



# Esri Imagery Solutions – Pushing Beyond Mere Visualization

Kurt Schwoppe  
Esri Federal Imagery Programs  
June 2012



All that you see,  
All that you hear...



# THE FINAL CUT

In the end he sees everything

# How do you Edit an Entire Life – *In Real time*

*Eight years before Big Data became big, Hollywood addressed the issue*

One Hour HD Video: 1.8 GB  
One Day HD Video: 43.2 GB  
One Year HD Video: 15.8 TB

Time Spent Sleeping: 275 TB  
Time Spent in the Bathroom: 49 TB  
Time Spent Commuting: 4.8 TB

**One Lifetime of HD Video: 1.25 PB**



Big Data is **BIG**

# Organizing Big Data before Analysis

*Reduction to Meaningful Datasets Using Aggregation and Filtration Techniques*

Hadoop

MapReduce  
Code

Data

Transformation

Web Logs

Sessionization (click streams) to study online behavior.

Social Media

Semantic analysis for target words and phrases

Sensor

Baseline Anomalies to the established (accepted) range

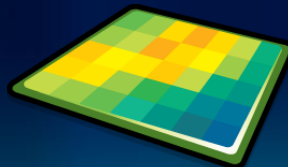
---

*Imagery Requires Different Aggregation Parameters*



Time

Spectral



Spatial



Signatures



Place

# Imagery – The Original “Big Data”

*Dealing with massive archives of geospatial imagery has always pushed limits*



**LANDSAT**  
4.7m Images  
1.8 PB



**Commercial  
Imagery Providers**  
500+ TB



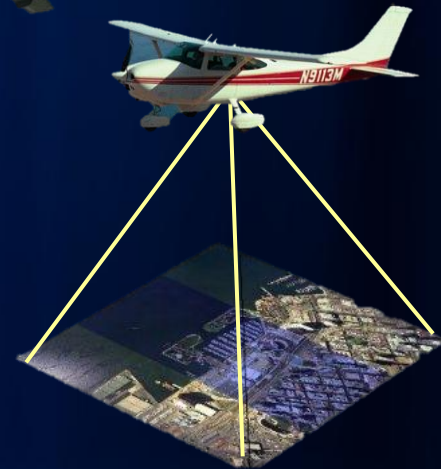
**National  
Reconnaissance**  
> 12 PB\*



