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Below is the English translation of the AHN specification document for the Netherlands nationwide mapping project. Note the translation may contain errors. When appropriate, users should consult the original document here:

https://fsn1.your-objectstorage.com/hwh-ahn/AUX/bestekken/AHN4_inwinning.pdf

Current Height Model of the Netherlands (AHN)

Specifications for acquisition of nationwide dataset AHN2020-2022

Version: 1.0 (Final)

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1. AHN2020-2022 Final Attainment Levels

The nationwide dataset AHN2020-2022 meets the final attainment levels listed below:

- The file possesses a **height accuracy** of no more than **5 cm standard deviation** and no more than **5 cm systematic deviation**.
- The file possesses:
 - **OPTION 1: MAPPING REQUIREMENT:** A density (minimum 7 pts/m² in 95% of 1x1m grid cells), distribution, and planimetric accuracy such that topographical objects of 2x2 meters can be unambiguously identified with a position deviation of max 50 cm.
 - **OR OPTION 2: POINT DENSITY REQUIREMENT:** A point density of minimum **10 pts/m²** in 95% of 1x1m grid cells, a stochastic deviation of less than 5 cm, and a systematic deviation of less than 8 cm in planimetry.
- In areas covered with deciduous forest, at least 25% of the pulses must hit the ground.
- The file is classified into the following classes:
 - Ground ("ground")
 - Buildings ("buildings")
 - Water ("water")
 - Civil structures ("Civil structures")
 - Other ("unclassified")
- The ground-classified file is resampled to an equidistant raster with a raster interval of 50 centimeters.

2. Available Materials

At the start of the assignment, the Client will provide the following documents to the Acquisition Contractor:

- A digital map image of the project area in shape-format, containing:
 - Boundaries of the area to be delivered.
 - Map sheet index.
- The following materials are available as open data:
 - Digital Topographical File (DTB, Rijkswaterstaat)
 - AHN3
 - BGT (Key Register of Large-scale Topography)
 - BAG (Key Register of Addresses and Buildings)
 - NIS Management Map (wet) from Rijkswaterstaat
 - Etc.

3. Acquisition Flight Specifications

The following points must be taken into account during the preparation and execution of acquisition flights:

- The entire project area must be measured using laser altimetry. The overlap between two adjacent strips must be sufficient to perform all prescribed control work according to specifications.
- The acquisition flight must be performed in the **leafless season** and must be completed **before March 23rd** of the project year, or earlier if necessary to guarantee no hindrance from foliage.
 - The flying season can only be extended if it is still a leafless season on March 23rd. The duration of the extension is determined by the Client.
- During the flight, the area must not be wholly or partially affected by flooding (including extensive wet spots due to rain).
- During the flight, the area must not be covered with snow, ice, or hail.
- Areas with floodplains must be dry during measurement; they cannot be measured if submerged.
- Flights must be executed under conditions guaranteeing the data meets the final attainment levels.
- Rules and restrictions from authorities like ILT and LVNL must be observed.

4. Laser Data Specifications

- **Coordinates:** All height data must be in the **NAP** coordinate system. Planimetric components must be in the **RD** coordinate system.
- **Transformation:** Coordinate transformation is performed with the most current version of RDNAPTRANS™ (currently 2008).

4.1 Height Accuracy

- **Systematic Errors:** Must not be larger than **5 cm**.
- **Stochastic Errors:** The standard deviation of the height data is at most **5 cm** (1-sigma criterion).
 - 68.2% of points < 1 sigma
 - 95.4% of points < 2 sigma
 - 99.7% of points < 3 sigma

4.2 Point Density

You may choose between two options:

- **OPTION 1: MAPPING REQUIREMENT:** Chosen density (min 7 pts/m²) ensuring 2x2m objects are identifiable with max 50cm deviation.
- **OPTION 2: POINT DENSITY REQUIREMENT:** Minimum **10 pts/m²**.
 - This applies to normally dry surfaces.
 - Additionally: **25%** of pulses must penetrate vegetation to ground level.

