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मसौदा भारतीय मानक

ऑर्थोइमेजरी- डेटा अधिग्रहण और सटीकता मूल्यांकन

Draft Indian Standard

Orthoimagery- Data Acquisition and Accuracy Assessment

ICS 35.240.70

LITD 22 Geospatial Information Sectional Committee	**Last Date for Comments:** 8th September 2025

Geospatial Information Sectional Committee, LITD 22

FOREWORD

(Formal clause will be added later)

This draft Indian Standard will be adopted by the Bureau of Indian Standards, after the draft will be finalized by the Geospatial Information Sectional Committee LITD 22 and after the approval of Electronics and Information Technology Division Council.

Orthoimage is georeferenced representation of the Earth's surface captured by sensors and processed to correct for sensor distortions, orientation variations, and terrain relief. These corrections eliminate object displacement within the images. Orthoimage encode the optical intensity of detected radiation across one or more bands of the electromagnetic spectrum as discrete values, organized into a grid of georeferenced pixels that model the observed scene.
This standard outlines comprehensive requirements for standardizing Orthoimage products to enhance data quality, interoperability, and spatial data sharing. It serves as a guide for data providers to improve data quality and assess its accuracy. The document provides insights into the current state of Orthoimage products offered by data providers and aligns with the objectives of the NGP 2022. Data providers are encouraged to meet or exceed the minimum data specifications outlined in this standard to ensure compliance and enhance product quality.

The composition of the Committee responsible for formulation of this standard is given in Annex A.

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Indian Standard

ORTHOIMAGERY- DATA ACQUISITION AND ACCURACY ASSESSMENT

1 SCOPE

This Indian standard describes data acquisition methodologies and accuracy assessment criteria for Orthorectified Imagery (ORI) within the geospatial data framework. It defines the technical specifications, accuracy requirement, and data quality parameters necessary for acquiring and processing orthoimagery.

2 REFERENCES

The standards listed below are necessary adjunct to this standard. They, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Doc No	**Title**
ASPRS, Edition 2, Version 2.0, (2024)	ASPRS Positional Accuracy Standards for Digital Geo-Spatial Data, Edition 2 Version 2 (2024)
Federal Geographic Data Committee, Feb 1999 (FGDC-STD-008-1999)	Content Standards for Digital Ortho-imagery
IS 16439 : 2016	Geographic Information: Meta data

3 TERMS AND DEFINITIONS

3.1 Accuracy: The degree of conformity of a measured or calculated value compared to a value that has been accepted as the actual value. Accuracy relates to the quality of a result and is distinguished from precision, which relates to the quality of the operation by which the result is obtained.

3.2 Absolute accuracy: A measure that accounts for all systematic and random positional errors in a data set when the data set is referenced to a known and explicitly specified datum.

3.3 Aero triangulation: Process of using aerial imagery or the extension of horizontal and/or vertical control whereby the measurements of angles and/or distances on overlapping imagery are related into a spatial solution using the perspective principles of the imagery. Aerial triangulation is the mathematical reconstruction of the positions and orientations of aerial photographs within a real-world 3D coordinate system at the moment of capture.

3.4 Airborne GNSS Based Positioning System (AGBPS): Consists of a GNSS unit mounted on the acquisition platform that captures range measurements from satellites and uses triangulation techniques to compute the position of the receiver's antenna and corresponding coordinates of the photo centre at time of capture. When combined with an Inertial Navigation System (INS), this can be used to provide direct geo-referencing of exterior orientations, which define both the position and orientation associated with an image as they existing during image capture.

3.5 Aliasing: Sampling effect that leads to spatial frequencies being falsely interpreted as other spatial frequencies.

3.6 Band: The sub-file or sub-files of images depicting reflectance or emittance brightness as measured by digital numbers within particular bandwidths. A panchromatic image consists of a single band sensitive to a spectral range within the visible portion of the electromagnetic spectrum (typically 400 to 700 nm), while multispectral images typically consist of three to five bands of medium width (e.g., 400 to 500 nm) and hyperspectral images consist of tens to hundreds of narrow bands (e.g., 10 nm wide).

