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## OUT OF CHAOS COMES ORDER...

From Client-Server to Service-Oriented Architecture  
Implementation - Imagery over the web

### Abstract

GeoEye maintains millions of reduced-resolution browse-images representing commercial and private holdings. The existing imagery management systems rely, in part, on outdated technology, including server hardware and automated processes based upon legacy code. GeoEye is upgrading existing legacy systems to an object-oriented architecture, using current technology and best practices within the following guidelines:

- ESRI 9.3 Server Technologies (used to store and serve imagery, image attributes, and presentation layers, both raster and vector).
- Out-of-the box capabilities, developing OGC-compliant web services and applications, which will support one-touch delivery systems and role-based subscription services, as well as enhanced overall search, discovery, and order-fulfillment capabilities.

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### Introduction

GeoEye is a premier provider of geospatial information, imagery, and solutions for the national security community, strategic partners, resellers and commercial customers. GeoEye’s products assist in visualizing, mapping, measuring, and monitoring the world. GeoEye operates two Earth-imaging satellites, IKONOS and OrbView-2. It utilizes two mapping aircraft, including one with LIDAR, possesses an international network of regional satellites and receiving ground stations. It also has advanced geospatial imagery-processing capabilities. GeoEye-1, the next-generation Earth-imaging satellite being launched this summer, will have the highest resolution and accuracy of any commercial imaging system.

With the upcoming launch of the GeoEye-1 satellite, the Business Systems and Applications Group has the task to provide new tools for GeoEye’s online catalog of imagery using up-to-date map visualization technologies which are popular with many internet users.

GeoEye’s current online reduced-resolution browse catalog now relies on aged technology, processes, and code which is customized, complex, and challenging to support. Instead of refactoring existing technologies, the Business Systems and Applications Group evaluated current technologies “from the ground up”. The analysis of Commercial Off-the-Shelf (COTS) packages resulted in a decision to use ESRI® ArcGIS Server 9.3, Google® Maps, and Google® Earth technologies. These systems allow for intuitive search and discovery of

GeoEye’s online catalog through many endpoints and client-based software packages. It also minimizes the need for specialized training or users by taking advantage of the large installed base of these COTS products worldwide. In early 2008, GeoEye deployed these packages to prototype numerous applications and solutions which will support future business operations.

### Problem Statement

GeoEye now manages millions of reduced-resolution browse images in legacy technology, processes, and code. A single endpoint and a complex browser-based web application allow internet users access to GeoEye’s online browse catalog. This system is neither interoperable nor scalable to meet anticipated requirements for the future.

New state-of-the-art technologies, business processes, and code must be developed and implemented to support the diverse requirements of current and future customers. Our goal is to provide fast, fluid, collaborative, and interoperable user experiences.



Image of Boeing Delta-2 Rocket  
Soon to Launch GeoEye-1

## Legacy Solution – “Chaos”

In a chaotic cloud of complex, custom, and difficult to support technology, including both hardware and automated processes, GeoEye currently operates and maintains an online catalog of reduced-resolution browse images. After more than nine-years in operation, the legacy solution is now being revamped and upgraded, not due to defects, but in order to better support the requirements of GeoEye’s current and future customers.

The legacy solution, including hardware, databases, automation code, and the single front-end web-based application are all candidates for replacement in order to transition to a new state-of-the-art solution.

### History

GeoEye, formed after the acquisition of Space Imaging by OrbImage, launched its first online access to reduced-resolution browse images in September 2000. Since then, customers have had access to browse images, image attributes, and metadata from differing air and space-borne sensors.

The first browser-based web application, CARTERRA Online, now called GeoEye’s Image Search was launched in 2001. Still in operation today, many customers depend upon Image Search due to its reliability, familiarity, and user-friendly presentation. Since 2001, users have had access to additional tools and services, with little change in the usage of the original web application.

With the growth in technology, in particular web-based mapping visualization software, GeoEye now has the opportunity to revamp and upgrade its current system to an up-to-date and state-of-the-art solution.

## Legacy Technology

### Hardware and Operating Systems:

- Imagery Archive Server: CPAQ PRO DL580 (1Gig RAM, 2/P3-700Mhz) running RedHat Linux 2.1ES and SDE 8.3
- Database Server: Sunfire V880 (12Gig RAM, 6/S750Mhz) running Solaris 8
- Web Application Server: CPAQ PRO DL380 (2Gig RAM, 2/P3-1 GHz) running RedHat Linux 6.2EE.

