HEXAGON

HxGN Content Program

Technical Product Guide

25 August 2022

Contents

Specifications

Specification	Metro HD Program – Acquisition
Nominal Image GSD (Planned)	5.0 centimeter (cm)
Lidar Density (Planned)	Target: 20 points per m^2, all swaths Minimum allowed: 8 points per m^2, all swaths
Aerial Accuracy	RMSE x/y = 15 cm RMSE z = 25 cm
Ortho Accuracy	RMSE x/y 25 cm RMSEr = 35.4 cm CL95 = 61.2 cm Data sets are produced to meet ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014) for a 25 (cm) RMSEx / RMSEy Horizontal Accuracy Class, which equates to Positional Horizontal Accuracy +/- 61.2 cm at a 95% confidence level.
LiDAR Accuracy	RMSEz = 10 cm CL95 = 19.6 cm In open, non-vegetated terrain Data sets are produced to meet ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014) for a 10 (cm) RMSEz Vertical Accuracy Class equating to an NVA = +/- 19.6 cm at 95% confidence level and VVA = +/- 29.4 cm at the 95th percentile.
Minimum Sun Angle	30° minimum; however, every effort should be made to acquire the downtown core and any tall building filler lines at the highest solar elevation possible in the day.
Cloud/Cloud Shadow	Must be less than 5% per 40 square kilometer block. Obscured details must not include urban areas or housing and roads in rural areas. Every effort will be made to remove clouds using adjoining imagery. In these limited circumstances, visible seam lines along cloud edges are acceptable.
Smoke/Fire	See cloud cover.

Persistent Smoke (volcano, factory, crop burn, etc.)	See cloud cover.
Snow/Ice Cover	Permanent snow/ice is acceptable. Seasonal snow/ice is acceptable if obscured details are not of high significance or represent key man-made, natural, or cultural features on the ground (e.g., paved roads, agricultural field boundaries, housing, communication routes).
Specular Reflection	Must not be detrimental to the image appearance or impede the ability to extract information from the imagery.
Flooding/Standing Water	Acceptable if obscured details are not of high significance or represent key man-made or cultural features on the ground (e.g., paved roads, agricultural field boundaries, housing, communication routes).
Maximum Allowable Orthomosaic Seamline Offset	25 cm (x/y)
Relative Stereo Accuracy	10 cm (x/y), 15 cm (z)
LiDAR Interswath Accuracy	RMSDz: ≤ 6.0 cm
LiDAR Intraswath Accuracy	RMSDz: ≤ 8.0 cm
Side Overlap	Urban areas planned 60% or greater with CityMapper (Nadir Image)
Forward Overlap	Urban areas planned 80% or greater with CityMapper (Nadir Image)
Non-pixel Data	DN values of 0 and 255 reserved for non-data
Sensor and Lens Artifacts	Imagery should be free of artifacts caused by defects in the image sensor or lens pollution.
Band-to-band Pixel Misregistration	≤ 0.5 pixels and no perceivable color fringing
Image Blur Due to Turbulence	Image blur caused by turbulence is not acceptable.

Radiometry and Color	Dynamic range adjustment to develop 8-bit imagery from digital camera raw images shall preserve feature detail across the full image histogram: in highlights, mid-tones, and shadows. The image's appearance must be a realistic representation of the color on the ground. Color and radiometry adjustments shall be made to minimize the impact of atmospheric and solar variance within orthomosaic and aerial images. The color and radiometry of images should be consistent across different flights within a block. Neutral color balance shall be preserved on manmade features (asphalt, concrete, rooftops). Neutral color shift due to histogram-based image adjustment methods is not permitted. Neutral objects shall have a DN difference of no more than 5 for any RGB triplet. Sample images may be requested to confirm that radiometry and color meet expectations.
Feature Warp/Smear	Bridge/freeway/causeway warp/smear is not acceptable. Where geometric fidelity of a feature is compromised, or pixel stretch occurs, special care will be taken to ensure the orthoimage is a realistic representation of real-world details and oversimplification or unrealistic fabrication has been minimized.
Building Seamline Sheer	Visible joins between ortho-images and flight lines within each block should be avoided but will be accepted under the following conditions: they do not hide detail or adversely affect the ability to extract information from the image; they do not stretch the entire length of the seamline, e.g., clearly outlining entire images; they do not impact geometric fidelity (no change in shape or alignment between images); there is not positional shift between images along visible lines; and the other color difference is slight and/or well graduated and consistent both within the block and with edge matched blocks in the imagery layer they are along cloud edges remaining from the cloud cover conformity.
Building Lean	Supplemental flight lines will be added as required to minimize building lean. Buildings over 120 ft tall that are not at nadir will be assessed for lean. Seamlines will be moved to use the most nadir data to alleviate road occlusions only. The objective is to have the center line of roads visible.

