

# INTERPRETATION CHARACTERISTICS OF IKONOS IMAGERY FOR MAPPING AND COORDINATE ACCURACY OF IKONOS ORTHO IMAGERY

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## Abstract

IKONOS is the satellite that has about 1-meter ground resolution (maximum 0.82m), and had launched on September 1999 by an American commercial company. In this presentation, the authors show the possibility of IKONOS imagery for making topographical maps.

At first, the authors have researched the possibility of interpretation for making and updating topographical maps using IKONOS imagery. They are trying interpretation of IKONOS imagery for preparation of large-scale map. They made interpretation card of items for large-scale map, and adjusted consideration for interpretation of IKONOS imagery.

Next, the authors validate coordinate accuracy of IKONOS ortho imagery that has about 1m ground resolution. The test area is plain area in Tsukuba City. Three cases are validated: ortho imagery using 27m grid DEM by IKONOS stereo images, using 5m grid DEM by laser profiler, and using 5m grid DEM by IKONOS stereo images. In each case, the coordinate accuracy of IKONOS ortho imagery is about 1m.

In the presentation, the authors will introduce the result of accuracy validation of IKONOS ortho imagery and DEM in mountain area such as Mt. Tsukuba.

## 1. Introduction

IKONOS is the satellite that has about 1-meter ground resolution (maximum 0.82m), and had launched on September 1999 by an American commercial company (Space Imaging Inc.). Digital image data including satellite imageries is one of National Spatial Data Infrastructures, and it is expected to be used in GIS field. In this background, Geographical Survey Institute (GSI) had done the collaboration research with Japan Space Imaging Corporation (JSI). In this research, GSI has pigeonholed the characteristics of interpretation of IKONOS imagery, and has validated the coordinate accuracy of IKONOS ortho imagery and the vertical accuracy of DEM by stereo IKONOS imageries. In this paper, the authors show the possibility of IKONOS imagery for making topographical maps.

## 2. Specification of IKONOS

Specification of IKONOS satellite and its sensor is as below.

Resolution	PAN	0.8~1.5m	
	MSS	3.3~6.0m	
Swath Width	Nadir	11.3km	
	Off Nadir 26°	13.8km	
Quantum bit No.	Each Pixel	11bit	
Positional Precision	With GCPs	1.0m(Horizontal)	1.6m(Vertical)
	Without GCPs	6.0m (Horizontal)	5.3m(Vertical)
Revisit Cycle	1.0m Resolution	2~3days	
	2.1m Resolution	1day	

### 3. Cartography using satellite imagery

The 1:25,000 scale topographic maps in Japan have been made since 1950. By 1983, almost all those maps were made except South Krile Island etc. and since then maintenance of those maps is important to manage land planning. There are two type of map revision. One is the 'Regular revision' and the other is 'Partial revision'.

'Regular revision' means that all objects such as small building, narrow road, vegetation and so on are revised. On the other hand, 'Partial revision' means that important objects such as expressway, railroad, airport and so on, are only revised. To revise maps, aerial photographs have been used as yet but there are some problems. For the 'Partial revision', aerial photographs with high resolution are not needed because target is large and aerial photograph is not economical. In addition, it takes long time to obtain aerial photographs. To improve above problems, GSI has been trying to use satellite imagery to revise the maps.

As the results of the present research for mapping using satellite imagery, it is possible to produce 1:100,000 scale topographical map using SPOT imagery with 10-meter resolution. And GSI updated 1:50,000 topographical maps of South Krile Islands using SPOT imagery only. Now GSI has been trying to update 1:25,000 scale topographical maps using more high-resolution satellite imagery.

SPOT imagery is not high resolution, then it's not practical to use for revising maps. IRS imagery (5.8-meter resolution) is more clearly than SPOT one, but it's also difficult to revise maps accurately. GSI tried interpretation of simulation imagery with 2.5-meter and 1-meter resolution, and made interpretation key of items for middle-scale map (Table.1). This table shows that at least 2.5-meter resolution is needed to distinguish the object.

