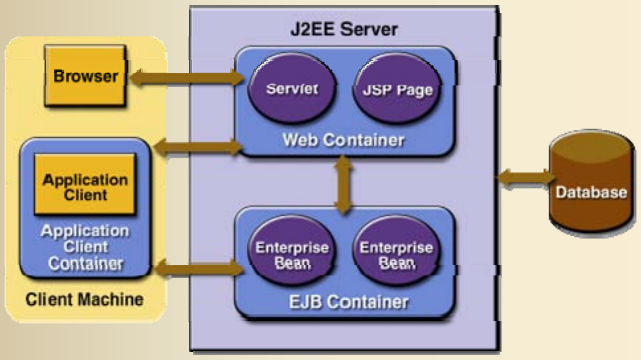

Image Exploitation for the Enterprise

Brad Skelton
Leica Geosystems Geospatial Imaging
Photogrammetric Week 2007

Imagery is being used more and more to drive decisions in large organizations. Maturing standards along with improvements in image compression, delivery and processing power are bringing image exploitation to the enterprise. The capabilities which have traditionally been locked in the image analysts' labs are now moving into the nearest browser.

- when it has to be right Leica Geosystems

Evolution of Geospatial Technology….

A Brief Look Back

- when it has to be right

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The 1st Generation….

1800's to 1900's

- Analog technologies were used to make hardcopy maps
- Maps were rarely updated
- Mapping was limited to a few
- Maps were not shared
- Referred to as the 'Paper Generation'

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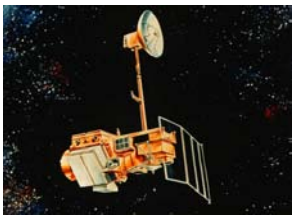
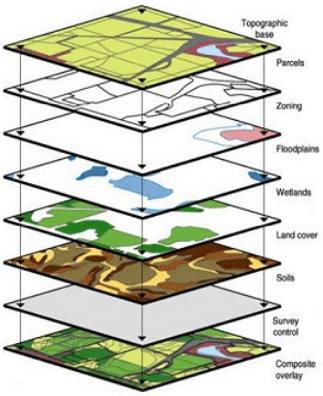
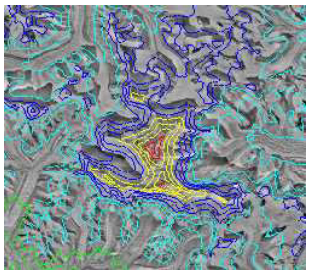
The 2nd Generation….

1970’s to 1990’s

- The ‘File’ Generation
- Digital Mapping Generation
- Birth of GIS
- Commercial Remote Sensing Satellites
- Digital Photogrammetry
- The ‘2D Mapping’ Generation







Which Brought About the SILO Effect

The ‘Silo’ effect of departments not working together to share data resulting in disconnected workflows and redundant mapping....

Photogrammetry Department

Remote Sensing Department

GIS Department

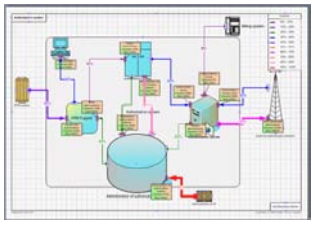
IT Department

The 3rd Generation….

1990's to 2000

- The Internet Age
- The beginning of the '3D Generation'
- Relational databases to share information within an organization
- Web services to deliver geospatial content to a wider audience
- Internet Mapping capabilities to shift paradigm from desktop to HTML
- Broadening of market from professional users to prosumer and consumers of geospatial information







The 4th Generation….

2000+….

- 'On-Demand' Generation – I Want it Now!
- Time is Critical…4D
- Mobile Generation
- Google Earth and Virtual Earth
- Online Collaboration for Sharing
- Instant Messenger
- Online Social Networks
- Synthesis of IT, Internet, Business Systems and Geospatial Technology to create true Decision Support Systems
- OGC/ISO standards for interoperability
- Open Source
- Geospatial Data Currency is a Driver

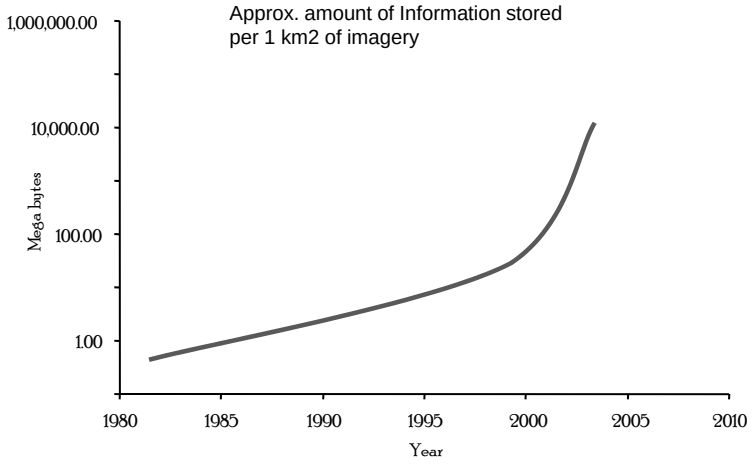


OGC®
TM
open source

The Size and Number of Images Continues to Grow

- **Imagery always contains information…**

In 2002, 1 km^2 of ADS40 imagery produced approx 14,222 Mbytes of information



Which increases the need for…

- **Management of the Data - Using folders to manage this data will no longer work. We must rely catalogs to organize and access our data.**
- **Effectively Manage Storage - Though disk space is cheap, it is never enough. Compression must be used to effectively store all of the data.**
- **Automation of Information Extraction – There is too much information for human processing and too few specialists. We need to publish algorithms as easily as we publish data.**
- **Collaborate and Share the Information – The information that is extracted must be effectively shared.**

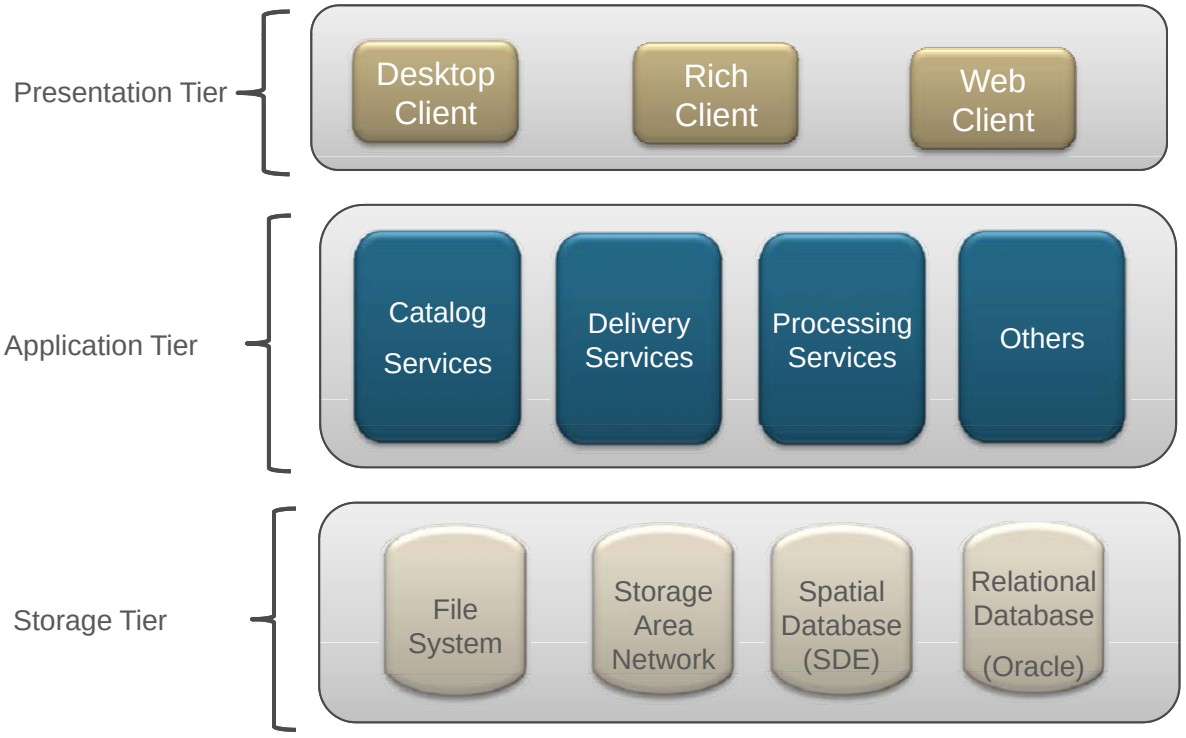
What is an Enterprise System….