Product Summary

Country Program		
Deliverable Product	**Resolution**	**Deliverable Product Format**
Orthorectified Mosaic Imagery	15 cm (6 in), 30 cm (12 in)	GeoTIFF, JPG, PNG, GIF
Digital Surface Model	Variable	Point Cloud: LAS/LAZ Raster: GeoTIFF, IMG
Digital Elevation Model	Variable	Point Cloud: LAS/LAZ Raster: GeoTIFF, IMG

Metro HD City Program		
Deliverable Product	**Resolution**	**Deliverable Product Format**
Standard Orthomosaic Imagery	5 cm (2 in)	GeoTIFF
True Orthomosaic Imagery	5 cm (2 in)	GeoTIFF
Lidar Point Cloud	20 points/m^2	LAS v1.4
Oblique Imagery	6.7 cm (2.64 in) average	GeoTIFF
Digital Surface Model	15 cm (6 in)	GeoTIFF
Digital Elevation Model	15 cm (6 in)	GeoTIFF
3D Building Model	Based upon nominal resolution of input data	GPKG (vector), OBJ
3D Tree Model	Based upon nominal resolution of input data	CSV, GPKG (vector), OBJ
Land Cover	5.0 cm (2-inch)	GeoTIFF
Aerial Mesh Model	Based upon nominal resolution of input data	B3DM, SLPK, OBJ

General

HxGN Content Orthorectified Imagery

Orthorectified imagery is processed using calibrated sensor parameters and surface elevations to remove optical distortions, sensor perspective, and differential scaling inherent in aerial image acquisition. Orthorectified images are mosaicked into a single image (i.e., Orthomosaic) and then subset into equal area tiles in the final steps before delivery.

Orthomosaic images are processed to maximize resolution and clarity. Automated seamlines are manually adjusted to optimize scene content. All imagery is ground controlled and subjected to a rigorous QA/QC routine prior to release. Final products yield accurate distance and angular measurements to be used as stable base maps and consistent and reliable image sources for artificial intelligence and machine learning algorithms. A complete Leica-Hexagon workflow from acquisition through processing ensures a highly consistent and reliable product between multiple data sets.

HxGN Content Digital Surface Models

A digital surface model (DSM) includes point elevations (i.e., x, y, and z) that are representative of all primary reflective surfaces of built-up (e.g., buildings, transportation infrastructure) and natural features (e.g., vegetated ground cover). When taken together, the points represent the real world and can be further classified based on material type, vegetation, elevation class or buildings. The HxGN Content Program provides two distinct types of DSM. As part of our traditional country and statewide acquisitions and urban areas collected within the context of this program, DSMs are produced via stereo photogrammetric reconstruction. In urban areas collected as part of the Metro HD Program, DSMs are derived from the first return lidar data.

HxGN Content Digital Elevation Models

A digital elevation model (DEM) includes elevations representative of the bare ground topographic surface devoid of trees, buildings and other surface features. The HxGN content program provides two distinct product types. Image-derived DEMs are a hybrid data product that relies upon an automated grid interpolation to minimize surface features in the data. Metro HD Program-derived DEM data is produced using ground data returns as classified in the point cloud data.

HxGN LiDAR Point Cloud

LiDAR is an active imaging technology that directly measures the distance from the sensor to the surface. The data is reconstructed to form a cloud of points that include values in x, y, and z with corresponding intensity returns. When imagery is collected concurrently with lidar, the subsequent elevation points are encoded with spectral information (i.e., R-G-B-NIR) to increase the realism of the point cloud. The supplemental spectral information increases the usability of the data by providing a closer match to reality allowing users and analysts to identify features and materials more easily.

The strengths of LiDAR sensing and data include accurate measurements in the z-dimension, the ability to operate in low-level or dark ambient lighting conditions, and penetrating the canopy. First return LiDAR returns are traditionally used to broadly represent the open ground, vegetation, and infrastructure, while ground points are relied upon to accurately represent the terrain surface. The vast array of the multiple returns between first return and ground points can be subjected to automated and manual classification routines to delineate features of interest, material type or elevation ranges.