Table.1 Difference of visible rate among 1.0m, 2.5m(aerial photo) and 5.8m(IRS imagery) resolution

		Visible rate of each Area (%)		
		Urban	Plain	Hill
Road	1.0meter	90	91	63
	2.5meter	41	78	57
	5.8meter	20	13	3
Building	1.0meter	87	75	70
	2.5meter	55	50	52
	5.8meter	32	39	2

### 4. Interpretation for mapping using IKONOS imagery

For using satellite imagery in cartographic field, it is important to clear how large objects can be interpreted and drawn by satellite imagery. The authors have researched the possibility of interpretation for making and updating topographical maps using IKONOS imagery. They were trying interpretation of IKONOS imagery for preparation of large-scale map (scale 1:5,000), and were comparing IKONOS with aerial photo and other satellite imageries. And they made interpretation card of items for large-scale map, and adjusted consideration for interpretation of IKONOS imagery.

#### 4-1 Road

It is almost possible to interpret the road of which width is over than 1-meter. The resolution of IKONOS imagery is 0.82m, however, white line (width is about 20-centi meter) in road can be interpreted using IKONOS imagery (Fig.1). Because, white line has high contrast against background and the width between each target is large.



IKONOS imagery

Field photo

Fig.1 Interpretation of white line on road

#### 4-2 Building

The interpretation of large buildings is possible. But, it is sometime impossible to interpret small buildings of which a short side is less than 4m, depending on the observation condition such as off nadir angle and so on. As the corner of building is not clear in IKONOS imagery (Fig.2), it is difficult to draw the building using IKONOS imagery.



IKONOS imagery

Aerial photo

Fig.2 Comparison of IKONOS imagery and aerial photo

#### 4-3 Vegetation

IKONOS data has wide dynamic-range (11bit), and wavelength of panchromatic sensor (0.45-0.90 micro meter) includes near infrared radiation. Then, interpretation of vegetation using IKONOS imagery has the advantage compared with using analog aerial photo. By combining 1m resolution panchromatic data and 4m resolution multi spectrum data, it is easy to divide needle-leaf trees from broad-leaf trees.

5. Accuracy validation of IKONOS ortho imagery and DEM by IKONOS stereo images

The authors validate coordinate accuracy of IKONOS ortho imagery that has about 1 meter ground resolution. The test areas are plain area in Tsukuba City and mountainous area in Mt. Tsukuba, Kanto District, Central Japan. Three cases are validated.

- 1) Ortho imagery using 27-meter grid DEM by IKONOS stereo images
- 2) Ortho imagery using 5-meter grid DEM by laser profiler (ALTMS: Tera Point)
- 3) Ortho imagery using 5-meter grid DEM by IKONOS stereo images

5-1 Horizontal accuracy of IKONOS digital ortho imagery in plain area

5-1-1 Coordinate accuracy of point targets in IKONOS ortho imagery

The coordinates of point targets measured from IKONOS digital ortho imagery were compared with the coordinates measured from stereo aerial photos by Digital Photogrammetric Workstation. The test area is shown in Fig.3a. Crossings of roads, corners of large buildings and pools of schools were selected for point targets. Specification of the aerial photos is as follows:

Date 1997 Oct. 16th  
Scale 1:10,000

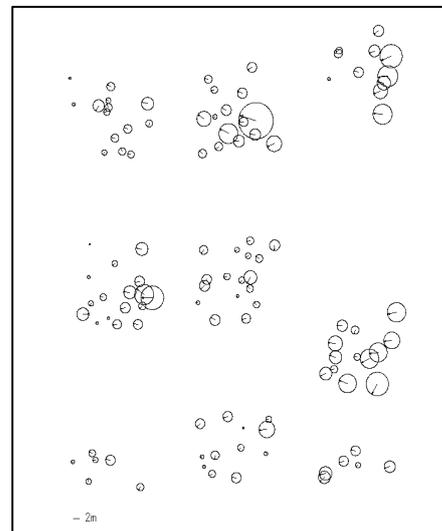
- 1) Coordinate accuracy of digital ortho imagery using 27-meter grid DEM by IKONOS stereo images

The coordinates of 111 points in IKONOS digital ortho imagery using 27-meter DEM were validated. The results are as follows (Fig.3b):

Difference	Max	RMSE(1 $\sigma$ )
X direction	5.1m	0.94m
Y direction	3.0m	0.73m
Vector		1.19m



a) Test area in Tsukuba (scale 1:200,000)



b) Vector of coordinate accuracy

Fig.3 Coordinate accuracy of IKONOS ortho imagery using 27m grid DEM by IKONOS stereo imageries

- 2) Coordinate accuracy of digital ortho imagery using 5-meter grid DEM by laser profiler

