

# Scottish National LiDAR Delivery Report

## Block: NO50

Prepared for: Scottish Government

Prepared by: Bluesky International Ltd.

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Project Number: QT\_112680\_1



## Location and Purpose of Survey

This project specifies the provision of aerial LiDAR across all of Scotland. This delivery refers to blocks NO50 and is highlighted in the figure below.

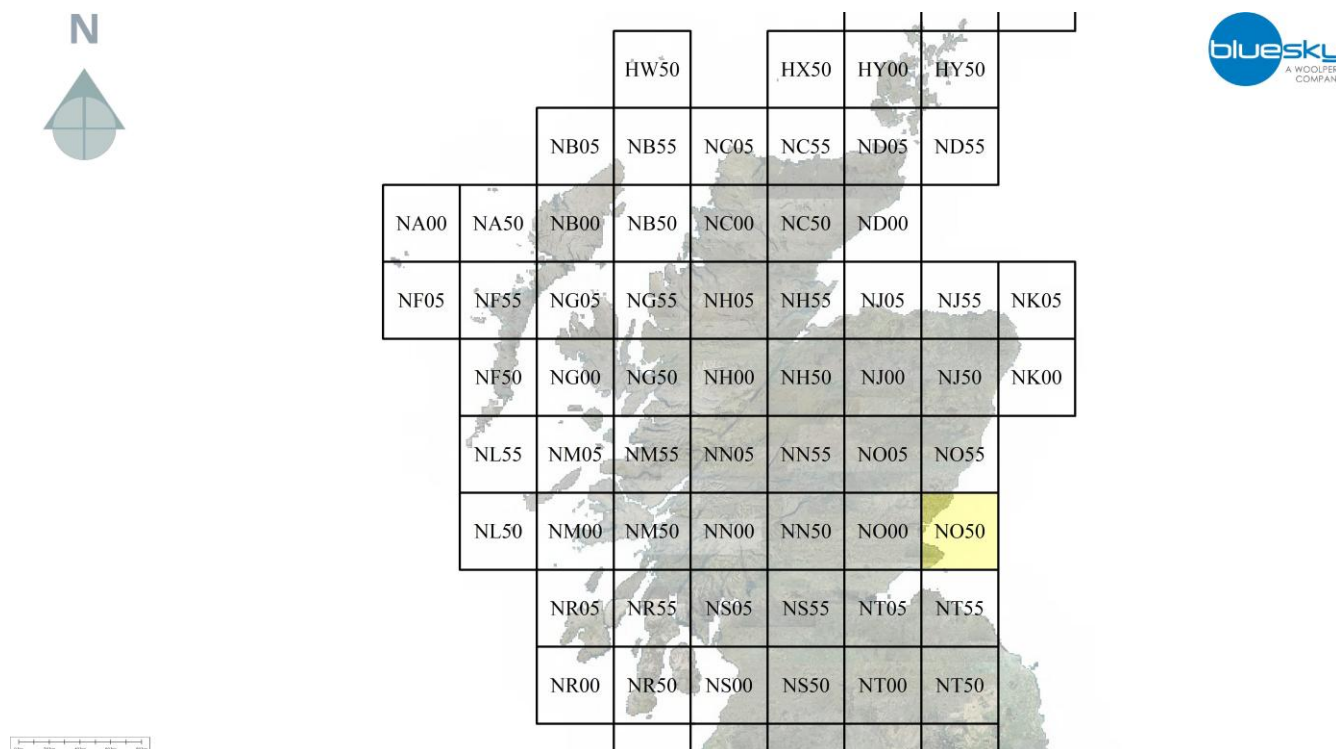


Figure 1: Overview of block areas for National LiDAR Survey Scotland.

## Data Capture

LiDAR data was acquired using a Leica Terrain Mapper scanner with an integrated Hyperion 2+ LiDAR unit. Scanner settings and flying height were optimized to meet the required specification for a minimum of 10 laser measurements per meter and an absolute vertical accuracy of 15cm or better.