Country Program

Imagery Product Overview

Orthomosaic imagery

Orthomosaic images are available at 6-inch (15 cm) and 12-inch (30 cm) ground sample distances. Standard perspective orthomosiac images include the visual effects of building lean (i.e., top and bottom appear displaced from vertical based upon the object's height and distance from the image center). As such, coordinate values represent the ground and not the top of the object's location as it appears in the imagery. This process relies upon a terrain elevation layer to remove the differential scaling and includes the removal of the bridge and building distortions. Metadata and seamline data are provided as part of the delivery. Depending on the purchase method, imagery is delivered as a full 4-band (Red-Green-Blue-NearIR) or 3+3 (Red-Green-Blue and/or Green-Red-NearIR).

Accuracy Specifications

- City Coverage 15.0 cm (6-inch)
    - RMSEx/y = 0.50 m (1.64 foot)
    - RMSEr = 0.71 m (2.33 foot)
    - CE90 = 1.07 m (3.51 foot)
    - CE95 = 1.22 m (4.00 foot)
- Statewide Coverage of 15 and 30 cm (6-inch and 12-inch)
    - RMSEx/y = 1.2 m (3.93 foot)
    - RMSEr = 1.7 m (5.58 foot)
    - CE90 = 2.6 m (8.53 foot)
    - CE95 = 3.0 m (9.84 foot)

Accuracy Statements

City Coverage 15.0 cm (6-inch)
Data is produced to meet ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014) for a 50 (cm) $RMSE_x$ /$RMSE_y$ Horizontal Accuracy Class which equates to a $RMSE_r$ = 71 (cm) and Positional Horizontal Accuracy = +/- 122 (cm) at a 95% confidence level.

Statewide Coverage 15 and 30 cm (6-inch and 12-inch)
Data is produced to meet ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014) for a 120 (cm) $RMSE_x$ /$RMSE_y$ Horizontal Accuracy Class which equates to $RMSE_r$ = 170 (cm) and Positional Horizontal Accuracy = +/- 300 (cm) at a 95% confidence level.

Coordinate Reference Systems

- Webstore Download*
    - NAD 1983 2011 State Plane <State> <feet or meters>
    - WGS UTM Zone <#> (native and adjacent zones)**
    - NAD 1983 2011 UTM Zone <#> (native and adjacent zones)
- Web Streaming
    - Dynamically projected on the fly based on the application's request

    - A list is retrieved by applications using the “request=GetCapabilities” call to the streaming endpoint URL
- Custom Order
    - NAD 1983 2011 UTM Zone <#> (native only)
    - Additional coordinate reference systems available upon request

*Two sets of 3-band delivered (RGB and CIR)
**Native UTM Zone is the UTM majority zone used for processing the data

Formats

- GeoTIFF
- TIFF
- JPG
- PNG
- GIF

Applications

HxGN Content Program imagery currently serves the autonomous vehicle, telecommunications, insurance, and electrical utility industries and numerous state government agencies.

- Base mapping
- Land use / Land cover analysis
- Ecological modeling and analysis
- Feature extraction (2D and 3D)
- Landscape and urban planning

Delivery

- Webstore Download
- Web Streaming
    - WMS
    - WMTS
    - ArcGIS REST/SOAP
- Custom Order

Elevation Product Overview

Digital Surface Model (DSM)

Stereo photogrammetry derived* elevation values represent the highest elevation within each pixel above a reference datum. Features represented are open terrain surface heights, roads, embankments, buildings, forest canopy tops, and cultivated field tops. Retained point features** can be tailored to general or specific user application categories (e.g., forestry, buildings, line-of-sight). Each point in the respective data set is encoded with false color infrared (FCIR) and normal color (RGB) spectral data derived from the imagery to produce two distinct data sets per geographic region. Data sets are delivered as original vector point clouds or interpolated raster grids at various point densities and resolutions. Point cloud data is formatted as ASPRS LAS v1.2 and delivered in a zipped LAS file format (*.laz). Resolution is based on the nominal acquisition GSD of the specific geographic region.

* A semi-global matching (SGM) photogrammetric process is employed that leverages overlapping high spatial resolution imagery to extract points at a resolution that approaches the native resolution of the imagery.
**Off-the-shelf files represent unfiltered (e.g., may contain noise) representations of the surface produced to aid in the orthorectification process and may need to be refined further to be fit for purpose based on the user's specific use case.