3.7 Band interleaved: Ordered mixing of data from one or more bands with corresponding data from other bands for the purpose of forming a single image file.

3.8 Band sequential: Sequence of one image band followed by another image band.

3.9 Band width: Range of spectral sensitivity of an image acquired by a sensor or digital camera. The bandwidth determines the spectral resolution of an image.

3.10 Bilinear interpolation: An extension of linear interpolation for interpolating data points on a two- dimensional regular grid using four neighbors.

3.11 Color Infrared/False color: Method for viewing or designating images sensed in the portion of the electro-magnetic spectrum generally from about 0.5 to 1.0 micrometers. This allows features like vegetation, water, soil, and urban areas to be visualized in a way that highlights differences not seen in natural color images.

3.12 Cubic convolution: A technique for resampling or interpolating raster data which uses the average for the focal cell based on the 16 cells surrounding that cell. Images resampled using this technique are often smoother and have fewer artifacts than when using other techniques such as nearest neighbor and bilinear.

3.13 Data dictionary: A catalog or table containing information about the datasets stored in a database.

3.14 Data Providers / Acquisition Agency: A data provider or acquisition agency is responsible for collecting, processing, and maintaining geospatial data.

3.15 Data Users / Indenting Agency: A data user or indenting agency is an organization that requires geospatial data for various applications such as mapping, infrastructure planning, disaster management, environmental monitoring, and urban development. They request, purchase, or subscribe to data from acquisition agencies to support their specific projects.

3.16 Digital image: Image stored in binary form and divided into a matrix of pixels, each consisting of one or more bits of information that represent either the brightness, or brightness and color, of the image at that point.

3.17 Digital number/Brightness value: It describes pixel values in an image that have not yet been calibrated into physically meaningful units (relative reflectance or emittance of an object in a digital image). Digital number is generally referred to as DN. Brightness value is referred as BV.

3.18 Digital Orthoimage: Geo-referenced digital image or other remotely-sensed data, in which displacement of objects in the image due to sensor distortions and orientation, as well as terrain relief, have been removed.

3.19 Displacement: Shift in the position of an image on an image resulting from tilt, scale change, and relief of the area imaged.

3.20 Framework: Collection of basic geospatial data upon which users may collect, register or integrate geospatial information. Thematic categories comprising the framework include: Geodetic control, digital orthoimagery, elevation, transportation, hydrography, governmental units, and cadaster.

3.21 Geo-registration: Alignment of one image to another image of the same area by placing any two pixels at the same location in both images "in register" resulting in samples at the same point on the Earth.

3.22 Global Navigation Satellite System (GNSS): Space based navigation systems that provide positioning and timing services through RF signals to users equipped with appropriate receiver hardware. The GNSS systems currently providing service are GPS (USA), GALILEO (EU), GLONASS (Russia), BeiDou (China), QZSS (Japan) and NavIC (India).

3.23 **Ground sample distance (GSD)/ Ground sample interval/ Ground resolution/ Ground pixel resolution:** In a digital photograph, which can be created by using a digital aerial camera or by scanning an analogue film negative, the ground sampling distance is the distance between pixel centers measured on the ground, expressed by using ground related units.

NOTE: This appears also on ortho-photos. For example, in an image with 0.20 m (20 cm) GSD, the distance between adjacent pixels on the ground appears as 20 cm. Since pixel elements are squares, it will cover an area of 20 cm x 20 cm on the ground.

3.24 **Horizontal accuracy:** The horizontal (radial) component of positional error in a data set with respect to a horizontal datum at a specified confidence level. The horizontal accuracy is computed from the horizontal positional error along the X and Y axes using the following formula:

$$RMSE_H = \sqrt{RMSE_X{}^2 + RMSE_Y{}^2}$$

3.25 **Horizontal datum:** Horizontal datum defines the reference surface used for measuring horizontal positions (latitude and longitude) on the Earth. It is a mathematical approximation of earth surface, for defining coordinates.

