Guidebook for

Virtual TOP/CSC (LiDAR)

1st Edition
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BuildSG BCA

Disclaimer

This Guide is a summary of practices and recommendations that may be adopted for the application of LiDAR capture for TOP/CSC virtual inspections and does not purport to be exhaustive or applicable to all situations.

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Introduction to Virtual Inspection

Introduction to Virtual Inspection

1.1 Background

Following the publication of the *Guidebook for Virtual TOP/CSC with 360 Capture* in November 2024, the construction industry has progressively adopted full or hybrid virtual Temporary Occupation Permit/Certificate of Statutory Completion (TOP/CSC) inspection arrangements using 360-degree capture as an alternative form of inspection evidence by the Building Construction Authority (BCA) in place of physical inspections.

This approach has reduced the resources required for inspections while ensuring that inspection objectives continue to be met. In addition to 360-degree capture technology, the industry has begun exploring more technologies to further enhance inspection processes, such as Light Detection and Ranging (LiDAR) technology scans.

This guidebook sets out the requirements for conducting, processing and submitting LiDAR Captures to BCA for TOP/CSC application.

The future of virtual inspection is not a matter of "LiDAR vs 360-degree capture", but of adopting a best-fit approach. The ideal virtual TOP workflow matches the technology to the project type and inspection requirements. While 360-degree capture provides a cost-effective and rapid method for visual scanning, LiDAR offers precise and measurable spatial data. Applying the appropriate technology to each project type or phase enables project teams to maximise cost efficiency without compromising accuracy.

Terms and Definitions

For the purpose of this guidebook, the definitions of key terms are listed below.

- "**Supervising Qualified Persons (QPs)**" refers to an individual responsible for overseeing the inspection process for a construction project. This individual typically holds professional qualifications and expertise relevant to the construction industry, such as an architect or engineer.
- "**Project Team**" refers to the group of individuals involved in the construction project.
- An "**Operator**" refers to an individual tasked to operate the LiDAR Capture equipment during LiDAR Capture.
- A "**LiDAR Capture platform**" refers to a software solution or online platform that facilitates the capture, processing, and sharing of point cloud captures and images.
- "**Virtual Inspection**" refers to the process of assessing and evaluating a physical environment remotely, typically using digital technologies and tools.

1.2 What is LiDAR Technology?

LiDAR is a high-precision sensing technology that measures distance by emitting laser light and recording the time taken for the reflected signals to return. When combined with RGB imagery, LiDAR produces highly accurate and photorealistic three-dimensional (3D) spatial datasets. These capabilities facilitate the creation of immersive and measurable digital environments, supporting applications such as virtual inspection, digital twin development, and smart construction monitoring.

LiDAR determines distance using the Time-of-Flight (ToF) principle, as outlined below:

Laser Emission
The sensor transmits rapid laser pulses toward target surfaces.

Reflection Detection
The receiver measures how long each pulse takes to return.

Distance Calculation
Distance is determined using the following formula:

$$\frac{\text{speed of light} \times \text{time of flight}}{2}$$

3D Point Cloud Generation
Millions of data points (XYZ coordinates) are aggregated to form a dense 3D "point cloud".

RGB Fusion
Integrated cameras overlay true-colour textures onto the 3D geometry, producing photorealistic and metrically accurate digital twins.

Processing & Alignment
Artificial Intelligence (AI)-assisted registration protocols automatically align multiple scans, filter environmental "noise", and generate both PLY datasets for an interactive virtual analysis.

1.3 Advantages and Limitations of LiDAR Compared with 360-degree Capture

While 360-degree capture technology is generally regarded as the baseline solution in terms of ease of use and cost, LiDAR Capture offers a range of value-added capabilities for more advanced applications.

The advantages and limitations of each technology are summarised below.

Data Type	LiDAR Capture	360° Image Capture
Data Type	True 3D with RGB texture	2D spherical imagery
Accuracy	High (mm–cm range)	Visual reference and spatial context
Visual Realism	High – colourised 3D scene	High – photo only (no depth)
Measurement Capability	True-to-scale 3D measurement	Approximate or none
Speed of Capture	Slightly slower capture per scan, but faster overall mapping accuracy	Faster individual capture, but lacks measurement reliability
Processing Complexity	Medium complexity to register or stitch point cloud via automated softwares	Simple upload protocols
Primary Utility	As-built verification, inspection, documentation	General visual record, communication
Integration with Building Information Modelling (BIM)	Native compatibility (e.g. IFC, Revit)	Compatible for comparison but not dimensionally exact (IFC, Revit)
Cost	Higher equipment cost	Lower equipment cost
Information Integrity	Retains spatial information integrity	Retains high-fidelity panoramic information, organised spatially (panoramic virtual tour)

1.4 Advantages of LiDAR

High-Precision Geometry

Sub-centimetre dimensional accuracy supports quality assurance and quality control (QA/QC), as-built versus design comparison, and clash detection.

Photorealistic Visualisation

Integration with RGB capture provides true-colour textures, enabling realistic virtual walkthroughs and effective stakeholder communication.

Rapid Capture

Millions of points and high-res imagery collected within a half-minute per scan position.

