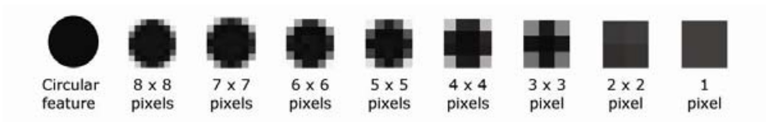
Source Data Specifications

Image GSD ≤ ¼ X/Y Feature Positional Tolerances

Image pixel projected onto the terrain is Ground Sampling Distance (GSD). GSD is a function of imaging altitude, which limits both feature resolution and mapping accuracy.

A cluster of 4 x 4 pixels is considered the threshold of shape recognition and therefore also limits of *pointing acuity* (ability to positively occupy a feature with the cursor).

For example, the round shape indicative of a man-hole will not be apparent if composed of too few square pixels. Without first able to positively place the cursor at a feature centroid, the mapping is unreliable.



If a mapping accuracy of ±1m is required, then an imaging pixel size of ≤25cm is advised.

N.B. Mapping Errors - Hardcopy mapping was originally designed for achieving a horizontal (X/Y) accuracy of ±0.5mm at plotting scale, with vertical (Z) spot accuracy within ½ the customary contour interval. Digital mapping supports variable hardcopy scales with accuracy tolerances now restated as X, Y and Z *Positional Accuracy* tolerances.

Mapping Scale	Contour Interval
1:500	0.5m
1:1000	1.0m
1:2,000	2.0m
1:5,000	5.0m
1:10,000	10.0m
1:20,000	20.0m
1:50,000	50.0m

Positional Accuracy			Image GSD
X	Y	Z	
0.25m	0.25m	0.25m	5cm
0.50m	0.50m	0.50m	10cm
1.00m	1.00m	1.00m	20cm
2.50m	2.50m	2.50m	50cm
5.00m	5.00m	5.00m	1.00m
10.00m	10.00m	10.00m	2.00m
25.00m	25.00m	25.00m	5.00m

Typical Applications
High accuracy engineering mapping
Municipal GIS Base Mapping
Regional District GIS Base Mapping
Road/Railway/Pipeline design/corridor Mapping
Mining/Exploration Base Mapping
Provincial Base Mapping, Military Town Plans
National Topographic Series Base Mapping

Image Geo-referencing via IMU

Image geo-referencing is comprised of 2 sets of parameters:

- X_0, Y_0 and Z_0 – positioning of the imaging system lens perspective center at the instant of image acquisition.

  X_0, Y_0 and Z_0 ≈ 1~1.5 GSD (≤ ¼ positional accuracy tolerance)

- K, φ and ω – respective aim angles of the imaging lens imparted by platform yaw, pitch and roll.

  K, φ or ω ≤ ½ arc minute

X_0 and Y_0 are Northing and Easting;
Z_0 is imaging altitude above a datum.

…or

Image Geo-referencing via Aerial Triangulation

- σ_0 ≤ 1 image pixel
- Block X/Y/Z RMSE ≈ 0.6 ~ 1 GSD
- Maximum X/Y/Z image/control point residual error ≈ 1.2 ~ 2 GSD

σ_0 indicates mensuration accuracy.

Block X/Y/Z RMSE depends on image control and contributes to global mapping error.

DEM

DEM are specified in terms of:

- Z-Accuracy – needs only be specified (as X/Y point positions are not necessarily regular or critical). In order to support contour interpolation via ArcTIN to an accuracy within ½ the customary contour interval, the DEM accuracy must be:

  90 ~ 95% ≈ 1 to 2 GSD

- Density – highly dependent on topographic slope.

  4 ~ 8X positional tolerance is typical.

Imaging platforms typically deployed limit LiDAR to 15cm accuracy and RADAR to 1m accuracy. Photogrammetric DEM accuracy can be as high as 10cm, if 5cm GSD imagery with imaging system f/b ratio ≤ 1.65 is used.

Excessive density may affect ArcTIN processing speed.

Selecting imaging scale or GSD

Correct selection is fundamental to achieving specified mapping accuracy.

In **film imaging**, scale is the primary parameter. The selected camera lens focal length (f) affects imaging altitude (H) where:

Image Scale = f/H

During digital conversion, various scanner pixel size may be selected to achieve specified GSD.

For example, 20cm GSD equivalent can be achieved by:
- scanning 1:20,000 scale imagery at 10µ pixel size, or
- scanning 1:10,000 scale imagery at 20µ pixel size.

