

TERRASCAN

High-Performance Aerial Photogrammetry, Native LiDAR & 3D Gaussian Splatting Workstation

Operational user guide for survey data upload, multi-sensor import, and precision 2D, 3D, LiDAR, and Multispectral reconstruction.

COMPREHENSIVE MULTI-SENSOR RECONSTRUCTION ENGINE

1. 2D Photogrammetry & Terrain:

High-resolution GeoTIFF orthomosaics, DSM canopy models, bare-earth DTM with morphological SMRF filtering, elevation contours, and live quarry volume / area tools.

3. Native Aerial LiDAR Processing:

Direct intake of DJI Zenmuse L1, L2, and L3 raw flight packages, SBET/RPOS trajectories, lever-arm offsets, automated strip alignment, and ASPRS LAS 1.4 classification.

2. 3D Surface & Gaussian Splats:

Watertight textured triangle meshes (OBJ, PLY, GLB), dense point clouds (LAS, 3D Tiles), and cutting-edge CUDA 12.8 3D Gaussian Splatting radiance fields.

4. Multispectral Analytics:

Radiometric panel calibration, band co-registration, and automated NDVI, NDRE, GNDVI, and false-color reflectance composite generation for precision agriculture.

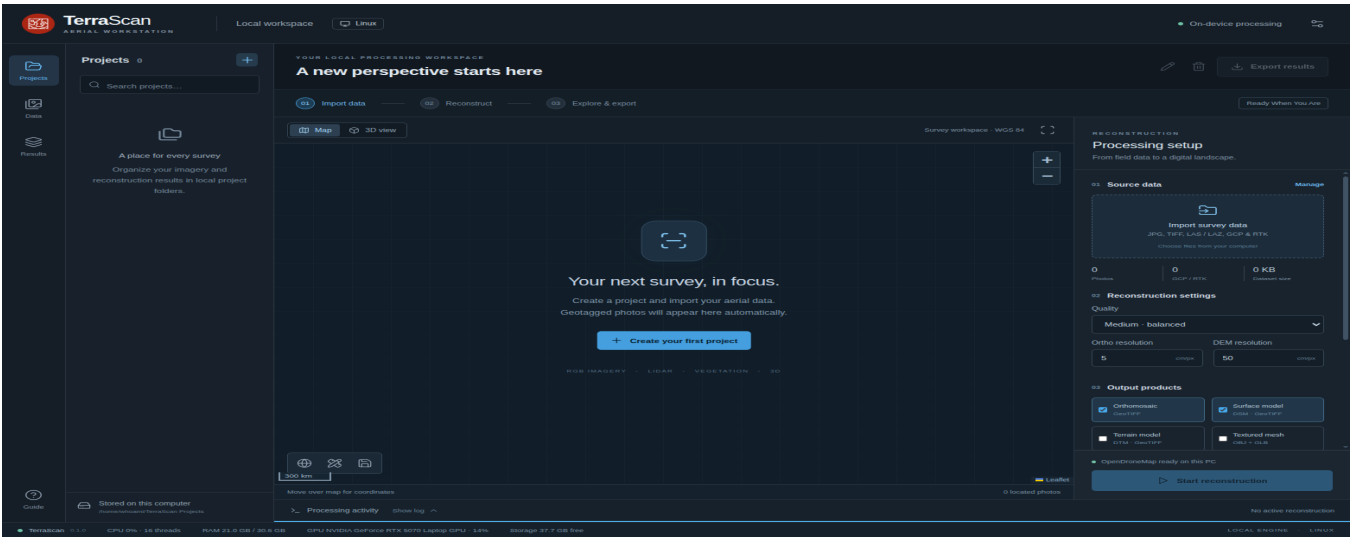


Figure 1: TerraScan Desktop Workstation — Integrated 2D GIS and 3D Viewport Interface

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1. Executive Summary & System Architecture

TerraScan is an independent, high-performance desktop aerial processing workstation designed for drone surveying, aerial photogrammetry, high-accuracy LiDAR classification, and next-generation 3D Gaussian Splatting. Built natively for **Windows 10/11** and **Linux**, TerraScan operates on a strict **100% on-premise local computing philosophy**.