Lighting Independence

Capable of operating in low-light conditions or complete darkness, unlike conventional camera-based systems.

Non-Intrusive and Safe

Enables remote measurement in restricted or hazardous areas.

Interoperability with BIM and Digital Twins

Data can be exported to commonly used formats and platforms (e.g. IFC, Revit, Navisworks), supporting inspection and collaboration.

AI-Ready Data

Point clouds and images support automated object detection, progress analytics, and defect recognition.

Repeatable and Comparable

Generates true-scale 3D data that supports asset management, construction progress tracking, and temporal comparisons for maintenance and audit purposes.

Automation Compatibility

Can be integrated with autonomous systems such as robots, drones, or terrestrial capture systems for consistent data collection.

1.5 Limitations of LiDAR

Surface Limitations

Dark, reflective, shiny, or transparent materials may result in gaps within the point cloud.

Object Limitations

Thin, curved, shiny, reflective, or very small elements may present challenges during data capture.

Data Size and Processing

Raw LiDAR datasets are typically large and require significant computing resources for post-processing and alignment.

Environmental Interference

External conditions such as strong sunlight or rainfall may affect data accuracy, depending on the system used.

Cost Considerations

High-end sensors can be costly, although rental models are available.

Skill Requirement

Traditional LiDAR workflows, including data capture and post-processing require trained operators to ensure accuracy.

2

LiDAR Hardware Requirements

LiDAR Hardware Requirements

2.1 Types of LiDAR Systems

LiDAR systems can be broadly categorised based on their emission principles, form factors, and intended application. Each type offers varying levels of accuracy, range, and suitability for virtual inspection.

Type	Technology Principle	Typical Form Factor	Key Characteristics	Common Use Cases
Mechanical or Rotating LiDAR	Time-of-Flight, with rotating laser beam and mirrors	Tripod or vehicle-mounted	Full 360-degree coverage, high precision, long range	Building, infrastructure, and terrain capture
Solid-State LiDAR	MEMS or Flash-based, with no moving parts	Compact sensor (e.g. handheld or drone-mounted)	Lightweight, durable, lower cost, shorter range	Rapid indoor scanning, mobile mapping
Structured Light or White Light Scanner	Projects pattern and measures deformation	Short-range handheld	Sub-millimetre accuracy, ideal for detailed objects	Façades, components, artefacts
Hybrid RGB-LiDAR System	Combines LiDAR depth with RGB imagery	Tripod-mounted or portable	Produces true-colour 3D models with accurate geometry	Virtual Inspection, digital twin applications
Multi-Channel Automotive-Grade LiDAR	Multi-beam rotating laser (16–128 channels)	Mobile, robotic, or drone-mounted	High-speed scanning, used for mobile robots and Unmanned Aerial Vehicles (UAVs)	Robotic and drone-based inspection

2.2 Minimum Technical Requirements for LiDAR Cameras

To ensure consistent, reliable, and measurable data for regulatory or technical inspections, LiDAR devices used in Virtual Inspection should meet or exceed the following minimum specifications:

Parameter	Recommended Specification	Rationale
Range	Up to 50 m	To cover large indoor and outdoor spaces.
Accuracy or Tolerance	< 5 mm to 10 mm for terrestrial scans at 10 m or better 20 mm to 50 mm for mobile or robotic mounted scans at 10 m or better	Sufficient for architectural and MEP verification.
RGB Integration	Built-in high-resolution camera	Enables photorealistic visualisation for review.
Field of View	360° (H) or 250° (V)	Provides near-complete environmental capture.
Data Output Formats	PLY, E57, RCP, LAS, OBJ	Ensures interoperability with BIM and digital-twin systems.
AI or Simultaneous Localisation and Mapping (SLAM) Compatibility	Necessary for mobile LiDAR scanners	Enables automated alignment and mapping.
Laser Class	Class 1 eye-safe (IEC 60825-1)	Safe for indoor operation.
Operating Temperature	0 °C – 40 °C (or wider)	Suitable for typical site conditions in Singapore.

2.3 Modes of LiDAR Capture Hardware Available in the Market

LiDAR data can be captured through three primary operational modes – **terrestrial, mobile, and robotic** – each optimised for specific site conditions, accuracy requirements, and productivity objectives.

The selection of an appropriate mode depends on the nature of the project, site accessibility, and the level of precision required for regulatory or engineering validation.

2.3.1 Terrestrial LiDAR Capture (Tripod-Based)

Terrestrial LiDAR involves using a fixed tripod-mounted scanner. The device performs a full 360-degree rotation to capture dense point cloud data at each scan position. Multiple scans are subsequently registered to form a complete 3D model.

This method is best suited for high-accuracy inspection, TOP documentation, BIM verification, structural alignment, and detailed progress validation.

Advantages	Limitations
Highest accuracy and density (millimetre-level precision) suitable for as-built verification, dimensional control, and façade analysis.	**Lower productivity** due to frequent repositioning of the scanner.
Stable reference geometry with minimal drift and high repeatability.	**Requires trained operators** to manage registration and scanning parameters.
Ideal for confined or complex environments where detailed measurement is critical (e.g. MEP plant rooms, heritage interiors).	**Limited flexibility** in large or obstructed areas.