### Software Packages:

- ESRI ArcView 3.3 Desktop Application
- Oracle 8i & 9i
- ESRI SDE 8.3
- CARTERRA Online Web Application
- Apache 2.x

### Programming Languages:

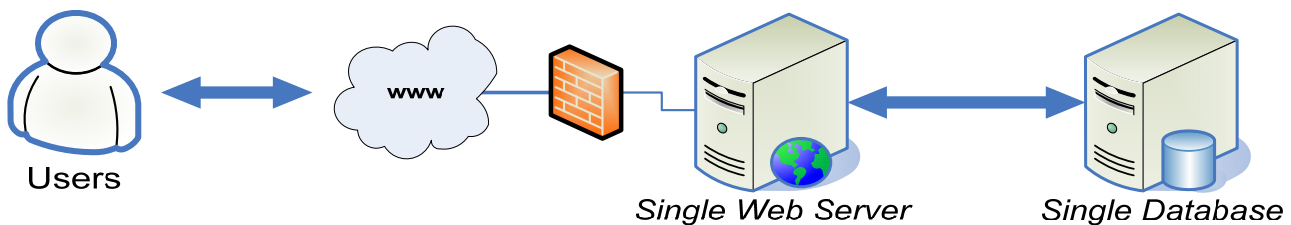
- Bash Shell Script
- C & ProC
- Perl
- AWK
- SQL
- PHTML
- Avenue

### Positive Aspects

- Stable back-end processing
- Customer familiarity

### Negative Aspects

- Automated processes engineered in unsupported code languages with many one-off scripts developed in haste
- Company and manufacturer unsupported hardware
- No Scalability
- Implementation of current GIS processes unfeasible
- One solution for all users
- Support of current and future business needs impossible



## Future Solution – “Order”

In order to support the growing demand for a server-oriented architecture, particularly web services, GeoEye has developed the prototype and replacement solution, using the ESRI 9.3 platform.

The prototype solution, including hardware, database, automation code, back-end Extract Transform and Load (ETL), front-end applications, and services is designed to meet the demand of current customers and to place GeoEye in a position to support future requirements.

## Technology

### Hardware and Operating Systems:

- Imagery Archive Server: CPAQ PRO DL360 (6 Gigs RAM, Quad Core 1-2.33Ghz) running Windows 2003 R2 and ArcGIS Server 9.3
- Web Application Servers: CPAQ PRO DL360 (4 Gigs RAM, Quad Core 1-2.33Ghz) running Windows 2003 R2

### Software Packages:

- ESRI ArcGIS Server 9.3
- ESRI ArcGIS Image Server 9.3
- Google Earth Enterprise Server (Fusion/Earth)
- Windows SQL Server 2005
- SQL Server Integration Services (ETL)
- Windows IIS 6.0

### Programming Languages:

- C# .NET (Framework 3.5)
- JavaScript
- Python

### API/Protocols:

- HTTP (Hypertext Transfer Protocol)
- SOAP (Simple Object Access Protocol)
- REST (Representational State Transfer)
- WMS (OpenGIS/OGC Web Map Service)
- ESRI ArcGIS JavaScript API for Google Maps

## Benefit 1: Integration of imagery and GIS in a single platform

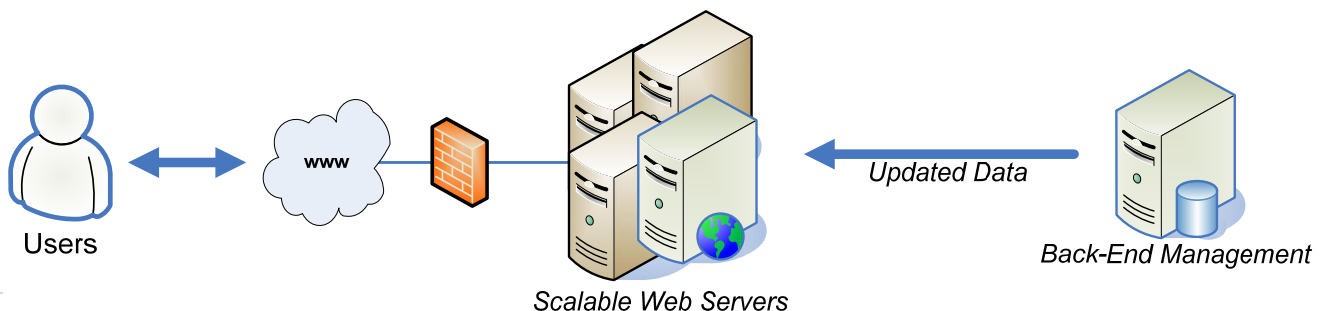
- ArcGIS 9.3 incorporates image management and processing techniques into a Server-Based GIS environment
- Supplies more out-of-the-box tools for remote sensing applications
- Supports petabytes of extremely high-resolution imagery that the GeoEye-1 Satellite will collect
- Reduces processing time and puts imagery in the hands of people who need it in a more timely manner
- New image service enables the full depth of time-sequenced imagery to be easily accessible and integrated into both GIS and image processing applications