Organize, Discover and Share Information

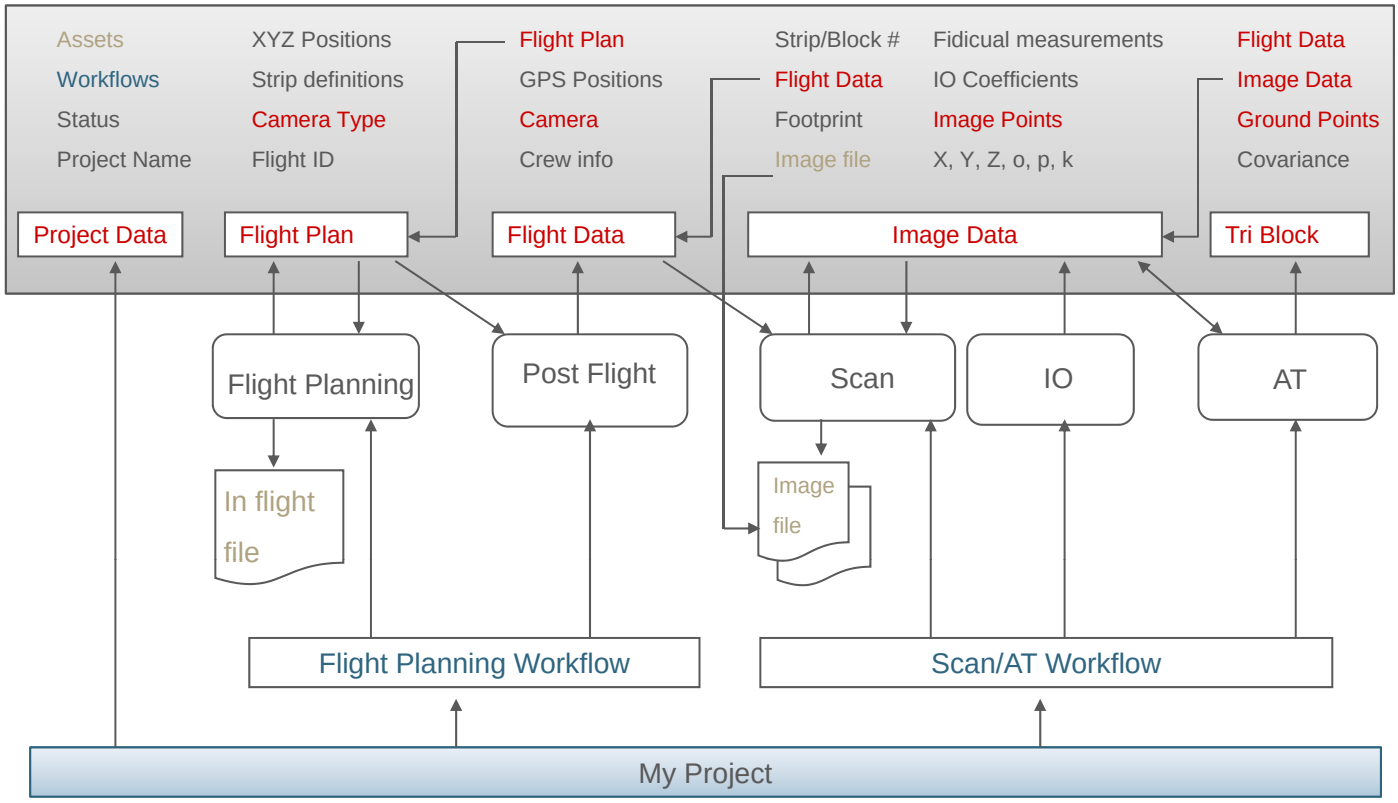
Characteristics of an Enterprise System

- True multi-user, simultaneous access to the same production project from any workstation in the production network
- Project access and security on par with the system domain
- Rational schemes for managing high volume data types
- Capabilities provided as interoperable services
- Scalable to meet the growing production and throughput demands of an organization
- Ability to persist all variables and parameters associated with the workflow
- Extensible platform for customizing the workflow and integrating them with other business workflows

An Enterprise Architecture



Full Domain Modeling Example



Interoperability Requires Standards

- **Open Geospatial Consortium (OGC)**
  - Coordinate Transformation Service - provides interfaces for general positioning, coordinate systems, and coordinate transformations
  - Catalog Service (CSW) - defines common interfaces to discover, browse, and query metadata about data, services, and other potential resources
  - Web Map Service (WMS) - provides three operations in support of the creation and display of registered and superimposed map-like views of information that come simultaneously from multiple remote and heterogeneous sources
  - Web Coverage Service (WCS) – supports the electronic interchange of geospatial data as "coverages" – that is digital geospatial information representing space-varying phenomena
  - Web Processing Service (WPS) – provides open method for describing and implementing interoperable processing engines
  - SensorML – provides an efficient method for transporting sensor data and preparing it for fusion through spatial and temporal associations
- **International Standards Organization (ISO)**
  - ISO 19130 – sensor and data models for imagery and gridded data
  - ISO 19115 – schema required for describing geospatial data and services

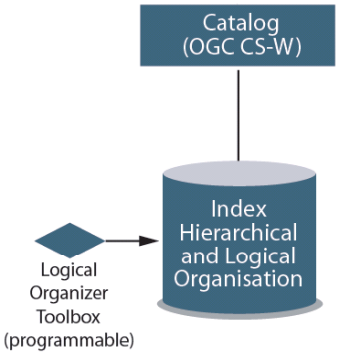
Catalog….

Organize and Discover Information

Catalog Capabilities

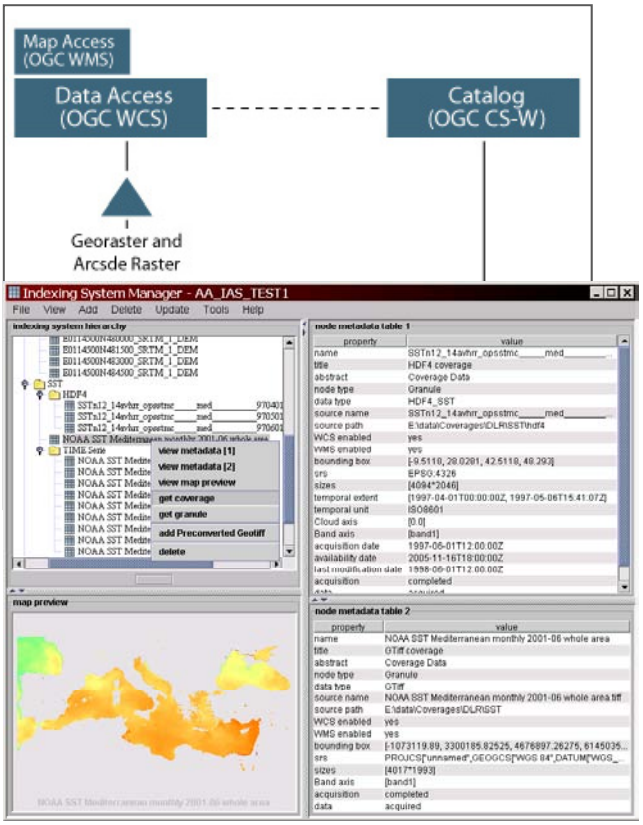
The catalog is the central mechanism for the storage and discovery of information about available data and services. It should have the following properties:

- Be based on a standardized data model (ISO 91130, ebRIM)
- Crawl and harvest geospatial datastores
- Register and harvest services
- Support multiple spatial reference systems
- Support access and edting of metadata
- Support complex queries
- Conform to OGC Catalog Service (CS-W)

