
Statewide Ortho Imagery Product Description

prepared for
The State of Michigan

prepared by
Vexcel, A Microsoft Company

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1. Introduction

This document describes Vexcel's statewide orthographic imagery product, which is part of Microsoft's Bing Maps unlimited transactions offering being extended to the state and local governments. Vexcel is a wholly owned subsidiary of Microsoft specializing in geospatial solutions. Vexcel's role is to provide current, high quality, custom full color orthographic imagery to the customer and oversee its publication on Bing Maps. Microsoft's Bing Maps business unit will at the same time provide unlimited Bing Maps transactions to participating government agencies at no additional charge under this purchase.

This version of the Statewide Orthoimagery Product Description has been specially prepared for the state of Michigan. Items unique to the state of Michigan are highlighted in bold text within this document.

Orthographic imagery mosaics will be collected and processed covering the applicable area at 1 foot resolution. The imagery is included with license of Microsoft Bing Maps Enterprise. These images will be published within Microsoft's Bing Maps Enterprise Platform available via the API at

<http://www.microsoft.com/maps/developers/> and also will be delivered to the state as full color ortho-mosaics in GeoTiff format. The joint product, as described herein, can be ordered on a yearly basis by the participating government entity for up to three years, or the duration of their existing Microsoft Enterprise Agreement. After this period, pricing will be adjusted to reflect economic conditions at that time, and the agreement may be extended with any modifications agreed to by the participating government entity and Microsoft.

The volume of imagery being collected during the remaining three year term of the current State of Michigan Microsoft Enterprise Agreement is three fifths of the State or approximately 34,089 square miles. Approximately here means within 300 square miles of this amount. The imagery will be collected by entire counties, or larger areas containing at least an entire county. The areas and counties to be collected during each flying season will be chosen by the state of Michigan.

Counties larger than 1600 square miles can participate based on 1/2 the area of their county being flown in a single year, and there is the opportunity, but not the obligation, to fly the rest of the county in a subsequent year. Counties larger than 2400 square miles can participate based on 1/3 the area of their county being flown in a single year on the same terms just described.

If the Area of Interest (AOI) being flown and processed contains an island, which the customer desires to have flown, the island shall be flown and processed like any other land area. In addition, a strip of water 3 miles wide connecting the island with the mainland shall be included in the area flown and processed, as well.

Areas to be flown each year need to be finalized no later than 3 months prior to the start of the applicable flying season in the area to assure that leaf-off collection is possible. If leaf-off collection is not possible, the participating government may, at its option, relax the leaf-off requirement in areas such as open fields and cities where it is less important, or the customer may choose to wait until the following flying season for leaf-off collection of these areas. If the customer chooses to defer flying until the following leaf-off season and also chooses to renew the agreement in the subsequent year, the deferred year will be collected and processed during the same flying season as the subsequent year, provided that the subsequent areas are finalized in time to allow leaf-off collection, in areas where that is required.

2. Reference Documents

GeoTiff Specification, version 1.8.2, found on the web at <http://www.remotesensing.org/geotiff/spec/geotiffhome.html>

3. Requirements

3.1 Characteristics

3.1.1 Image Format

Images shall be delivered in GeoTiff format. Individual GeoTiff images shall form a mosaic that covers the areas of interest. The file format shall conform to the GeoTiff Specification, version 1.8.2 at

<http://www.remotesensing.org/geotiff/spec/geotiffhome.html> . Proprietary tags shall not be used.

Image size shall be 5000 x 5000. The No Data value shall be specified in the metadata and shall not occur within the image data. A No Data value of (0,0,0) shall be used. No Data areas shall only occur outside the boundary of the specified AOI.

All ortho-imagery shall be delivered on digital media to the customer by Vexcel.

Image files from each area of interest (AOI) shall be labeled with names that end in five digit numbers. The number fields at the end of the filenames within an AOI shall all be consecutive without omission or duplication and shall begin with "00001". The text preceding the image number within the image filename shall be of the form

(area code)_(contractor code)_YYYYMMDD

where YYYY is the year, MM is the two digit month, and DD is the two digit day of acquisition. The area codes and contractor codes will be supplied by Vexcel.

3.1.2 Image Type

Image files shall be 24 bit color images with the three bands representing colors which appear natural to a human observer.

3.1.3 Image Coordinates

Image coordinates shall be specified in geographic coordinates. Image coordinates shall be referenced to the Universal Transverse Mercator (UTM) system tied to the NAD83 datum. If specified at the time of ordering an AOI, image coordinates shall be referenced to the applicable Stateplane system instead.

3.1.4 Image Scale

Data collection shall occur at 30 cm ground sample distance (GSD) $\pm 10\%$. Processed images shall be sampled at a GSD, which is TBD between 30 cm and 1 foot. The customer may specify whichever value is preferred at the time of ordering. If the value is not specified at the time of ordering, 30 cm shall be used for UTM coordinate system maps and International Feet (0.30480 m) shall be used for Stateplane coordinate system maps.