Unlike legacy cloud photogrammetry software, TerraScan requires no recurring cloud processing credits, imposes no upload bandwidth bottlenecks, and never transfers sensitive enterprise drone surveys to third-party servers. All original flight photos, raw sensor trajectories, classified point clouds, and CAD-ready deliverables reside permanently on your local physical workstation.

KEY ARCHITECTURAL ADVANTAGES

- **Complete Data Sovereignty:** Zero mandatory cloud uploads; full compliance with enterprise and defense survey data privacy.
- **Multi-Engine Unified Framework:** Seamlessly fuses NodeODM aerial photogrammetry, PDAL LiDAR processing, and CUDA 12.8 Nerfstudio 3D Gaussian Splatting.
- **Native DJI Sensor Parity:** Direct ingest of raw proprietary flight formats from DJI Zenmuse L1, L2, and L3 systems without expensive external pre-converters.
- **Atomic Survey Deliverables:** Exports clean, boundary-clipped GeoTIFFs, ASPRS LAS 1.4 point clouds, 3D meshes, and GIS-standard vector layers.

System Hardware & Runtime Requirements

Hardware Component	Minimum Specification (Standard)	Recommended Specification (Enterprise Pro)
Operating System	Windows 10/11 64-bit or Ubuntu 22.04 LTS	Windows 11 Pro 64-bit with WSL2 enabled
Processor (CPU)	Intel Core i7 / AMD Ryzen 7 (8 cores)	Intel Core i9 / AMD Ryzen 9 / Threadripper (16+ cores)
System Memory (RAM)	32 GB DDR4 / DDR5	64 GB – 128 GB DDR5 (for 2,000+ photo flights)
Graphics Card (GPU)	NVIDIA RTX 3060 (8 GB VRAM)	NVIDIA RTX 4080 / 4090 / A5000 (16–24 GB VRAM)
CUDA Environment	NVIDIA Driver 550+ with CUDA 12.0+	NVIDIA Driver 560+ with CUDA 12.8 & PyTorch 2.7.1
Storage Disk	500 GB NVMe PCIe SSD (100 GB free)	2 TB Gen4 NVMe SSD (Read/Write > 5,000 MB/s)

2. Project Lifecycle & Multi-Sensor Data Intake

2.1 Creating a New Survey Project

Each survey project in TerraScan is initialized in a self-contained folder equipped with an isolated project.json manifest that tracks input sensor files, coordinate systems, processing runs, vector annotations, and deliverable manifests.

Step-by-step procedure:

1. Launch **TerraScan** from the desktop shortcut or Start Menu.
2. In the left navigation sidebar or welcome screen, click **Create new project (+)**.
3. Enter a descriptive survey project name (e.g., East_Quarry_Phase2_RGB or Sumatra_Forest_Lidar_L3).
4. Select the primary **Workflow Mode**:
 - **RGB Mapping**: Standard drone photogrammetry producing orthophotos, DSM, and 3D textured meshes.
 - **LiDAR Processing**: Flight trajectory solver, strip alignment, point classification, and DTM generation.
 - **Multispectral Survey**: Reflectance calibration, band registration, and vegetation index mapping.
5. Click **Create project**. The interactive Leaflet 2D GIS canvas and side panels initialize immediately.

2.2 Multi-Sensor Data Import & Preflight Validation

Under panel **01 Source data** in the right sidebar, click **Import survey data** or drag-and-drop your dataset folder directly into the viewport. TerraScan supports heterogeneous multi-sensor inputs:

Sensor / Data Type	Supported Formats & File Extensions	Validated Metadata & Preflight Checks
Drone RGB Imagery	Standard JPEG (.jpg, .jpeg) and uncompressed TIFF (.tif, .tiff)	EXIF GPS tags (lat/long), ellipsoidal height, camera focal length, sensor pitch/roll/yaw, and estimated GSD.
Raw DJI LiDAR Packages	Zenmuse L1 / L2 / L3 folders (.cld, .rpos, .sbet, .rtk, .imu)	IMU trajectory time continuity, RTK base station sync, antenna lever-arm calibration, and boresight integrity.
Standard Point Clouds	ASPRS LAS (v1.2, v1.3, v1.4) and compressed LAZ (.laz)	Coordinate Reference System (WGS84 / UTM), point density (pts/m²), return count, and bounding box extents.
Multispectral Bands	Multi-page TIFF or separate single-band TIFFs (Blue, Green, Red, RedEdge, NIR)	Calibration reflectance panel captures (albedo target), Sunshine Sensor (DLS) irradiance, and band alignment tags.

