

# HANDLING OF IKONOS HIGH RESOLUTION SPACE IMAGERY IN 3D

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## ABSTRACT:

High resolution satellite images reflect significant details to be demonstrated in 3D using DEMs and stereo pairs for wide range of applications. This specification is becoming more important to reach geographic information as the resolution gets better. Having the capability of acquiring stereo images, IKONOS, leads the the processing of different levels of DEMs required for ortho correction and 3D applications. This paper presents managing IKONOS with the ability of stereo acquisition of high resolution satellite images for 3D applications and DEM extraction. Ex-works performed are also included in this paper to emphasize the content.

## 1. INTRODUCTION

The world's first commercial high resolution satellite imaging system, Ikonos, with its launch on September 1999 has changed the way the public and private industry worldwide view the Earth's surface and plan for its future. The Ikonos satellite imagery providing access to any location on Earth's surface offers stunning information for the applications ranging from national security and disaster assessment to urban planning and agricultural monitoring.



Figure1: Ikonos Satellite

Ikonos moves over the ground at approximately 7 kilometers per second at an elevation of 680 kilometers. The Ikonos sensor represents a significant step forward in commercial satellite imaging, with an agile spacecraft giving the ability to acquire 1m black-and-white and 4m multispectral (red, green, blue, near infrared) imagery simultaneously.

1-meterBlack-and-White	Panchromatic	0.526–0.929 micrometers
4-meter Multispectral or 1-meter Color	Band 1 (blue)	0.445 – 0.516 micrometers
	Band 2 (green)	0.506 – 0.595 micrometers
	Band 3 (red)	0.632 – 0.698 micrometers
	Band 4 (near infrared)	0.757 – 0.853 micrometers

Table1: Spectral range

## 2. IKONOS Product Levels

Ikonos imagery products are provided in 3 levels as; GEO, Ortho, and Stereo.

Geo products are ideal for impact analysis, visual and interpretive applications such as intelligence (national and global security) or visualization that does not require high positional accuracy which is limited by terrain displacement.

Ortho products provide map-accurate metric imagery data that are orthorectified to a specified ellipsoid and map projection. The orthorectification process removes image distortions introduced by the collection geometry and variable terrain using the digital elevation models and ground control points, and re-samples the imagery to a uniform ground sample distance and a user-specified map projection. This group of products is provided in a range of metric accuracy levels, and as black-and-white, multispectral or color (pan-sharpened).

	Positional Accuracy		
	CE90	RMSE	NMAS
Geo	15 m	N/A	N/A
Standard Ortho	50 m	25 m	1:100.000
Reference	25.4 m	11.8 m	1:50.000
Pro	10.2 m	4.8 m	1:12.000
Precision	4.1 m	1.9 m	1:4.800
Precision Plus	2 m	0.9 m	1:2.400

Table2: Accuracy of Ikonos Ortho Products

Ikonos stereo collection capability fulfills the need for extracting accurate vector layers for mapping and creating DEM data for ortho process and 3D applications.

High resolution Ikonos stereo pairs are collected along track and on the same date to reduce radiometric image variations (temporal changes, sun illumination, etc.) and this helps increasing the correlation success rate in any image matching process.

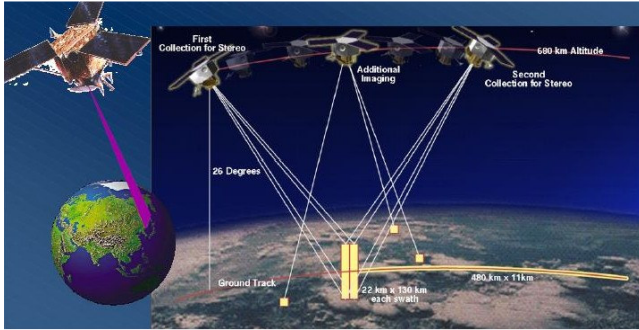


Figure2: Ikonos Stereo Acquisition

The stereo images are available in Reference and Precision accuracy levels with a rational polynomial coefficient (RPC) camera model file. The RPC file provides camera model data to popular software packages for photogrammetric extraction of 3D feature coordinates, digital elevation models (DEMs) and orthorectified imagery. Reference Stereo products have a horizontal accuracy of 25 meters CE90 and a vertical accuracy of 22 meters LE90. Precision Stereo products have a horizontal accuracy of 4 meters CE90 and a vertical accuracy of 5 meters LE90.

### 3. IKONOS DTM

A digital terrain model (DTM) is a digital file consisting of terrain elevations for ground positions at regularly spaced horizontal intervals. Digital terrain products may be used in the generation of three-dimensional graphics displaying terrain slope, aspect (direction of slope), and terrain profiles between selected points.

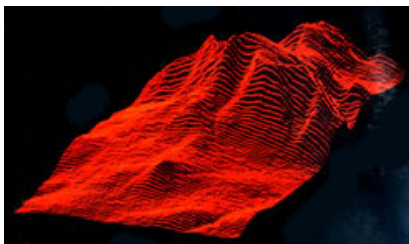


Figure 3: DTM

Ikonos DTM consists of regularly distributed elevation points and can be produced for any geographic region fulfilled by stereo images. After successful acquisition of stereo pairs, Commercial Remote Sensing System, by Raytheon, handles DTM production process. The system creates the elevation points to be edited to ground level to remove buildings and vegetation. The editing process end with Ikonos Terrain Models with different accuracy levels. There are 5 levels of DTM for Ikonos which can be used in wide range of photogrammetric and geographic applications.