4.3 Planimetric Accuracy

- **OPTION 1:** Objects of 2x2m measured with max 50cm deviation.
- **OPTION 2:** Systematic error max **8 cm**, stochastic error max **5 cm**, with density min 10 pts/m² (95%).

4.4 Classification

- The file must be free of extremes (tolerance: 1 extreme value per 1000 hectares).
- **Classes:**
 - Ground
 - Buildings
 - Civil structures
 - Water
 - Other
- Classification must be consistent across map sheet boundaries.
- **Tolerances:** (Detailed error margins are provided for each class, e.g., max 1 hectare per 10,000 hectares of Ground wrongly classified).

4.5 Resampling

- Rasters must describe the terrain as well as possible.
- Rasters follow the TOP10 map sheet division.
- **Required Files:**
 1. **0.5m DTM:** Source = Ground class. Method = Squared IDW.
 2. **0.5m DSM:** Source = All classes except "water". Method = Squared IDW.
 3. **5m DTM:** Source = 0.5m DTM. Method = Unweighted average.
 4. **5m DSM:** Source = 0.5m DSM. Method = Unweighted average.

5. Deliverables

5.1 Flight Plan and Ground Stations

Before flight execution:

- **Flight plan (PDF & Shape):** Strip locations, GPS stations, reference areas, project boundaries, planning.
- **Reference Areas Requirements:**
 - *Height Connection Fields:* Used for adjustment. Min 1 per 250 km² and 1 per 5 flight lines. Min 1 per 30km on parcel borders.
 - *Height Control Fields:* Used for checking (not adjustment). Min 1 per 750 km².

- *Planimetry Fields*: Contractor specifies method.

5.2 Acquisition Flights and Flight Report

- **Daily**: Progress report (PDF) and website update.
- **Weekly**: Geographic overview of acquired areas, percentages, planning.
- **Final Flight Report (within 2 weeks after flights)**:
 - **PDF**: Chronological overview, flight data, terrestrial control usage, trajectory quality, proof of compliance with attainment levels.
 - **Shape**: Flown lines with attributes (Date, Flight #, Aircraft, Speed, Altitude, Scanner type/ID, Pulse rate, Scan rate, FOV, Overlap, Density), network overview.

5.3 Geometrically Correct Dataset

Delivered within 3 months (max June 23rd):

- **LAZ Files (per strip)**: Naming U_<STRIPNUMBER>.LAZ. LAS 1.4 format.
- Tags: File Source ID, Project ID (Year/Parcel), System ID, Creation Date.
- Records: X, Y, Z, Intensity, Return #, Classification (0), Scan Angle, GPS Time.
- **Trajectory Data**: .trj or .txt (Time, X, Y, Z, H, R, P, quality).
- **Quality Report (PDF)**: Description of work, results, deviations, conclusion on attainment levels.
- **Overview (Shape)**: Location/naming of LAZ files.
- **Delivery Medium**: External NTFS hard drives (USB 3.1/C).

5.4 Classified Dataset

Delivered within 3 months (max June 23rd):

- **LAZ Files (per map sheet)**: Naming C_<SHEETNAME>.LAZ.
- Classification codes applied (Ground, Building, Water, Civil Structure, Other).
- **Raster Files (GeoTIFF)**:
 - R_<SHEETNAME>.TIF: 0.5m DSM (Maaiveld + Building + Civil + Other).
 - M_<SHEETNAME>.TIF: 0.5m DTM (Maaiveld only).
 - R5_<SHEETNAME>.TIF: 5m DSM.
 - M5_<SHEETNAME>.TIF: 5m DTM.
 - GeoTIFF Header: EPSG:28992, NoData value defined.
- **Metadata**: XML (ISO 19115 profile).
- **Quality Report (PDF)**: Classification work, results, deviations.
- **Statistics File (Text/Excel)**: Per sheet counts, min/max values.

6. Controls

The Contractor checks data per component to prove attainment levels are met. 98% of data must meet conditions; remaining 2% must not be clustered.