3.26 **Imagery:** Visible representation of objects and/or phenomena as sensed or detected by cameras, infrared and multispectral scanners, radar, and photometers.

3.27 **Inertial Measurement Unit (IMU):** Instrument that records the pitch, roll, and heading of a remote sensing platform.

3.28 **Inertial navigation system (INS):** A system composed of an IMU and a navigation processor that solves for the motion of the IMU; the two combined provide a navigation solution for the platform's position, velocity and orientation.

3.29 **Interpolation along two axes:** The axes are derived using a coordinate transformation algorithm to locate the quadrilateral of the four nearest profile points surrounding the unknown point. The interpolation computes the unknown value based on the average, by use of weights and distances of the four nearest known values.

3.30 **Linear interpolation:** A technique that uses a linear function and linear distance between known values to estimate unknown values or new data points within the range of a discrete set of data points with known.

3.31 Mosaic: Assemblage of overlapping or adjacent photographs or digital images whose edges have been matched to form a continuous pictorial representation of a portion of the Earth's surface.

3.32 Natural color: Pertaining to a portion of the electro-magnetic spectrum, 0.4 to 0.7 micrometers, that measures blue, green, and red reflectance.

3.33 Nearest neighbor: A two-dimensional technique for resampling raster pixel values in which the value of each cell in an output raster is assigned to the value of the nearest pixel in an input raster, where nearest is defined by the minimum distance between the output pixel's centroid and the centroids of neighbor pixels in the input raster. Nearest neighbor assignment only shifts a value's position in space; some input values may be used more than once as output value, while other input values may not be used at all. Because no mathematical transformation is used in this method it is often used to resample categorical or nominal data (for example, land use, soil, or forest type), or radiometric values, such as those from remotely sensed images.

3.34 Non-vegetated vertical accuracy (NVA): The vertical accuracy of the elevation surface in open terrain or bare earth.

3.35 Metadata: Data about data Textual information describing the content, quality, condition, another characteristic of data.

3.36 Orthorectification: Process of removing geometric errors inherent within photography and imagery caused by relief displacement, lens distortion.

3.37 Overedge: Refers to data extending beyond the defined primary area of interest. This may be image data, or fill data required to "square" the image to achieve fixed record lengths.

3.38 Panchromatic (photography): A term applied to photographic materials possessing sensitivity to all visible spectral colors, including red.

3.39 Panchromatic: Pertaining to mono spectral imagery that records the intensity of reflected or emitted radiation in the visible spectrum, 0.4 to 0.7 micrometers.

3.40 Pan-sharpening: Fusing of high-resolution panchromatic imagery with lower-resolution, multispectral imagery to create a high-resolution multispectral image.

3.41 Pixel/Picture element: A component of either a digital image or a digital sensor. In the case of a digital image, the pixel is the smallest discrete unit of information in the image's structure. Images based in raster data can be thought of as a grid.

3.42 Pixilation: Describes the abrupt and unnatural transition over an edge feature. Also referred to as "staircasing" because of the jagged and abrupt transition.

3.43 Radiometric resolution: Describes its ability to discriminate very slight differences in energy. Radiometric resolution refers to the sensitivity of a sensor to detect differences in electromagnetic radiation. The finer the radio metric resolution of a sensor, the more sensitive it is to detect small differences in reflected or emitted energy.

NOTE: Radiometric resolution is inversely related to the number of digital levels used to express the data collected by the sensor. The number of levels is normally expressed as the number of binary digits needed to store the value of the maximum level, for example a radiometric resolution of 1 bit would be 2 levels, 2 bits would be 4 levels, 8 bits would be 256 levels, and 16 bits would be 65,336 levels. The number of levels is often referred to as the digital number, or DN value.