42.5 Million  
DVDs



**UAV Motion  
Imagery**  
> 1.8 PB

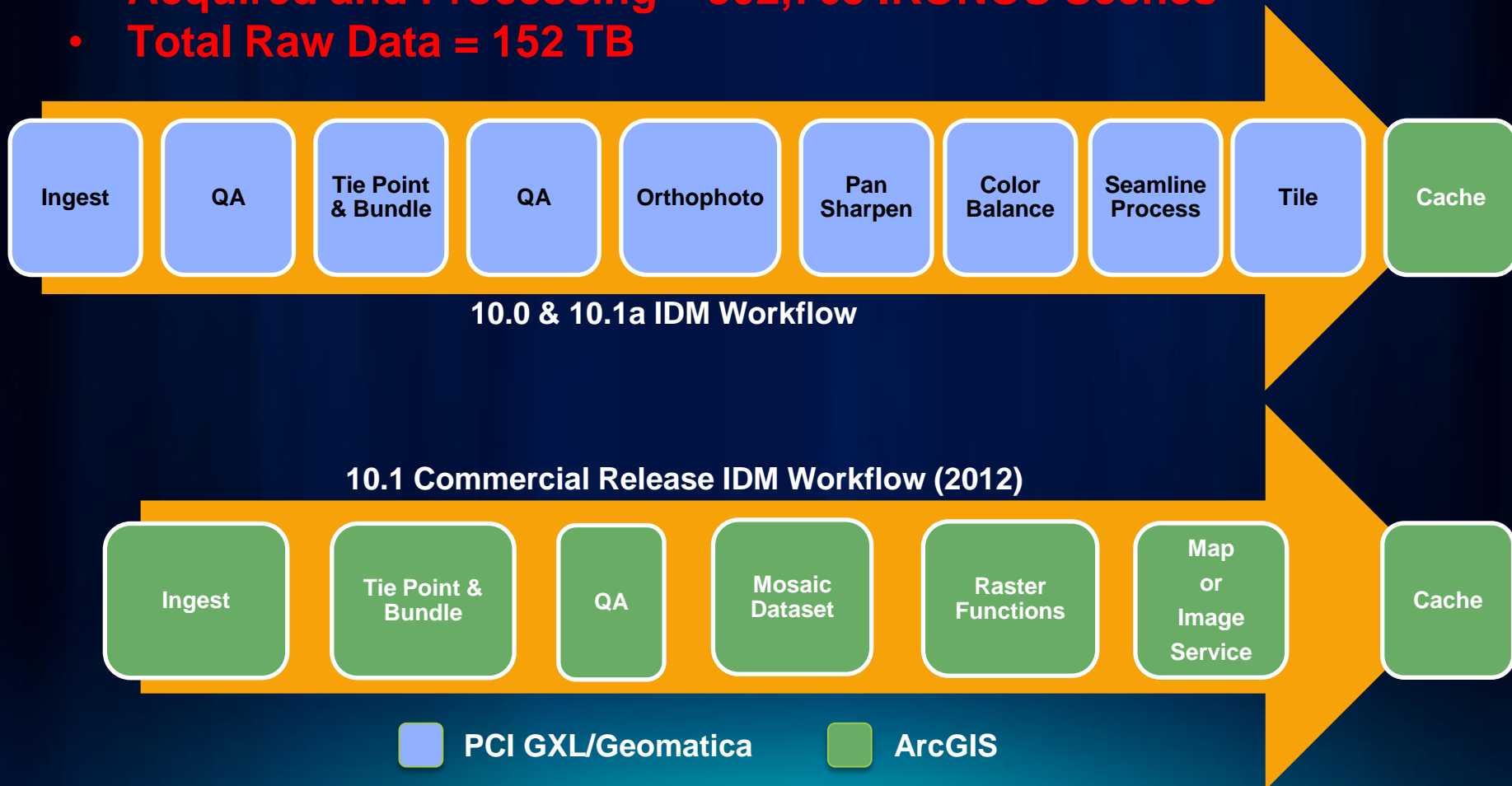


**Aerial Photography**  
> Unknown

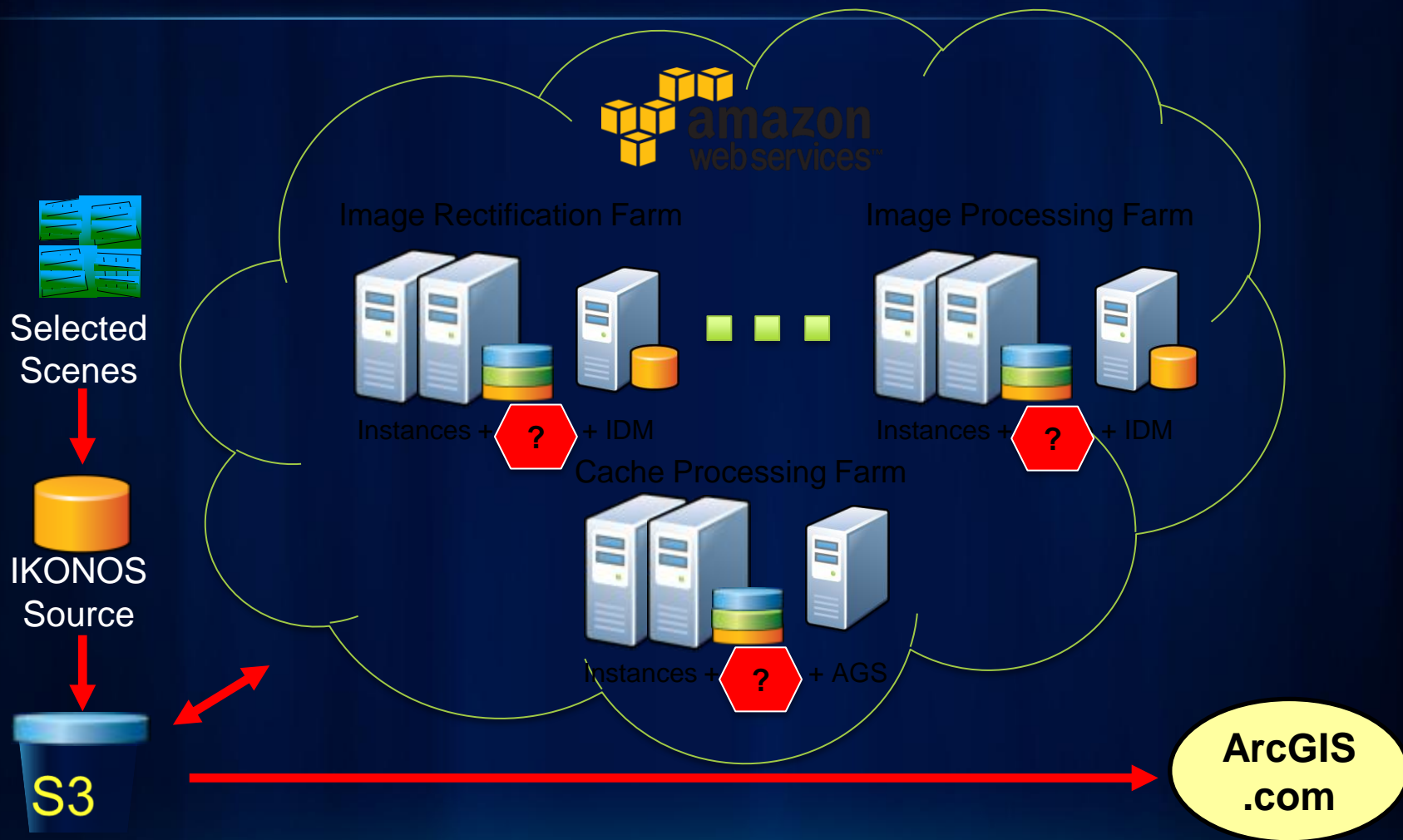
## To Big to Move

# Moving the Image Processing Cycle into the Cloud

- **Code Name: KING KONG**
- **Initial Project Scope = 50 million sq km**
- **Acquired and Processing = 302,765 IKONOS Scenes**
- **Total Raw Data = 152 TB**