2.3.2 Mobile LiDAR Capture (Handheld, Backpack, or Mobile Device)

Mobile LiDAR utilises SLAM technology to capture 3D data while the operator moves through the site. Devices include backpack-mounted scanners, handheld units, and LiDAR-enabled mobile devices.

This method is best suited for routine site documentation, progress monitoring, rapid spatial verification, and pre-inspection scanning.

Advantages	Limitations
High mobility and coverage speed, enabling efficient scanning of large floor areas or multiple levels.	**Reduced geometric accuracy** (typically ±50–100 mm).
No requirement for fixed targets or tripods, reducing manpower requirements.	**Possible SLAM drift or misalignment** in featureless or narrow corridors.
Efficient for repetitive indoor spaces, corridors, and complex layouts.	**Lower point density** compared to terrestrial LiDAR.
Lightweight and compact, ideal for day-to-day site documentation.	**Performance may depend on consistent movement and environmental conditions** for RGB-LiDAR hybrid systems.

2.3.3 Robotic LiDAR Capture (Autonomous or Drone-Based)

Robotic LiDAR Capture integrates sensors onto autonomous platforms such as quadruped robots (e.g. Boston Dynamics Spot), wheeled inspection robots, or UAVs/drones (e.g. DJI Matrice 300 with LiDAR payload). These platforms enable automated, repeatable, and remote scanning in large or hazardous environments.

This method is best suited for large-scale or repetitive inspection routes, remote industrial sites, outdoor façades, roofs, or safety-critical environments (e.g. water treatment plants, tunnels, elevated walkways).

Advantages	Limitations
Automation and repeatability, enabling the system to follow pre-programmed routes with consistent data capture.	**High initial investment** for robotic systems and integration.
Enhanced safety by eliminating the need for human access to hazardous or high-altitude areas.	**Regulatory approvals** may be required for **drone** operations in Singapore.
High productivity through simultaneous multi-sensor capture (LiDAR, RGB, thermal).	**More complex** calibration and navigation requirements.
Suitable for outdoor façade and lightning protection system inspections at roof level using UAV LiDAR.	**Limited battery life** for operations requiring long durations.

2.3.4 Comparative Summary

The following table provides a comparative overview of the three LiDAR capture modes:

Mode	Accuracy	Speed or Coverage	Level of Automation	Cost Level
Terrestrial or Tripod	< 5 mm to 10 mm at 10 m	Slower	Manual	$$$
Mobile or Handheld	20 mm to 50 mm at 10 m	Faster	Semi-automated	$$
Robotic or Drone-based	20 mm to 50 mm at 10 m	Very Fast	Semi- or fully-automated	$$$$

2.4 Technical Limitations of LiDAR Equipment

While LiDAR technology offers significant advantages, certain technical limitations should be considered to ensure data quality and accuracy:

Proximity of Capture

Optimal accuracy is typically achieved within 40–50 m, although some sensors are capable of reaching up to 100 m. For mobile scanning, maintaining a distance of approximately 3–4 m from the target surface is important to ensure accurate reconstruction.

Walking Speed (Mobile Scanning)

A recommended walking speed of 0.5–1 m/s should be maintained during mobile scanning. Consistent and steady movement, without abrupt turns, is vital for SLAM stability.

Object Limitations

Certain objects may present challenges during data capture, including surfaces that are shiny, reflective, thin, curved, or very small (typically smaller than 10 mm).

3

LiDAR Capturing

LiDAR Capturing

High-quality LiDAR Capture depends on a combination of **proper site preparation, optimised scanning parameters**, and **disciplined operational practices**.

To ensure accuracy, repeatability, and completeness, standardised procedures should be followed across all LiDAR Capture modes – terrestrial, mobile, or robotic.

3.1 Site Preparation and Pre-Capture Checklist

Prior to LiDAR Capture, the site should be adequately prepared to minimise obstructions, interference and data gaps. The following best practices are recommended:

01

Ensure Works are Completed

Scanning should be conducted when the relevant architectural, MEP, or structural works have reached the intended stage of completion to avoid rework and inaccuracies.

02

Clear Obstructions and Ensure Access

All doors, risers, and access panels should be opened and secured. Movable objects (e.g. tools, boxes, safety cones) should be removed to prevent an obstruction of laser beams.

03

Restrict Personnel Movement

Personnel and moving objects should be cleared from the area during scanning to prevent noise and misregistration.

04

Ensure Environmental Safety

Confirm that the site is safe for scanning operations, with no hazards such as wet floors, unstable scaffolding, or electrical risks.

05

Verify Device Calibration and Settings

Check battery levels, calibration status, Wi-Fi synchronisation, battery power, and data storage capacity prior to deployment.

06

Assign Control Markers (Where Necessary)

For terrestrial or hybrid setups, establish ground targets or reference markers to support accurate scan registration.

3.2 Conducting LiDAR Capture and Best Practices in Ensuring Quality Captures

Lighting Conditions

Indoor
Maintain adequate, diffused lighting. Avoid direct glare or reflective spotlights If captures are to be taken at night, ensure that all areas of interest are properly illuminated.

