GeoEye's Imagery Collection and Production Services

Current Performance and Future Systems

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GeoEye

GeoEye continues to grow as a major provider of imagery collection and production services. The recent NGA EnhancedView Award assures image availability and product improvements without interruption through the next decade. GeoEye's collection assets include GeoEye-1, IKONOS and Aerial. We will present an overview of these systems, including their current products and performance. The recent GeoEye product improvements include rigorous camera models and higher resolution. Performance includes radiometric calibration, geometric accuracy, focus and other image quality metrics. We also discuss the schedule and capabilities of GeoEye-2, which will provide 33 cm color imagery, and plans for GeoEye-3.

1. GeoEye Overview

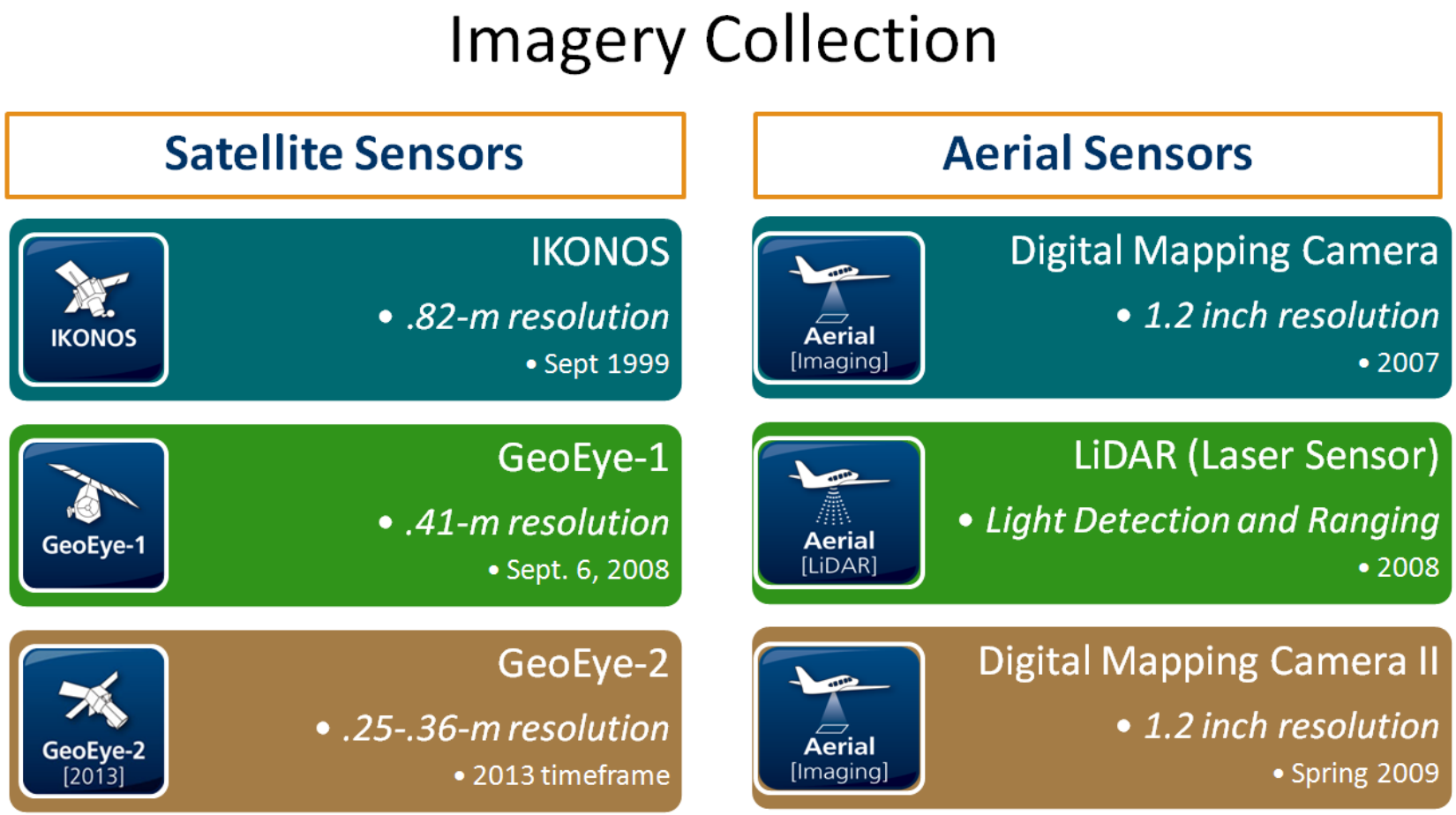
GeoEye is a leading commercial provider of high-accuracy, high-resolution earth imagery, image processing services and imagery information products to U.S. and foreign government defense and intelligence organizations, domestic federal and foreign civil agencies, and commercial customers. We own and operate two Earth-imaging satellites, GeoEye-1 and IKONOS, and three fixed-wing aircraft with advanced high-resolution imagery collection capabilities. GeoEye-1 is the world's highest resolution and most accurate commercial imaging satellite.