Accuracy Specifications

All accuracy specifications are based on flat, open terrain and full resolution DSM

- RMSEz = 2x GSD
- RMSEx/y = 2x GSD

Coordinate Reference Systems

- North America
  - Horizontal – UTM NAD83 (2011) epoch 2010 meters
  - Vertical – NAVD88 (Geoid12b) meters
- Europe
  - Horizontal – UTM IRTF2008 epoch 2005 (wgs84-g1674)
  - Vertical – EGM08 meters

Formats

- Point cloud – ASPRS LAS/LAZ v1.2***
- Raster
  - GeoTIFF
  - ERDAS Imagine file format (.img)

***All files are delivered in a zipped LAS file format (*.laz) that may need to be unpacked before being used in some software.

Applications

Photogrammetrically derived elevation data sets typically offer better correspondence with accompanying image data, improved point densities, better canopy modeling, increased building material identification, classification accuracy, and thus feature extraction compared to LiDAR data. Photogrammetrically derived point clouds are suitable for many modeling applications in urban and rural environments. Off-the-shelf DSM data may not be suitable or fit for all applications. A custom derivative data generation process can potentially provide data that is more suited for specific requirements and specifications.

Past customer usage includes but is not limited to:

- Forest structure modeling (heights, habitat mapping, fire fuel loading, growth rates, productivity, site index)
- Change detection
- Telecommunications engineering and planning
- Vegetation encroachment analysis
- Radio line-of-sight analysis
- Solar potential modeling
- Airport obstruction modeling

Digital Elevation Model (DEM)

The digital elevation model (DEM) is a hybrid derived data set which includes direct and interpolated bare earth surface heights. Surface extraction methodology involves grid interpolation, and a smoothing kernel applied to the thinned key points with some automated ground classification. Buildings, isolated trees and objects of similar size/extent are removed through an automated process. Directly measured elevations include open terrain surface heights, road surface heights, and otherwise unoccupied/non-vegetated terrain surfaces. Interpolated data appear in areas of the forest canopy, crops, buildings, isolated trees, and other objects of similar size/extent removed through the automated process. The resolution is 5.0 meters.

Accuracy Specifications

- RMSEz = 1.6 m (5.25 foot)
- RMSEx/y = 0.50 m (1.64 foot)
- RMSEr = 0.71 m (2.33 foot)
- CE90 = 1.07 m (3.51 foot)
- CE95 = 1.22 cm (4.00 foot)

Coordinate Reference Systems

- North America
  - Horizontal – UTM NAD83 (2011) epoch 2010 meters
  - Vertical – NAVD88 (Geoid12b) meters
- Europe
  - Horizontal – UTM IRTF2008 epoch 2005 (wgs84-g1674)
  - Vertical – EGM08 meters

Format

- TIF + TFW
- Float 32 bit

Applications

Past customer usage includes but is not limited to:

- Base mapping
- Landscape planning
- Image orthorectification
- Terrain modeling and extraction
- Surface heigh normalization
- Flooding analysis

- Change detection
- Flight planning

Stereo Imagery

Stereo models are in a sensor-specific format, ADS pushbroom, or DMC frame. Imagery viewing angles are ADS system-dependent (i.e., 100 or 120). The ADS 100 uses 19 degrees back and 26 degrees forward, while the ADS 120 uses 10 degrees back and 14 degrees forward. ADS imagery as a stereo product is unique and requires a more focused workflow. The delivery includes aerial images, exterior orientation parameters, and a sensor model description. The nominal resolution for wide area coverage in urban areas is 40 cm and 20 cm.

It is important to note that the following photogrammetry software handles ADS pushbroom imagery:

- BAE Socet Set or Socet GXP
- DATEM Summit Evolution
- Intergraph Imagestation
- Leica/Erdas Imagine LPS
- Leica/Erdas Stereo Analyst for ArcGIS
- KLT-Atlas

Accuracy Specifications

- RMSEz = 1x GSD
- RMSEx/y = 1x GSD

Product accuracy estimates are based on a combination of aerial triangulation results, comparison to ground control, and subsequent three-dimensional (3D) shear analysis that ensures relative alignment between flight lines in a standard photogrammetric block. Final accuracy estimates are evaluated against ground object positions in flat and open terrain.