3.44 Resample: Change in the pixel dimensions of an image by either adding or removing the total number of pixels using an interpolation method.

3.45 Resampling: Calculation of new digital numbers (DN) for pixels created during geometric correction of a digital scene, based on the values in the local area around the uncorrected pixels. 2. is the process of trans forming a sampled image from one coordinate system to another. 3 changing the amount of image data as you change either the pixel dimensions or the resolution of an image.

NOTE: Resampling always reduces image quality. Resampling to smaller dimensions reduces file size and sharpens appearance. Resampling to larger dimensions increases file size and blurs appearance.

3.46 Resolution: Measure of spectral sensitivity, radiometric sensitivity, or the smallest spatial unit represented in an image.

3.47 Root mean square error (RMSE): The square root of the average of the squared discrepancies.

NOTE: The RMSE statistic is used to describe accuracy encompassing both random and systematic errors.

3.48 Sharpening: Amplification of the SFR by means of image processing to achieve sharper appearing images. Also, a class of image processing operations that enhances the contrast of selective spatial frequencies, usually visually important ones. It is a technique used to enhance the edges and fine details in an image, making it appear clearer and more defined.

3.49 Source: Sources imagery for digital orthoimagery is collected by a variety of remote sensors. Remote sensing systems can be divided into two general categories: imaging and non-imaging. This standard focuses on imaging systems. Commonly used types of imaging systems include photo-optical, electro-optical, passive microwave, RADAR, LIDAR, IFSAR, SONAR.

3.50 Spatial Frequency Response (SFR): An imaging system's ability to maintain the relative contrast of input stimuli.

3.51 Spatial resolution: Ability to separate closely spaced objects on an image or photograph. Commonly expressed as the most closely spaced line-pairs per unit distance that can be distinguished (size of the smallest possible feature that can be detected by the sensor).

3.52 Spectral resolution: Measure of the narrowest spectral feature that can be resolved by a spectral sensor. It is also defined as the full width at half maximum (FWHM) response in each band of data (the way an optical sensor responds to various wavelengths of light).

NOTE: High spectral resolution means that the sensor distinguishes between very narrow bands of wavelength; a “hyper spectral” sensor can discern and distinguish between many shades of a color, recording up to 256 degrees of color across the infrared, visible, and ultraviolet wavelengths. Low spectral resolution means the sensor records the energy in a wide band of wavelengths as a single measurement; the most common “multispectral” sensors divide the electromagnetic spectrum from infrared to visible wavelengths into four generalized bands: infrared, red, green, and blue.

3.53 Survey: Act or operation of making measurements for determining the relative positions of points on, above, or beneath the Earth’s surface.

3.54 Temporal resolution: Revisit time repeat cycle frequency at which data are captured for a specific place on the earth.

NOTE: The more frequently data they are captured by a particular sensor, the better or finer is the temporal resolution of that sensor. Temporal resolution is relevant when using imagery or elevations datasets captured successively over time to detect changes to the landscape.

3.55 Vertical Accuracy: The vertical component of the positional accuracy of the Digital Surface Model (DSM) with respect to a vertical datum, at a specified confidence level. The vertical accuracy is computed from the vertical positional error along the Z axis. Vertical accuracy is presented as $RMSE_v$.

3.56 Vegetated vertical accuracy (VVA): Accuracy of the elevation surface in areas where terrain is covered by vegetation.

3.57 Void: Areas in an image or other geospatial dataset with no data.

4 DATA ACQUISITION PARAMTERS

The process of acquiring orthorectified imagery depends on several factors, including accuracy requirements, intended use, budget constraints, and delivery timelines. These factors help determine key acquisition parameters such as the type of sensor used, the choice of platform (whether airborne or UAV), and terrain considerations. To ensure precision, the use of Ground Control Points (GCPs) and a suitable Digital Elevation Model (Digital Surface Model - DSM in case of orthorectification) is essential. Additionally, operational planning, weather conditions, cloud cover, and lighting play a crucial role in determining the reliability and feasibility of data collection. Table 1 provides a detailed overview of the key specifications for orthorectified imagery.