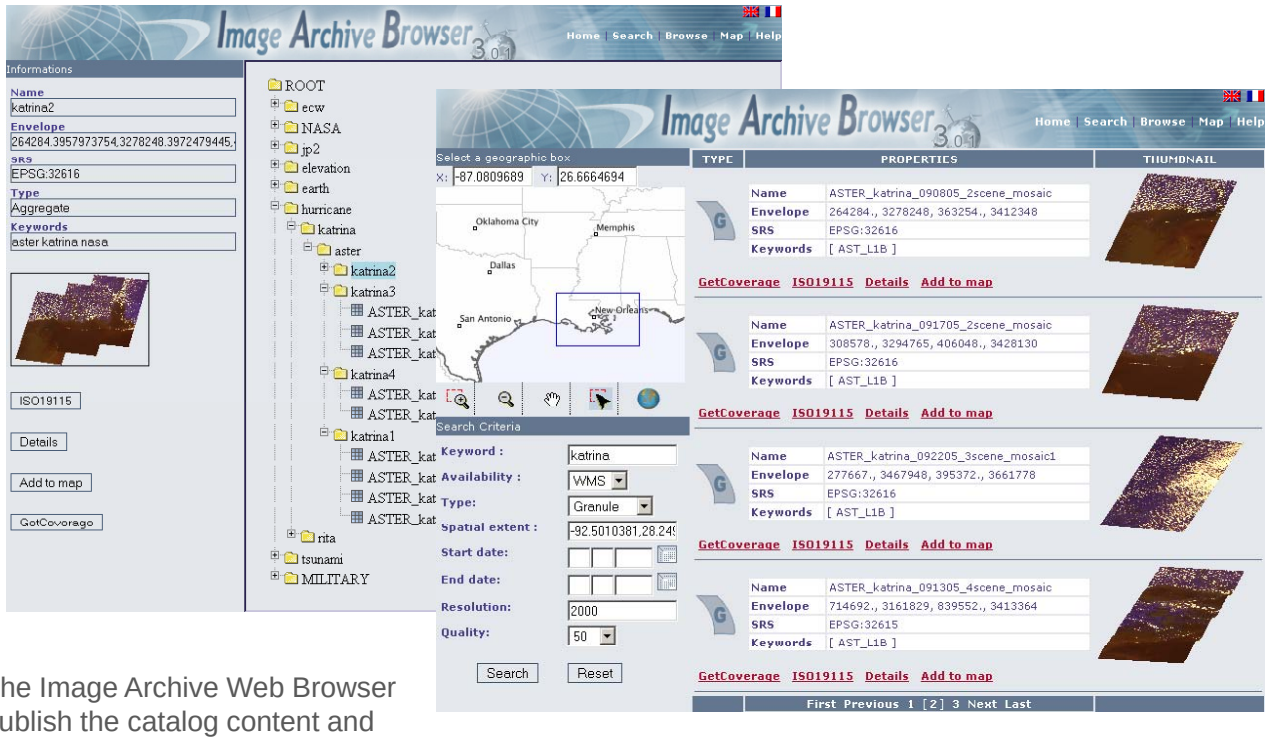


IONIC Red Spider Image Archive

- **CS-W Compliant Catalog Implementation.**
- **Full ebRIM support**
- **Capable of registering tens of thousands images per day**
- **Metadata viewing and editing along with image and content viewing**



Management Console and Query Interface

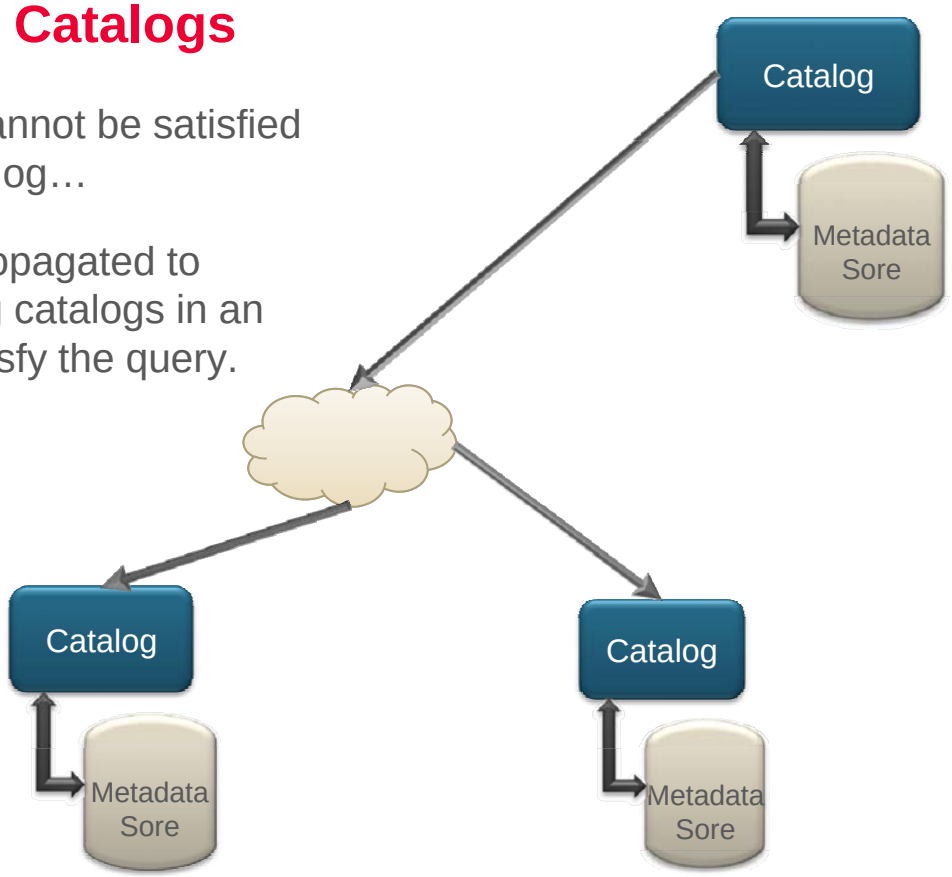


The Image Archive Web Browser publish the catalog content and demonstrate the power of the CS-W, WCS and WMS interfaces

Federating Catalogs

If a query cannot be satisfied by one catalog…

It can be propagated to participating catalogs in an effort to satisfy the query.

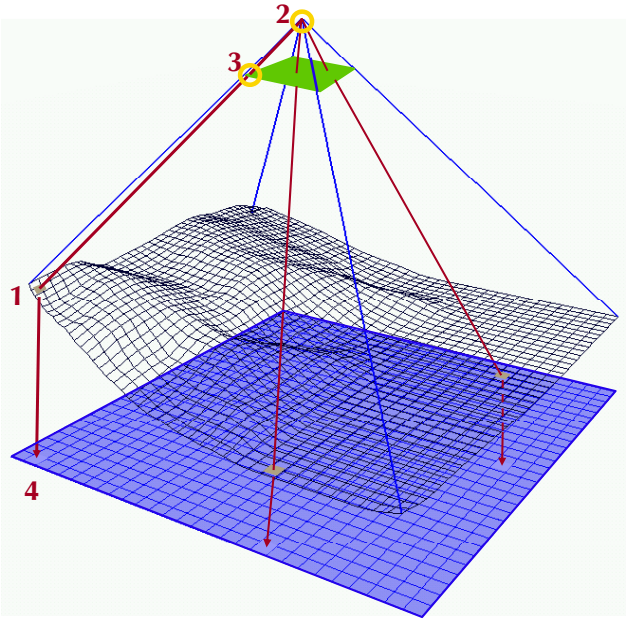


Sensor Models….

Creating a 3D Image…

Sensor Model

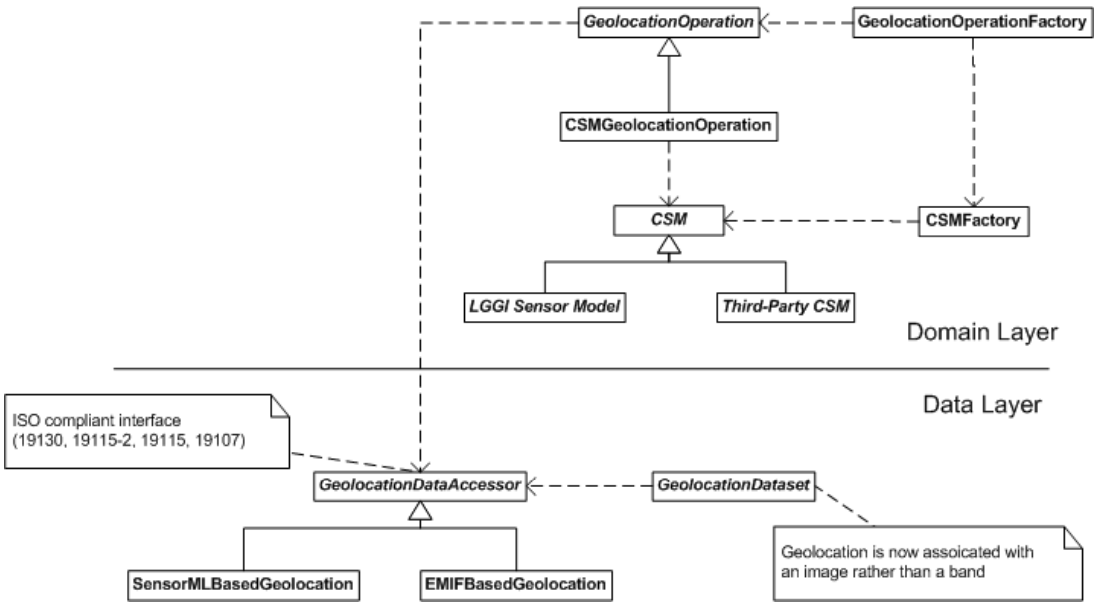
- **Describes the Image to Ground Transformation.**
- **Enables**
  - Stereo Viewing
  - 3D Measurement
  - 3D Feature Collection
  - Terrain Extraction



Standards are moving it to mainstream

- **OGC Standardization now exists for Coordinate Transformation Service - provides interfaces for general positioning, coordinate systems, and coordinate transformations**
- **Sensor Model Standardization is in progress**
  - ISO 19130 defines features of an interface
  - SensorML defines persistence
  - Community Sensor Model (CSM) implements standard API for sensor model DLL

Merging ISO 19130, SensorML and CSM



Deliver Effectively….