Table 1: Typical flight-plan settings for aerial survey.

| LiDAR Scanner               | Leica Hyperion 2+ Terrain Mapper |
|-----------------------------|----------------------------------|
| Approximate Flying Altitude | 2130m AMSL                       |
| Approximate Flying Speed    | 160 Knots                        |
| Pulse Repetition Frequency  | 1.927 – 1.930 GHz                |
| Scan Rate                   | 150Hz                            |
| Scan Pattern                | Circle                           |
| Scanner Field of View       | 30 - 31 Degrees                  |



Figure 2: Date of capture YYMMDD and associated footprints

## Data Processing

On completion of operations all data was transferred to the Bluesky Ashby office for data processing. Raw flight data was processed using the following methods. Data was output to coordinate system: **British National Grid (EPSG 27700) Ordnance Datum Newlyn (ODN)** using **OSTN15/OSGM15**. (note: OSGM15 incorporates local datums such as Stornoway, Lerwick and Newlyn, Orkney)

## Initial Trajectory Processing

The initial flight trajectory was processed using **Waypoint Inertial Explorer 10.0**. This software processed GNSS recordings made in-flight against nearby ground measurement from continually operating reference stations. Processed GNSS values are coupled with inertial measurements recorded by the scanner IMU which in turn provides an accurate reported aircraft position and orientation at a rate of 500Hz.

## LiDAR Processing

**Leica HxMap Workflow Manager 4.8** was used to combine the processed trajectory created in the previous step with raw laser range data recorded from the scanner. This created an accurate geo-referenced three-dimensional point cloud that was output in LiDAR Data Exchange Format (LAS). Raw data was refined using the LiDAR matching tool within the software. Quality control of LiDAR point cloud data was carried out using **Bentley Microstation Connect** with **TerraSolid v26**. LiDAR data was checked for coverage, point density and relative/absolute accuracy.

## Ground Control

Ground control sites for LiDAR verification were chosen roughly every 20 square kilometres. Repeat measurements within a 5m x 5m grid from a hard surface was used to determine vertical alignment to LiDAR point cloud data. Clear surface features such as road markings were used to determine values of horizontal alignment from easily identifiable intensity values in LiDAR and RGB imagery.

The suitability of sites was determined on the following factors:

**Accessibility** – Only publicly accessible areas were chosen.

**Safety** – Sites were away from areas of high traffic.

**Hard consistent surfaces** – Sealed minor roads away from dense vegetation.

**Feature Markings** – Where available distinguishable features such as road markings were chosen.

The average residual vertical error at each control site was applied to the LiDAR point cloud. If an adjacent finalised processing block was present, hard surface vertical offsets were calculated from block boundaries and applied to the data to ensure seamless matching.

## LiDAR Classification

**TerraSolid v26** was used to classify the point cloud. Spurious data points that appeared at anomalous elevations above and below the model were classified out of the dataset. An automated ground classification macro was then run to delineate the difference between ground and non-ground features. The iteration angle of the macro was adjusted accordingly to better identify features such as drainage ditches and local embankments. The classified ground model was then manually checked for any errors.

The LiDAR point cloud was manually classified into the following classes.

*Table 2: LiDAR data has been classified to the following feature codes.*

| Class | Description            |
|-------|------------------------|
| 1     | Default (Unclassified) |
| 2     | Ground                 |
| 3     | Low Vegetation         |
| 4     | Medium Vegetation      |
| 5     | High Vegetation        |
| 6     | Building               |
| 9     | Water                  |

## DTM/DSM Generation

The LAS files were converted to raster DEMS using the following methods:

All terrain classes were converted to a TIN model and then sampled at a regular interval to produce the digital terrain models. The highest elevation value from all classes (except noise and water) were sampled at a fixed interval and used to produce the digital surface models.

Hydro-breaklines were digitized around large water bodies in **Bentley Microstation Connect** and used to remove large bodies of water in the DEM where irregular interpolation from sparse LiDAR hits occurs. For large inland water bodies, these were replaced by flattened points to provide a smooth water surface in the DEMs. As seawater heights vary, these areas were replaced with no-data.

## Quality Checks – Point Density

### Point Density

A point density raster map for the survey area is displayed below. The colours in the legend refer to the average number of measurements per meter recorded in the raw LiDAR data. The map was generated by rasterizing the average points per meter within a 5m x 5m cell outputting an ASCII grid of point density values. These values were then verified to check data exceeded 10 points per meter. As per client specification, only first returns were used for this analysis and excess points in areas of flightline overlap removed. Areas of low returns reflect water bodies where the laser is typically absorbed.