3.1.5 Metadata

Metadata shall be supplied for all images and shall include

- Image location and outline
- Accuracy statement giving the measured RMS 2D error and the corresponding error at 90% and 95% confidence levels, assuming a circular Gaussian error distribution
- Accuracy statement referencing the National Map Accuracy Standard
- Camera used
- Date and time of acquisition
- Ground sample distance as collected
- Focal ratio and exposure time
- Remarks on image quality and artifacts, if any

- FGDC compliant metadata for the Area of Interest, if requested at the time of order

3.2 Image Quality

3.2.1 General Image Quality

Images shall appear sharp when viewed at 1 pixel per GSD and displayed or printed on high quality equipment at 80 to 100 pixels per inch. Mosaicking artifacts and other image artifacts shall be minimal or completely unnoticeable. Color mosaics shall be free from clouds, cloud shadows, haze, prominent seams, gridding due to uncorrected camera vignetting, and other obvious, uncorrected artifacts. Hot spots and water glint shall be corrected.

3.2.2 Instrumental Corrections

Instrumental corrections for distortion and radiometric level shall be applied to raw data values based on most recent and up-to-date camera calibrations. Camera calibration records shall be maintained on file by the aerial photography company and copies of these records shall be furnished to Vexcel or the participating government for inspection on request.

3.2.3 Radiometric Correction

Images shall be color balanced to minimize perceptible differences in color tones within and between adjacent images. Color balancing shall result in colors which appear natural to a human observer.

Image contrast and brightness shall be adjusted to minimize perceptible differences within and between adjacent images.

Lakes larger than 10 square miles will be edited to make water areas appear uniform, if desired by the customer.

The minimum numerical adjustments necessary to meet these requirements shall be performed.

3.2.4 Spatial Correction

The best available digital elevation map (DEM) from the United States Geological Survey (USGS), or other high quality DEM provided by the participating government in GeoTiff or other compatible format, shall be used to ortho-rectify the images. Images shall be rectified for terrain elevation and perspective using the DEM, which may be supplemented by automated cross-correlation of image features in stereo pairs.

Cultural features, such as major roads, bridges, overpasses, buildings, and other important features that are impacted by DEM artifacts shall be repaired. DEM artifacts noticeable at a scale of 400 feet per inch in rural areas shall also be corrected.

During ortho-rectification, images shall be re-sampled at the specified GSD.

3.2.5 Mosaicking

Images shall be delivered in adjacent sections free of overlap, suitable for tiling.

Image seams shall be placed to minimize disruption of important features of cultural or geographic significance—for example, large buildings, bridges, and major rivers. Image seams shall not run through

elevated structures, such as bridges, overpasses, and large buildings. When feasible, seams shall be placed at naturally occurring lines in the image to render them less noticeable.

Skews greater than one pixel shall be corrected.

3.2.6 Accuracy

Planimetric accuracy corresponding to the National Mapping Accuracy Standard for a scale of 1:2,400 shall be achieved. This means that 90% of image pixels representing well-defined points shall be within 6.67 feet (2 m) of their apparent location in the imagery. Sufficient control points to achieve this accuracy shall be used.

Existing ground control supplied by the participating government shall be used if available, supplemented as necessary by marking of monumentation supplied by the customer, commercially available ground control, and newly created ground control.

All control points used shall be surveyed to less than 20 cm horizontal and 30 cm vertical accuracy and shall be taken at locations which are clearly identifiable on aerial images.

3.3 Image Collection Constraints

3.3.1 Equipment

All imagery from a single AOI shall be collected using a single digital aerial survey camera in good working order with up-to-date calibrations, an image stabilization system using a suitable inertial measurement unit, and a GPS receiver with differential correction capability in areas where available.

The camera shall provide forward motion compensation during the exposure time.

The camera lens and detector array shall be clean and free of excess dust or lint.

3.3.2 Flight Path

Imagery in all AOIs shall be collected on either north-south (which is preferred) or east-west lines whenever feasible, and all imagery in a single AOI shall be collected on parallel lines, unless flight path restrictions in the area make this impractical. Flight lines shall be parallel to a UTM projection using the UTM zone containing the centroid of the collected area.

3.3.3 Camera Orientation

Imagery shall be collected at a crab angle of less than 5 degrees, which is measured between the camera's along-track image axis and the aircraft line of flight. The camera shall be nadir pointed within 2 degrees on average and shall not exceed 4 degrees off nadir at any time during image collection.

3.3.4 Image Overlap and Sidelap

Imagery of the AOIs shall be collected with >60% in-track overlap and >30% sidelap.

3.3.5 Camera Settings

Camera aperture and exposure time shall be adjusted for light conditions to achieve optimal image quality, consistent with the camera manufacturer's recommendations or automated settings, unless the

camera operator has data which demonstrate that a different setting produces superior results under conditions at the time of collection.