Coordinate Reference Systems

- North America
  - Horizontal – UTM NAD83 (2011) epoch 2010 meters
  - Vertical – NAVD88 (Geoid12b) meters
- Europe
  - Horizontal – UTM IRTF2008 epoch 2005 (wgs84-g1674)
  - Vertical – EGM08 meters

Format

- Resolution: 1x GSD
- Imagery for each ADS-L1 image is contained in multiple files:
  - *.ads - a pointer file that lists each of the *.tif image segments for the strip
  - *.hist - histogram for strip in XML format
  - *.odf - orientation data file containing the x,y,z, omega, phi, and kappa orientations for each scanline
  - *.odf.adj - orientation data after AT adjustment
  - *.min - list of minification files (minifications are normally not included on distribution media)

- *.sup - BAE SocetSet support file, georeferenced data for SocetSet and other softcopy stereo applications.
- *.tif – plain TIFF file (no georeferencing). Multiple TIFF files containing ADS imagery rectified to the AMT elevation

Applications

Elevation mapping and modeling for the top surface of objects and ground cover as per the traditional usage of DSM data sets derived from imagery

Metro HD Program

Imagery and Derivative Product Overview

Aerial Imagery (Oblique and Nadir)

A Leica CityMapper-2 sensor exposure includes five (5) individual images (i.e., one (1) nadir image and four (4) oblique images). Oblique data is acquired and stored based on the orientation of the sensor (i.e., forward, right, backward, left at successive 90° angles with respect to the direction of flight) at the time of acquisition. All imagery data is accompanied by a text file that includes corresponding exterior orientation parameters based on a refined GNSS solution and bundle adjustment. Raw image frames are not distortion-free, and the spectral bands are only red, green and blue. All images are radiometrically balanced to minimize the effects of different oblique viewing angles. GSD is 5.0 cm (2-inch) for nadir orientation and on average 6.7 cm (2.64 inch) for oblique.

Accuracy

- RMSE x/y: 15 cm (5.91 inch)
- RMSE z: 25 cm (9.84 inch)

Coordinate Reference System

See the corresponding section as per the Metro HD Program.

Format

- Nadir imagery:
  - GSD: 5.0 cm (2-inch)
  - Delivered in R-G-B-NIR spectral order
- Oblique imager
  - GSD: 6.7 cm (2.64inch) average
  - Delivered in R-G-B spectral order
- Lossless 8-bit TIFF
- Internally tiled
  - 256 x 256 or;
  - 512 x 512
- Exterior Orientation Parameters
  - Delivered in ASCII text format
    - Image name
    - x-coordinate
    - y-coordinate
    - z-coordinate
    - omega
    - phi
    - kappa
    - Adjusted GPS timestamp
    - Camera parameters can be delivered as needed

Applications

- LOD texturing
- Insurance
- Tax Assessment

Orthorectified Imagery

Standard perspective orthomosiac images include the visual effects of building lean (i.e., top and bottom appear displaced from vertical based upon the object's height and distance from the image center). As such, coordinate values represent the ground and not the top of an object's location (visualized) as it appears in the imagery. This process relies upon a terrain elevation layer to remove the differential scaling and includes the removal of the bridge and building distortions.

True orthomosiac imagery is a raster product that goes a step further from the standard perspective, offering where each pixel represents true nadir viewing geometry. This process removes the building lean and perspective distortion of the final image product using a DSM in the rectification process. The result is that all surface objects are visually represented and located in their true orthogonal 2D position, with the top and bottom of the structure aligned. Image geometry provides a uniform and consistent scale across the entire image while the perspective decreases obscurations and reveals an increased observation of surface features (e.g., streets, utilities, street furniture).

Orthomosaic images are available at a 5.0 cm (2-inch) ground sample distance. Metadata and seamline data are provided as part of the delivery. Depending on the purchase method, imagery is delivered as a full 4-band (Red-Green-Blue-NearIR) or 3+3 (Red-Green-Blue and/or Green-Red-NearIR).

Accuracy

- RMSE x/y: 25 cm (9.84 inch)
- RMSEr: 35.4 cm (13.94 inch)
- CL95: 61.2 cm (24.09 inch)

Format

- Raster
- Lossless 8-bit GeoTIFF
- Tile
    - 256 x 256 or;
    - 512 x 512
- Mapsheets
    - As defined in the provided shapefile
    - UTM projection of a 1500 by 1500 meter tile
    - Snapped to even pixel dimensions and UTM zone origin
    - Edge matched with no overlap
- Radiometrically balanced between mapsheets and UTM zone lines without visible seam lines

Coordinate Reference Systems

See the corresponding section as per the Metro HD Program.