# KING KONG Cloud Processing Environment



Deploy an Amazon Cloud-Based Compute & Storage Solution for Scalability

# ArcGIS On-Line – Global Imagery Layer

*King Kong Results – Online and available to our users*

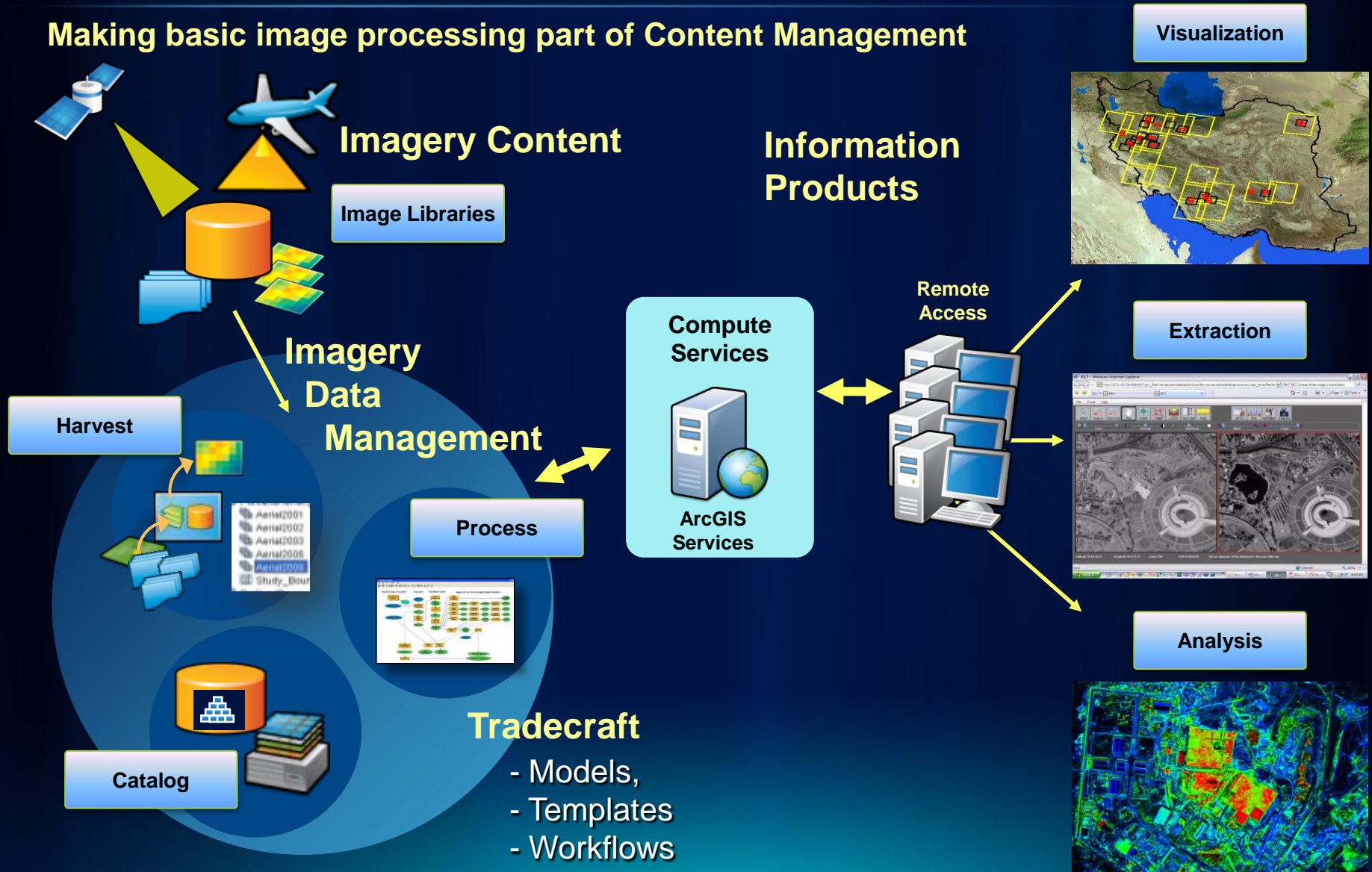
You be the Judge

**600,000+ Images**  
[www.arcgis.com](http://www.arcgis.com)



# IDM - A New Framework for Imagery Driven Capabilities

Making basic image processing part of Content Management



# Imagery Data Management (IDM) – Cataloging Functions

Imagery Catalog Web (ICW) provides Online\On Demand Access

The screenshot displays the Esri Imagery Catalog Web interface. At the top left, the Esri logo and 'Imagery Catalog Web' title are visible, along with the subtitle 'ArcGIS for Imagery Management and Discovery'. A 'Zoom To:' input field is located at the top right. The main map area shows a geographical view with several satellite imagery thumbnails overlaid. A 'Discover' button and a 'Browse' button are positioned above the map. On the right side, a 'Selected Image Thumbnail View' panel is open, displaying a larger thumbnail of the selected image and a list of 'Selected Image Details'.