In addition to our imagery collection capacities, we are a global leader in the creation of enhanced satellite imagery information products and services. We operate four high-resolution image processing and production facilities which can process, manage, analyze and share imagery from any commercial or government satellite. Our satellite and aerial imagery products and services provide our customers with the timely and accurate location intelligence, enabling them to analyze, monitor and map to their needs and demands.

We own one of the largest commercial color digital satellite imagery libraries in the world, which contains more than 405 million square kilometers of color imagery of the Earth. We believe the combination of our highly accurate satellite and aerial imaging assets, our high-resolution image processing and production facilities, and our color digital imagery library differentiates us from our competitors. This enables us to deliver a comprehensive range of imaging products and services to our diverse customer base.

Products and Services

We offer a wide range of imagery products and services, including: the collection of satellite and aerial imagery, imagery processing, and production services and information services.



Satellite Imagery

Commercial Imagery Products

Geo™ *Map Oriented Imagery*

For those who want satellite imagery for visual and interpretive applications that are geometrically accurate and cost effective.

Typical Applications

- Environmental monitoring
- Image interpretation
- Photogrammetric applications
- Disaster response

GeoProfessional™ *Terrain Corrected Imagery*

Perfect for anyone demanding greater image positional accuracy. The optimal choice for regional mapping or for tasks requiring terrain-corrected imagery.

Typical Applications

- Base mapping
- Planning
- Infrastructure management
- Location services
- Visualization and simulation
- Online mapping

GeoStereo™ *Imagery*

For those requiring images that deliver three-dimensional viewing, feature recognition and feature extraction.

Typical Applications

- 3-D feature extraction
- DEM extraction
- Stereo visualization of natural features
- Building height extraction

Aerial Imagery

Our aerial imagery products are designed to support specific customer requests for high-resolution and highly accurate images. We offer two main types of aerial imagery collected by our dedicated fleet of three imaging aircraft:

1. Digital Aerial Imaging
2. Light Detection and Ranging (LiDAR) imaging - an optical remote sensing technology using laser pulses to determine distances to an object or surface

Production Services

We have developed advanced processing systems that enable us to process raw data from a wide range of both government and commercial sensors (imaging satellites) and then merge the source images into very precise information and image products in order to meet the needs of a broad range of customers.

Our production services range from the generation of precision imagery products (for example, digital elevation maps) to the extraction of site-specific features (for example, airports, highways, and buildings) for our customer's database development. Our production services, which are designed to increase the accuracy and precision of satellite and aerial imagery, include the following production processes:

- *Georectification.* This is a computer processing operation which corrects the pixel locations of a digital image to remove image distortions caused by the non-vertical pointing and movement of the sensor during the imaging event.

- *Image Mosaicing.* This is the combination and merging of separate digital images into a seamless locationally accurate image.

- *Tonal Correction.* The scientific correction of the color variations between various component images of an image mosaic so that the image or picture reflects a coherent color structure.

- *Orthorectification.* This is a computer processing operation which corrects the pixel locations of a digital image to remove image distortions caused by non-vertical pointing and movement of the sensor during the imaging event and distortions caused by earth elevation differences at the image location.

Information Services

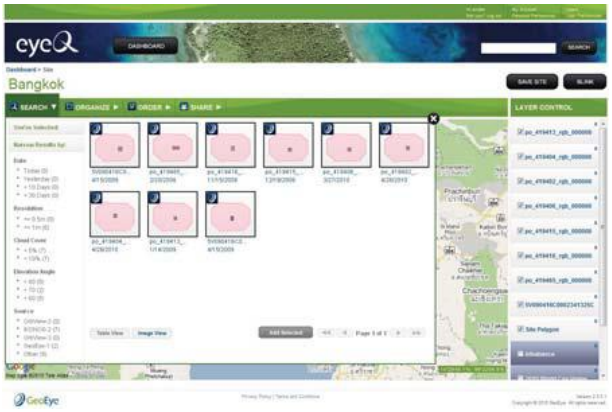
We also provide imagery information services, which combine our imagery with real-time, third-party data to create a sophisticated and customized information product for our customers. For example, our SeaStar marine information service, which is offered on a subscription basis, provides the commercial fishing industry with sophisticated mapping information, which includes such data as sea surface temperatures and ocean currents as well as analysis of this information, to assist fishermen in locating fish more efficiently.