The standard focal lengths for film cameras are:
- 88.5mm (3.5") – seldom used
- 152mm (6") – standard mapping camera
- 305mm (12") – popular in forestry applications

Available precision photogrammetric scanners support pixel sizes ranging from 5µ to 12µ, with many also provide intermediate pixel sizes.

In **digital imaging**, sensor native pixel size (P_S) is fixed. Specified GSD is achieved only by varying the imaging altitude. Image scale is simply:

Image Scale = P_S/GSD

Since Image Scale = f/H also, therefore f/H = P_S/GSD. Imaging altitude (H) can be derived from:

H = GSD x f/P_S

In the Z(I DMC f = 120mm and P_S = 12µ, to achieve a 20cm GSD:

H = 20cm x 120mm/12µ = 2000m

Imagery Source	f	P_S	f/P_S
Film			
Scanned @ 10µ	152mm	10.0µ	15,200
Scanned @ 10µ	305mm	10.0µ	30,500
Digital			
JenOptik JAS-150	150mm	6.5µ	23,077
Leica ADS-40/52	63mm	6.5µ	9,692
Vexcel UC_D	100mm	9.0µ	11,111
Vexcel UC_X	100mm	7.2µ	13,889
Z(I DMC	120mm	12.0µ	10,000

N.B. A short-hand method in determining imaging altitude is to multiply the required GSD by the fixed f/P_S factor in each imaging system.

Horizontal (X/Y) mapping accuracy

PurVIEW horizontal mapping accuracy is dependent on the pointing acuity of the monitor cursor using a standard mouse, which extracts the X/Y terrain coordinates of the nearest monitor pixel. Adopting a correct view scale supports specified accuracy tolerance.

N.B. PurVIEW-MX supports sub-pixel pointing acuity using higher resolution 3D input devices.

Using the same DMC example:

For the 20cm GSD selected, the image scale is:

Image scale = 12µ/20cm = 1:16,667

View scale is best set based on monitor dot pitch (≤ 0.4mm) and X/Y accuracy tolerance (4~5 GSD), thus:

View scale = 0.4mm/4 GSD = 1:2,000

An 8X magnification from image scale is therefore appropriate.

H x V	20"	18"
Monitor Resolution	**Dot Pitch**	
1,024 x 768	.40mm	.37mm
1,280 x 1,024	.30mm	.28mm

Vertical (Z) mapping accuracy

Vertical measurements can be manual or passive within PurVIEW.

Manual measurement accuracy – is dependent on image GSD under the chosen view magnification and exaggerated by the imaging system lens focal length (f) to image base (b) ratio, or f/b ratio.

N.B. f/b ratio is the same as H/B ratio, where B is the distance between exposure stations.

Continuing with the DMC example:

The 4~5 GSD horizontal accuracy, magnified by the f/b ratio of 3.13 will results in a vertical accuracy >12.5 GSD (2.5m)—unacceptable for mapping at 1:2,000 entailing 1m X/Y/Z positional accuracy, and normally supported by 20cm GSD.

The alternatives are: lowering imaging altitudes, deploying imaging systems with better f/b ratio, or **use Virtual-Z with quality DEM**.

Imaging systems	f	stereo angle	f/b
Film camera	152mm	34 °	1.65
Film camera	305mm	17 °	3.32
ADS-40/52 Pan.	63mm	42 °	1.28
ADS-40/52 R/G/B/IR	63mm	16 °	3.36
DMC	120mm	18 °	3.13
JAS-150 Stereo	150mm	41 °	1.30
JAS-150 Pan.	150mm	24 °	2.35
UC_D or UC_X	100mm	15 °	3.70

The 152mm lens focal length film camera has been the standard mapping camera whose f/b ratio is the foundation of most existing mapping specifications. Long lens focal length and/or short image base will result in high f/b ratios but less apparent object leans—more suitable for orthophoto processing.

Virtual-Z – is passive and dynamically interpolates ArcTIN dataset that represents the topographic model. Virtual-Z accuracy is solely dependent on the adopted source DEM.

If a DEM accurate to within 1m is chosen, then feature vertical coordinates extracted will be accurate to within 1m regardless of image f/b ratio.

Virtual-Z is based on the notion that features naturally residing on terrain surfaces should be conformal to the terrain model surface when mapped. All standard map features—except roof outlines—conceptually comply.

Roof outlines are planar objects above the terrain surface and would be correctly mapped by first off-setting the cursor to match the roof edges.