Table 1: Specifications of Ortho Rectified Image

Sl. No.	Description	Specifications
1.	Horizontal Datum	The World Geodetic Datum 84 (WGS84)
2.	Vertical Datum	All deliverables specified below as ellipsoidal will be in terms of the WGS-84 reference frame.
3.	Projection	The coordinate system for all deliverables is the Universal Transverse Mercator (UTM) in respective zones.
4.	Horizontal accuracy of ORI	5 - 10 cm for urban areas & rural areas and 50-100 cm for forest & wastelands. If the area of interest does not align with the above categories, the acquisition/indenting agency shall decide upon the horizontal accuracy requirement of the Orthorectified Imagery depending upon their application.
5.	Vertical Accuracy of DSM	25 cm for plain and 1-3 meter for hilly and mountainous areas. If the area of interest does not align with the above categories, the acquisition/indenting agency shall decide upon the vertical accuracy requirement of the Orthorectified Imagery depending upon their application.
6.	Buffer during acquisition	Data provider shall provide buffer beyond the area of interest to ensure data completeness, overlap and quality at the edges of ORI. The acquisition/indenting agency shall decide upon the buffer distance during acquisition.
7.	Ground Sampling Distance/Ground pixel resolution	The ground sampling interval shall be from 0.5 to 1.0 times the horizontal accuracy. (Refer Table 3) The acquisition/indenting agency shall decide upon the Ground Sampling Distance requirement of the Orthorectified Imagery depending upon their application.
8.	Image format	Uncompressed GeoTIFF, TIFF, JPEG.
9.	Radiometric	Minimum 8 bit per band in accordance with chosen image

	Resolution	format
10.	Type of image	• Panchromatic, • Multi-spectral- RGB, Near Infrared(NIR), Colour Infrared (CIR), SWIR (Short wave Infrared)
11.	DN/ Radiance or Reflectance Value	0 (Black) – 255 (White)
12.	Rectification Process	Digital Surface Model (DSM) created in post processing shall be used for rectification process.
13.	Ellipsoidal Heights Units	Meters
14.	Sensor Detail	To be specified by acquisition agency
15.	Solar Elevation	Min 30 Degree
16.	Image Product	Single scene/ mosaic/tiles The acquisition/indenting agency shall decide upon the tile size
17.	Resampled Pixel Size/Resolution	The acquisition/indenting agency shall decide upon the Resampling Resolution.
18.	Data completeness	No gap shall exist in the image. In case of void areas/ masked areas, "nodata" value shall be assigned to the DN values of the area.
19.	Cloud Cover	No Cloud Cover or cloud shadows shall obscure image features in the image. However, if the cloud cover does not affect the indenting application, cloud cover up to 5% shall be accepted.
20.	Image Smear	No Image smear shall exist in the image.
21.	Geometric correction Method	Nearest neighbor/ bilinear interpolation/ Cubic Convolution
22.	Data Transfer Format	GeoTIFF, Cloud Optimized GeoTIFF (COG) , OGC APIs.
23.	Edge Matching	Single image created through mosaicing of multiple images shall be edge matched and shall have seamless appearance.
24.	Geo-referencing Method	Ground Control Point or AGBPS (Airborne GNSS Based Positioning System) combined with Inertia Navigational System (INS) corrected by RTK or PPK processing.
25.	Ortho rectification	1. The camera's focal length, principal point, and orientation parameters (position and rotation) are refined iteratively by solving a collinearity equation. This process establishes a rotation matrix that defines the camera's orientation relative to the ground coordinate system. 2. The derived rotation matrix and camera parameters enable the transformation of any ground X-Y-Z point into image coordinates. 3. If working with scanned aerial photographs, a two-dimensional transformation is applied between the measured fiducial marks on the digitized image and their theoretical camera coordinates. This step ensures geometric corrections in the image space. Transformation constants are developed from the calibration fit.