The EyeQ® Web Services Platform

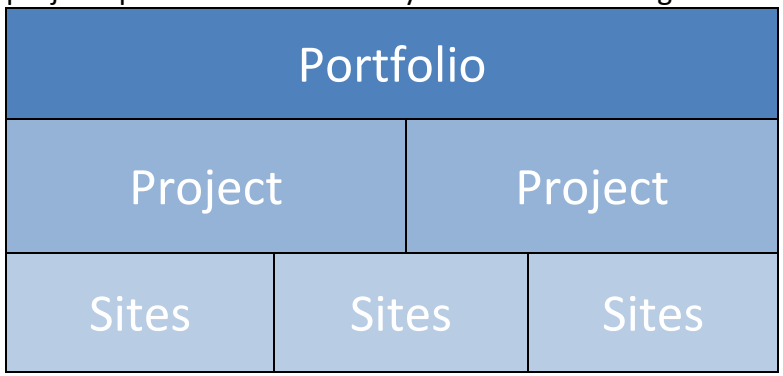
EyeQ managed services enable enterprise, global access to secure, timely and accurate location information seamlessly integrated into your current business environment. EyeQ combines imagery products with on-demand tools for managing your geospatial information and project-based collaboration. With EyeQ, you can search, organize, and share geospatial data while reducing the total cost of ownership. By hosting the data and providing an easy-to-use user interface, EyeQ allows non-technical as well as advanced user to interact with geospatial data.

EyeQ® capabilities

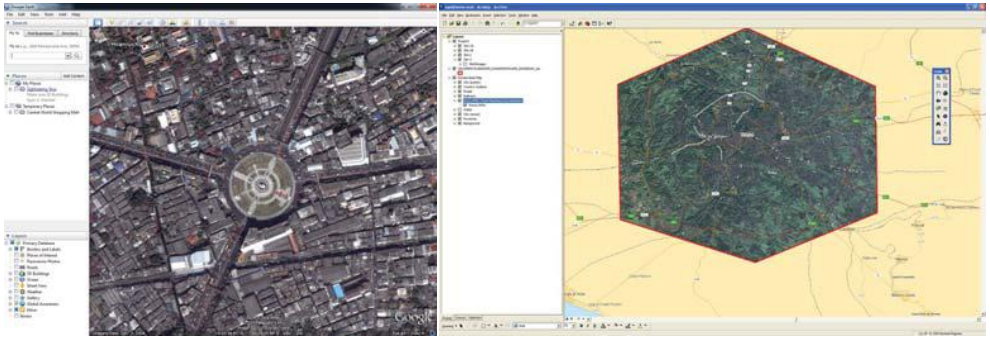
Search: Search and view your predefined collection of GeoEye-1, IKONOS, and other geospatial content.



Organize: EyeQ enables Web-based access for a wide range of user in the office or field. Your content order match your project specifications because your team works together.



Share: With Web Map Service (WMS), Web Coverage Service (WCS), and Keyhole Markup Language (KML), Your content is available anywhere you need it. Using BLINK Broadcast and the BLINK Viewer URL, users have A simple interface to share project and site content with Others, view and download JPEGs, or Clip-and-Ship GeoTIFF or NITF sections of imagery.