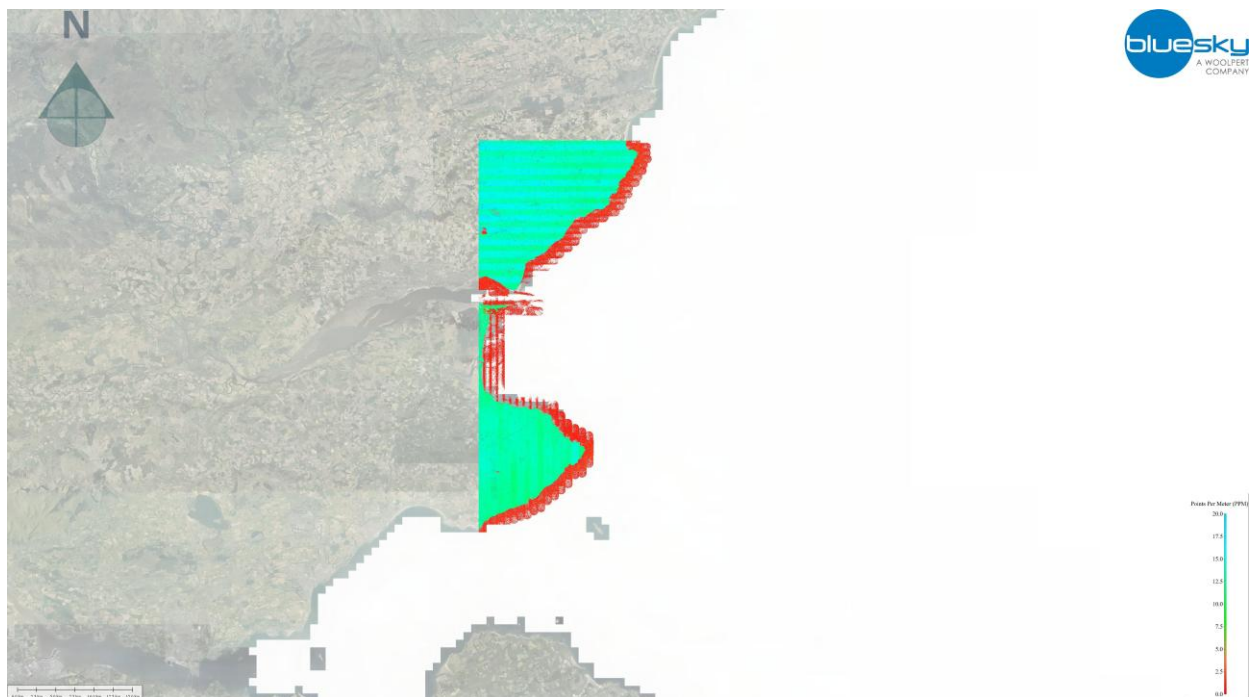


Figure 3: LiDAR point density map of survey area. The colours in the legend refer to the average number of measurements per meter recorded in the raw LiDAR data. The average point density exceeds 10 points per meter.

## Quality Checks – Accuracy

### Relative accuracy

A map showing relative alignment within the survey area is displayed below. The colours in the legend refer to the relative alignment between individual flight-strips. The tool lasoverlap within the LAsTools software suite was used to output a PNG grid of average flight-line overlap, a cell size of 5m x 5m was used. All records from hard surfaces are reporting misalignment values lower than 0.05m.