High Speed Delivery of Pixels

Protocols for Delivering Pixels

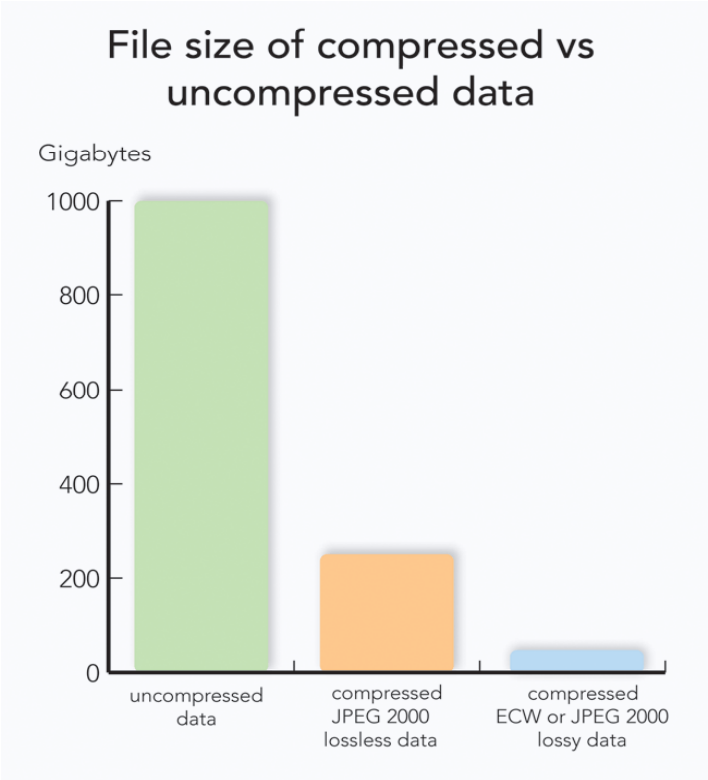
- **WMS** is a simple protocol for delivering a “map” as pixels in the form of a web image (PNG, JPG) at a selected scale.
- **WCS** is a rich protocol for delivering a true image in a broad range of formats.
- **JPIP** is an evolving standard for streaming delivery of pixels as a wavelet (JPEG2000) compressed stream along with metadata.
- **ECWP** is an existing protocol for delivering pixels as JPEG2000 code blocks.

Benefits of Compressed Imagery

- Compressed imagery is *easier* to use and *manage* than uncompressed image tiles
- Compression can be lossless
- Serving compressed imagery is *faster* than uncompressed images
- Share and use imagery throughout your business processes (desktop and server applications)

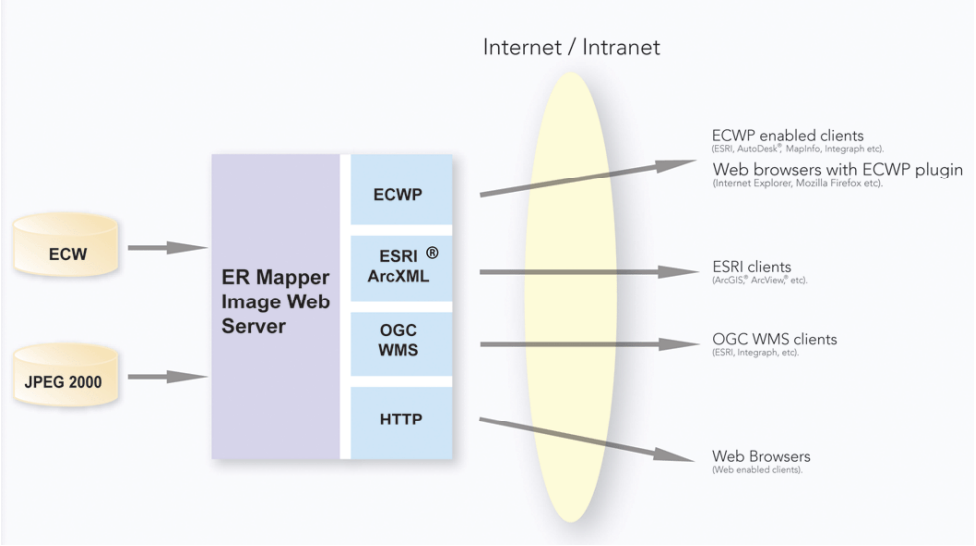
Wavelet Compression

- Wavelet compression can provide up to 5 fold improvement without loss.
- The improvement can up to 20 times with minimal loss of data.
- Subsets can be accessed without decompression.



ER Mapper Image Web Server

- Terabytes or more of imagery
- 1000's of concurrent users (ECWP)
- Moderate hardware requirements



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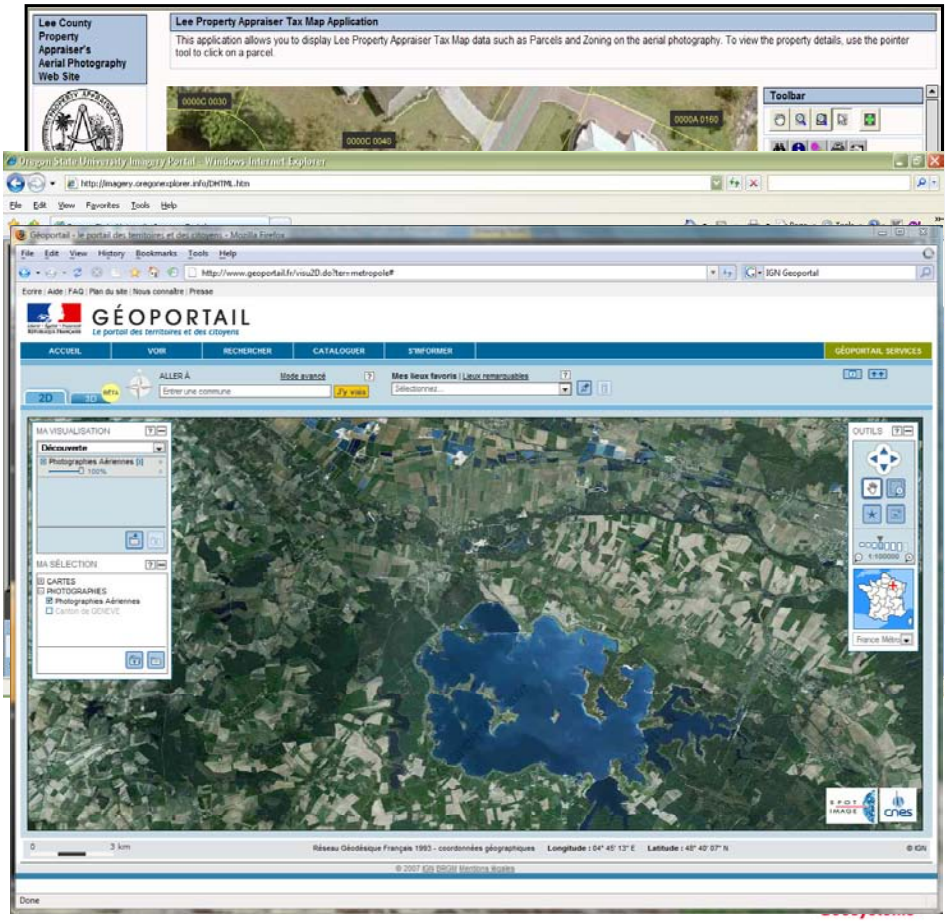
Implementations of Image Web Server

- Lee County
- Oregon State
- IGN Geoportal



High Performance Computing….

Maximizing Production

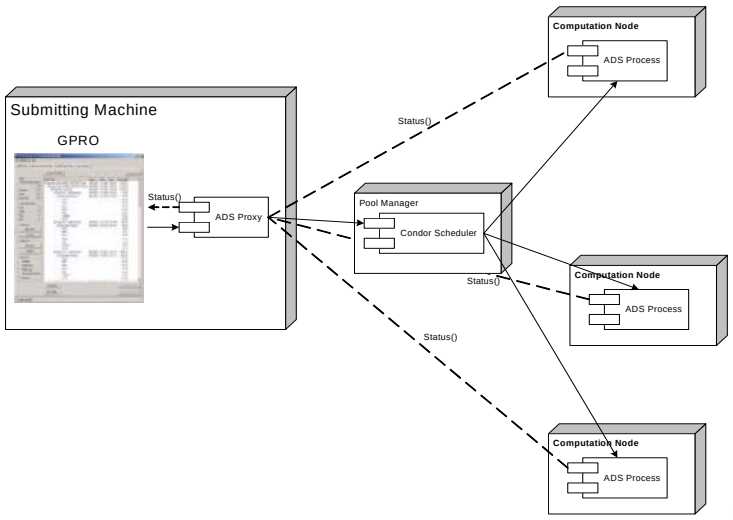
Models for High Performance Computing (HPC)

- **Coarse Grained**
  - MPI: Message Passing Interface
  - PVM: Parallel Virtual Machine
  - Condor: High Throughput Job Scheduler
  - DCOM: Distributed Component Object Model
- **Fine Grained**
  - OpenMP: Shared Memory Parallelization

HPC Approaches in GPRO

GPRO **Uses a mix of fine and coarse grained strategies**

- **Uses Condor to distribute computation across participating machines**
- **Rectifier uses multithreading to improve per image performance**