## Benefit 2: State-of-the-art solution that is open and interoperable to meet the needs of many users

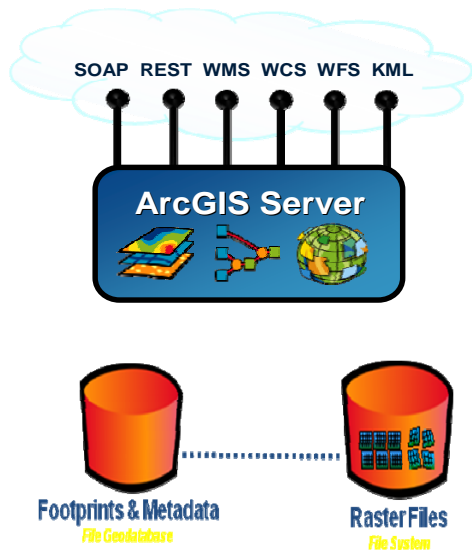
- Promotes access to huge volumes of imagery and associated metadata
- Supports thousands of concurrent users (and is scalable)
- Provides enhanced security options
- Allows for collaboration and “mash-ups” using GeoEye data
- Utilizes new web services: OGC WCS & KML

## Benefit 3: Leading technology platform in the industry

- Improves functionality that can easily integrate into other leading edge technologies, while still supporting existing legacy technologies and systems.
- Forms the foundation for future needs.



## Component: ArcGIS Server 9.3



The ESRI ArcGIS Server 9.3 platform is the backbone for GeoEye's prototypes. Scalability, interoperability, and usability are all accomplished utilizing the capabilities of Server 9.3.

The rich functionality of the ArcGIS desktop products are used to manage data, design, and author image services.

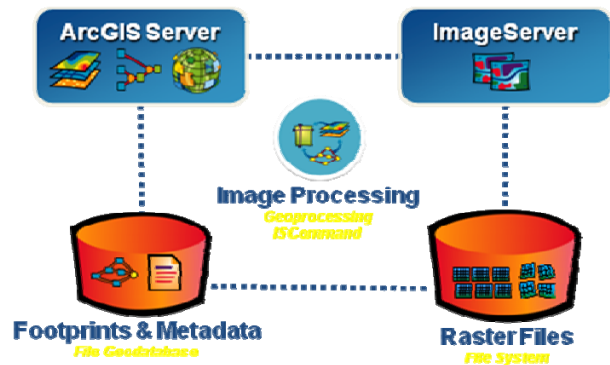
Image services are then published and served via server products and presented, where users cannot only be provided access, but also be able to interact with these services in order to obtain information from a large range of different client interfaces, including desktop, web, and mobile applications.

A number of different services are available from ArcGIS Server, including metadata, globe, charting, geoprocessing, and tracking services.

- Numerous interoperable web services provide access to imagery (SOAP, REST, WMS, WFS, WCS, KML)
- Services are accessible via off-the-shelf ESRI and non-ESRI tools
- Client software development kits (SDKs) support custom application development

Achieving a server-oriented architecture extends GeoEye's capabilities to support a wider audience. Support of current and future customers, the number one priority, is now paired with support for developers, OGC users, web mash-ups, and other interoperable functionality.

## Component: ArcGIS ImageServer 9.3



ArcGIS Image Server is the product which performs image processing services. Conventional imagery-serving technology has always been utilized to create one single large image from a large set of individual images, and then to serve this static image. Such solutions have many drawbacks, including lengthy pre-processing times, which result in imagery only being available a long time after acquisition.