Outdoor
Avoid harsh mid-day sunlight if possible. Use HDR capabilities where available. Consistent lighting is important for RGB-LiDAR fusion.

Coverage Verification

Conduct
quick on-site data checks after scanning each section to ensure completeness before proceeding.

Use
live preview or low-resolution verification scans where supported by the equipment.

Walking Speed (for Mobile SLAM Scanning)

One
The recommended speed is **0.5–1 m/s** (approximately normal walking pace), or as specified by the vendor.

Two
Maintain steady movement without abrupt turns or acceleration to ensure SLAM stability.

Three
For larger floor areas, adopt a “Loop Closure” walking pattern in a figure 8 shape, walking back to the same position and criss-crossing to ensure continuous overlap and complete coverage.

Four
Creating loops (i.e. returning to a previously scanned area) to improve SLAM alignment.

Distance from the Object

Terrestrial Scanning
Maintain an optimal distance of approximately 3–5 m for indoor scans and 5–20 m for outdoor scans to achieve good point density and minimal occlusion.

Mobile or Handheld Scanning
Maintain a distance of approximately 3–4 m from target surfaces to support accurate reconstruction.

Environmental Conditions

Avoid
scanning during rain, haze, or in environments with high dust levels.

In high-temperature environments
(e.g. rooftops), allow equipment to acclimatise for at least 10 minutes prior to scanning.

3.3 Best Practice Considerations by Capture Modes

Mode	Operational Focus	Best Practice Considerations
Terrestrial (Tripod)	Fixed-position high-accuracy scanning	Ensure line-of-sight overlap (≥ 30%) between scan stations; maintain stable tripod placement on firm ground.
Mobile (Handheld or Backpack)	Continuous motion scanning	Maintain constant walking speed and adequate visual features; avoid tight loops, wide empty spaces or featureless walls to reduce drift.
Robotic (Ground or Drone)	Automated and repeatable scanning	Pre-plan navigation routes; verify obstacle detection and safety boundaries; monitor battery and sensor temperatures.

3.4 Limitations and Mitigation Measures

Despite its precision, LiDAR Capture is subject to physical and environmental constraints. Understanding these limitations enables appropriate mitigation and improves data quality during post-processing.

Limitation	Description	Mitigation Strategies
Reflective or Shiny Surfaces	Metal panels, polished tiles, and glass may cause beam scattering or absorption.	Adjust angle of incidence, apply matte tape or capture from multiple positions.
Transparent or Dark Surfaces	Glass and dark materials may absorb infrared light, resulting in incomplete point data.	Capture oblique angles and supplement with photogrammetry textures, where necessary.
Small Structures or Fixtures	Objects smaller than 10 mm may fall below the sensor's effective sampling threshold.	Use close-range scanners or a high-resolution 3D camera for such elements.
Narrow Spaces	Some LiDAR systems may have difficulty capturing very confined areas (e.g. small toilets, narrow maintenance spaces).	Use handheld or rotating LiDAR systems with good reconstruction algorithms.
Moving Elements	Personnel, moving doors, or vibrations may result in ghosting or misalignment.	Minimise movement and secure movable parts prior to scanning.
Extreme Weather or Lighting	Bright sunlight or heavy rain can introduce noise.	Schedule scanning during stable weather; utilise HDR features for outdoor capture.

3.5 Recommended Quality Control

To ensure the reliability and completeness of LiDAR data, the following quality control measures are recommended:

Verify **overlap** between adjacent scans (minimum 30%).

01

Review **point cloud density maps** to identify gaps or missing data.

02

Confirm that **equipment accuracy and tolerance levels** are met during post-processing.

03

Generate **RGB-colourised preview models** to verify visual consistency prior to submission.

04

4

LiDAR Capture Processing and Review Platform

LiDAR Capture Processing and Review Platform

A robust LiDAR processing and review platform is essential to transform captured point cloud data into meaningful, measurable, and collaborative inspection information.

Modern platforms typically combine cloud-based visualisation with AI-assisted processing, ensuring that inspectors and consultants can verify, annotate, and report findings remotely with a high degree of confidence.

4.1 Minimum Running Performance Requirements for LiDAR Platforms

A secure, cloud-based Software-as-a-Service (SaaS) environment is recommended for concurrent multi-user access, version control, and audit logging.

The table below outlines the recommended processing requirements:

Category	Recommended Specification or Configuration	Remarks
Hosting Environment	Secure cloud-based SaaS with HTTPS and AES-256 encryption	Enables concurrent multi-user access, version control, and audit logging.
Client Device or Operating System (OS)	Browser-based viewer on Windows 10/11 or macOS 13+	No installation required; runs via WebGL / WebGPU.
Processor or Graphics Processing Unit (GPU)	CPU - x64 Processor with at least 6 cores / 12 threads; GPU - 6GB VRAM minimum	Supports smooth rendering of large RGB-LiDAR datasets.
RAM or Storage	≥ 16 GB RAM, 1 TB SSD	Supports local processing of large point cloud datasets, where required.
Network Bandwidth	≥ 50 Mbps down / 10 Mbps up	Enables real-time streaming of high-density 3D models.
Mobile Access	Native Android / iOS apps with cloud sync	Enables on-site inspection via a tablet or mobile device.