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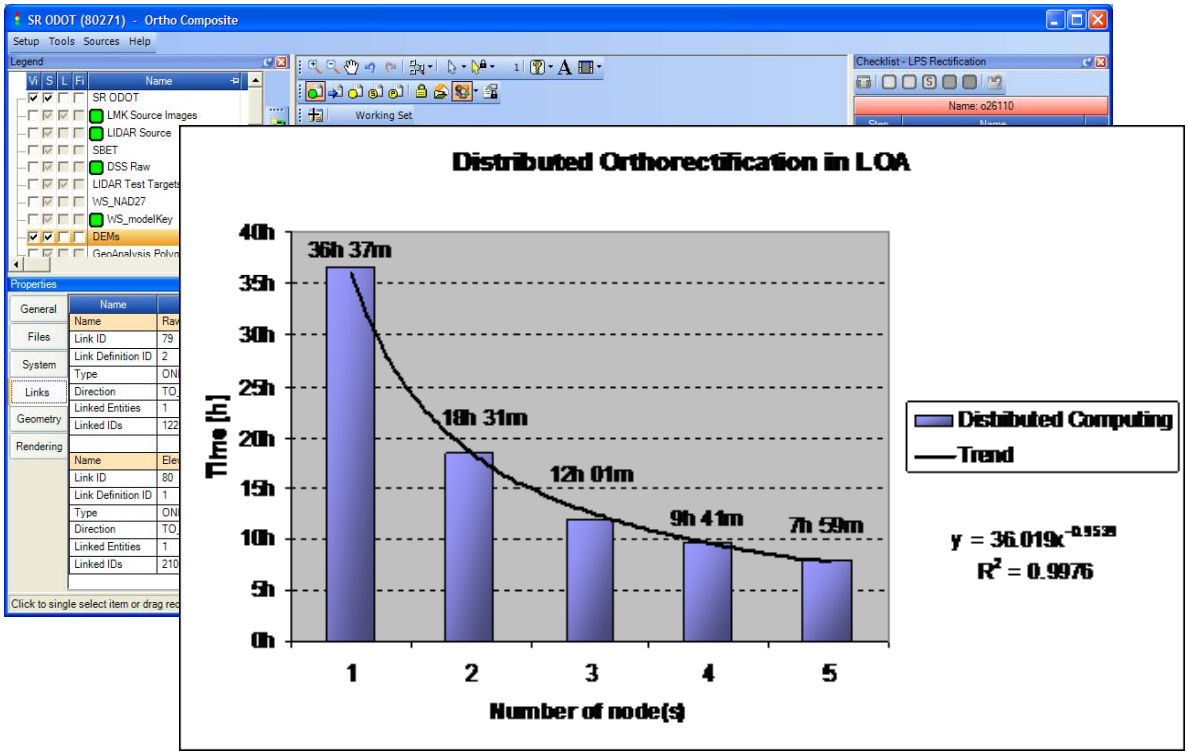
Performance Realized in Leica Ortho Accelerator



- when it has to be right

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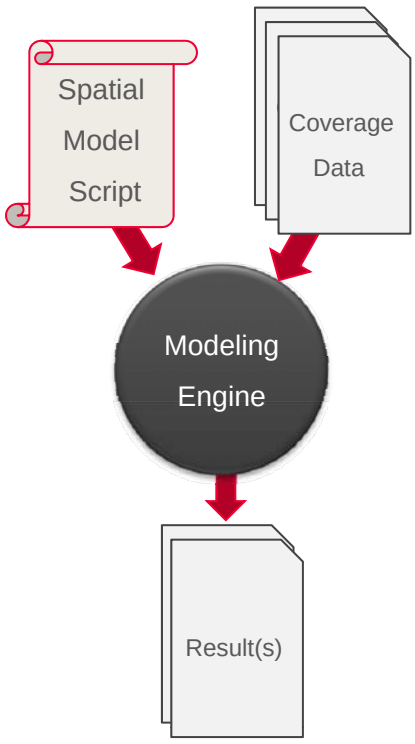
Spatial Models….

Extracting Information from Imagery

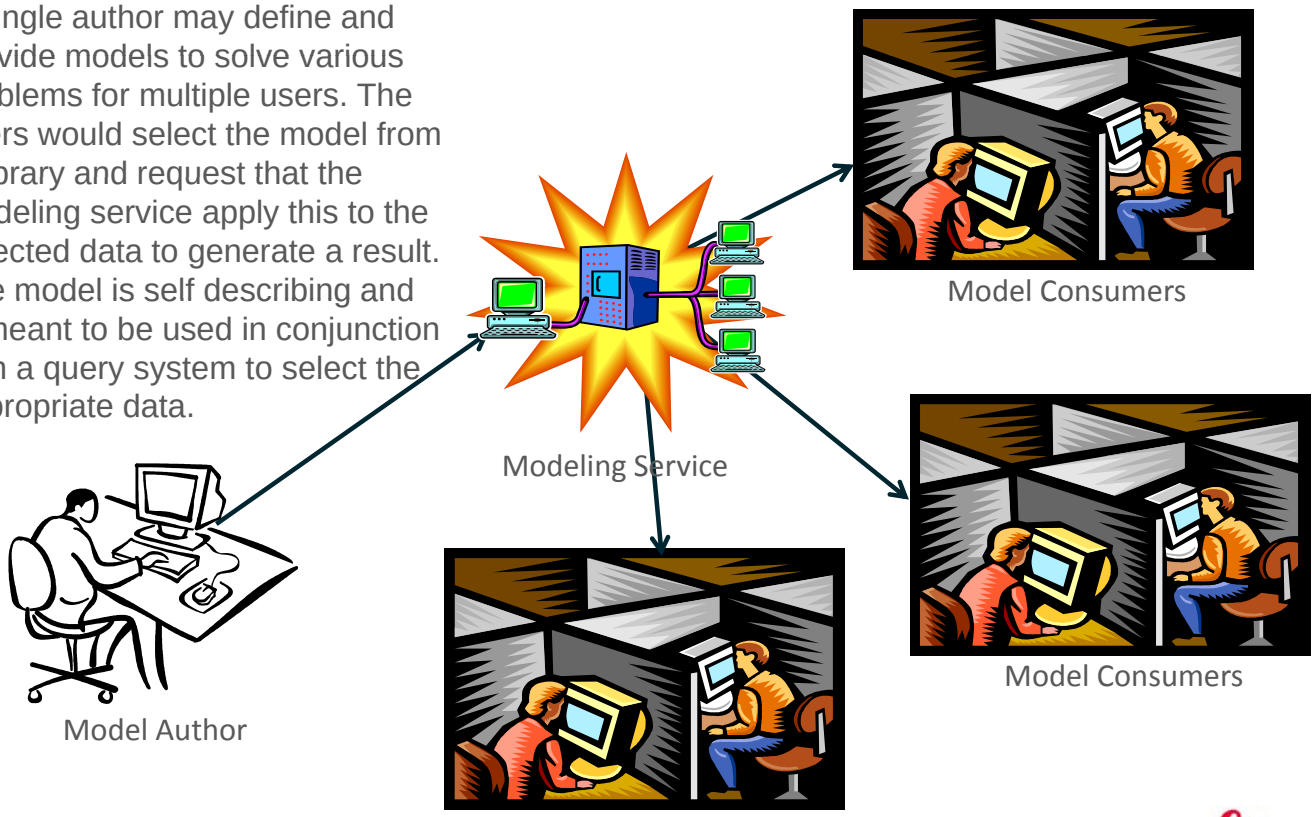
Spatial Modeling Engine

- **Combines an algorithmic script with data to produce results**
- **One or more results from a single script**
- **Multiple Instances of the engine can be run simultaneously**



Modeling Service Concept

A single author may define and provide models to solve various problems for multiple users. The users would select the model from a library and request that the modeling service apply this to the selected data to generate a result. The model is self describing and is meant to be used in conjunction with a query system to select the appropriate data.



