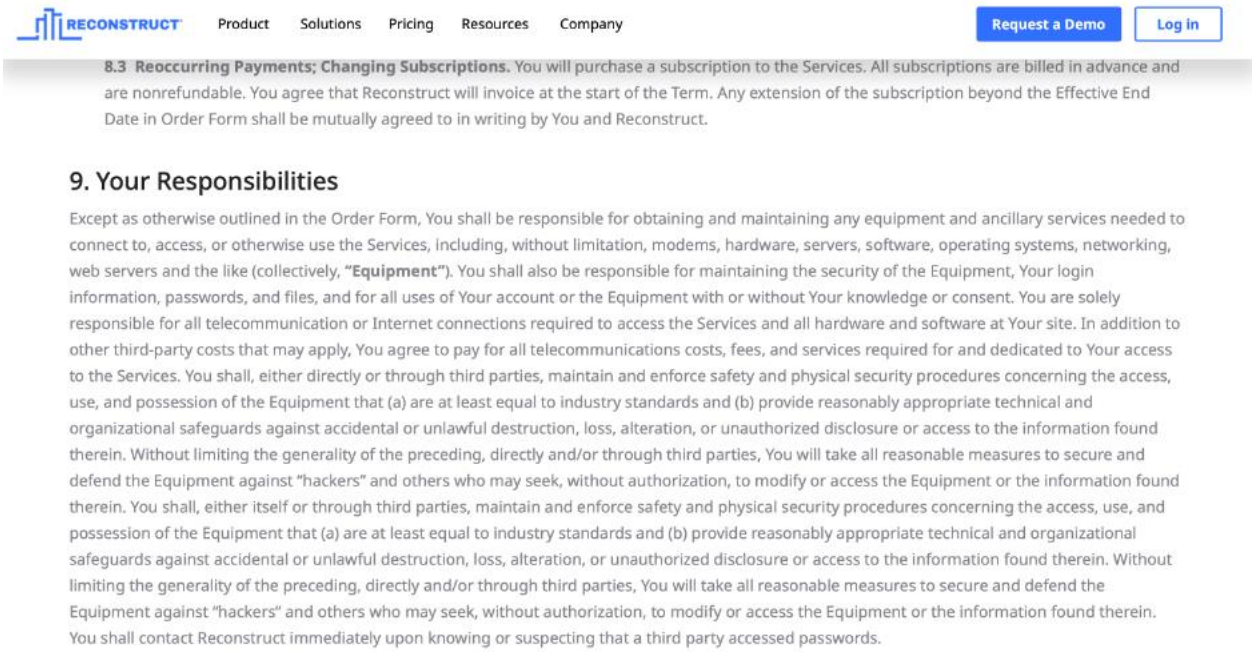
Exhibit 12: 2D Measurement capability (ReconstructInc.com)

Appendix 12: Additional Technology Recommendations

The following are the additional technologies that can enhance the reality data capture for Gloco. These are only optional recommendations. The Reconstruct software along with Autodesk can provide the necessary features to meet the business requirements. [Note: The implementation of these software is not in scope of the current implementation]

Software Solution	Description
Meshlab	Reconstruct's software solution can work with Meshlab software to convert the Point Cloud Model (PCM) into a Mesh model. Mesh models help in adding texture to PCM models to make them more photorealistic objects. Exhibit 3 illustrates how a building object image captured by a drone is converted to a PCM and then to a Mesh Model. The Mesh model assists the AI in object recognition, an essential component in building the 3D digital twin, as it can help the software recognize a door from a window. Meshlab software works behind the scenes in the Reconstruct Application.
YOLOv5	You Only Look Once (YOLOv5) is a software solution that aids object recognition. Once the 2D images are converted into 3D models, YOLOv5 is used to recognize the objects. YOLOv5 is a superior AI tool because of its "expansive area scanning capability, superior object recognition accuracy, and brisk processing speeds" (Choi, 2024, p.7). YOLOv5 is trained on labelled datasets and then applied in detecting objects in real-time processing. Exhibit 4 illustrates how building objects are identified by YOLOv5. Exhibit 6 shows a live demonstration of how a video of a pipe converts to an object in the Reconstruct app. The object can then be measured and viewed in 3D. The YOLOv5 software can be used along with the Reconstruct app and the end user need not directly interact with the software code.
PIX4D	PIX4D is a photogrammetry software solution developed in Switzerland. The photogrammetry software "extracts 3D geometrical data and point cloud data" to create a 3D digital twin (Jarahizadeh, 2024, p.2). The software uses "collinearity or coplanarity" to identify the relationship in which an "object point, and its image point lie on a straight line passing through the sensor perspective center" (Jarahizadeh, 2024, p.5). This helps in stitching fragmented objects (created in YOLOv5) into a 3D digital twin. The 3D model created from the objects shows the existing state of the construction site, which can then be overlaid on the BIM Model provided by Gloco.
WebODM Library	WebODM library is an open-source library that is widely used to transform drone photography into a Point Cloud Model (PCM) (Choi, 2024, p.6). PCM converts 2D data into a 3D model. Exhibit 2 illustrates how a chair image is converted into a PCM. This library can support converting drone images into a 3D object in Reconstruct. The 2D images undergo "post-processing techniques using matching key points through the structure from motion (SfM) or multi-view stereopsis (MVS) algorithms" (Benzon, 2022, p.2). Reconstruct App uses WebODM libraries to perform the transformation of 2D images to 3D.

Appendix 13: Terms and Conditions



Appendix 14: Reconstruct Platform Product Description

Product	Description
Visual Command Centre	Allows users to see and measure their construction structure from anywhere, providing a comprehensive overview and detailed insights into the project.
Reality Mapping	Enables the capture of the construction structure using any device, ensuring that data from diverse sources is integrated into the monitoring system.
Schedule Integration	Empowers users to take control of their construction timeline by integrating project schedules, ensuring that deadlines are met, and delays are minimized.
4D Scheduling	Facilitates the visualization of the next steps in construction with 4D BIM, combining time-related information with 3D models for better planning and execution.
Design Integration	Allows the overlay of 2D and 3D designs and plans against the actual construction, helping to identify discrepancies and ensure the project stays on track.
Collaboration & Reporting	Provides tools for pinning concerns directly on visualized issues and sharing insights, enhancing communication and collaboration among project stakeholders.
Project Snapshot	Enables users to share surveys and captures with anyone, promoting transparency and easy sharing of project progress and data.
Progress Monitoring	Allows for the inspection of construction progress and generation of on-demand reports, ensuring that stakeholders are always informed of the current project status.

Product	Description
Security & Compliance	Ensures adherence to security processes, providing peace of mind that all data and operations meet necessary security and compliance standards.

Appendix 15: References

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