4.2 Essential Features for LiDAR Platforms

To support the review of LiDAR Capture submissions, the platform should include the following minimum set of features.

Feature Category	Key Functionalities	Description or Benefits
Visualisation	• Colourised imagery overlaid on point clouds • 360° panoramic imagery (optional function) • Hybrid 3D and 2D viewing (optional function)	Integrates precise LiDAR geometry with high-definition imagery for intuitive visual review.
Collaboration	• Commenting, mark-ups, and annotations • Attachment of photos, videos, documents, and supporting records (e.g. rectification photos, waivers) • Role-based access control and audit logs • Optional linkage to project plans or models	Enables coordinated review among agencies, consultants, and contractors.
Documentation	• Generation of summary reports for comments and rectifications • Support for attachments (e.g. photos, videos, PDFs) • Integration with rectification workflows	Facilitates digital submission of TOP or QA documentation with traceability.
Measurement	• Saving of measurements within virtual space • Optional digital measurement tools	Allows validation of pre-measured dimensions and assisted dimensional audit checks.
AI and Automation	• Optional object recognition and automated measurement of elements	Reduces manual alignment effort and enhances measurement accuracy.

4.3 Optional Digital Measurement Tools and Accuracy Considerations

Measuring Tools and Techniques

Tool or Method	Purpose	Description
Point-to-Point Snap Tool	Rapid linear measurements	Snaps to the nearest point cloud vertices; ideal for wall-to-wall distances or fixture spacing.
Plane-to-Plane Measurement	Assessment of alignment or deviation	Enables coordinated review among agencies, consultants, and contractors.
XYZ Triangulation Tool	Complex 3D distance analysis	Measures true spatial distance across irregular geometries in an X-Y-Z space.
Cross-Section or Slice Tool	Sectional review	Allows detailed inspection of specific height or depth zones.

4.4 Best Practices for Digital Measurements

The following practices are recommended to ensure measurement accuracy and consistency.

Use clear geometric references, such as tile lines, gridlines, or structural axes for consistency.
01

Switch to raw point cloud mode by disabling RGB textures, to ensure measurements are based on geometric data rather than visual imagery.
02

Zoom in and use precise cursor control to minimise manual selection errors.
03

Validate measurements against known references, such as benchmark dimensions or BIM elements.
04

Record and tag measurements with reference IDs and comments to support audit tracking.
05

Apply consistent units and coordinate systems, by using the metric system (mm) and project grid alignment to maintain uniformity.
06

4.5 Limitations of Digital Measurements

The following limitations should be considered when performing measurements using LiDAR data:

Small-Scale Measurements:
Accuracy may degrade for very small measurements. For dimensions below 100 mm or where accuracy is critical, supplementary photo evidence is recommended to demonstrate compliance.
01

Surface Reflectivity:
Highly reflective materials such as glass or polished metal, may introduce signal noise or partial returns, affecting point selection.
02

User Selection Error:
Errors may arise when user select points based on RGB texture instead of true geometric vertices.
03

5

LiDAR TOP Submission Workflow

LiDAR TOP Submission Workflow

In preparation for Virtual Inspection, the Supervising QP will first access the project's suitability and subsequently submit a request to BCA to confirm whether the inspection can be conducted virtually (either as a fully virtual or hybrid inspection).

5.1 Assessing Project Suitability for Virtual Inspection

The use of LiDAR Capture is permitted for both Full Virtual Inspection and Hybrid Inspection arrangements. The Supervising QP should assess the suitability of the project prior to indicating intent to proceed with Virtual Inspections.

Please refer to **BCA website** (https://go.gov.sg/virtualtopcscinspection) for the types of projects accepted for Full Virtual Inspection or Hybrid Inspection.

5.2 Booking of Pre-Consultation

The QP is to arrange a pre-consultation session with BCA prior to proceeding with Virtual Inspection. The QP may contact the assigned BCA Processing Officer or submit a request via the BCA feedback portal.

The pre-consultation session may be scheduled at any time before the inspection booking date. However, BCA may decline requests for Virtual Inspection if the pre-consultation is scheduled less than three days from the booking date.

5.3 Areas to be Scanned

All non-typical areas within the project must be scanned. This includes landscape areas and common spaces within the project boundary.

For typical designed areas, the QP shall select representative floors or areas for Virtual Inspection. In selecting these, please note that the QP should consider the following requirements:

- A minimum of three typical floors, or one for every 10 floors, are to be selected within each building for Virtual Inspection.
- Selected floors should be spread out within that building.
- A scan of any roof with maintenance access in the building must be included.
- All other additional non-typical floors (e.g. common areas, external works) must be included where applicable.

5.4 Virtual Inspection Plan

To facilitate the Virtual Inspection process, a Virtual Inspection Plan is required. Projects may divide their TOP application into multiple scanning phases, in accordance with this plan.

