

# Improving Access and Use of Imagery using Open and Interoperable Off-the-shelf Technologies

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**Abstract** – ESRI Inc. has supported the “Group on Earth Observation Architecture Implementation Pilot”, using its open and interoperable ArcGIS products. At the heart of its solution is ArcGIS Server. ArcGIS Server may be used to create interoperable services following the specifications from the Open Geospatial Consortium. Extensive experience has been gained in building catalogs of structured metadata documents. Providing similar discovery capabilities to the vast collections of imagery presents a new set of challenges, including performance, and processing of collected imagery. ESRI ArcGIS Server addresses these challenges with its Image extension.

**Keywords:** GEOSS, interoperability, open interfaces, ESRI, ArcGIS Server, GIS Portal Toolkit, Imagery.

## 1. INTRODUCTION

### 1.1 Business Needs

For several years, geographers have worked to define structures to describe their geospatial resources for the purpose of informing users of those resources of the content, usage permissions, origins, and other characteristics of the geospatial resources. These descriptions (metadata) have been formalized into international standards resulting in a common language for describing geospatial resources that facilitates exchanging those resources. Following these metadata standards, creators of those resources have started to create and publish catalogs containing the standardized metadata descriptions and enabling standard interfaces to those catalogs. Using these standardized interfaces, geographers and other scientists can discover these geospatial resources quickly and readily use the resources in their analysis and data production workflows.

The recognition that international collaboration is essential for exploiting the growing potential of earth observations to support decision making in an increasingly complex and environmentally stressed world is what has driven the Group on Earth Observations (GEO) to create a common architecture for sharing, discovering, and using earth observation resources.

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In recent years technological developments in the areas of collecting earth observation information, computing power and storage capacity has resulted in an exponential growth of available data and processing capacity. Butter's law (an equivalent to

Moore's law) says that the amount of data coming out of an optical fiber is doubling every nine months. Thus, the cost of transmitting a bit over an optical network decreases by half every nine months (Wikipedia, 2009).

With the increased availability of high-quality imagery, reduced cost of storage and distribution, and the increasingly complex problems analysts and scientists are faced with; demand for imagery has also increased. This became especially obvious in the aftermath of recent natural disasters across the world. Remotely collected earth observation data sometimes was the only remaining source of information about the affected area. These events also made clear that collecting and storing imagery was no longer sufficient. The collected data was needed in almost real-time to support the emergency response and later the recovery and rebuilding efforts.

Most of these catalogs built to-date have focused on complete datasets or web services as the basic units. This meant that a nation-wide street dataset containing millions of features could be described as a single dataset or service. However, the use cases for discovery and use of imagery are not necessarily the same, and the characteristics of imagery present new challenges to providers of catalogs and the technologies supporting these.

This paper describes a number of these challenges and outlines a solution to address these.

### 1.2 Challenges

One of the most obvious distinctions between vector data and image collections are the sheer volume and size of the items involved. Catalogs, such as the now freely available collection of Landsat Imagery (<http://landsat.usgs.gov/index.php>) by the United States Geological Survey (USGS) contain many 100,000s to millions of items.

Each of the images in such catalogs is very similar with differences limited to aspects as collection date, area, and a number of sensor-specific attributes. Rather than items in a catalog that would be described by individual metadata documents, the images are more like features in a dataset. For collections of this size, it would be impossible to manage structured metadata for every item. Verbose structured metadata would be applied to the entire collection (for example the entire Landsat collection mentioned before), rather than at the individual image level.

In addition to these volume and size challenges, each sensor may have specific characteristics collected for every image that complicates developing generic search clients that can search these collection using criteria beyond time and place.

Finally, imagery has represented considerable value for the collecting organization and is thus not necessarily made available

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for free. The decision to make the entire Landsat collection available for free to the public was only made in 2008.