Applications

- True orthomosiac imagery
    - Planimetric data extraction (including building footprints)

Special Considerations

- Bridge and building distortions removed (standard orthoimagery)

Elevation Product Overview

LiDAR Point Cloud

Lidar data represents the raw elevation point cloud after system calibration, noise removal and strip adjustment. LiDAR point data is encoded with spectral information (i.e., Red-Green-Blue-NearIR) from the corresponding aerial imagery and includes intensity, the return number, and scan angle as attributes. All points are classified as LAS Class 0 (Created Never Classified).

Accuracy

- RMSEz: 10 cm (3.94 inches)
- CL95z: 19.6 cm (7.72 inches)

Coordinate Reference Systems

See the corresponding section as per the Metro HD Program.

Format

- Density: 20 points per meter^2 (minimum allowable 8 points per meter^2)
- ASPRS LAS v1.4
- Point attributes: intensity, return number, scan angle
- RGBNir spectral encoding
- One-kilometer tile

Special Considerations

- Orthorectification DEM – 5.0 meter or better in 32-bit *.img format

Terrain Products (Raster)

Digital Surface Model

Digital surface models (DSM) are derived from lidar first return pulses.

Accuracy

- RMSE x/y: 20 cm (7.87 inch)
- RMSEz: 10 cm (3.94 inches)

Coordinate Reference Systems

See the corresponding section as per the Metro HD Program.

Format

- 32-bit floating point
- Single band raster image
- GSD based on lidar point density
- GeoTIFF
- DEFLATE compression

Applications

Special Considerations:

None

Digital Elevation Model

Digital elevation models (DTM) are constructed from identified lidar ground points.

Accuracy

- RMSE x/y: 20 cm (7.87 inch)
- RMSEz: 10 cm (3.94 inches)

Coordinate Reference Systems

See the corresponding section as per the Metro HD Program.

Format

- 32-bit floating point
- Single band raster image
- GSD based on lidar point density
- GeoTIFF
- DEFLATE compression

Applications

Special Considerations:

None

AI Derivative Products Overview

3D Building Models

CityGML-compliant XML-based encoding for the representation, storage, and exchange of digital 3D city models to facilitate efficient visualization and data analysis. Standardized 3D object models with respect to geometry, topology, semantics and appearance. Increased detail and representation of reality building models have differentiated footprints, roof structures (e.g., pitch angle and orientation), heights (derived from DSM), and thematically differentiated boundary surfaces. Buildings are untextured.

Accuracy

- RMSE x/y: 15 cm (5.91 inch)
- RMSEz: 10 cm (3.94 inches)

Coordinate Reference Systems

See the corresponding section as per the Metro HD Program.

Format

- Delivered in GPKG containing vector building footprints *(Default)*
- OBJ format containing simplified building models.

Applications

This model level is most appropriate for city districts and projects. Past customer usage includes but is not limited to:

- Urban analysis
- Estimation of solar exposure
- Classifying building types
- Urban planning
- RF engineering/planning

3D Tree Models

Tree positions are identified from derived landcover maps with 2D segmentation of individual trees based on heights from DSM. Derived tree data contains stems and crowns modeled as a modified sphere. Corresponding attribute information includes tree positions, height, crown diameter and crown volume. Trees are classified as coniferous or deciduous.

Accuracy

- RMSE x/y: 15 cm (5.91 inch)*
- RMSEz: 10 cm (3.94 inch)*

*based upon the accuracy of the input data sets as the specific location of tree crowns is difficult to delineate due to surface winds

Format

- Attributes delivered in CSV
- Models delivered in:
    - OBJ (simplified tree models)
    - GPKG (containing tree position and height)

Coordinate Reference Systems

See the corresponding section as per the Metro HD Program.