Where applicable, the QP may submit multiple virtual scan packages within a period not exceeding three months. Each submission shall clearly identify the typical and non-typical areas covered, together with the areas that would be scanned.

5.5 Process for Submitting a LiDAR Virtual Inspection Plan

The following steps outline the process for submission:

STEP 01

The QP contacts BCA to arrange a pre-consultation meeting regarding the proposed Virtual Inspection.

STEP 02

Prepare the relevant documents for discussion, including the site layout, identification of typical and non-typical areas, and the proposed scan coverage.

STEP 03

During the pre-consultation, BCA will assess the feasibility of the proposed approach and advise on any other project-specific requirements.

STEP 04

Based on BCA's feedback, the QP shall prepare a Virtual Inspection Plan that includes:

- A comprehensive list of all areas to be scanned.
- A Building Plan indicating scan zones, with clearly identification of typical and non-typical areas.

STEP 05

Submit the Virtual Inspection Plan to the BCA Officer, including the Building Plan with coloured zones. Any areas requiring additional scans or close-up verification should be highlighted.

STEP 06

Await feedback or approval on the initial submission from the BCA Officer. BCA may request for some adjustments or additional requirements.

STEP 07

Revise the Virtual Inspection Plan in accordance with feedback from the BCA Officer.

STEP 08

Where multiple submissions are proposed, specify the intended submission dates for each scan package, ensuring that all submissions are completed within a maximum period of three months.

STEP 09

Resubmit the revised Virtual Inspection Plan to the BCA Officer, including:

- The completed plan that outlines single or multiple submissions.
- The finalised Building Plan indicating all Virtual Scan zones.

STEP 10

Upon BCA's acceptance of the plan, the QP is to prepare and proceed with Virtual Inspection in accordance with the outlined schedule.

STEP 11

For each virtual scan submission, the QP shall update the remarks in the approved Virtual Inspection Plan to track the progress of the submission.

A sample template of the Virtual Inspection Plan is as follows:

Project Reference Number	Please fill	**Project Title / Description**	Please fill
LiDAR Capture Platform Vendor	Please fill	**LiDAR System Accuracy**	Please fill

Type of Inspection	Areas Covered (Please distinguish between typical and non-typical designs)	Proposed Scanned Areas	Expected Submission Date	Remarks
e.g. Virtual Scan 1	e.g. Typical office from floors 5 to 8	e.g. Sample office floor 5	Please fill Note: Must be within three months of the latest scan or physical inspection.	e.g. Submitted on XX. Link to platform: https://XXXX) Note: Provide the current scan status and platform link. (Update this column with every submission.)
e.g. Virtual Scan 2	e.g. Typical floors 1 to 4, all common areas	e.g. Sample floors 2 and 4, all common areas	Please fill Note: Submit the final LiDAR Capture at least three working days prior to the physical inspection.	NIL
e.g. Physical Inspection	e.g. Common areas, or restricted areas Note: Restricted areas and/or other areas where BCA needs to validate the scan.	N.A.	Please fill	NIL

Notes:
1) Unused Rows: Remove excess rows if the project is submitting only a single scan.
2) Colour Coding: Provide a Building Plan alongside the Virtual Inspection Plan, with the different Virtual Scan zones clearly coloured out.
3) Written Advice: Written Advice is issued only after the final scan or physical inspection, interim comments will be recorded directly on the 360-capture platform
4) QP Responsibilities: Use the same approved Virtual Inspection Plan for all submissions, but the QP is to update the status in the Remarks column to reflect current progress.

5.6 Request for Virtual TOP/CSC Inspection

The process for requesting a Virtual TOP/CSC Inspection is outlined below:

QP to arrange for a pre-consultation.

BCA reviews QP's request.

BCA Processing Officer (PO) accepts the Virtual Inspection for Full Virtual Inspections.

Full Virtual Inspections
(Inspections done virtually)
- QP to submit full virtual capture before the booking date.
- To scan all non-typical levels
- Allowed to scan a sample of the typical levels.

BCA PO accepts the Virtual Inspection for Hybrid Inspections.

Hybrid Inspections
(Selected portions are done virtually, while the remaining are done physically).
- QP to submit virtual captures at least one day before booking date
- To scan all non-typical levels.
- Allowed to scan a sample of the typical levels.

BCA PO rejects the Virtual Inspection and proceeds with Physical Inspections.

Physical Inspections
(Inspections done physically)

The QP is required to contact BCA to arrange a pre-consultation for Virtual Inspection, either via the BCA feedback portal or by contacting the assigned BCA Processing Officer directly.

BCA will respond to the Supervising QP within three working days upon receipt of the Virtual Inspection Plan and will confirm one of the following outcomes:

a) Acceptance of the Virtual TOP/CSC Inspection;
b) Acceptance of the Virtual TOP/CSC Inspection, subject to additional areas to be scanned or the requirement of a Hybrid Inspection; or
c) Rejection of the Virtual Inspection request, with a physical site inspection to proceed on the scheduled date.

The Supervising QP shall proceed to book inspection via the BCA system once the works are completed and ready for inspection.