**Selected Image Details:**

- Sensor: QuickBird
- Collect Date: 06/21/2009
- Catalog Date: 01/18/2012
- Image Type: Multispectral
- Cloud Cover: 0%
- Resolution: 2.57m
- Sun Azimuth: 123.4
- Sun Elevation: 70.5
- Sattelite Azimuth: 97.2
- Sattelite Elevation: 71.5
- Off NADIR: 17.2

At the bottom of the interface, a 'User Queue Details' section contains a table with the following data:

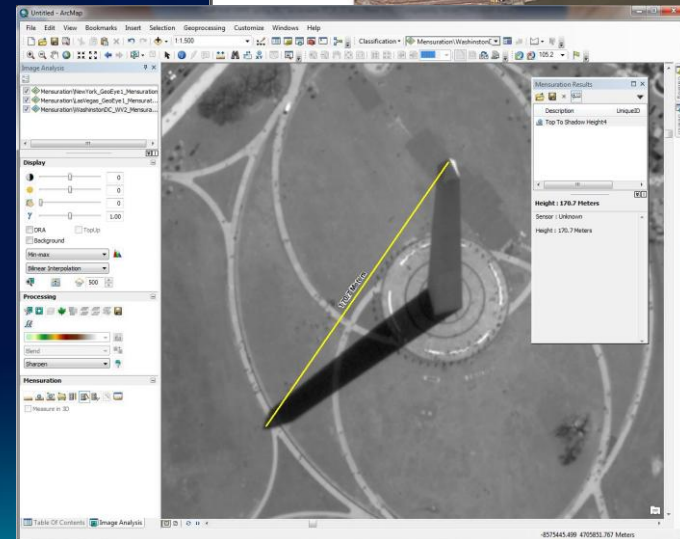
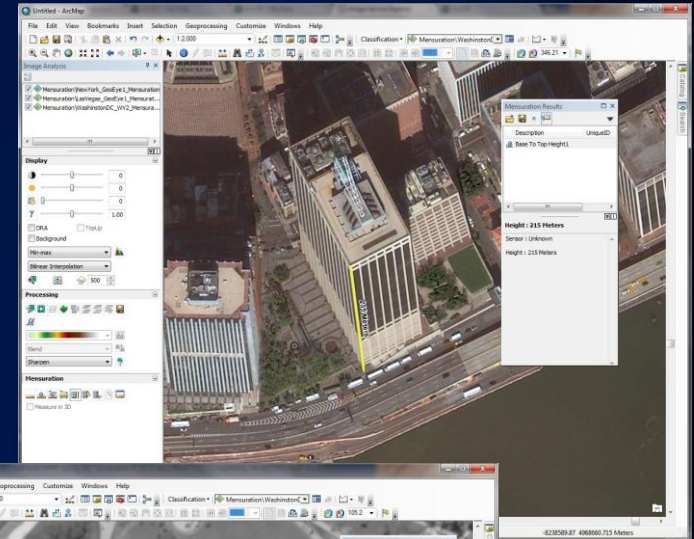
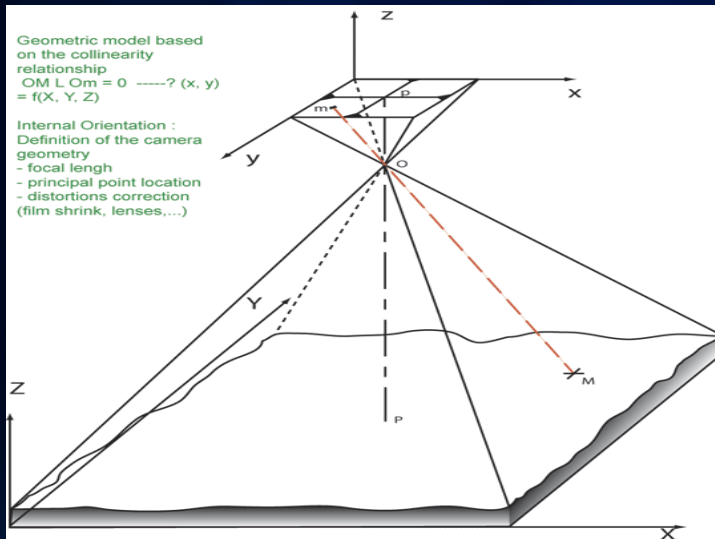
Sensor	Image Date	Cloud Cover
GeoEye-1	Wed 06/10/2009	0%
QuickBird	Sun 06/21/2009	0%
WorldView-1	Sun 01/10/2010	0%

Below the table, it indicates 'Images in User Queue: 4'. To the right of the table is a control panel with several buttons: 'Coverage', 'Preview', 'Report', 'Clear All', 'Clear Selected', and 'Share'.