6.2 Navigation

- **Goal:** Prove 100% coverage.
- **Task:** Overview of strip location/width using post-processed positions. No gaps allowed.

6.3 Planimetry and Height

- **Goal:** Check accuracy.
- **Method:** Saddle Roof Method (Zadeldakmethode).
 - Min 1 calculation per 5 km strip length (min 10 objects per overlap).
- **Requirements:**
 - Height differences between strips: Standard deviation $\max \sqrt{2} * \sigma_z$ (max 5cm).
 - Planimetry: Matches Option 1 or 2 requirements.

6.4 Absolute Height and Planimetry

- **Goal:** Prove absolute accuracy against reference data (NAP/RD).
- **Task:** Calculate differences with reference objects. Visualize height differences (colors per 5cm interval).

6.5 Height Differences Between Strips

- **Task:** Generate difference grids (50x50cm IDW) for all overlaps.
- **Output:** Difference grids and tables. Visualized with color per 5cm diff.

6.6 Point Density

- **Task:** Analyze 1x1m cells. Count points.
- **Requirement:** 95% of cells must meet the threshold (7 or 10 pts/m²). 25% ground hits in deciduous forests.

6.7 Point Distribution

- **Task:** Analyze using Voronoi/Delaunay (Method 8.4). One sample per 10 km².

6.8 Classification

- **Task:** Verify classification using hillshades (50cm).
- **Output:** Hillshade rasters of ground class.

6.9 Resampled Data

- **Task:** Verify 20 locations for correct resampling (DSM/DTM generation).

7. Acceptance Procedure

- **Step 1: Entry Control.** (Check conditions).
- **Step 2: Quality Control.** (Qualitative check of geometry and classification).
- Verification is done by a third party ("Contractor Control").

8. Methodologies

8.1 Saddle Roof Method

Used for strip overlap control. Select a point on a ridge in strip 1, project it to the ridge line in strip 2. Calculate shifts in X, Y, Z. Minimize sum of squares.

8.2 Squared Inverse Distance Weighting (IDW)

Formula provided for interpolating points to raster (0.5m).

$$\text{Height} = \text{Sum}(\text{Height}_i / \text{Distance}_i^2) / \text{Sum}(1 / \text{Distance}_i^2)$$

8.3 Unweighted Average

For resampling 0.5m to 5m. Average of underlying cells. No-data if >60% underlying is no-data.

8.4 Voronoi/Delaunay for Point Distribution

Used to determine spatial distribution homogeneity. Parameters: Polygon length, width, area, orientation.

8.5 Mapping Accuracy

Formula provided: $\text{Accuracy} = \Delta_{pd} + \sqrt{\Delta_x^2 + \Delta_y^2} + 3 \cdot \sigma_x$

9. Definitions

- **9.1 Ground (Maaiveld):** Boundary between land/air or land/water. Natural/scenic character. Includes: Dykes, dams, parking lots on ground, accessible tunnels, bare slopes. Excludes: Vegetation, buildings, loose jetties.
- **9.2 Buildings:** Based on BAG (Key Register). Includes houses, houseboats, extensions, solar panels on buildings.
- **9.3 Civil Structures (Kunstwerken):** Non-water-retaining infra structures. Bridges, aqueducts, viaducts, ecoducts. (Locks/weirs are Ground/Other).
- **9.4 Water:** All water surfaces >100m² or >4m wide. Includes rough water (waves).

- **9.5 Extreme:** Points far above/below topography or isolated spikes. Points inside buildings at ground level.
- **9.6 Other:** Everything else (vegetation, cars, street furniture, poles, animals).

10. Delivery Structure

Defines the folder structure for the hard drive delivery:

- 01_LAZ (Strips, MapSheets)
- 02a_DTM_50cm, 02b_DTM_5m
- 03a_DSM_50cm, 03b_DSM_5m
- 04_QualityDescription
- 10_FlightReport
- 20_Data (Trajectory, Absolute Height, etc.)