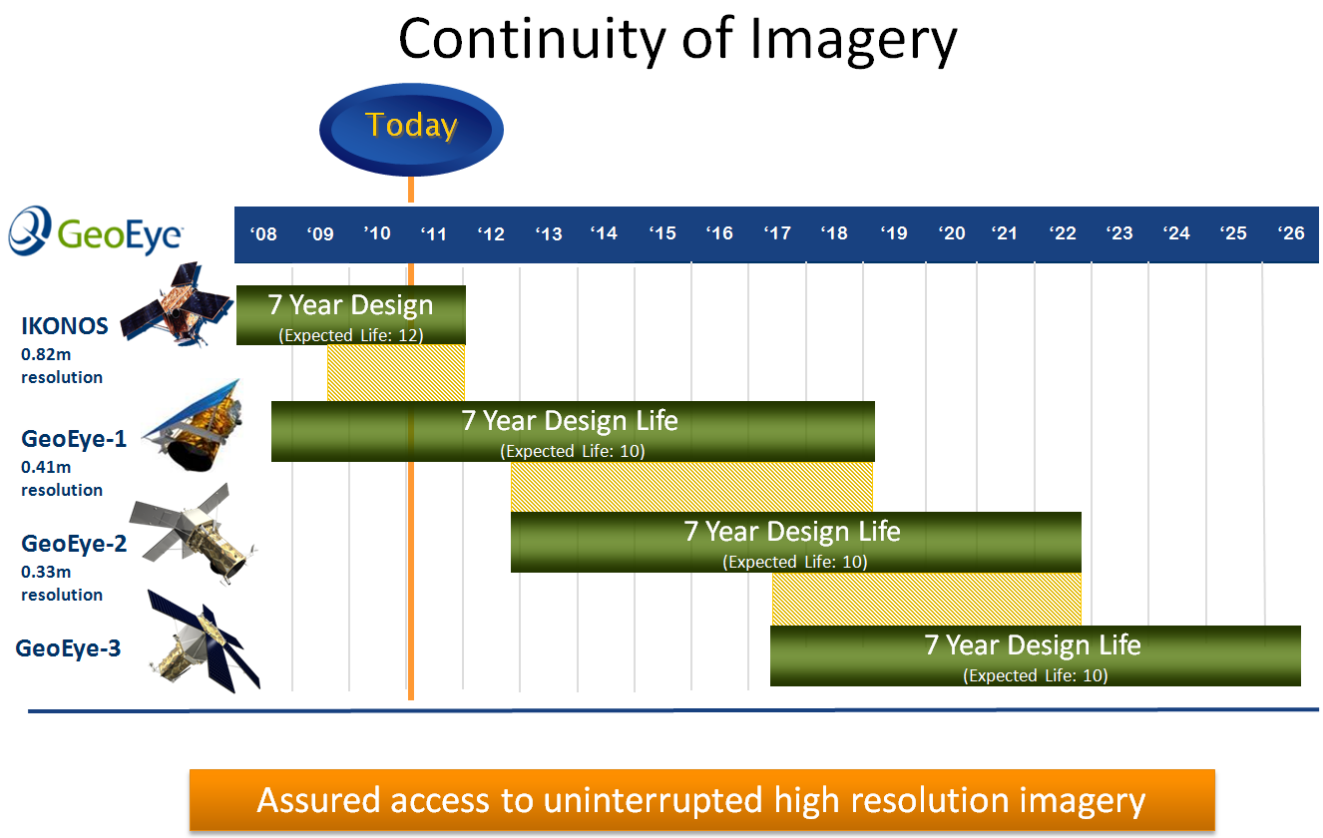
2. <u>EnhancedView Award</u>

In August, 2010, NGA announced an award to GeoEye under its EnhanceView commercial imagery program for $3.8 billion with a period of performance of 10 years.

Key Components:

- $2.8 billion for imagery purchases over the next decade
- $337 million for GeoEye-2 development and launch
- $700 million for value-added products, infrastructure, and other services including EyeQ

EnhancedView will help with assured access to high resolution imagery for the next decade



3. Sensor Summary

Satellite Performance Summary

Orbital	IKONOS	GeoEye-1	GeoEye-2 [2013]
Altitude	681 km	684 km	500 km (TBR)
Equatorial Crossing Time	10:30 am	10:30 am	10:30am or 2:30pm (TBR)
Image Quality			
Spatial Resolution	Pan = 0.82 m @ nadir MSI = 3.2 m @ nadir	Pan = 0.41 m @ nadir MSI = 1.65 m @ nadir	Pan = .25 m - .36m @ nadir MSI = 1.0 m - 1.44m @ nadir