INSTANT PREFLIGHT GSD CALCULATION:

Upon importing drone photos, TerraScan calculates the **Ground Sampling Distance (GSD)** using camera sensor width (S_w) , focal length (F) , and average flight height above ground (H) :

$$GSD = (H \times S_w) / (F \times Image_Width)$$

Camera exposure pins appear immediately on the map, color-coded by altitude.

3. 2D Photogrammetry & Terrain Reconstruction

3.1 Selecting 2D Deliverable Products

In panel **03 Output products**, configure the required deliverables prior to executing reconstruction:

- **Orthomosaic:** Orthorectified, radiometrically balanced GeoTIFF mosaic removing camera lens distortions and perspective tilt.
- **Digital Surface Model (DSM):** 32-bit elevation raster representing top-of-canopy, buildings, and ground features.
- **Digital Terrain Model (DTM):** Bare-earth elevation raster generated via progressive Simple Morphological Filter (SMRF) that eliminates vegetation and human structures.
- **Elevation Contours:** Vector contour lines in GeoJSON and Shapefile format with customizable interval steps (e.g., 0.5m, 1.0m, 5.0m).

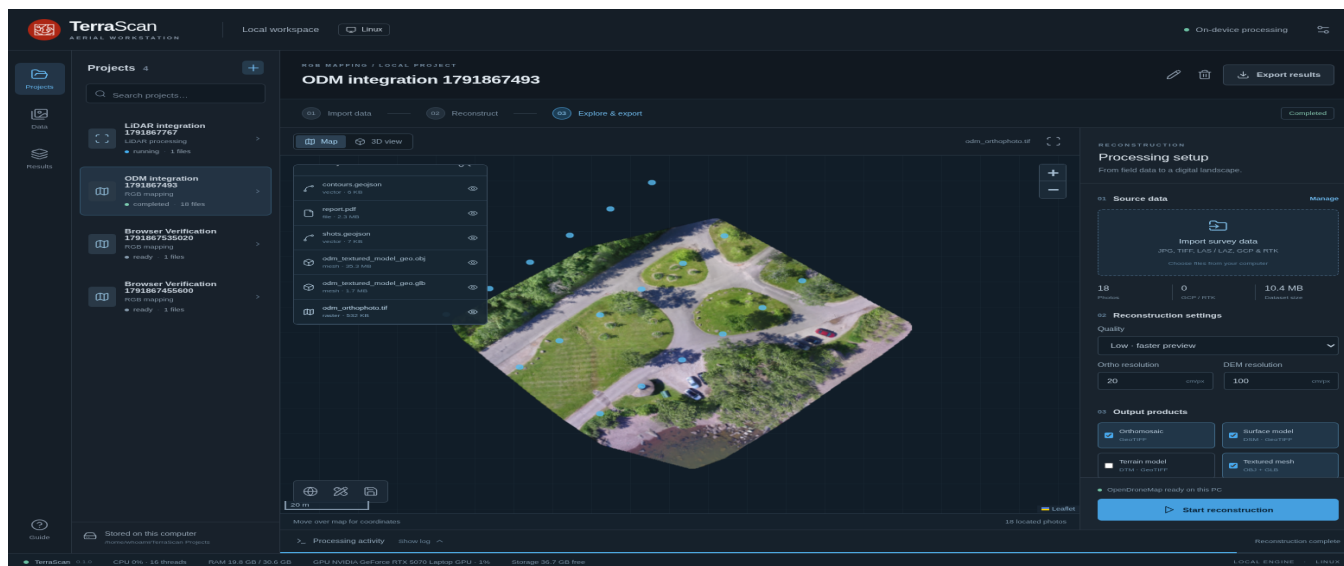


Figure 2: 2D Orthomosaic Displayed with Live Elevation Contours and Volumetric Boundary Polygon

3.2 Reconstruction Execution & Monitoring

1. Click the green **Start reconstruction** button in the lower action panel.
2. The activity status bar displays real-time stages: Feature Extraction → Structure from Motion (SfM) Matching → Bundle Adjustment → Dense Cloud → Mesh Texturing → Orthorectification.
3. Click **Show log** to inspect standard output streams directly from NodeODM and Python processing engines.
4. Upon completion, products load automatically as toggleable raster and vector layers on the 2D map.