		4. The adjusted image coordinates are back-projected to determine their corresponding pixel locations in the digital image. 5. Distortion corrections (lens distortions, terrain relief displacement, and perspective distortions) are applied to produce a geometrically corrected image. 6. Ortho-rectified Image shall be tonally balanced prior to generation of an image mosaic. Relative join (misalignment) of transportation features between adjacent image chips/tiles shall be within the tolerance defined by the horizontal positional accuracy requirement. 7. The rectification process shall involve a solution of the appropriate photogrammetric equations for each pixel in the output image. It is not preferable to solve photogrammetric equations at anchor points only and then warp the content of the original image between the anchor points. 8. The acquisition agency will describe its approach for ortho-rectification.
26	Radiometry	All images shall be clear and sharp in detail with no light streaks, static marks, scratches, ice effect or other noticeable blemishes. The imagery should be free from defects, such as out-of-focus imagery, and should not contain inconsistencies in tone and/or density. The ortho-rectified image should be free from tilt and relief displacement. To ensure consistency, the imagery should be radiometrically and geometrically corrected to enable adjacent files to be displayed simultaneously without obvious distinctions between them.

5 ORTHOIMAGERY ACCURACY ASSESSMENT

5.1 Horizontal Positional Accuracy Standard for ORI

The primary horizontal accuracy standard for orthoimagery is given in Table 2. These standards specify horizontal accuracy classes in terms of $RMSE_H$, the combined linear error along a horizontal plane in the radial direction. $RMSE_H$ is derived from $RMSE_X$ and $RMSE_Y$ according to the following formula:

$$RMSE_H = \sqrt{{RMSE_X}^2 + {RMSE_Y}^2}$$

$RMSE_x$ – Root Mean Square error in Easting
$RMSE_y$ – Root Mean Square error in Northing

The horizontal accuracy needs shall be determined by project requirements, and the horizontal accuracy class of a data set shall be expressed as a function of $RMSE_H$. For example, a project's scope of work may ask for orthoimagery produced to meet the Positional Accuracy Standards for 7.5 cm Horizontal Accuracy Class, meaning that the $RMSE_H$ for the resulting data set shall be ≤ 7.5 cm.

Table 2: Horizontal Accuracy Classes for Geospatial Data

Horizontal Accuracy Class	**Absolute Accuracy** $RMSE_{H_1}$(cm)	**Orthoimagery Mosaic Seamline Mismatch(cm)**
#-cm	≤ #	**≤ 2*#**

 # - Horizontal Accuracy Requirement
*** - Multiplied by**

In the case of orthoimagery mosaics, an additional criterion for the allowable mismatch at seamlines of ≤ 2* $RMSE_H$ is specified.

5.1.1 *Horizontal Accuracy Classes*

The Ground Sample Distance (GSD) of an orthoimage has a direct and significant impact on the accuracy of measurements that can be derived from it, such as distances, areas, and volumes. A more precise, or finer, GSD inherently leads to higher accuracy in these measurements because each pixel represents a smaller, more localized area on the ground. The fundamental principle is that the accuracy of any measurement taken from an orthoimage cannot exceed the GSD of that image. For projects requiring precise quantitative analysis, selecting an orthoimagery product with an appropriate GSD is paramount.

The horizontal accuracy classes for digital planimetric data, GSD of source imagery for high accuracy planimetric data are listed in Table 3.