# Imagery Precision – Rectification and Mensuration

## Rigorous Photogrammetry is a fundamental part of Imagery Data Management

- Correction based on Rational Polynomial Coefficients (RPC)
- Correction based on Rigorous Sensor Models
- DEM Library for orthorectification
- Auto-Tie for image to image precision
- Certified Mensuration Capability (MSP – US Defense)



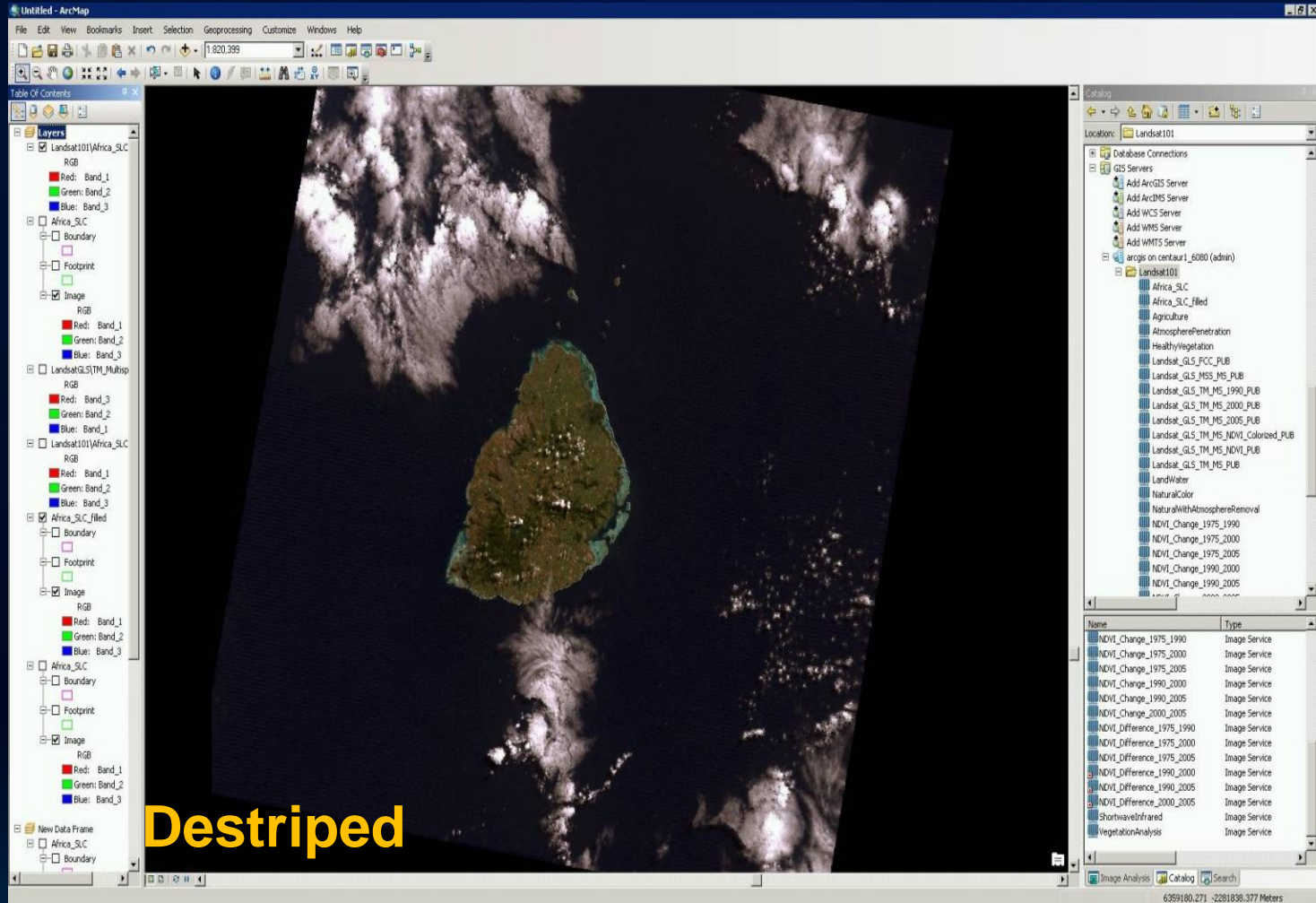
# Imagery Quality – Building a Seamless Mosaic