Applications

- RF engineering/planning
- Urban planning
- Understanding the spatial composition of the urban landscape
- Vegetation inventory (tree cover change)
- Shadow analysis
- Solar potential modeling
- Urban microclimate prediction

Landcover Map

The land cover product is a raster product where each pixel is assigned to one of the 25 most probable classes. The segmentation process is based on artificial intelligence 2D semantic segmentation of input image techniques taking advantage of the database of hand-labeled training data created from various images taken at diverse locations around the world. The training database is built through a manual delineation and identification process from various dedicated training set images. The accuracy of the process is assessed against a test set of images that are held out of training and processing. This is for the overall algorithm and is not assessed on a project-by-project basis.

Roof	Facade	Terrace	Tree	Shrub
Structure	Object	Solar panel	Vehicle	Train
Boat	Airplane	Wall	Retaining Wall	Stairs
Bridge	Object	Dirt Road	Railway	Sports Field
Water	Agriculture	Grass	Sand	Rock

Accuracy

- Overall single image accuracy: 87% - averaged across all classes

Format

- Single band indexed raster image
- 5.0 cm (2-inch)
- GeoTIFF

Coordinate Reference Systems

See the corresponding section as per the Metro HD Program.

Applications

- RF-engineering/planning
- Ecological modeling and analysis
- Landscape planning
- Urban heat mapping
- Further feature extraction (e.g., building footprints, vegetation)

Aerial Mesh

The aerial mesh data product is derived from a combination of imagery and LiDAR to create a virtual representation of the real world. The aerial mesh is a product where a mesh of triangles represents the surface of all-natural and built-up objects within the imaged scene. Aerial mesh texture is achieved by assigning 2D RGB image data for each corresponding triangle that forms the 3D Mesh. The foundation of the aerial mesh is a spatial data structure that enables a Hierarchical Level of Detail (HLOD), so only visible tiles are streamed and rendered, improving overall performance. The b3dm format defines a spatial hierarchy for fast streaming and precise rendering, thereby balancing performance and visual quality at any scale.

Accuracy

- RMSEx: 2x nominal RMSE_x accuracy of aerial imagery data*
- RMSEy: 2x nominal RMSE_y accuracy of aerial imagery data*
- RMSEz: 3x nominal RMSE_z accuracy of lidar data*

*Areas considered to be known limitations of the processing and artifacts are excluded from this definition. This includes cases such as near roof edges, areas with single-color texture, areas with highly repetitive patterns in texture (e.g., agricultural fields), and thin structures such as wires or cables.

Format

- Tiles stored as OGC 3D Tiles (built on glTF) *Default*
    - Optimized for web streaming
    - Containing five levels of detail as a minimum
    - Texture resolution of highest LOD is the same resolution as input imagery
    - Coarser LODs image resolution halved progressively
    - Batch 3D Model (b3dm)
- OBJ with JPG texture (best purposed for offline work)
    - Output at a variety of resolutions (highest level is the default)
    - Includes shapefile with irregular grid corresponding to the real-world position
- SLPK (scene layer package)

Coordinate Reference Systems

See the corresponding section as per the Metro HD Program.

Applications

- Observe and monitor change
- Landscape planning and analysis
- City Planning
- Smart city integration and analysis
- Line of sight analysis
- Transportation analysis

Special Considerations

- This is not the super mesh product
- This is an automated process with known and inherent limitations in texture and geometry
- Artifacts are corrected either by manual editing or AI to the best extent possible
- Texture and geometric (i.e., incomplete or incorrect modeling) artifacts include but are not limited to:
    - Highly reflective surfaces like (e.g., glass facades)
    - Moving objects (e.g., cars)
    - Building edges, wires, traffic signs/lights)
    - Balconies with delicate structures (warping)
    - Slim/fine objects (background texture extension)

LiDAR-based DTM

The raster digital terrain model (DTM) is a bare earth representation of terrain or surface topography. Non-ground features are filtered out by a combination of AI and geometry filters, where voids are filled by interpolation. LiDAR allows for more robust capture and inclusion of ground under vegetation.

Format

- 32-bit floating point
- Resolution: 3x nominal nadir GSD
- Binary raster mask marking interpolated areas
- GeoTIFF with DEFLATE compression

Applications

- Various environmental applications
- Drainage modeling
- Land-use studies
- Geological applications

Special Considerations

- Product Generation
    - Not derived through typical lidar point classification to determine ground points
    - Process relies upon all the semantic by-products (e.g., building footprints, forest/vegetation areas) of the aerial mesh process
    - Generated as part of aerial mesh processing

Ancillary Data Sets

The following data sets are not standard Metro HD products for sale or distribution. These files are generated as part of standard image product generation and could be provided at an organization's request and/or to support a bid package.