3.3 Built-in 2D GIS Measurement & Volume Tools

Use the **Pencil & Ruler toolbar** on the map canvas to perform live geometric measurements:

- **Distance & Perimeter:** Click consecutive points to calculate slope distance and horizontal 2D distance.
- **Area Measurement:** Draw any polygon boundary; planar surface area is calculated live in square meters (m^2) and hectares (ha) .
- **Stockpile Volume Calculation:** Traces quarry stockpiles or excavation trenches against a triangulated baseline plane (Z_{base}) to compute cut and fill cubic volumes (m^3) instantly.

4. 3D Surface Reconstruction & Gaussian Splatting

4.1 Textured 3D Mesh Generation (OBJ / GLB)

TerraScan constructs watertight, photorealistic 3D triangle meshes from dense point clouds using Screened Poisson Surface Reconstruction followed by UV texture projection.

Configuration parameters:

- **Mesh Resolution:** High (depth octree 11), Medium (depth 9), Low (depth 7).
- **Texture Resolution:** 4096 × 4096 px or 8192 × 8192 px texture atlas for crisp architectural and topographical detail.
- **Formats Generated:** Wavefront .obj with .mtl and JPEG textures, compact binary .glb for web viewers, and OGC 3D Tiles .b3dm.

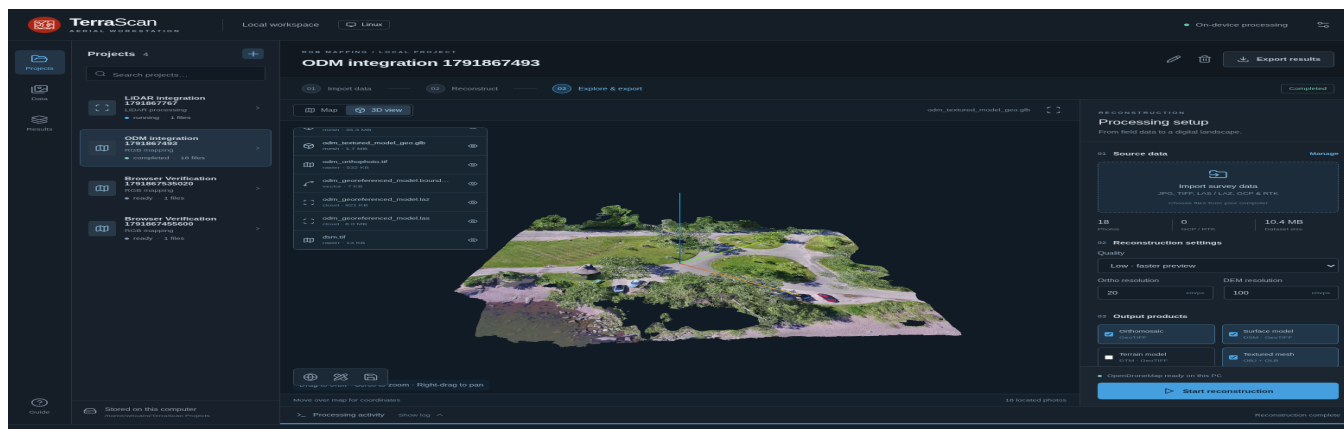


Figure 3: Textured 3D Triangle Mesh Inspected in TerraScan 3D Interactive Orbit Viewer

4.2 Photorealistic 3D Gaussian Splatting (CUDA 12.8)

For complex industrial installations, telecommunication towers, and heritage structures where traditional triangle meshing struggles with thin geometry, TerraScan features **3D Gaussian Splatting (3DGS)** powered by Nerfstudio and NVIDIA CUDA acceleration.

- **Operational Workflow:** Select **7,000 steps** (fast preview, ~5 mins) or **30,000 steps** (full survey fidelity, ~20 mins). The result renders in real time at **60 FPS** and exports standard .ply and .splat files.