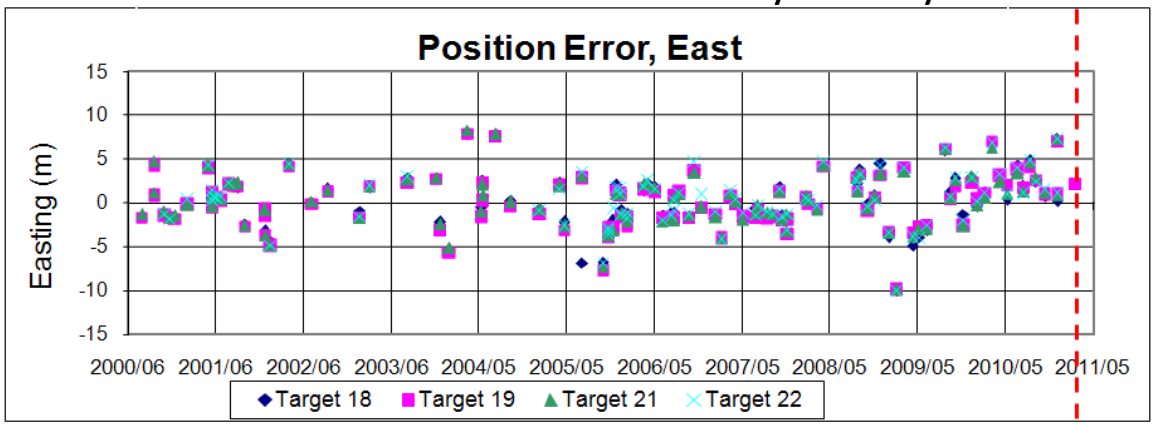
Collection Capacity	IKONOS	GeoEye–1	GeoEye-2
Daily Pan Area	150,000 sqkm	700,000 sqkm	~700,000 sqkm @36cm GSD
Daily MSI Area	150,000 sqkm	350,000 sqkm	~350,000 sqkm
Swath Width @ nadir	11.3 km	15.2 km	14.2 km
Geolocation Accuracy	**IKONOS**	**GeoEye–1**	**GeoEye 2**
Mono: CE90 w/out external GCPs	≤10 meters	<5 meters	<3 meters
Stereo: CE90 / LE90 w/out external GCPs	10 meters / 10 meters	4 meters / 6 meters	2 meters / 3 meters

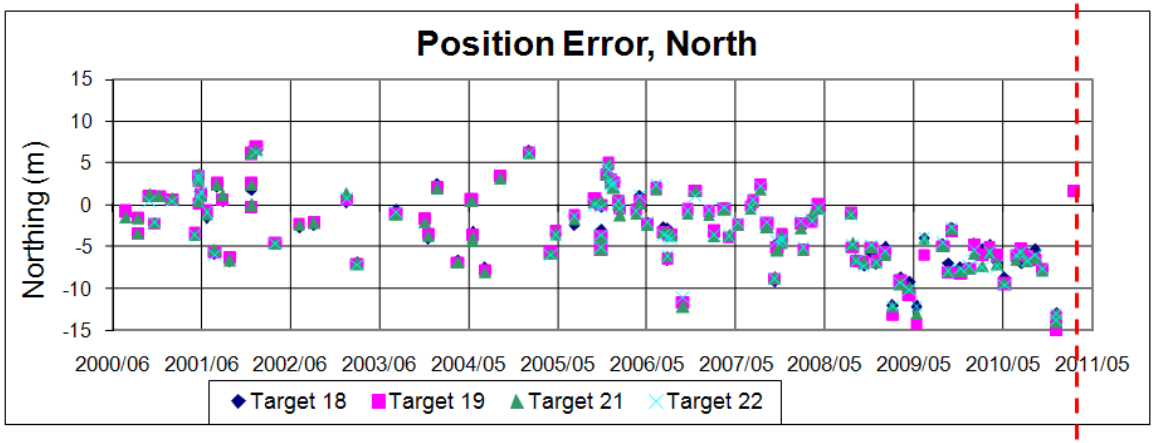
IKONOS Performance Update

IKONOS Geolocation Accuracy

IKONOS geolocation accuracy is regularly tested by imaging Big Spring, TX. A painted target and multiple other checkpoints are measured from the image. The difference between the position measured in the image and predicted by the RPC camera model is plotted at left. The charts show absolute accuracy, as difference from zero, and relative accuracy, as coincidence of multiple target measure-ments from the same scene. IKONOS calibrations were recently updated to correct a southward drift in calibrations since the last update in 2007.