Mosaic Seam Lines

- Vector representation of mosaic seamlines stored as polygons in shapefile format.
- Polygons shall represent the total area included from each individual image in the final mosaic
- Polygons will be topologically correct, with no gaps or overlaps
- Shapefile attribute table must contain, at a minimum, the following attributes:
    - Image acquisition date and time (time format: UTC HH:MM:SS)
    - Sensor manufacturer and type (Leica CityMapper, etc.)
    - Sensor serial number (System serial number or Nadir camera serial number is acceptable)
    - Tail number of aircraft which acquired the image

Triangulation Report

- If Leica HxMap is used, the HxMap Triangulation Project Folder and a screenshot of the Triangulation perspective showing Statistics and Settings tabs shall be delivered
- For other Triangulation workflows, a Report which details the Triangulation results:
    - Residuals and standard deviation of adjusted exposure station position and orientation, compared to direct georeferencing from the trajectory
    - Residuals and standard deviation of adjusted image measurements. Tie points and control points are summarized independently.
    - Residuals and standard deviation of adjusted control measurements. Control points and checkpoints (if used) are reported individually.
    - Datum transformation (if any) calculated in Triangulation

Raw Data

The distribution and/or sale of raw data will be handled case-by-case. Raw data will only be sold if it is proven that the organization is attempting to extract information and/or produce products that Hexagon cannot. A royalty commitment should be put in place as part of the agreement.

The following raw data items will be provided upon request:

- A copy of raw data as it appears on the MMs or as created by HxMap Data Copy
- Processed GPS/INS file in SOL format
- Base station data

Coordinate Reference System

North America

- Horizontal datum: North American Datum 1983 (NAD83) 2011
- Vertical datum: North American Vertical Datum 1988 (NAVD88) – Geoid 12B
- Projection: Universal Transverse Mercator (UTM) in native UTM zone

Europe and Canada

- Horizontal datum: World Geodetic System 1984 (WGS84) – ITRF08 epoch 2005)
- Vertical datum: Earth Gravitational Model 2008 (EGM08)
- Projection: Universal Transverse Mercator (UTM) in native UTM zone

Acronyms

WGS – World Geodetic System
NAD – North American Datum
UTM – Universal Transverse Mercator
EGM – Earth Gravitational Model
ITRF – International Terrestrial Reference Frame
NAVD – North American Vertical Datum
RMSE – Root Mean Square Error
CL95 – Confidence Level of 95%
LAS – LASer format
DSM – Digital Surface Model
DEM – Digital Elevation Model
CSV – Comma Separated Values
LOD.X – Level of Detail
3D – Three Dimensions
QA/QC – Quality assurance / Quality control
TIFF (GeoTIFF) – Tagged Image File Format
OBJ – Object file format
SLPK – Service Layer package
TFW – TIFF World File
JPEG – Joint Photographic Experts Group
PNG – Portable Network Graphics
GIF – Graphics Interchange Format
RGB – Red- Green-Blue (spectral channels)
NIR – Near-infrared (spectral channel)
GSD – Ground Sample Distance
Lidar – Light Detection and Ranging
GNSS – Global Navigation Satellite System
GPS – Global Positioning System
LAZ – Zipped LAS file
2D – Two Dimensions
GPKG – GeoPackage
DTM – Digital Terrain Model
REST – Representational State Transfer
SOAP – Simple Object Access Protocol
CityGML – City Geography Markup Language

Definitions

Omega, Phi and Kappa – three axes of rotation typically used to represent the orientation of an image at acquisition

Datum (horizontal and vertical) – Any quantity or set of quantities that serve as a reference or basis for calculating other quantities

RMSE – The square root of the average of the set of squared differences between data set coordinate values and coordinate values from an independent source of higher accuracy for identical points

RMSEr – horizontal radius of a circle of uncertainty that includes RMSE_x and RMSE_y

WMS – defines an interface that allows a client to get maps of geospatial data and gain detailed information on specific features shown on the map

WMTS – Standard protocol for serving pre-rendered or run-time computed georeferenced map tiles over the internet

REST/SOAP – REST is a set of architectural principles, while SOAP is an official protocol maintained by the World Wide Web Consortium

SGM – Stereo elevation derivation method that is based on the idea of pixel-wise matching cost (disparity) of Mutual Information (MI) for compensating the radiometric differences of input images