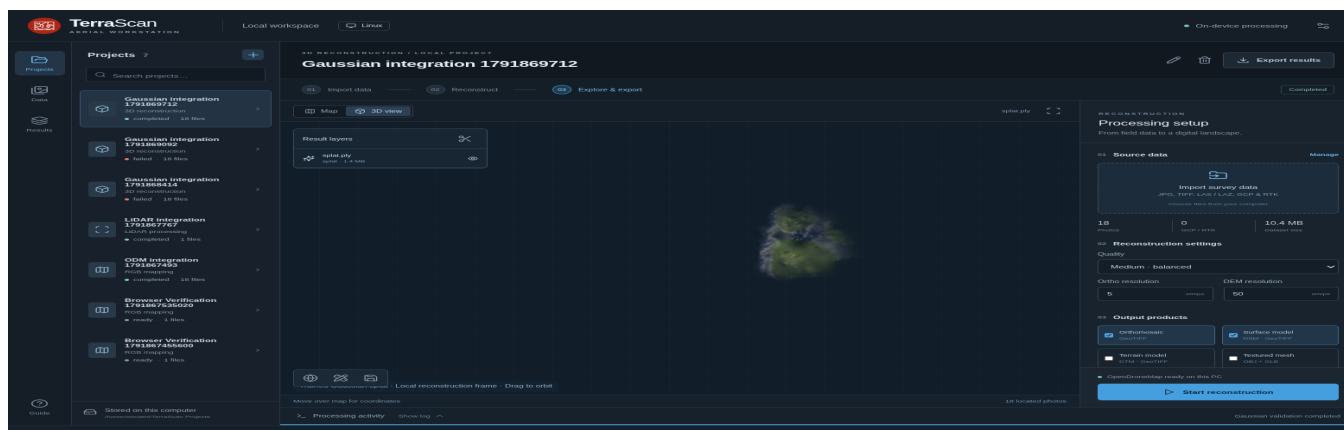


Figure 4: Real-time 3D Gaussian Splatting Digital Twin with Volumetric Light and Thin Geometry Preservation

5. Native DJI Zenmuse LiDAR Processing Pipeline

5.1 DJI Zenmuse L1, L2 & L3 Architecture

TerraScan provides native, independent parsing of DJI Zenmuse aerial LiDAR datasets. Operators do not need external commercial software to process raw flights. TerraScan solves the native trajectory and laser pulses directly on your PC.

Processing Stage	Technical Engine Action & Algorithm	Survey Output Deliverable
1. Trajectory Solving	Synchronizes GNSS carrier-phase with IMU high-frequency accelerometer and gyroscope data. Computes smoothed best estimate trajectory (SBET/RPOS).	Validated 6-DOF flight trajectory with precise timestamp tagging.
2. Laser Boresight	Applies lever-arm offsets $(\Delta X, \Delta Y, \Delta Z)$ between GNSS antenna phase center, IMU origin, and laser scanner mirror.	True georeferenced coordinates in target EPSG CRS.
3. Strip Adjustment	Identifies planar correspondences across overlapping flight strips. Solves rigid registration to eliminate elevation drift between passes.	Uniform, drift-free point cloud matching calibration flight tolerances.
4. SMRF Ground Filtering	Multi-pass progressive morphological filtering separates ground returns from vegetation canopy and structural reflections.	Classified ASPRS LAS 1.4: Ground (Class 2), Low Veg (3), Med Veg (4), High Veg (5), Buildings (6).
5. Bare-Earth DEM	Interpolates ground-classified points into a continuous bare-earth Digital Elevation Model using TIN-linear or IDW gridding.	Survey-grade bare-earth DTM GeoTIFF with no tree canopy interference.