The coordinates of 95 points in IKONOS digital ortho imagery using 5-meter grid DEM by laser profiler were validated. The results are as follows:

Difference	RMSE(1 $\sigma$ )
X direction	0.66m
Y direction	0.68m
Vector	0.96m

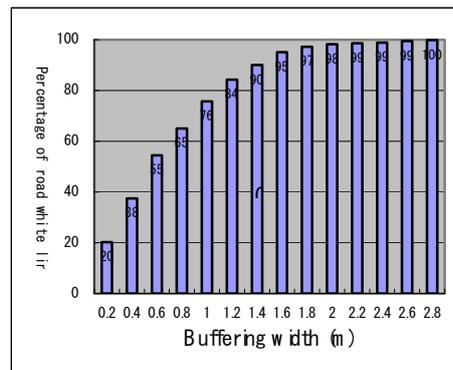
### 3) Coordinate accuracy of digital ortho imagery using 5-meter grid DEM by IKONOS stereo images

The coordinates of 95 points in IKONOS digital ortho imagery using 5-meter DEM by IKONOS stereo images were validated. The results are as follows:

Difference	RMSE(1 $\sigma$ )
X direction	1.05m
Y direction	0.55m
Vector	1.19m

### 5-1-2 Linier accuracy of line target in IKONOS ortho imagery

Linier accuracy validation of line target in IKONOS ortho imagery was done using test road course in Public Works Institute (Fig.4a). The digitized data of the white line on the test road course from IKONOS ortho images by 27-meter DEM was compared with the reference data of the white line obtained by photogrametric method using stereo aerial photos. Positioning error was measured using buffering function in the GIS application, which finds features within a specified distance of features. The results were shown in Fig.4b. The 98 percent of the data from the IKONOS ortho image is included in the 2.0-meter buffering, which is calculated from the reference data from the aerial photos. The 68 percent is included in 0.8-meter.



a) Test area in Public Works Institute  
Red line: location data of road white line  
by stereo aerial photo  
IKONOS digital ortho imagery

b) percentage of road white line  
in each buffering width

Fig.4 Linear accuracy of IKONOS ortho imagery using 27m grid DEM by IKONOS stereo imageries

## 5-2 Horizontal accuracy of IKONOS digital ortho imagery in mountainous area

The test area is mountainous area around Mt. Tsukuba. The coordinates of point targets measured from IKONOS digital ortho imagery using 5-meter DEM by IKONOS stereo images were compared with the coordinates measured by GPS. The coordinates of 15 points in IKONOS digital ortho imagery were validated. The results are as follows:

Difference	Max	Ave.
X direction	1.3m	0.58m
Y direction	2.0m	0.50m
Vector		1.37m

## 6. Accuracy validation of DEM by IKONOS stereo images

The authors validate vertical accuracy of 5-meter grid DEM produced by IKONOS stereo images. The test area is mountainous area around Mt. Tsukuba.

DEM by IKONOS stereo images was compared with DEM produced by stereo matching method of aerial photos using Digital Photogrammetric Workstation. Specification of the aerial photos is as follows

Date 1998 Nov. 10th  
Scale 1:30,000

For the results, the difference of Z direction is 4.61-meter (RMSE).

## 7. Conclusion

In this paper, the authors considered the possibility of IKONOS imagery for making topographical maps.

Concerning the possibility of interpretation for making and updating topographical maps, IKONOS imagery has advantageous characteristics on the interpretation of road and vegetation, compared with analog aerial photo. However, concerning the possibility of drawing objects, it is difficult to interpret the corner of buildings.

Horizontal accuracy of IKONOS ortho imagery using DEM by IKONOS stereo images is about 1.2-meter in flat area, and horizontal accuracy of IKONOS ortho imageries using DEM by laser profiler is about 1.0-meter. In mountainous area, horizontal accuracy is worse.

From these results, IKONOS imagery has high possibility of interpretation for making and updating middle-scale topographical maps, such as 1:25,000. For large-scale topographical map, IKONOS has some problems, such as drawing buildings and horizontal accuracy in mountainous area.

## Reference

Mamoru KOARAI, Toshihiro KADOWAKI, Nobuyuki WATANABE and Kaoru MATSUO (2001): Interpretation Characteristics of IKONOS Imagery and its Coordinate Accuracy Validation. Journal of the Geographical Survey Institute, No.94, 38-47.