IKONOS Geolocation Accuracy History





Calibration Update 2011-03-17

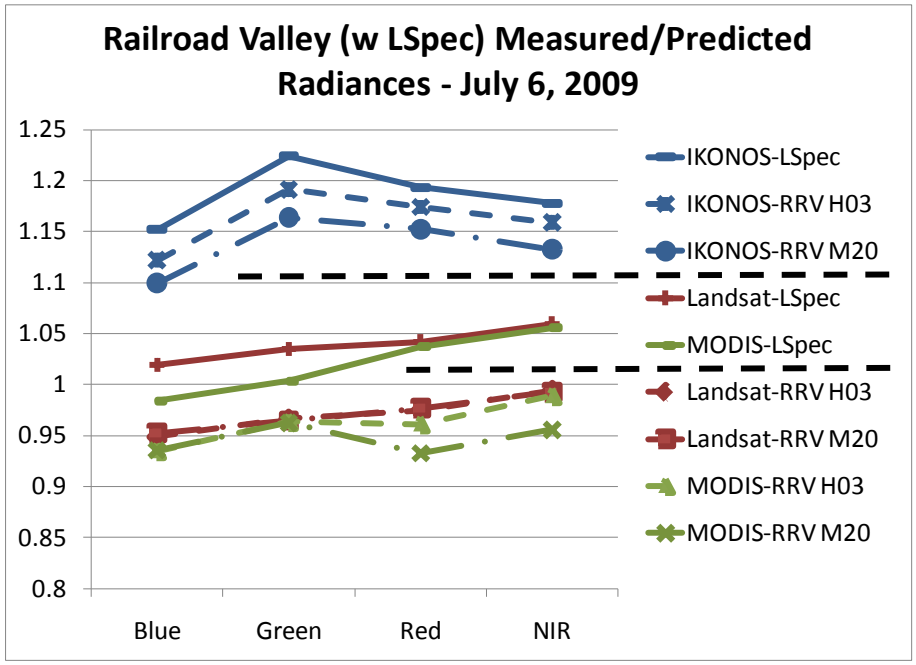
IKONOS Absolute Radiometry

The most recent work in measuring and comparing IKONOS absolute radiometry has been performed by *Polder, et al.* (2010) and *Schiller & Silny* (2010). The results are summarized below.

Vicarious radiometric calibration using SPecular Array Radiometric Calibration (SPARC) method which reduces uncertainties in target reflectance, atmospheric effects, and temporal variability.
S.J. Schiller & J. Silny, *SPIE Proceedings, Remote Sensing System Engineering III*, Vol. 7813 (2 Aug 2010)

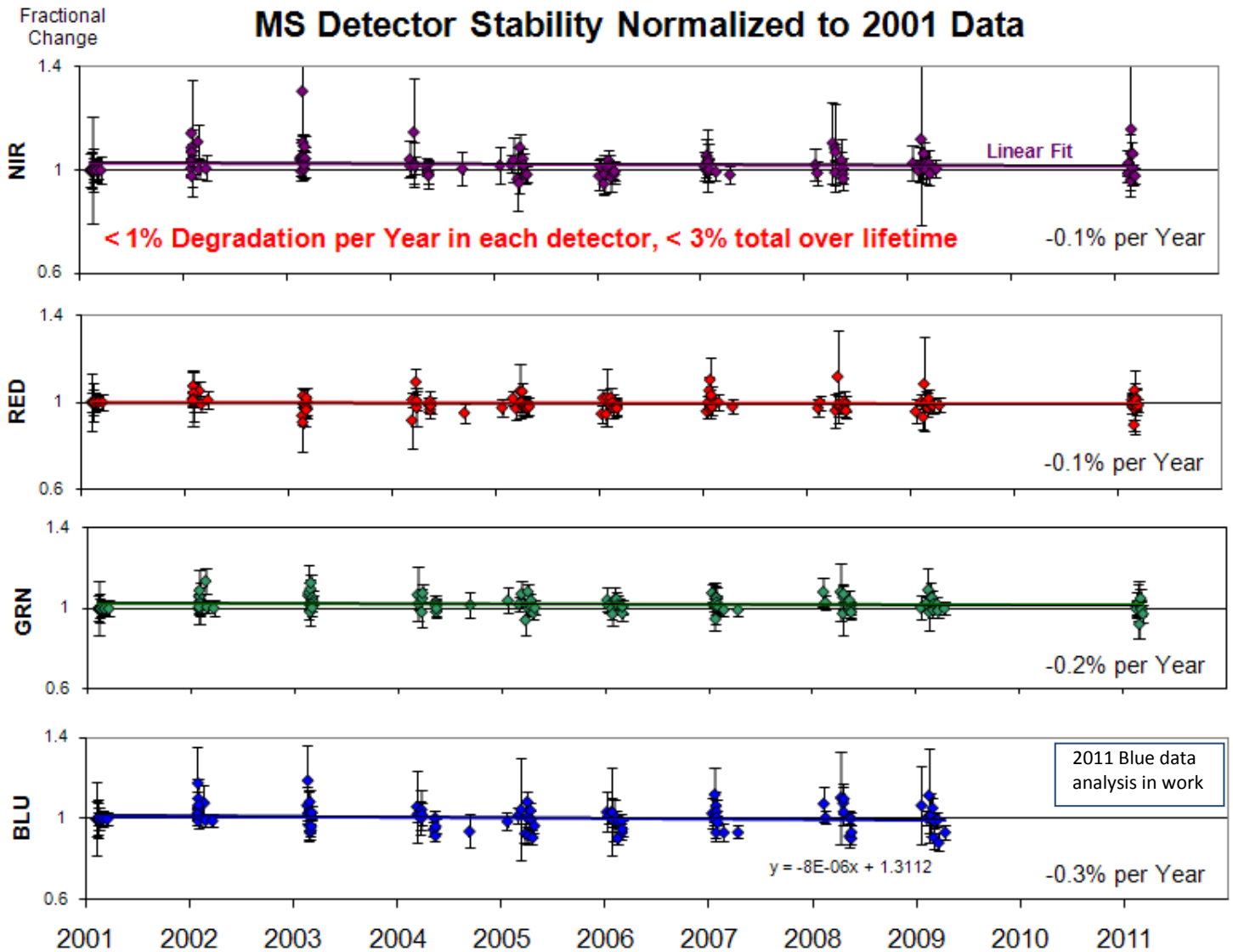
	Gain Coefficients [DN/(W/m^{2}sr)]			
IKONOS Band	Blue	Green	Red	NIR
SPARC Results				
Image # po_356282	63.1	68.1	92.4	77.8
Image # po_356283	60.9	67.1	95.4	71.6
Average	62.0	67.6	94.0	74.7
Reflectance-Based Results				
Pagnutti et al. (2003)	63.3	64.9	84.0	74.6
% difference	2.1	4.2	11.9	0.1