Table 3- Horizontal Accuracy Class

Horizontal Accuracy Class (cm)	**RMSE (cm)**	**GSD of Source imagery (cm)**
0.63	0.63	0.31 to 0.63
1.25	1.25	0.63 to 1.25
2.5	2.5	1.25 to 2.5
5.0	5.0	2.5 to 5.0
7.5	7.5	3.8 to 7.5
10.0	10.0	5.0 to 10.0
12.5	12.5	6.3 to 12.5
25	25	12.5 to 25
50	50	25 to 50

5.2 Vertical Positional Accuracy Standard for Elevation Data

Vertical accuracy shall be expressed as $RMSE_V$ for both vegetated and non-vegetated terrain. While the Non-Vegetated Vertical Accuracy (NVA) shall meet accuracy thresholds listed below, the Vegetated Vertical Accuracy (VVA) has no pass/fail criteria and needs only to be tested and reported as found. If the NVA meets user specifications, VVA should be accepted at the reported accuracy level (Table 5).

Below table provides the Vertical Accuracy Class specifications for digital elevation data (Table 4).

Table 4: Vertical Accuracy Classes for Digital Elevation Data

Vertical Accuracy Class	Absolute Accuracy	
	NVA $RMSE_V$ (cm)	VVA $RMSE_V$ (cm)
#-cm	≤ #	As found

#- Vertical Accuracy requirement

Table 5: Vertical Accuracy Classes

Vertical Accuracy Class (cm)	NVA $RMSE_V$ (cm)	VVA $RMSE_V$ (cm)
1	1	As found
2.5	2.5	As found
5	5.0	As found
10	10.0	As found
15	15.0	As found
20	20.0	As found
33.3	33.3	As found

5.3 First Component of Positional Error – Product Fit to Checkpoints

For each checkpoint, the surveyed coordinates are compared to the coordinates derived from the tested product and their discrepancies are computed and tabulated. The product fit to checkpoints is represented by the first component of error, $RMSE_{H_1}$ or $RMSE_{v_1}$. RMSE shall be computed in each dimension from all the individual computed discrepancies between the product and the checkpoints or control points in that dimension, as stated in the following formula:

$$RMSE_X = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_{i(map)} - x_{i(surveyed)})2}$$

$$RMSE_Y = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_{i(map)} - y_{i(surveyed)})2}$$

$$RMSE_Z = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(z_{i(map)} - z_{i(surveyed)})2}$$

The first component of horizontal error is:

$$RMSE_{H_1} = \sqrt{RMSE_{X^2} + RMSE_{Y^2}}$$

The first component of vertical error is:

$$RMSE_{V_1} = RMSE_Z$$

5.4 Second Component of Positional Error – Survey Control and Checkpoint Error

The second component of positional error arises from the survey errors of control points and checkpoints. This component, represented as $RMSE_{H_2} or\ RMSE_{v_2}$, is the quantity reported by the field surveyor.

5.5 Horizontal Positional Accuracy

To compute the horizontal accuracy of a two-dimensional product, such as a planimetric map or orthorectified image, the height component of the survey point error is ignored. We assume that X (Easting) and Y (Northing) survey point errors are equal; that is, $RMSE_{x_2} = RMSE_{y_2}$.

Using error propagation principles for Euclidean vectors:

$$\text{Horizontal Product Accuracy } (RMSE_H) = \sqrt{{RMSE_{H_1}}^2 + {RMSE_{H_2}}^2}$$

5.6 Vertical Positional Accuracy

Vertical product accuracy is computed from the first and second components of vertical error:

$$\text{Vertical Product Accuracy } (RMSE_V) = \sqrt{{RMSE_{V_1}}^2 + {RMSE_{V_2}}^2}$$

6. ACCURACY REQUIREMENTS FOR ORTHOIMAGERY:

6.1 Accuracy Requirements for Ground Control used for Aerial Triangulation

Ground Control Points (GCPs) are fundamental to the orthorectification process, serving as identifiable reference points on the Earth's surface with precisely known coordinates. These points are crucial for establishing an accurate geometric relationship between the raw imagery and the real-world coordinate system. During orthorectification, GCPs are used to calculate the position and orientation (including roll, tilt, and yaw) of the imaging sensor at the precise moment of image capture.
The use of well-distributed and accurate GCPs is essential for achieving high horizontal accuracy in the final orthorectified product.