*Apparent Reflectance Processing Model – Adapted from Atmospheric Correction*



# Imagery Quality – Sensor Correction

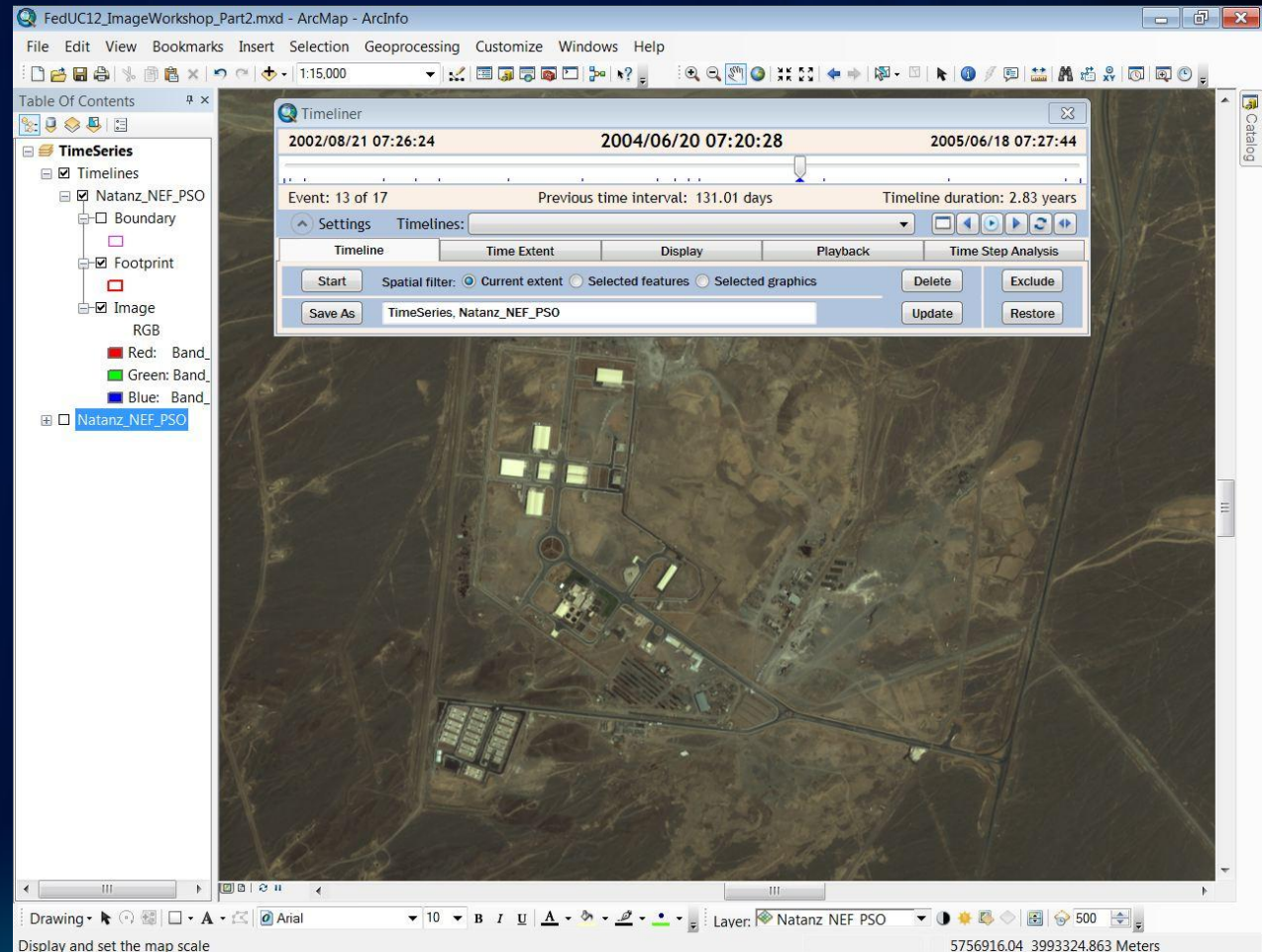
*Processing models remove null stripping and fills with archive base imagery*