With ArcGIS Image Server, the methodology is very different than what is currently used. Acquired or collected imagery can be kept in its native form without the need for conversion. The data can be derived from a satellite, digital camera, or a large set of pre-generated orthoimages. Any of these files can be stored as separate files or within a database.

Image services are authored in ArcMap and stored as image-service definitions. These image-service definitions delineate all the properties of the imagery, including georeferencing and associated metadata. They do not contain the pixel data - only the link to the data. The image-service definitions also identify how imagery should be processed and made into a mosaic to create a specific product. Because each image service is stored as a light and easy to access definition, multiple image services can be created into different representations of the same imagery that may be required for different applications.

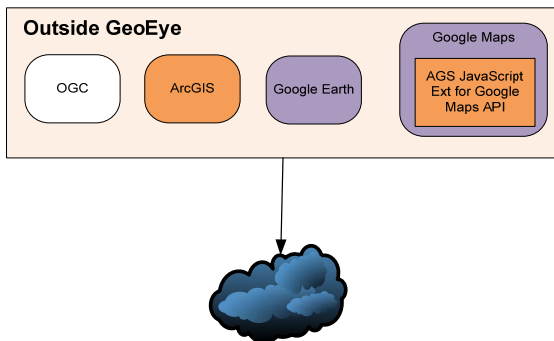
These services are published through the server and accessed by multiple client applications. Client applications can open and access image services as if they were one larger virtual image. As a user pans and zooms around, requests for imagery are sent to the server which quickly processes the required imagery and returns the imagery almost instantaneously to the client's application. Not only does the user get fast

access to high-quality imagery, but can access the important image metadata.

Additionally, users can interact with the image service and its properties, such as compression or mosaic methods, further customizing the imagery for their specific requirements.

- Automated scripts can be used to create, optimize, and publish image services
  - ImageServer supports advanced image-processing options
- Source imagery can be kept in native form
  - Newly acquired imagery
  - Existing raster datasets
  - Files or DBMS
- Author image services that define:
  - Image properties: *georeferencing, metadata, etc.*
  - Processes to apply: *mosaic methods, enhancements, classifications, etc.*
- Publish image services for client access
  - Fast access to imagery and metadata
  - On-the-fly server-based processing
  - Changeable service properties
  - Lossless image data

**Component: ESRI ArcGIS JavaScript API for Google Maps**



The ArcGIS JavaScript API is probably the biggest new feature of ArcGIS Server at 9.3. Now, instead of being limited to .NET or Java, one can pick a simple JavaScript API to publish to ESRI's JavaScript API or Google Maps.

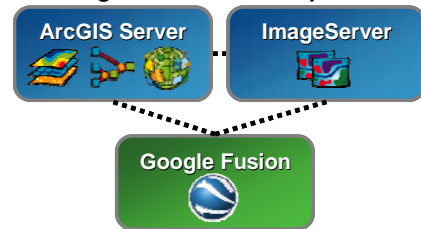
With the Google Maps API, one is able to embed Google Maps into application web pages with JavaScript. The API provides a number of utilities for manipulating maps (just

like on the <http://maps.google.com> web page) and adds content to the map through a variety of services.

- Allows the creation of robust maps applications on your website
- Accesses the Maps API (is a free service), available for any web site that is free to consumers
- Supports tiled and dynamic maps

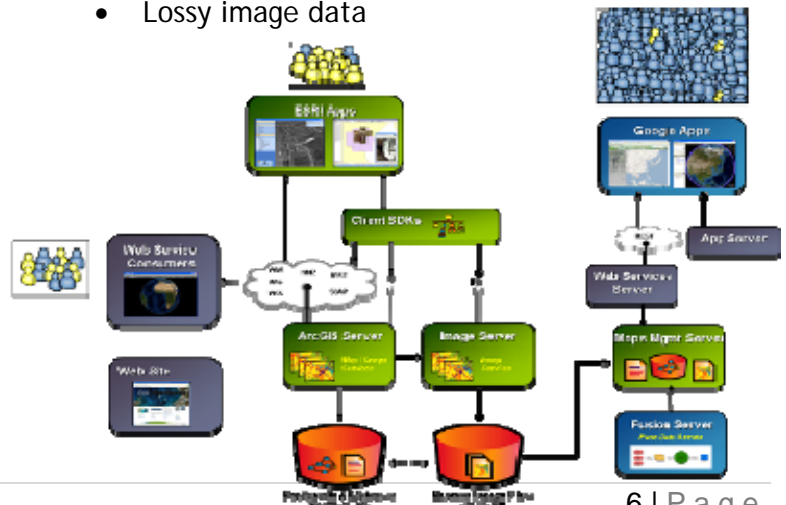
ArcGIS Server being leveraged in Google Maps gives developers the ability to take classic GIS analysis and put it in a context that "ordinary" users can make use of.