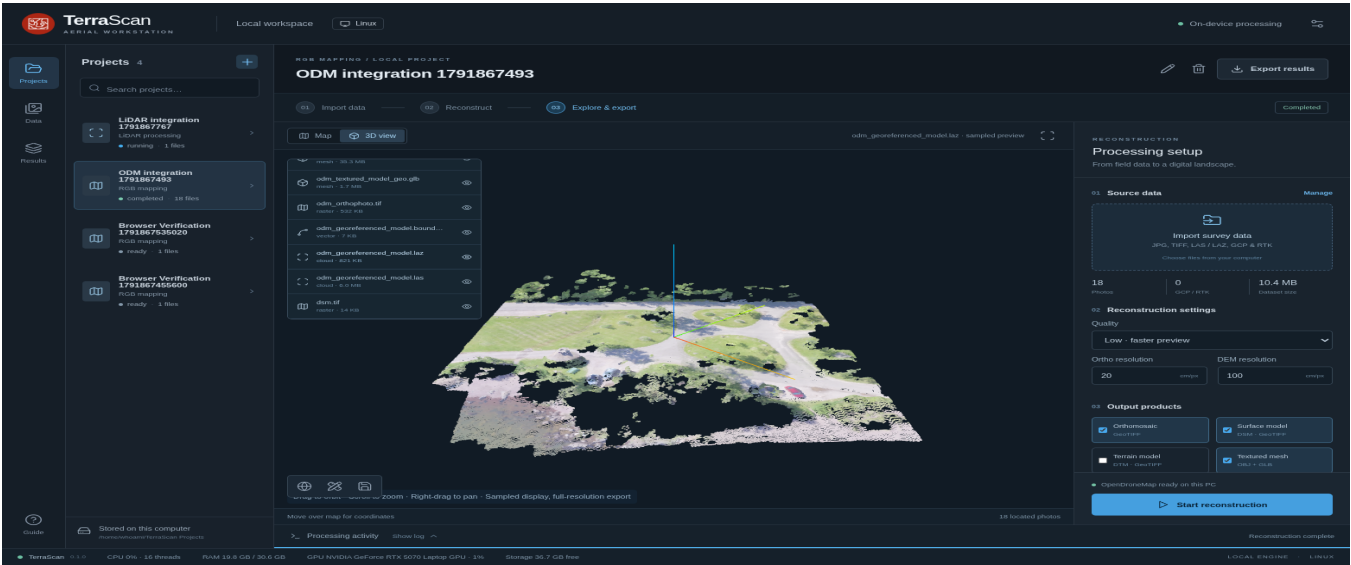


Figure 5: Dense Classified Aerial LiDAR Point Cloud Colored by Elevation and SMRF Ground Classification

6. Multispectral Survey & Agricultural Analytics

6.1 Radiometric Calibration Workflow

For precision agriculture, forestry health monitoring, and environmental reclamation surveys, TerraScan supports multi-band multispectral sensors (e.g., **DJI Mavic 3 Enterprise Multispectral (M3M)**, **Phantom 4 Multispectral (P4M)**, and **MicaSense RedEdge-P / Altum**).

Calibration procedure:

- 1. Downwelling Light Sensor (DLS):** Corrects for changing solar irradiance, cloud shadows, and sun angle during the flight.
- 2. Reflectance Panel Capture:** Upload pre-flight photos of your calibrated reflectance panel. TerraScan auto-detects panel fiducial markers and normalizes digital numbers (DN) to absolute surface reflectance (0.0 to 1.0).
- 3. Band Co-Registration:** Automatically aligns the optical offsets between separate sensor lenses (Blue, Green, Red, RedEdge, and Near-Infrared).

6.2 Automated Vegetation Indices Computation

TerraScan automatically derives critical vegetation health indices from calibrated multi-band orthomosaics:

Vegetation Index	Mathematical Formula	Agronomic Application & Interpretation
NDVI Normalized Difference Vegetation Index	$(\text{NIR} - \text{Red}) / (\text{NIR} + \text{Red})$	Standard biomass vitality indicator; values > 0.6 indicate dense, healthy green vegetation; values < 0.2 indicate bare soil or rock.
NDRE Normalized Difference Red Edge	$(\text{NIR} - \text{RedEdge}) / (\text{NIR} + \text{RedEdge})$	Sensitive to chlorophyll content in thick, mature canopies where NDVI saturates; ideal for nitrogen deficiency and mid-to-late season crops.
GNDVI Green NDVI	$(\text{NIR} - \text{Green}) / (\text{NIR} + \text{Green})$	Measures photosynthetic activity and moisture stress; highly sensitive to variations in canopy leaf water content.
False-Color NIR Color Infrared Composite	RGB composite: Band 5 (NIR), Band 3 (Red), Band 2 (Green)	Vibrant red hues highlight healthy vegetation, while damaged crops appear pink, cyan, or brown; ideal for visual field scouting.

VARIABLE RATE APPLICATION (VRA) EXPORT:

Vegetation index rasters can be zoned into 3 to 7 management classes (e.g., Very Low, Low, Moderate, High, Vigorous) and exported as vector shapefiles (.shp) compatible with precision farming tractor terminals (John Deere, Case IH, Trimble) for targeted fertilizer spraying.