# Exploitation – Temporal Analysis

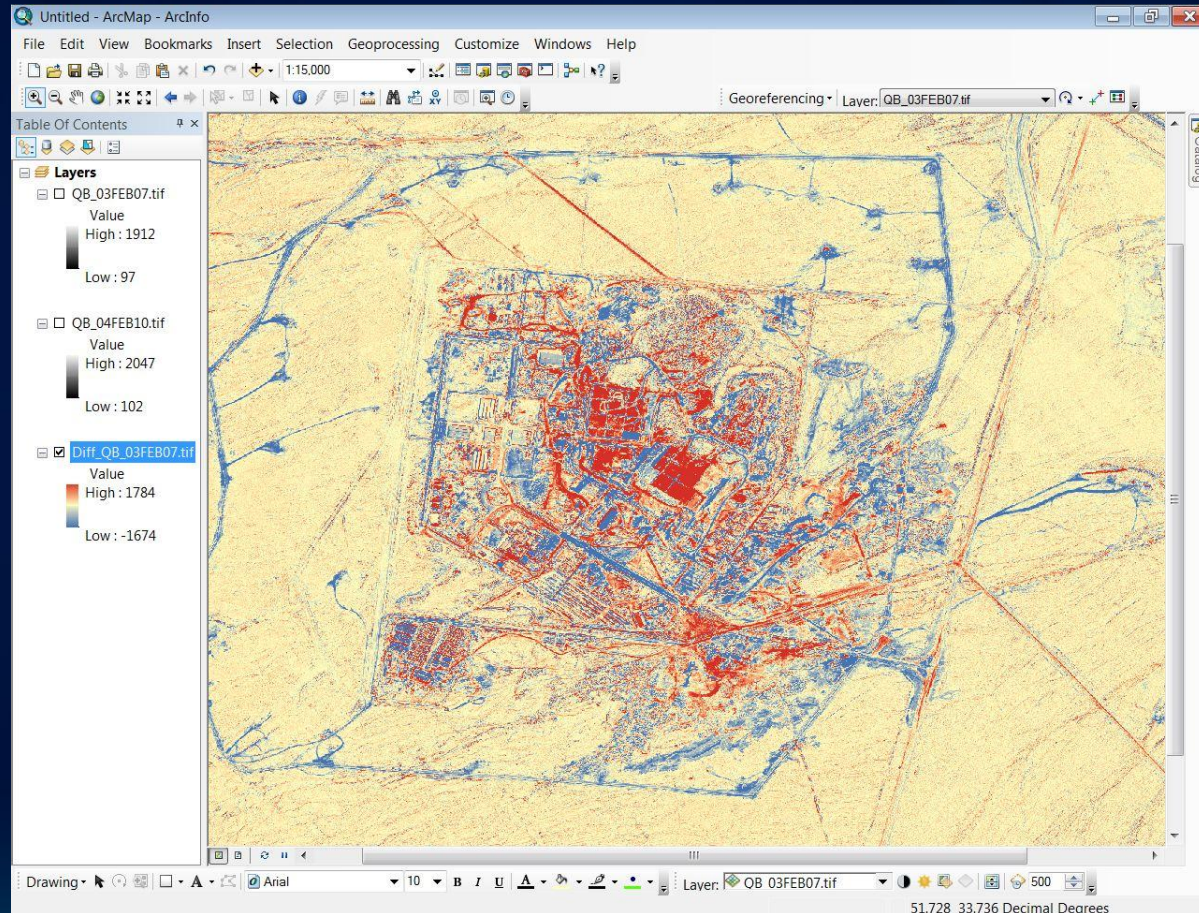
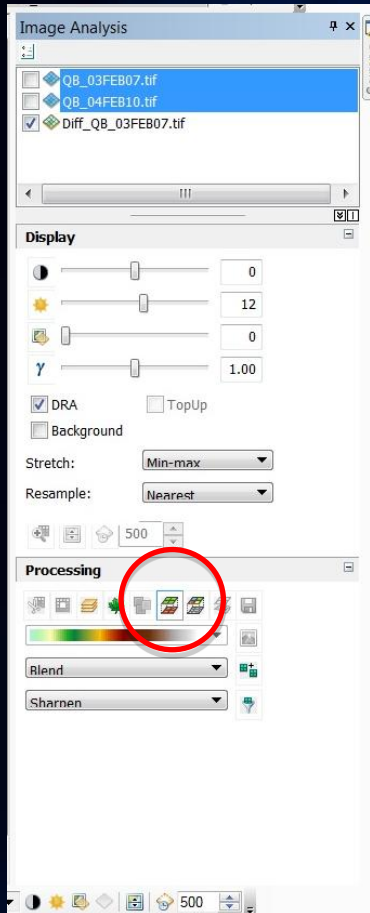
## Visual Change for both Raster and Vector Feature Layers

- Ingest, display, and analyze temporal data content in ArcMap.
- Supports ESRI data formats such as file geodatabase, shapefiles, and Mosaic Raster datasets.
- Temporal data can be used if it has actual date and time fields as part of its attribute table or if it has fields formatted as date and time values.



# Exploitation – Change Detection

Uses basic image differencing to find changes between image pairs



Before Image

After Image

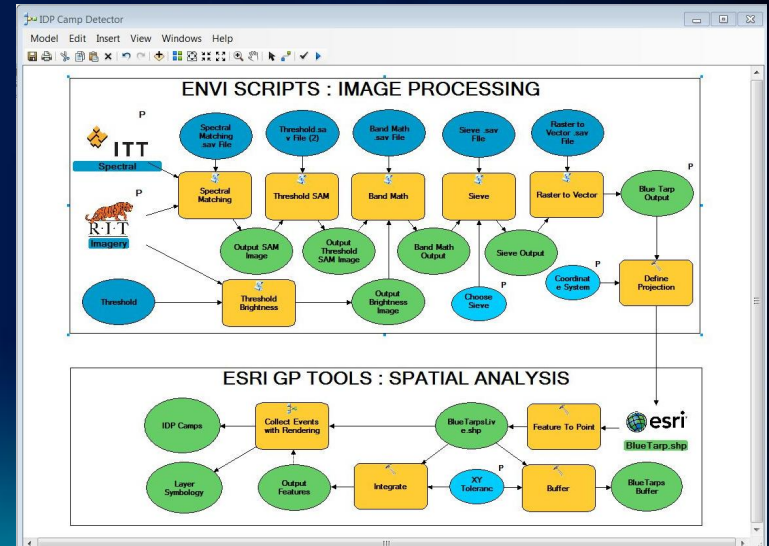
Blue New  
Red Fled

# Capturing Tradecraft in a Process

## AGI as a Modeling Process

- Authoring Tradecraft into a Digital Model (DIAGRAM)
- Native Support for both Vector and Raster Processing
- Works with Multipoint files as well (Point Clouds)
- Publish On-Line as a Service
- Optimized and Scalable
- Extensible