Level	Vertical Accuracy	Post Spacing
5a	30m LE90	3 arc-sec (~90 m)
5b	30m LE90	1 arc-sec (~30 m)
5c	12m LE90	1 arc-sec (~30 m)
5d	12m LE90	0.5 arc-sec (~15 m)
5e (gcp needed)	3m LE90	0.2 arc-sec (~6 m)

Table3: Ikonos DTM Specifications

## 4. APPLICATIONS of 3D MODELLING

In many geographic research, 3D modelling becomes indispensable to carry out the studies for assessing the results. According to the nature of the geographical applications, the more accurate data you have, the more easy to reach information. In this manner, digital terrain models provide a spectacular assistance for slope-aspect analysis, contour line generation, planning and managing utilities including telecommunication networks.

In this part, the applications mentioned above are told to emphasize the use of terrain models and 3d features created from Ikonos stereo models.

### 4.1. Mission Planning for Military

For military intelligence, dominating the target area is very important to demonstrate the mission planning and control the sources. A detailed and accurate terrain model is the tool that is needed for such applications.

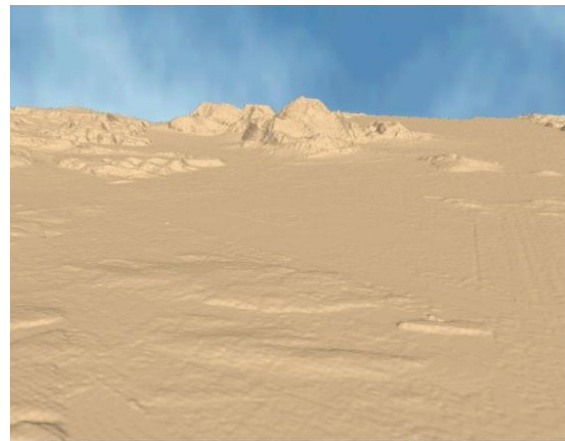


Figure 4: Ikonos DTM

### 4.2. Telecommunication Network

3D site models are widely used to optimize the allocation of GSM base stations. Especially, in urban areas, telecommunication network planning highly requires accurate site models.

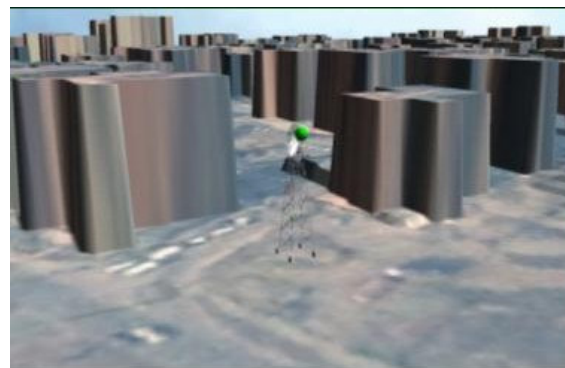


Figure 5: 3D site model



Figure 6: Network Analysis on Site Model

#### 4.3. Disaster Management

Some analysis required for disaster management are also performed using detailed and accurate Ikonos terrain models. Those are flood analysis, slope and aspect analysis and environmental monitoring.

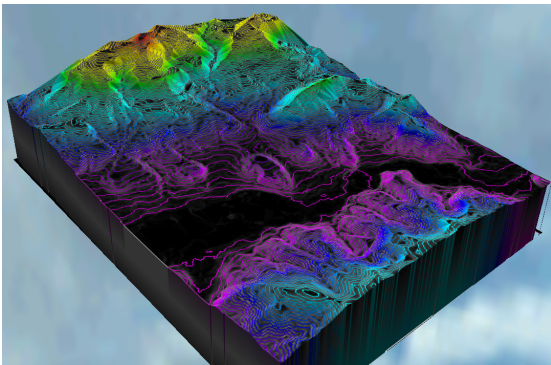


Figure 7: Countour Lines on Terrain Model

#### 4.4. Urban Planning

In urban planning, Ikonos imagery gives the most recent and detailed base map for users to analyse the situation. The combination of elevation model and the imagery provide absolute virtual reality.

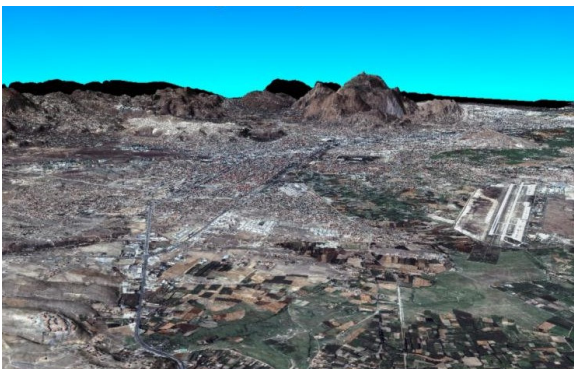


Figure 8: Ikonos imagery draped over ITM

## 5. CONCLUSION

As the visibility of features in digital imagery increases, the size of the information extends accordingly. Future imaging systems will enable us to build more powerful and complex geographical based information systems. In this paper, very high resolution satellite imaging system, Ikonos, is focused on how to handle 3D data in desired applications. There are also other sources to be used in 3D applications however, Ikonos is the one which combines the easy use and quick access for the imagery and terrain data. The vision of 3D modelling now contributes to the the geograpy we live in and is broadened out by high resolution satellite imaging systems.

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IKONOS Satellite "ITT's Digital Camera System On Board" <http://www.ssd.itt.com/heritage/ikonos.shtml>