7. Quality Control, Accuracy Reports & Exports

7.1 Ground Control Points (GCPs) & Checkpoints

- To achieve certified survey-grade accuracy (sub-2 cm horizontal and vertical), TerraScan supports importing surveyed Ground Control Points (GCPs) and independent Checkpoints:
- 1. In panel **02 Ground control**, import your surveyed CSV coordinates (Point_ID, X_Easting, Y_Northing, Z_Elevation).
 - 2. Select coordinate reference system (e.g., EPSG:32748 - WGS 84 / UTM Zone 48S).
 - 3. Use the interactive GCP marker tool to pinpoint target crosshairs on overlapping drone photos.
 - 4. TerraScan executes constrained bundle adjustment and computes Root Mean Square Errors \$(RMSE_X, RMSE_Y, RMSE_Z)\$ and total \$(RMSE_{3D})\$.

7.2 Boundary Polygon Clipping & Atomic Deliverables Export

When exporting deliverables for engineering hand-off, operators frequently need to trim jagged flight boundary edges. TerraScan includes an atomic boundary clipping engine:

- 1. Click **Export results** in the top navigation bar.
- 2. Check **Clip export inside boundary polygon** to restrict rasters and point clouds strictly inside your designated property line.
- 3. Select target output directory. Deliverables are generated atomically in standard survey structures:

```
C:\Users\Surveyor\TerraScan Exports\North_Quarry_Survey/
■■■ 2D_Orthomosaic/
■   ■■■ North_Quarry_Orthomosaic.tif      (GeoTIFF 32-bit RGB, georeferenced)
■   ■■■ North_Quarry_DSM.tif             (Digital Surface Model)
■■■ Terrain_DTM/
■   ■■■ North_Quarry_DTM_BareEarth.tif    (SMRF Filtered Ground DTM)
■   ■■■ Contours_1m.geojson              (Vector Elevation Contours)
■■■ Point_Cloud/
■   ■■■ North_Quarry_Classified.laz       (ASPRS LAS 1.4 Classified Cloud)
■   ■■■ 3D_Tiles/                        (OGC 3D Tiles for web GIS)
■■■ 3D_Models/
■   ■■■ Textured_Mesh.obj + .mtl          (High-resolution CAD/BIM mesh)
■   ■■■ Gaussian_Splat.ply               (Photorealistic 3D Radiance Field)
■■■ Multispectral/
■   ■■■ NDVI_Index.tif & NDRE_Index.tif   (Calibrated Vegetation Rasters)
■   ■■■ VRA_Prescription_Zones.shp        (Tractor Variable Rate Shapefile)
■■■ Quality_Report.pdf                   (Certified Survey Accuracy Report)
```

8. Troubleshooting, Maintenance & Support

Issue Description	Root Cause Diagnosis	Recommended Resolution Procedure
Docker container does not start	WSL2 virtualization disabled in BIOS/UEFI, or Docker Desktop daemon not initialized.	Enable Virtualization (VT-x / AMD-V) in BIOS. Open Docker Desktop and select Linux containers. Rerun TerraScan installer to verify localhost:3000 endpoint.
Gaussian Splatting option disabled	NVIDIA GPU driver missing or CUDA toolkit not configured in runtime settings.	Install NVIDIA Driver 550+ from official website. In TerraScan Settings, select Scan & install missing dependencies to verify CUDA 12.8 and Nerfstudio.
LiDAR trajectory mismatch error	Missing .rpos or .sbet file in DJI Zenmuse raw directory or GPS leap second offset.	Ensure the entire SD card folder from Zenmuse L1/L2/L3 is imported intact. Verify base station RTK logs match flight date.
Out of Memory (OOM) during 3D Meshing	Reconstruction depth set too high for available system RAM on large survey (>2,000 photos).	Lower octree depth from 11 to 9, or enable memory paging in Settings. Ensure at least 32 GB RAM is installed for ultra-high settings.

TECHNICAL SUPPORT & PUBLISHER CONTACT

Publisher Organization: RyzeDev-Labs
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Product: TerraScan Workstation v0.1.0 Enterprise Documentation

Community & Updates:
Visit our official portal and community repository for software updates, calibration flight templates, and technical issue tracking.

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