These challenges and other considerations have resulted in the development of closed applications that allow users to browse, view, and order imagery (Glovis, EarthExplorer, DataDoors ...). EarthExplorer allows users to find, select, and download scenes, but warns: "Due to high demand and limited bandwidth, please limit downloads to one file per session." and "Note that data you have requested may be several hundred megabytes in size and transfer time may exceed an hour on a broadband (DSL, cable, T1) line." (EarthExplorer, 2009). A limitation of this application-centric approach is that in order for data to be useable in analyses one *has* to download the data. Even for reference purpose only, the images may not be available for use in applications other than the browse/view/order applications developed by the providing organization.

### 1.3 Solution Requirements

To achieve widespread availability and use of imagery a technology is needed that addresses the challenges mentioned above. At a high level the requirements for such a solution are:

- minimize work to maintain image collections,
- minimize time between image collection and availability for use,
- find scenes matching criteria specific for an individual sensor, but adapts to different sensors easily,
- supports geo-processing on-the-fly without downloading imagery,
- is interoperable with many source data formats, and
- exposes standards-based interfaces to enable use of the imagery outside of the context of a specific application.

The next section will outline a solution architecture that addresses the above requirements.

## 2. SOLUTION ARCHITECTURE

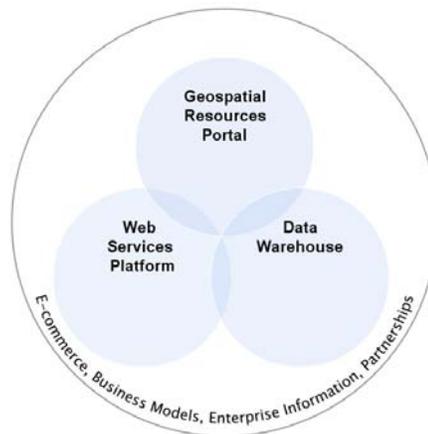
### 2.1 Solution Overview

Our proposed solution is an integrated platform – comprised of data warehouses, a web services platform, and a portal – that addresses the following objectives:

- Provide a means for cataloguing, discovery, and access of imagery, including but not limited to data and services.
- Provide a means to offer access to these data and services in a commercial context.
- Provide a platform to offer web services, as well as providing applications to make imagery accessible to the general public, education, and GIS professionals.
- Provide an environment for authoring data and services that integrates seamlessly with existing geospatial business processes.

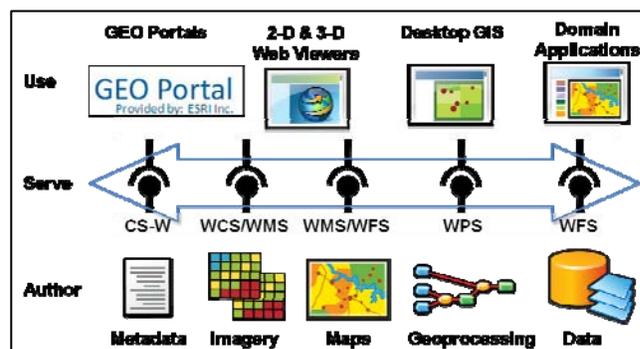
The authors propose three elements as key concepts of a solution that addresses the above requirements:

- Geospatial Resources Portal
- Web Services Platform
- Data Warehouses



Supporting the Web Services Platform, Data Warehouse, and Geospatial Resources Portal are processes that relate to:

- E-commerce – Services may be offered for free or users of the services may be charged a specific fee.
- Business Models – There exist various business models for a provider of imagery to application developers.
- Enterprise Information – As part of managing this will need management reports not only on the use of the Portal, but also on the products sold from the Data Warehouse(s), and the use of the Web Services Platform..
- Partnerships – Developing stakeholder partnerships is one of the key success factors of the proposed solution. Partners may be application developers (system integrators) that integrate the geospatial and business services provided by the solution into focused applications, making use of open web services and IT specifications.