3.4 Environmental Conditions

Imagery shall be collected under clear skies. The air shall be free of smoke, dust, and excessive haze. Imagery may be collected under high, thin cirrus conditions, if it does not result in noticeable image artifacts, such as a mottled appearance or low light levels. Such conditions may not be combined with clear skies in the collection of a single AOI.

Imagery shall be collected at sun elevation angles greater than 30 degrees. Adjacent flight lines shall be flown at sun elevation angles which differ by less than 15 degrees.

Roadways shall not be wet from recent precipitation.

The ground shall be free of snow cover and lakes free of ice. The ground shall not be obscured by fog.

Imagery shall be collected while deciduous trees are free of leaves, unless this requirement has been waived by the customer in writing for the specific AOI. The requirement for leaf-free collection may be waived by the customer, at the customer's option, in areas where this is not critical, such as open fields, pine forest, and urban areas, in order to allow collection of imagery after the leaf-off season is over with.

4. Areas of Interest

Areas of interest (AOIs) shall range in size from 300 to 1800 square miles and shall be located within or near the boundary of the applicable jurisdiction. Three months before the applicable flying season for each year, areas of interest totaling the desired number of square miles shall be identified by the customer.

5. Quality Assurance Provisions

5.1 General

Independent quality checks shall be performed to certify the accuracy of the product and conformance to image quality specifications. Specific inspections shall be carried out at appropriate image scale and frequency to verify the Image Quality requirements.

5.2 Visual Inspection for Specific Artifacts

All Image Quality Requirements in Sections 3.2.1, 3.2.2, 3.2.3, 3.2.4, and 3.2.5 shall be inspected at a scale of 400 feet per inch or larger. Seam lines, glints, color balance, DEM artifacts, and bridges on major roadways shall be addressed in this inspection, and artifacts noticeable at this scale shall be corrected. In urban areas, a scale of 200 feet per inch or larger shall be used for inspection.

5.3 Planimetric Accuracy

Accuracy shall be measured by statistical inference from ground control point residuals in the aero-triangulation solution that compares survey data with on-board GPS and IMU data with known error

distributions. Data used in the fit shall be properly weighted according to the a priori error distributions, so that the solution is not biased towards artificially low residuals.

One or more AOI's where 15 or more control points are available to obtain accurate statistics using points excluded from the aero-triangulation solution shall be used as a check on this method.

At least six ground control points shall be used in each AOI, and at least one ground control point in each AOI shall be collocated with a survey monument, as an independent check on accuracy. Four ground control points will be located in near the four corners of a rectangular approximation to the AOI, and one point will be located near the center of this rectangular region.

5.4 Warranty Against Image Defects

Defects in imagery collection that are reported by the customer within 90 days shall be corrected by re-acquisition and re-processing. Defects in image processing reported by the customer within 12 months shall be corrected by re-processing.

5.5 Sample Imagery

An imagery sample with an area of approximately 1% of the AOI can be furnished on request, once processing is underway and a sufficient area has been completed. Customers requesting such samples must furnish a USB drive with sufficient capacity of at least 2 GB and pay shipping at least one way.

6. Delivery Schedule

Collected imagery in each season shall be delivered to the customer within 4 months of the end of the applicable flying season, or receipt of order for the AOI, whichever occurs later, and shall appear on Bing Maps online within 3 to 5 months after this time (unless better imagery, as defined below, is already available on Bing Maps at that time). For this purpose, better imagery means imagery which is more current and comparable in resolution and/or accuracy or comparably recent and better in resolution and/or accuracy.

7. Options

7.1 High Resolution Areas

If this option is chosen for an AOI the area will be imaged at 6 inch resolution, rather than 12 inch resolution. The minimum size of a High Resolution Area (HRA) is 10 square miles.

Data Collection in the HRAs shall occur at 15 cm GSD $\pm 10\%$.

Processed images for the HRAs shall be sampled at a GSD, which is TBD between 15 cm and 6 inches. The customer may specify whichever value is preferred at the time of ordering.

HRAs in high density urban areas shall be collected with 80% in-track overlap and 60% sidelap. This results in reduced building lean in these areas.

Partner to provide map or shapefile defining HRA areas.

7.2 Six Inch Resolution Upgrade (100% of AOI)

If this option is chosen for an AOI, 100% of the AOI's land area will be imaged at 6 inch resolution, rather than 12 inch resolution.

Processed images with the Six Inch Upgrade shall be sampled at a GSD, which is TBD between 15 cm and 6 inches. The customer may specify whichever value is preferred at the time of ordering.

Images in high density urban areas with the Six Inch Upgrade shall be collected with 80% in-track overlap and 60% sidelap. This results in reduced building lean in these areas.

Six inch AOI's shall meet the same Image Quality requirements as 12 inch AOI's.

7.3 Updated DEM (100% of AOI)

If this option is chosen for an AOI, the updated DEM resulting from image feature correlation processing and any DEM editing performed will be supplied to the customer for the AOI. The DEM supplied will be the DEM used to produce the orthoimagery for the AOI.