The following documents shall be completed, e-signed, and digitally submitted at least three working days prior to the scheduled inspection date:

- BCA-CSC-TOPCSCDQP (QP Declaration Form)
- BCA-CSC-CSPBW (Certificate of Supervision)

6

Submission and Review of the LiDAR Capture for Virtual Inspection

Submission and Review of the LiDAR Capture for Virtual Inspection

Upon completion, the LiDAR capture shall be submitted to BCA for review. The BCA PO will assess the captured footage to identify areas that require clarification, instances of non-compliance, or observations. The Supervising QP will be required to provide the necessary clarifications and attach supporting documents. Once all clarifications are deemed satisfactory, the BCA PO will close the inspection process.

6.1 Preparing the LiDAR Capture for Submission

Within the virtual environment where the LiDAR capture is hosted, the Supervising QP is to pre-measure the required elements (for dimensions of ≥100 mm) and save these measurements within the platform for BCA's review.

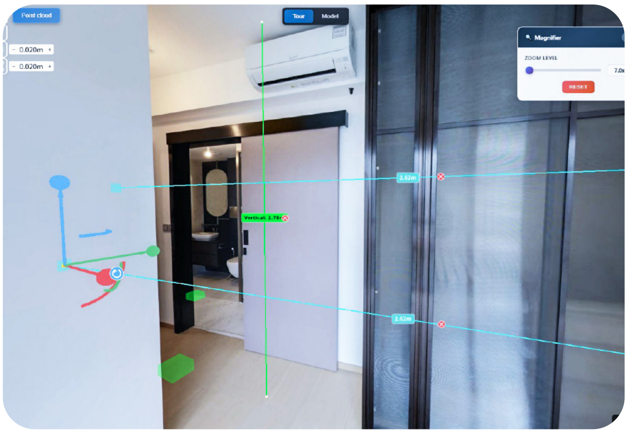
For elements with dimensions of <100 mm, the Supervising QP is to attach the required photos of measurements for BCA's review. The list of required measurements and photos is available on **BCA's website** (https://go.gov.sg/virtualtopcscinspection).

To support accurate measurement, the virtual environment should include the appropriate guiding tools, as outlined in Part 4, Section 3 (Digital Measurements and Accuracy Considerations) of this guide.

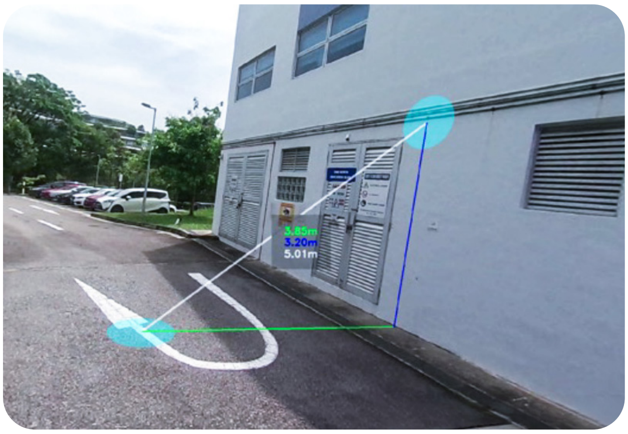
These may include:
- Edge snapping functionality;
- Plane-to-plane (perpendicular) measurement tools;
- Surface recognition tools (e.g. a plane that moves along the surfaces of objects to help users identify changes in planes); and
- XYZ triangulation tools for measurements across the X, Y, and Z planes.

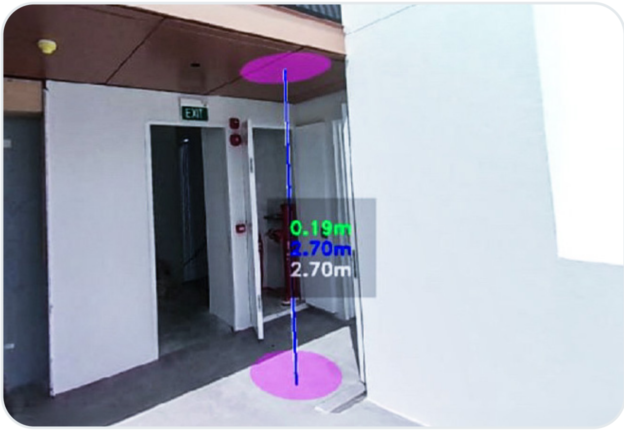
Illustrative examples of some these tools are provided below:

Plane-to-plane snap measurements



XYZ triangulation tool





6.2 Submission of LiDAR Capture to BCA

Once the LiDAR Capture has been verified and is deemed satisfactory to the Project Team, the Supervising QP is to notify the BCA PO via email that the site capture is ready for the inspection. The email shall include the necessary access instructions to enable the BCA PO to log into the platform to audit and provide comments on the Virtual Inspection.

The BCA TOP PO will review the submitted LiDAR Capture and issue comments on the Virtual Site Inspection to the Supervising QP for follow-ups within three working days from the submission of the LiDAR Capture.

6.3 Review of LiDAR Capture by BCA

The BCA TOP PO will review the submitted LiDAR Capture and provide comments based on the items observed.