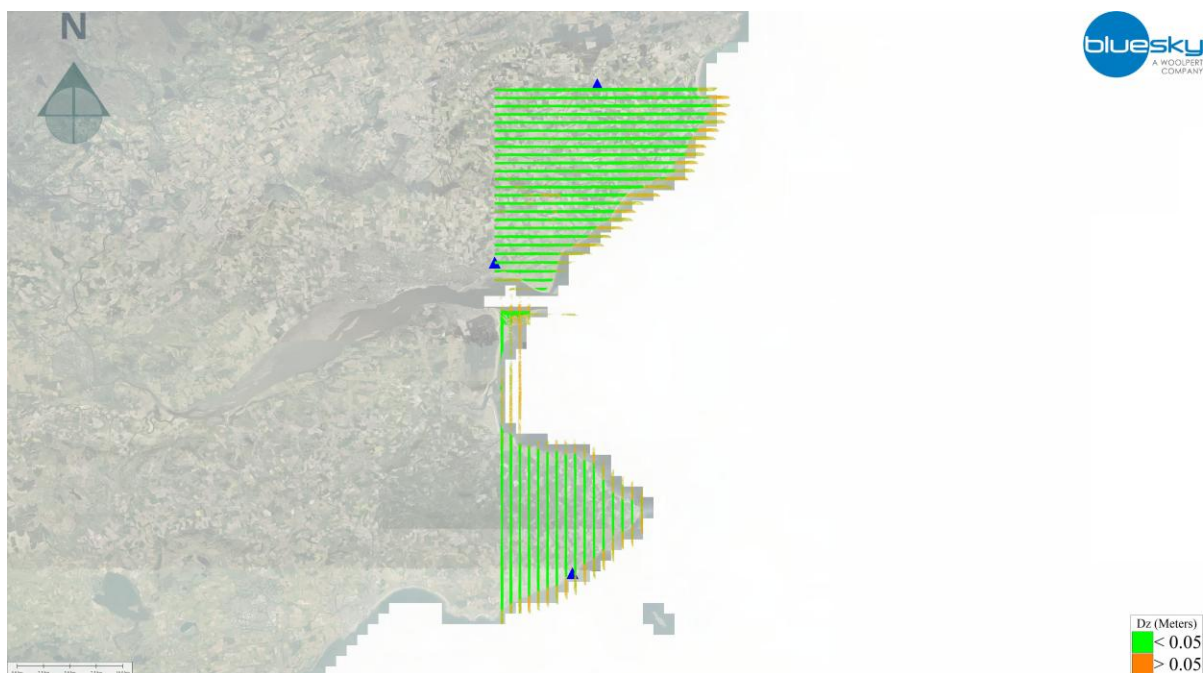


Figure 4: LiDAR Flightline Dz Map of survey area The colors in the legend refer to the relative alignment between individual flight-strips. All records from hard surfaces are reporting misalignment values lower than 0.05m. Blue triangles refer to location of ground control sites.

### Absolute accuracy

The ground control sites for this block are represented by the blue triangles in the above figure. Control height was compared against elevation values in the LiDAR point cloud. XY positions were determined from GCPs surveyed on bright objects such as road markings. These can be verified against high intensity values in the LiDAR point cloud. Due to the point spacing of the dataset the positional accuracy cannot be determined to a high precision however visual checks indicated strong positional correlation between the control. Location analysis results of the GCPs against the LiDAR point cloud data are shown below:

Table 3: Dz RMS results from ground control against LiDAR elevation values from road surface. 367 control points were used in this analysis.

| Measurement (Laser to Ground Control) | Value (m)    |
|---------------------------------------|--------------|
| Average dz                            | 0.004        |
| Minimum dz                            | -0.058       |
| Maximum dz                            | 0.084        |
| Average Magnitude                     | 0.018        |
| Std Deviation                         | 0.024        |
| <b>Root Mean Square</b>               | <b>0.025</b> |

## Final Deliverables

Final deliverables for this project are listed in the table below. All data has been provided in **British National Grid (EPSG 27700) Ordnance Datum Newlyn (ODN)** using **OSTN15/OSGM15**. (note: OSGM15 incorporates local datums such as Stornoway, Lerwick and Newlyn, Orkney). A tile index, quality control rasters and LASTools metadata output was provided for all the deliverables.

Table 4: Final Deliverables with associated file type. All deliverables have been transformed from ETRS89 to British National Grid using OSTN15 / OSGM15. If a product has an associated projection/world file it will be grouped as one file. As seawater is removed from the DTM/DSM but not LAZ, total file sizes may not match between the two.

| Product                                     | File Type               | Area                   | Files |
|---------------------------------------------|-------------------------|------------------------|-------|
| Classified LAZ                              | LAZ 1.4                 | Tiled 1km <sup>2</sup> | 623   |
| Digital Terrain Model                       | Cloud Optimized Geotiff | Tiled 1km <sup>2</sup> | 469   |
| Digital Surface Model                       | Cloud Optimized Geotiff | Tiled 1km <sup>2</sup> | 473   |
| Tile Index                                  | Shapefile               | AOI                    | 1     |
| QC Files - Meta Report/ LASInfo             | txt                     | Tiled 1km <sup>2</sup> | 623   |
| QC Files Ground only - Meta Report/ LASInfo | txt                     | Tiled 1km <sup>2</sup> | 469   |
| QC Files - Point_Density_Rasters            | ASCII Grid              | Tiled 1km <sup>2</sup> | 623   |
| QC Files - Flightline Dz Files              | PNG                     | Tiled 1km <sup>2</sup> | 623   |

The total file size for the delivery is below:

**Delivery NO50** – 18/08/2026: 60,672,175,831 bytes

Note – Tile NT5099 has been included in this delivery as it adjoins the southern end of NO55 and geographically makes the delivery geographically complete.

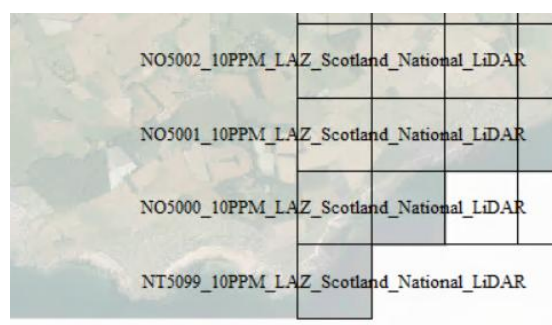


Figure 5: NT5099