**Component: Google Earth Enterprise Server**



Google Earth Enterprise makes rich geo-data available to users with amazing speed and full context. Google Earth Fusion integrates geospatial - raster (imagery and terrain), vector, KML, 3D models and even data stored in traditional databases.

- Fuse and host flyable databases of virtually unlimited size
- Deliver fully interactive access to the entire store of corporate geospatial data
- Incorporate geospatial data from dozens of industry-standard formats
- Manage published databases using a robust set of administrative tools
- Provide 2+3D high performance, intuitive user interfaces designed for decision makers to work more productively and collaborate more effectively
- Lossy image data





Simulated Image of GeoEye-1 Spacecraft

## The Future for GeoEye

The ESRI 9.3 platform provides many opportunities for GeoEye to develop and deploy functionality in order to facilitate the access, use, and analysis of imagery.

As described in this paper, GeoEye's first objective is to develop simple search and discover functionality. This functionality will enable multiple user endpoints to consume GeoEye's catalog data (i.e. ESRI products, products with ESRI extensions, Google Earth-KML, and applications that can conform to the OGC specifications). GeoEye will continue to enhance the system based on user needs and the capabilities available in the ESRI 9.3 platform.

## Summary

GeoEye is transitioning from a legacy solution, "chaos", to a state-of-the-art service-oriented architecture, "order", to better meet the needs of business requirements throughout the growing commercial satellite-imaging industry.

GeoEye selected ArcGIS Server 9.3/Google Solution for four important reasons:

1. GeoEye needs a system that provides a solid foundation for state-of-the-art search and discovery applications, (both web and desktop).
  - Provides access to vector, metadata, and associated image files for huge volumes of imagery
  - Scalable and supports thousands of concurrent users
  - The new format File-GeoDatabase has a proven track record of managing some of

the largest spatial databases in the world; it made sense to build on this platform.

2. GeoEye needs a server solution that is capable of deploying petabytes of high-resolution satellite imagery, quickly and efficiently.
  - Old school delivery techniques utilizing CDROMs, DVDs, and FTP add overhead that GeoEye wants to reduce with state-of-the-art delivery systems which will put imagery in the hands of the people who need it more quickly.
  - GeoEye wants to provide dynamic processing capabilities to create different image products, on the fly, on demand.
  - GeoEye is raising the standard for dynamic image access, without the overhead of pre-existing custom solutions.
  - The world has grown accustomed to seeing free imagery on the web; typically this is one image from a single point in time. GIS professionals need more imagery, more time slices, and the ability to manipulate them. GeoEye has adopted a solution that could provide the full depth of imagery collected over the years.
  - When ArcGIS Server 9.3 added Image Server, GeoEye saw the potential to bring together vector and imagery into a single integrated system.
3. Because this system was going to drive GeoEye's entire company, it needs to be a system that is open and interoperable.
  - GeoEye needs to provide access to many different applications and clients, so we wanted a system that supports industry standards like OGC.
  - GeoEye wants to take advantage of the new OGC web coverage service in ArcGIS Server so that users could actually manipulate the pixels of the imagery in a web service.
  - GeoEye has been watching the explosion of mashups and how web developers are using KML and JavaScript to bring together content with GIS web services as well as Google Maps and Google Earth. The JavaScript API in ArcGIS Server 9.3 was incredibly valuable in building this open system.
4. And lastly, GeoEye wanted an enterprise business solution.
  - GeoEye needs a system that can easily integrate into our existing business systems.

GeoEye's Business Systems and Applications Group is very excited to be involved in the evolution of GIS at GeoEye... moving to an integrated desktop-service oriented-web solution will continue to drive our business and position GeoEye to further support our vast customer base and ongoing imagery needs.

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