An official response will subsequently be issued in the form of Written Advice. However, after receiving comments via the review platform, the Project Team may proceed to perform the necessary rectifications in parallel.

The following type of comments will be tagged within the LiDAR Capture platform for the Supervising QP to follow up:

BCA Comments	QP/Project Team's Reply
Non-Compliance	Rectified (Photo evidence of rectification to be attached)
Observation	Rectified (Photo evidence of rectification to be attached)
Clarification	Clarified (Photo evidence in response to the required clarification to be attached)

Note: The Project Team should work with the vendor to establish standardised status tags for communication within the LiDAR platform.

6.4 Documentation of Virtual Inspection

Upon completion of the inspection and rectification process, the QP must generate a site inspection closure report.

The report should contain:
a) All BCA comments relating to non-compliance and observations
b) Details of rectifications carried out for each item
c) All unresolved clarifications*

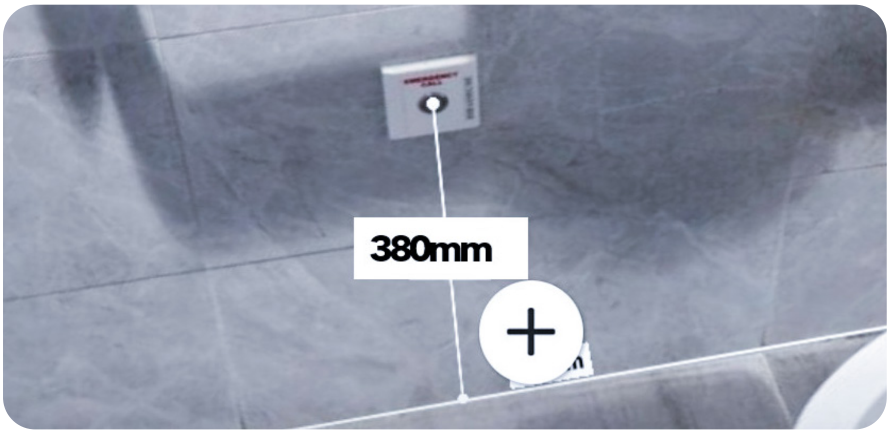
*All clarifications must be addressed. However, resolved clarifications need not be in this report.

The closure report must be submitted along with all the other TOP/CSC documents prior to the issuance of the TOP/CSC certification.

LiDAR Capture platforms must be capable of generating a closure report that consolidates all inspection comments alongside the corresponding rectifications. A suggested template is provided below:

S/N	Location	BCA's Comment	Remarks
1	Toilet	5.6.4.3(a) located between 150mm and 300mm from either the front or side edges of the water closet as illustrated in Fig 49(c), 51(c), and 53(c).	NIL

Photo of Measurement



Rectification Photo

Frequently Asked Questions (FAQs)

1. How much does the LiDAR hardware and software cost?

Hardware: Costs vary significantly based on the type and capability of the LiDAR scanner.

- Entry-Level: $1,000 – $5,000 (e.g. iPhone Pro LiDAR (for capture of small spaces), entry-level solid-state)
- Mid-Range: $6,000 – $25,000 (e.g. Hybrid RGB-LiDAR, systems such as FJD Trion, Matterport Pro 3, Leica BLK360 G2, Silversea D3 Pro)
- High-End: $40,000 – $90,000+ (e.g. survey-grade systems like FARO Focus S Plus, Trimble X9)

Rental options are also available, which can reduce upfront costs.

Software: Processing and review platforms are typically available at a range of price points, with costs varying based on system capabilities, data volume, and user licences.

2. What is considered good accuracy tolerance for digital measurements?

For dimensional control, it is recommended to aim for ±10 mm tolerance using terrestrial tripod-based LiDAR and ±20 mm tolerance using mobile LiDAR.

3. What items would require photos to demonstrate compliance?

Photos should be provided in the following scenarios:

- Elements smaller than 100 mm, where precise measurement is difficult.
- Areas not captured in the LiDAR Capture due to physical or technical limitations.
- Specific details or conditions that are better visualised with high-resolution photography.
- Completed rectification work.

4. What are the typical errors in digital measurements?

- Registration Error: Slight misalignment between multiple scans.
- Surface Reflectivity: Poor point cloud captures of shiny or transparent surfaces.
- Environmental Drift: Minor geometric offsets due to temperature or humidity.
- User Selection Error: Selection of points based on visual texture rather than geometric data.

5. What kind of AI tools can help with analysing the virtual LiDAR Capture?

- Object Recognition: Identifies and classifies objects (e.g. doors, windows) within scan data, to enable automated checks and measurements.
- Segmentation: Segments point cloud into different categories (e.g. vegetation, structural elements) for analysis.
- Dimension Recognition: Extracts measurements from recognised objects.
- Scan-to-BIM Comparison: Compares point cloud data against BIM models to assess progress and deviations.
- Scan merging: Stitches scans together automatically.

Feedback

We welcome your comments about this Guide to help us continue to develop and improve it. Please provide your inputs **here** (https://go.gov.sg/lidarguidefeedback) or scan the QR code on the right.

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