The main components of the server-side architecture are:

- ArcGIS Server
- ArcGIS Image Server
- GIS Portal Toolkit (GPT)
- sdi.suite licenseManager

## 2.2 Solution Components

### 2.2.1 ArcGIS Server

ArcGIS Server is a complete and integrated server-based geographic information system (GIS). It comes with COTS end user applications and services for spatial data management, visualization, and spatial analysis. ArcGIS Server offers open access to extensive GIS capabilities that enable organizations to publish and share geographic data, maps, analyses, models, and more. With ArcGIS Server's rich standards-based platform, centrally managed, high-performance GIS applications and services can be accessed throughout an organization using browser-based, desktop, or mobile clients.

ArcGIS Server offers the following advantages: browser-based access to GIS; lower cost of ownership through centrally managed, focused GIS applications; integration with other enterprise systems; support for interoperability standards; and the ability to create custom applications and services for browser, desktop, mobile, Smart Client, and enterprise deployments using .NET or Java.

ArcGIS provides a range of web services including Image Services. These enable users to access imagery through a wide range of web protocols. The imagery can be stored on the server in a wide range of formats and, through out-of-the-box capabilities of ArcGIS Server, becomes directly accessible through OGC service interfaces such as Web Map Services (WMS), Web Coverage Services (WCS) and KML services. This removes the requirement to convert the data to formats for serving making it accessible. As the server renders only the client required imagery, it is also capable of re-projecting and optionally compressing the imagery for use over low bandwidth networks.

### 2.2.2 ArcGIS Server Image Extension

The Image Extension for ArcGIS Server extends the capability of ArcGIS server to manage very large number of image and also serve these as Image Services. Image Service definitions can be created that define the properties for large numbers of images, including detailed metadata and how they are to be processed to create different imagery products. When viewed by client applications, such Image Services become accessible as large virtual images with the server processing the imagery directly from its native format into the optimum image product that a user requires. The on-the-fly processing can perform radiometric enhancement of imagery such as band extraction and pan-sharpening as well as geometric processes such as re-projection, clipping to footprints and ortho-rectification. These capabilities enable multiple image products to be created from a single set of source imagery without any data redundancy or pre-processing. For example services returning pan-sharpened true color, false color and different vegetation indices can be created directly from a single source.

The methodology also ensures that the full pixel and metadata information content of the original imagery is retained and data is not lost through additional image sampling or mosaicking. Users can query the server and obtain detailed information about the imagery displayed as well as similar imagery falling in the same region.

The Image Extension performs dynamic mosaicking that enables the user to control the order of overlapping imagery and order the imagery based on metadata attributes such as acquisition date, quality or cloud cover.

By default when a user accesses an Image Service coming from an Image Service definition, the imagery is ordered based on parameters defined by the author of the service. Typically services are authored with the latest and best quality imagery on top. A user may query the image service to obtain information about the overlapping image, select a specific order, else change the default ordering of the imagery based on a set of predefined attributes.

### Different Image Access Methods

ArcGIS Server is providing a new paradigm for how images are accessed. The more scientific community has been accustomed to querying catalogs to identify imagery, then download and analyze them.

Most consumer users are accustomed to accessing large (often worldwide) caches of imagery such as those provided by Google Earth, Microsoft Virtual Earth and ArcGIS online. These provide fast access to imagery only as simple background information. For the publishers of these services the creation of such mosaics is time and disk consuming.

Image Services provide publishers of the imagery the ability to substantially reduce data storage, management and processing costs, while providing their users access to multiple image products that fully utilize the multispectral capabilities of modern sensors. The users gain intuitive and quick global access to a range of image products, with better image quality and full access to the rich image information content.

The significant advantages are provided by the fact that the information from overlapping imagery is not lost and users can fully exploit not only the pixel data, but also the metadata information associated with the imagery.