- when it has to be **right**

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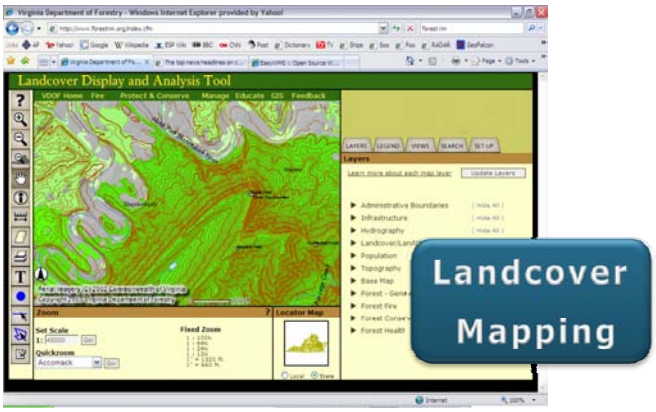
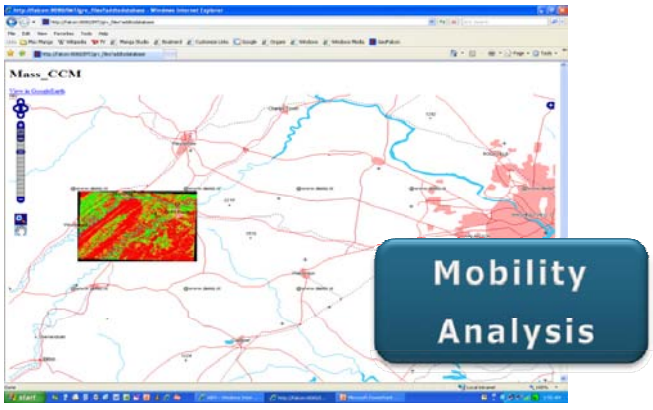
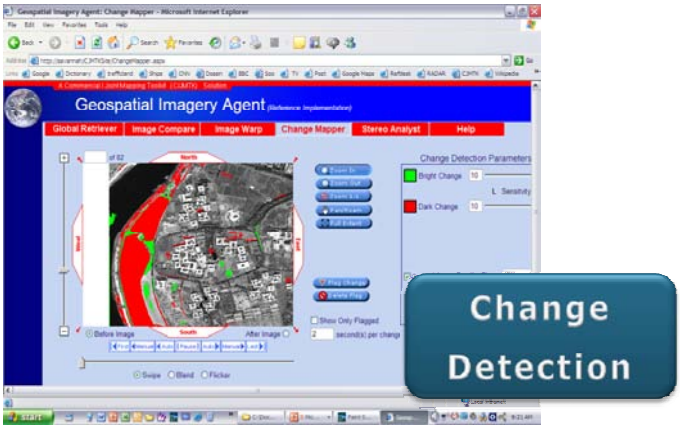
Potential Applications







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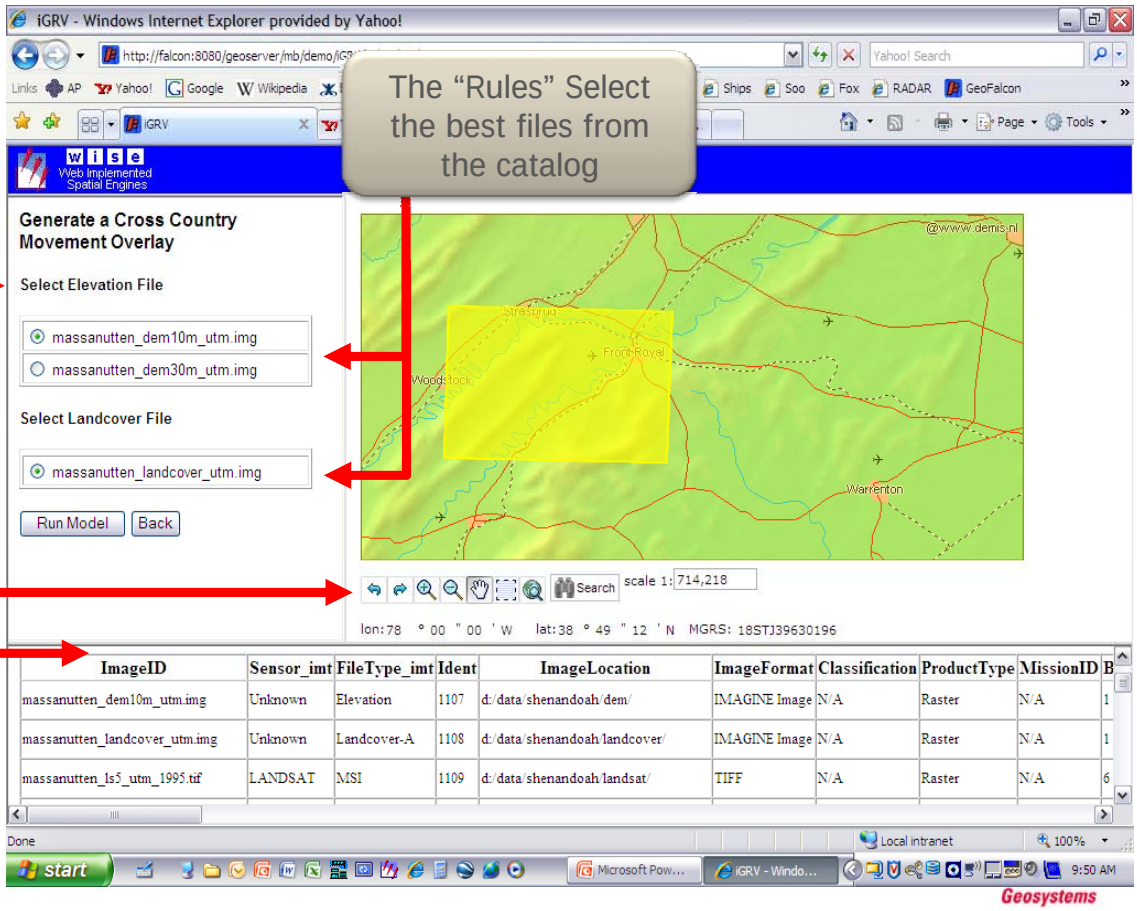
Mobility Analysis Example

Models that can be run with the available data

Graphical Selection of the Area of Interest (AOI)

Catalog display of available data

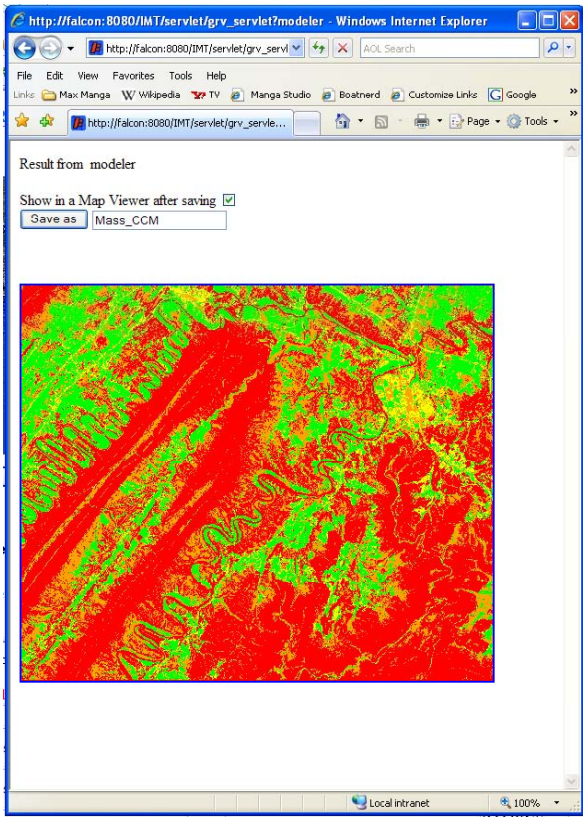


Geosystems

A Simple Web User Experience

The Result of the Model is returned as a separate HTML from which it could be:

- **Downloaded to a Local File**
- **Stored in the Catalog**
- **Loading into a WMS Client**



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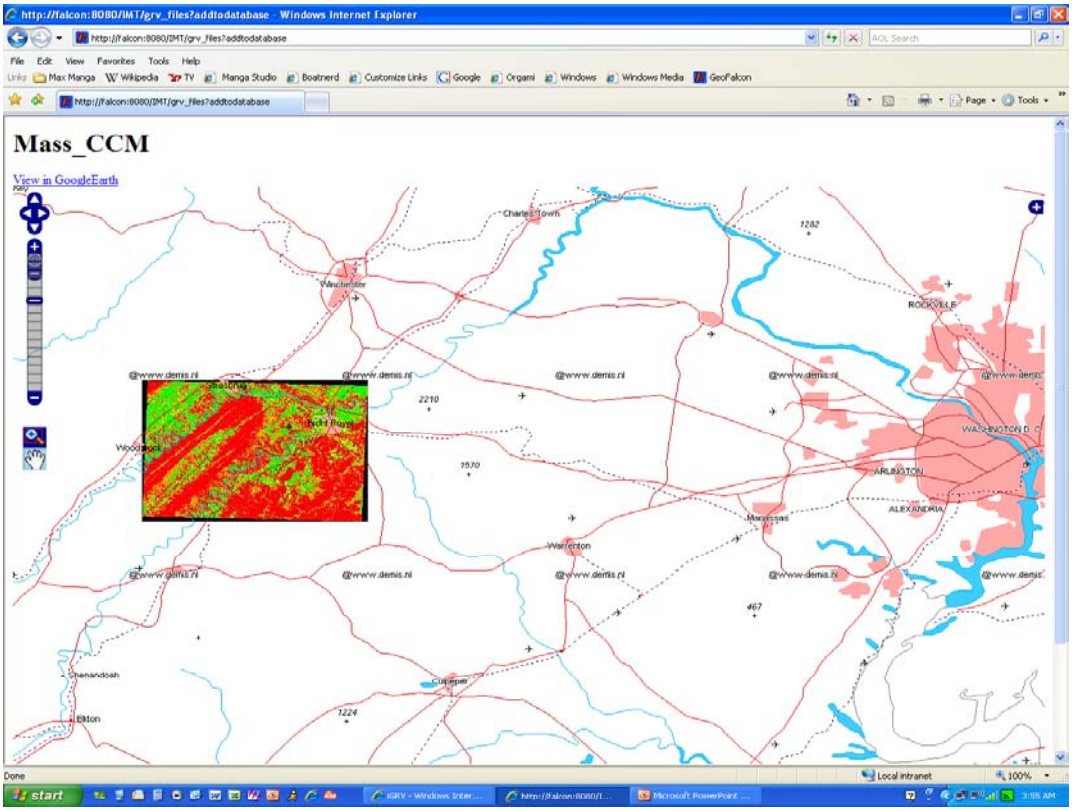
Display the Results in an OGC Client