Vicarious radiometric calibration using autonomous LED Spectrometer (LSpec) site at Frenchman Flat, Nevada, and Railroad Valley. IKONOS was compared to Landsat 7 ETM+ and Terra MODIS measurements. IKONOS showed significantly higher radiances.
M. Polder, *et al.*, JACIE Conference, (16-18 Mar 2010)



IKONOS Radiometric Stability

Standard calibration stars have been imaged each year (with the exception of 2010) and used to measure degradation in detector response. IKONOS continues to show excellent stability with < 1% degradation per year and < 3% degradation over its entire life to date, and no failed detectors.



IKONOS Focus Assessment

A yearly focus assessment is performed by imaging the same target multiple times while moving the focus mirror from an out-of-focus position through its ideal focus. The latest "through-focus" assessment in Fall, 2010, resulted in no need for a focus adjustment. Focus adjustments have not been needed since 2006, consistent with an asymptotic leveling-off of telescope growth.

OV-2 (SeaWiFS) – The End of an Era

Designed for a 5-year life span, and launched August 1, 1997, OV-2 lasted well into its 14th year before NASA declared it unrecoverable earlier this year. In addition to its support of commercial services and GeoEye, SeaWiFS was nicknamed "The Little Satellite That Could" for the quantity and quality of science it produced. SeaWiFS data has appeared in nearly 5,000 publications. It has been a model for partnership of a NASA science mission with commercial operator and imagery provider. We bid a fond farewell and thanks for its years of service to NASA and GeoEye.

GeoEye-1 Performance Update

GeoEye-1 continues to have excellent radiometric performance and unprecedented Geolocation accuracy. See talk by David Mulawa (GeoEye) for latest performance results.

GeoEye-2

GeoEye-2 is the next-generation, high-resolution, commercial Earth-imaging satellite in the GeoEye constellation with a launch scheduled to support start of operations in 2013. GeoEye-2, being designed and built by Lockheed Martin Space Systems, will provide map-accurate images with a high-resolution camera provided by ITT. GeoEye-2 is currently on schedule, having successfully completed its Preliminary Design Review (PDR) in November, 2010.