Selecting effective GCPs is critical for the success of the orthorectification process. Firstly, a GCP must correspond to a feature that is clearly visible and easily identifiable within the imagery. This allows for precise pinpointing of the exact location of the point in the image, ideally at the center of the feature or a well-defined corner. Secondly, the feature chosen as a GCP should be stable and permanent over time. Ideally, GCPs should also exhibit high contrast with their surroundings in the imagery, making them easier to locate and measure accurately. The spatial distribution of GCPs across the image is of paramount importance. To ensure optimal geometric correction, GCPs should be well-distributed throughout the entire image area, covering the edges, corners, and central portions of the scene. In areas with significant variations in terrain elevation, it is also beneficial to select GCPs at different altitudes to improve the accuracy of the terrain correction process.

The accuracy of the ground control points shall be twice the target accuracy of the final products. Ground control for aerial triangulation shall be designed for digital plan metric data (orthoimagery and/or map) only:

$$RMSE_{H_{(GCP)}} \leq ½ * RMSE_{H_{(MAP)}}$$

$$RMSE_{V_{(GCP)}} \leq ½ * RMSE_{H_{(MAP)}}$$

6.2 Accuracy requirement for Check Points (CP):

The primary method for quantitatively assessing the geometric accuracy of orthorectified imagery involves the use of independent check points. These are well-defined points whose coordinates are known with a high degree of accuracy (derived from an independent source that is more accurate than the orthorectified imagery being assessed) and which are also clearly identifiable in the orthorectified image. Importantly, these check points should be distinct from the ground control points (GCPs) that were used to perform the orthorectification itself. The accuracy assessment involves comparing the planimetric coordinates of the check points as measured in the orthorectified imagery with their known ground coordinates.

Checkpoints are used to assess product accuracy that should be derived from an independent set of points apart from the ones used in processing or calibrating the product under evaluation. Checkpoints shall be at least twice the accuracy of the final product specification.

$$RMSE_{H_{(CP)}} \leq ½ * RMSE_{H_{(MAP)}}$$

Checkpoints for accuracy assessment shall be well distributed around the project area. Considerations made for challenging circumstances such as rugged terrain, water bodies, heavy vegetation, and inaccessibility are acceptable if agreed upon between the data producer and the indenting agency. Table 6 provides recommended number of checkpoints for horizontal accuracy based on project area (Ref ASPRS, Edition 2, Version 2.0, (2024) as per which minimum check points shall be 30).

These check points should be well-distributed across the entire area covered by the orthorectified imagery and should correspond to features that can be identified with high confidence in both the imagery and the ground truth data. The number of checkpoints to be used for the horizontal accuracy testing of digital orthoimagery is given below.

Table 6 Recommended Number of Checkpoints for Horizontal Accuracy based on Project Area

Project Area (Square Kilometers)	Total Number of Checkpoints
≤1000	30
1001-2000	40
2001-3000	50
3001-4000	60
4001-5000	70
5001-6000	80
6001-7000	90
7001-8000	100
8001-9000	110
9001-10000	120
>10000	120

Note: For very small projects where the use of 30 checkpoints is not feasible, the number of well distributed checkpoints shall be kept as 5 per scene or shall be decided by indenting agency for achieving the required accuracy standard.

ANNEX A

The composition of Orthoimagery thematic working group is as under:

Table I: Working Group

S. No.	Structure	Member
1	Nodal Ministry representative	Shri Sandeep Shrivastava, Director-Coordinator & Convener
2	Academician	Dr RD Garg, Department of Civil Engineering, IIT Roorkee Dr RP Singh, Director, IIRS
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4	Sectoral specialist/ Data Specialist/ Data Theme Expert	Shri Dhiraj Goel, M/s ESRI India Technologies Pvt. Ltd. Shri Gangadhar Rao, M/s RSI Softech India Pvt. Ltd. Shri Krishnakant Kumar, M/s Scanpoint Geomatics Ltd.
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