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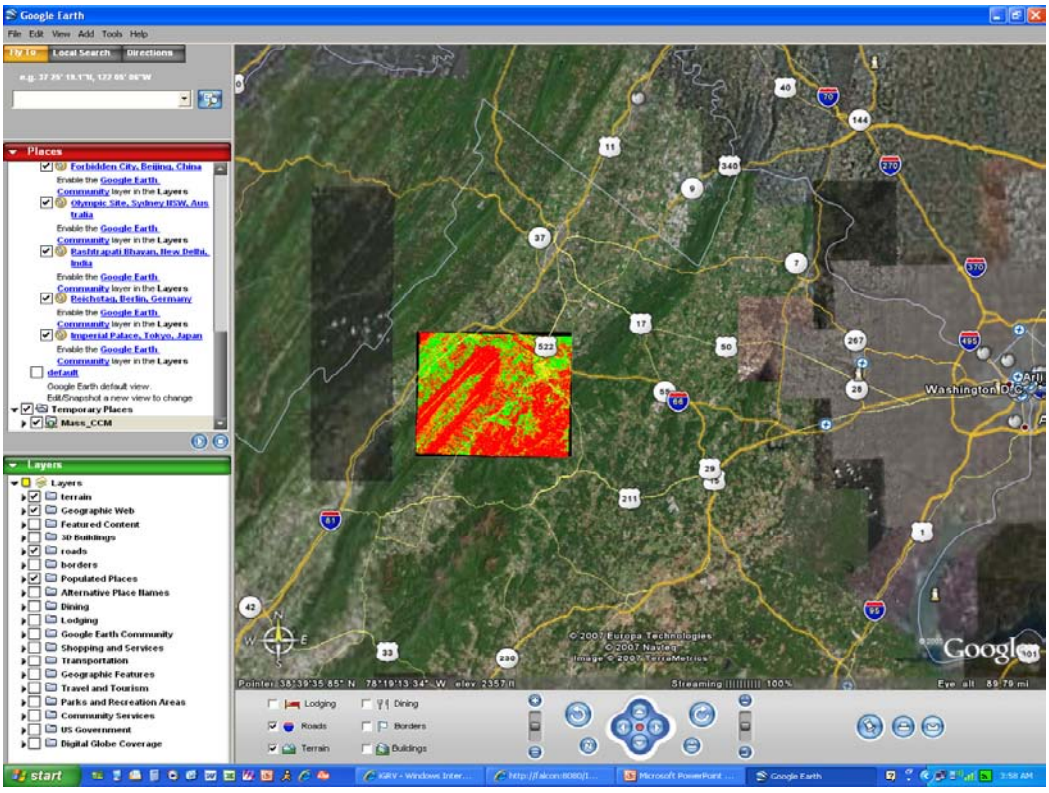
Or Display the Results in Google Earth…



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What if we put all together…

Combine these elements into a single rich client

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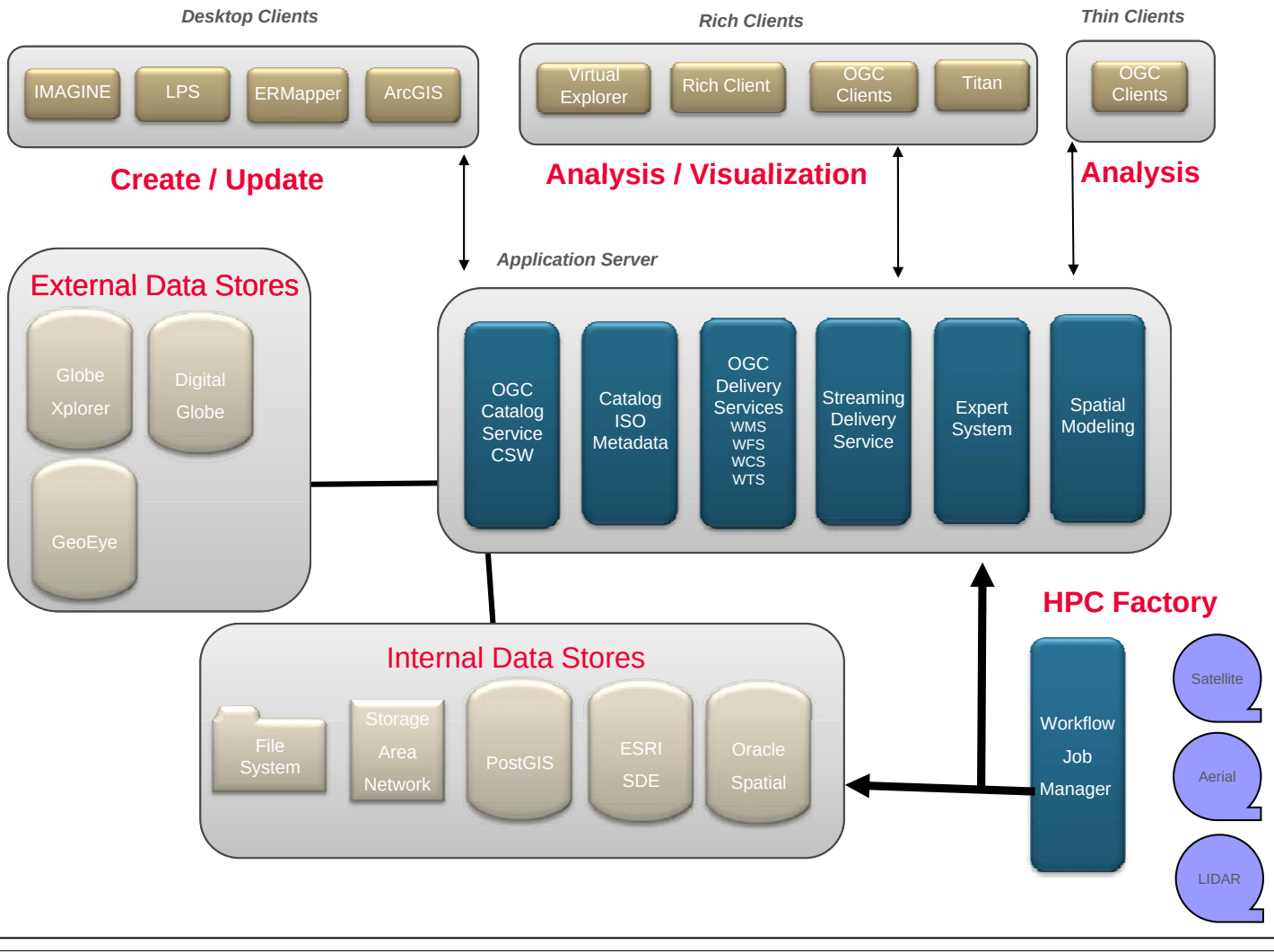
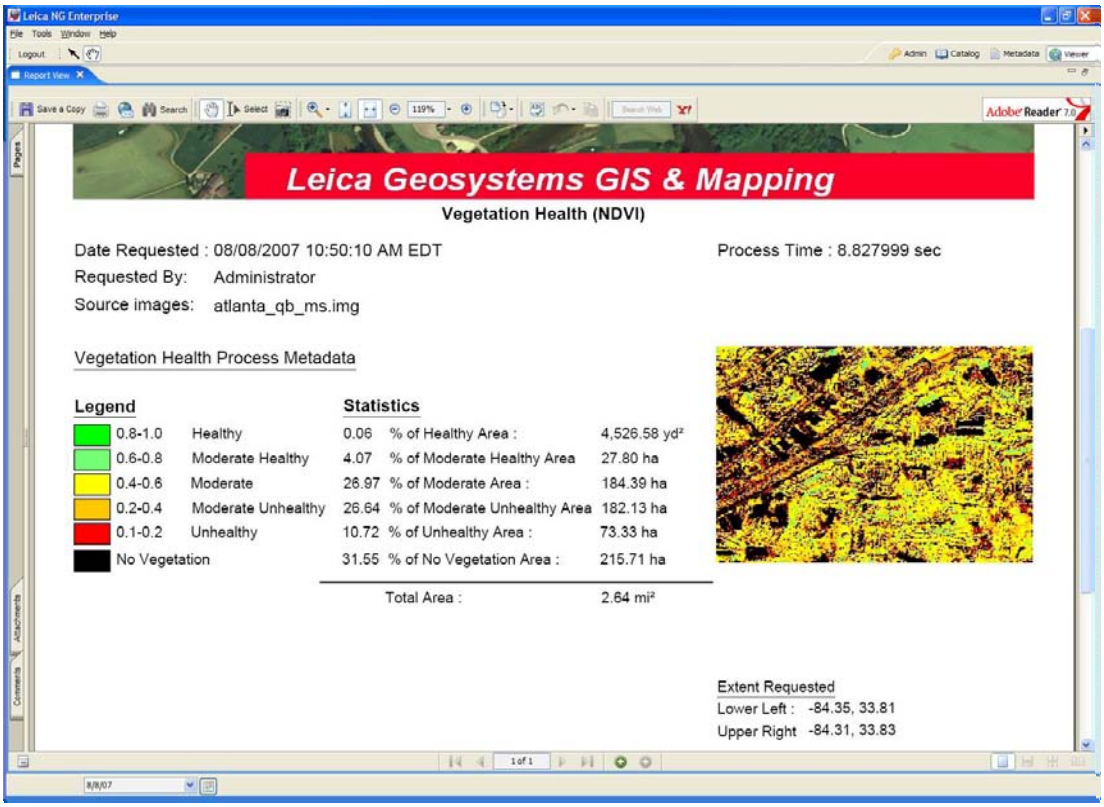