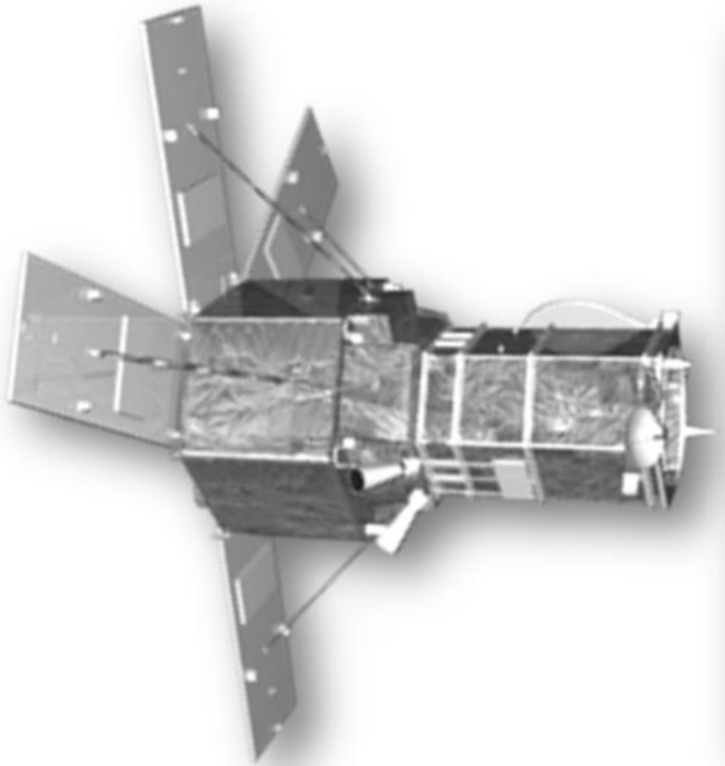
GeoEye-2 Spacecraft Capabilities

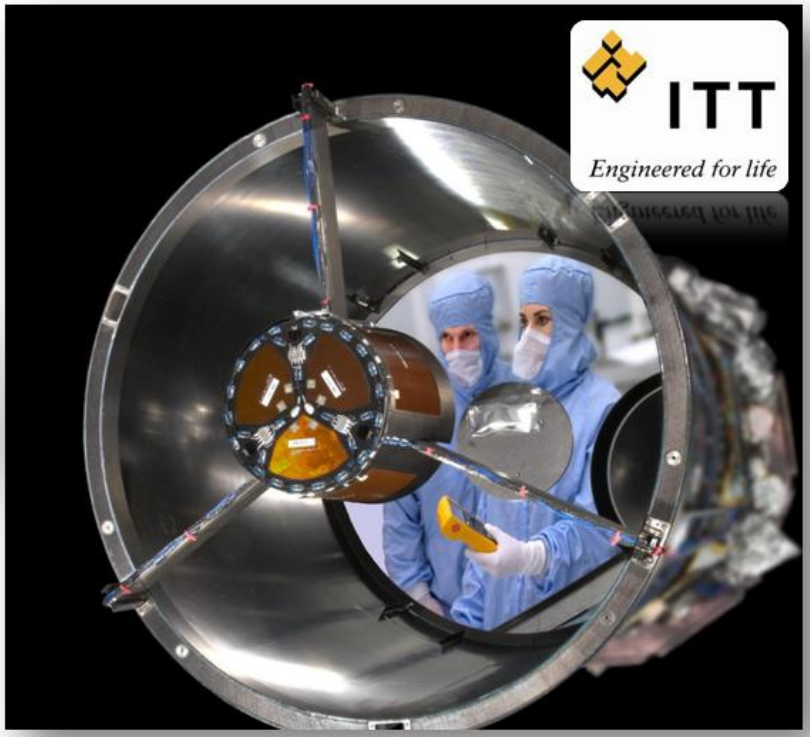
Description

- Agile Control Moment Gyros (CMG)-based Low Earth Orbit spacecraft
- High geolocation accuracy
- 1.1m optical payload
  - Visible panchromatic
  - 4 multispectral bands
- Satellite Command and Control
- 200 min imaging time/day
- Weight: 2,087 kg (4,600 lbs)
- Store and forward buffer size 3.2 Tbits

GeoEye-2 Camera

- Sensor in development since Oct 2007 with ITT
- 1.1-meter primary mirror
  - Prescription polished for 25cm collection at 500km altitude
- Camera components procured
- Satellite PDR completed, Payload CDR completed





GeoEye-3

GeoEye's commitment to assured access to high-resolution imagery will continue as plans are in work for GeoEye-3, the next satellite in our constellation. GeoEye-3 is currently scheduled to begin operations as early as 2017, overlapping with GeoEye-1 expected mission duration of 10 years. Watch for future announcements regarding its capabilities and schedule as this schedule may be accelerated.

Summary

GeoEye continues to provide imagery with excellent performance from its suite of sensors. GeoEye-1 and IKONOS continue to perform beyond their design capabilities in both radiometric and pointing accuracy. The recent EnhancedView award will ensure this source continues through the next decade with the addition of GeoEye-2, and plans are in work for GeoEye-3.

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