ArcGIS Server provides value to any organization involved in image processing and distribution. By reducing data storage and management costs and making valuable imagery quickly accessible, the ArcGIS Server Image Extension provides an immediate return-on-investment.

The fact that the Image Service definition is based on a form of catalog of imagery with footprints, metadata, and processing parameters lends itself to enabling these catalogs to be used as catalogs by the GIS Portal Toolkit. These catalogs of image footprints may be served as OGC Web Feature Services (WFS), or be consumed using open SOAP or REST interfaces.

### 2.2.3 GIS Portal Toolkit

GIS Portal Toolkit is an extension to ArcGIS Server that gives organizations the ability to organize and publish the locations of geospatial datasets, map services, applications, and other Web resources. It gives users the ability to discover those resources and facilitates access to them. The GIS Portal Toolkit extension includes

- Support for recognized international technology and data standards

- Ability to catalog your existing GIS resources regardless of location or type
- The GIS Portal Site Starter to facilitate discovery of GIS resources
- A ready-to-go map viewer to consume resources
- Ability to discover, use, and share registered GIS resources within desktop GIS clients
- Ability to harvest content from other GIS portals and catalogs
- Support for GeoRSS, KML, and HTML to expose content from the catalog service to external clients
- Ability to integrate with third-party content management systems, portal frameworks, and authentication systems

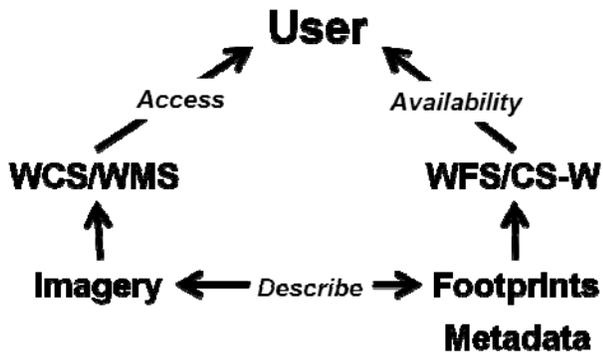
#### 2.2.4 sdi.suite licenseManager

sdi.suite licenseManager is a complementary product by ESRI Inc.'s partner con terra GmbH. It provides e-commerce and digital rights management functionalities for web services within spatial data infrastructures.

It enables service providers to create, manage and apply license models to their web services. These models can cover a broad range from non-commercial license terms only (click-through) to commercial models (pay-per-use or pre-paid). Applied models enable a license-based access to geospatial web services by enforcing agreement with user conditions, use restrictions, and price/fee models, whenever a service is accessed by a user. Users can benefit from extended portal functionality by being able to review license conditions and conclude a license online without delay.

### 2.3 Integrating the Solution Components

The above mentioned solution components are put together to help build a system of systems that focuses on making imagery data discoverable and usable following the principles laid out above.



We expanded the traditional metadata search provided by GIS Portal Toolkit with the ability to direct search to a specific image catalog, using an OGC WFS or CS-W Interface. This directed search accounts for sensor-specific image metadata (through property filters), but focuses on the generic spatio-temporal search. Some of the imagery catalogs allow for visualization-only services through OGC WMS, while others may support downloading data through OGC WCS. In an open market environment, there may be providers that use ArcGIS Server with the Image extension to allow users to generate 'virtual services' on-the-fly that only contain the selected images out of the large catalog. These services could be available during the user's

session or could be persisted as a commercial service. In this case, con terra's sdi.suite licenseManager solution could be used by the service provider to control access to the image content or to support commercial business models for making imagery available to users.

Although the solution components may be combined to provide a complete solution for providing access to imagery, the approach and technology described here differs in an important aspect from existing applications related to exploiting image catalogs. The distinction is in the choice to use an open, standards-based services approach to the overall solution where the imagery, its metadata, licensing, access control, and e-commerce components are provided as services by off-the-shelf technologies, independent of the client environment.

### REFERENCES

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