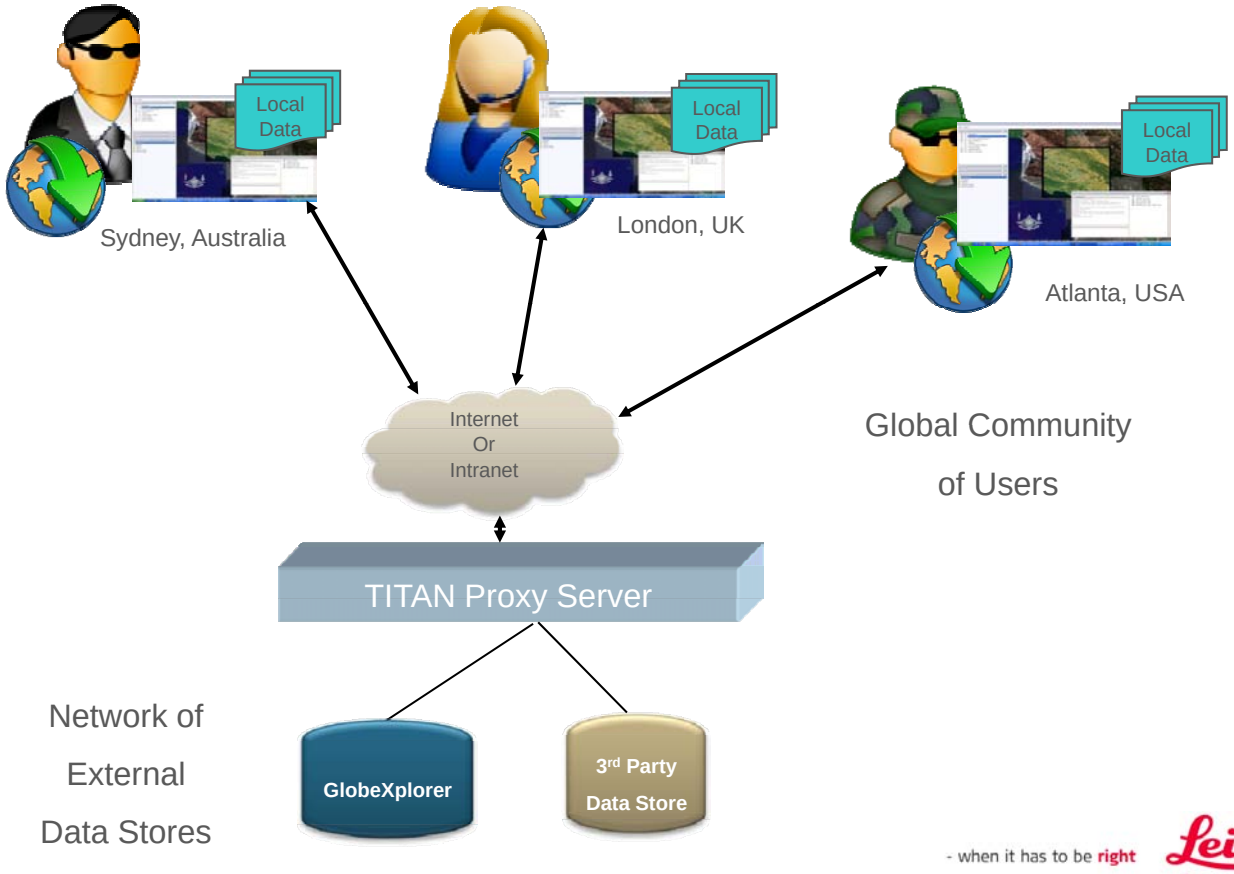
A Single Simple to Operate Interface



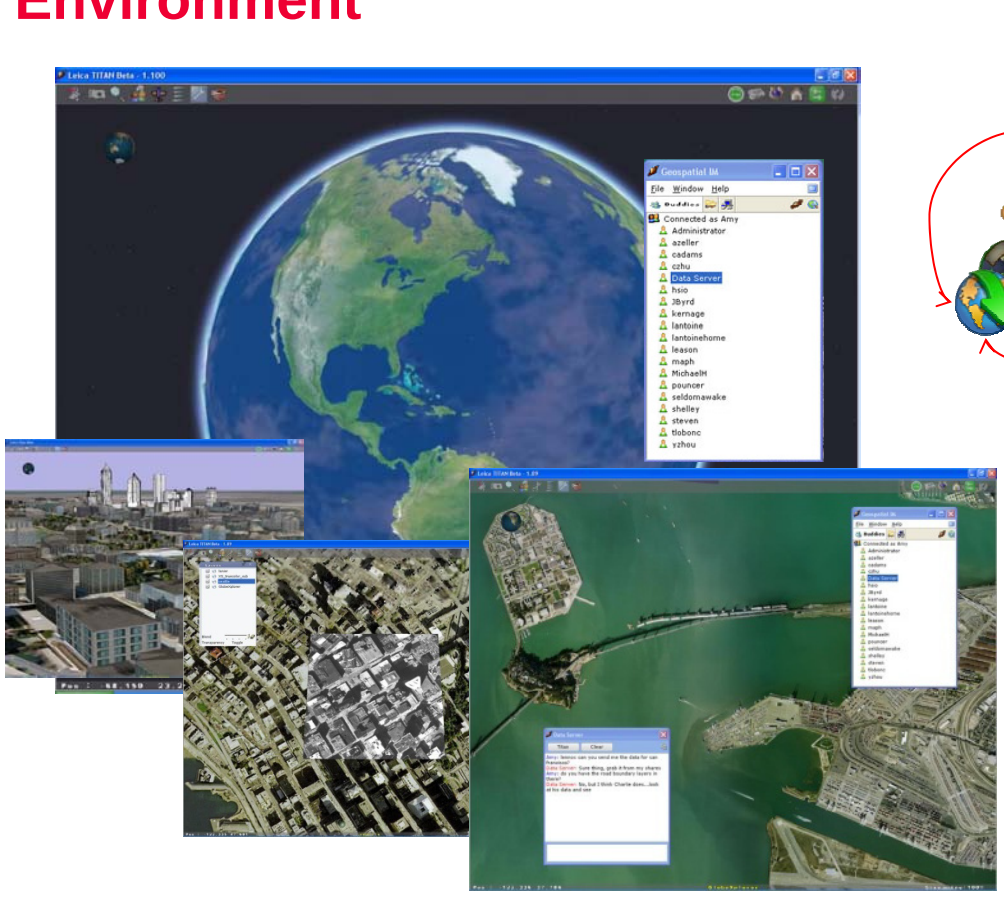
What if the Enterprise gets in the way…

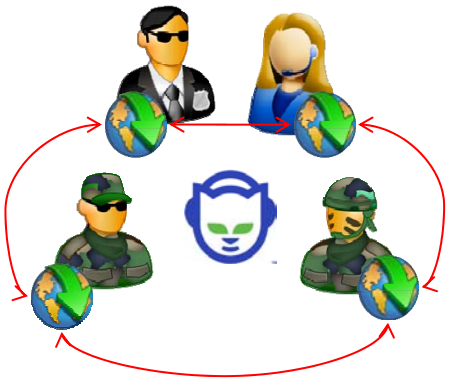
Peer to peer collaboration and sharing

Light Weight Enterprise Sharing…



Collaborate and Share Data Directly in a 3D Environment





Conclusion

Geospatial processing will become a mainstream tool in the general enterprise toolbox which will be integrated at many levels throughout the organization.

Thank You