Multispectral Change Analysis of Natanz





# Integration of Partner Technology – Exelis VIS

*Envi tools and access to IDL are now part of the Esri modeling capability*

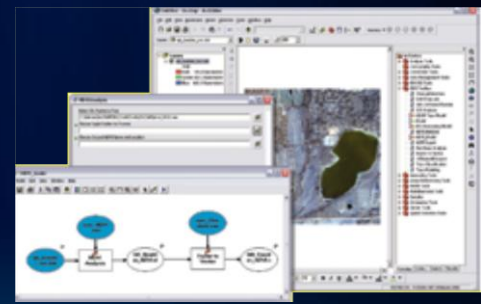
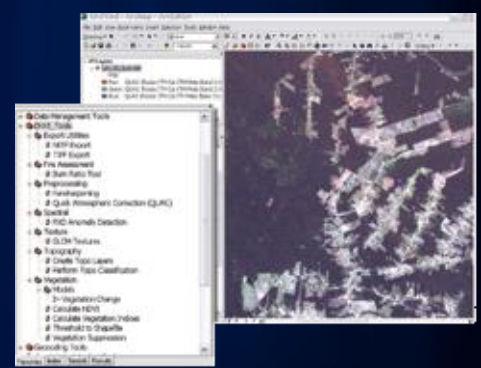
ENVI Tools and Workflows for ArcGIS®	Desktop Environment		Server Environment	
	ENVI EX	ENVI	ENVI for ArcGIS® Server - Standard**	ENVI for ArcGIS® Server - Advanced**
Auto-Threshold Difference Raster	•	•	•	•
Calculate Image Difference	•	•	•	•
Classification Raster to Vector	•	•	•	•
Classify with Training	•	•	•	•
Classify without Training	•	•	•	•
Cleanup Classification Raster	•	•	•	•
Detect Anomalies	•	•	•	•
Intersect Rasters	•	•	•	•
Threshold by Percentage	•	•	•	•
Detect Anomalies with Thresholding	•	•	•	•
Detect Image Difference with Thresholding and Cleanup	•	•	•	•
Detect Thematic Change with Cleanup	•	•	•	•
Supervised Classification with Cleanup	•	•	•	•
Unsupervised Classification with Cleanup	•	•	•	•
Convert Raster Format		•	•	•
Filter with Convolution		•	•	•
LiDAR to Raster		•	•	•
Extract Features with Ruleset	•		•	•
Custom Tools and Services		•		•
NITF and TFRD File Support	•*	•*		•



Advanced Remote Sensing

Customize with IDL

Publish to ArcGIS Server



# Exploitation - Fusion with Other Intelligence Sources

GIS Functionality Facilitates Multi-INT – Everything Happens Someplace

ICW Air Order of Battle Analysis

www.arcgis.com/apps/Compare/SideBySideViewer\_Configure/index.html?appid=dfda5fefa88a4bdc969138588ecc76a6

Crew Mail Wikipedia Facebook LinkedIn Router Crew 1396 ESRI News Shipping Cool Weather Scouts Aero Other bookmarks

## Air Order of Battle Analysis

460<sup>th</sup> ISR

**SIGINT Air - Intercepts**

**SIGINT Air - Proximity Analysis**

SYNCHRONIZE MAPS:

- Scale
- Location

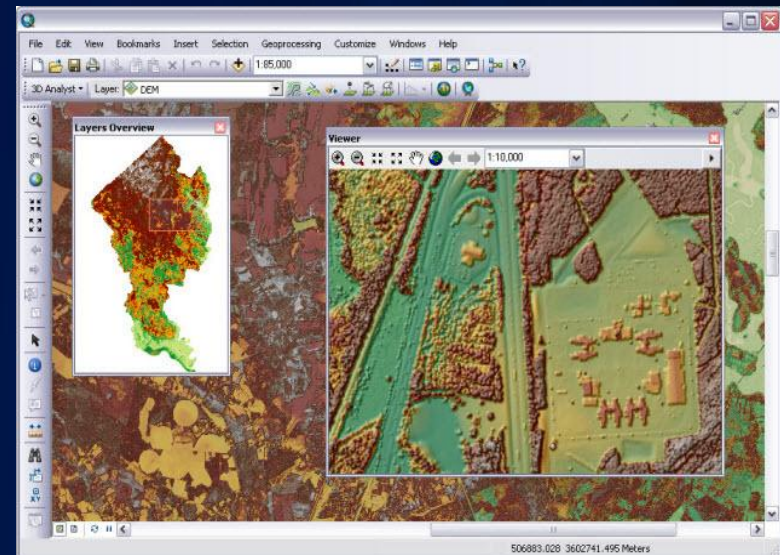
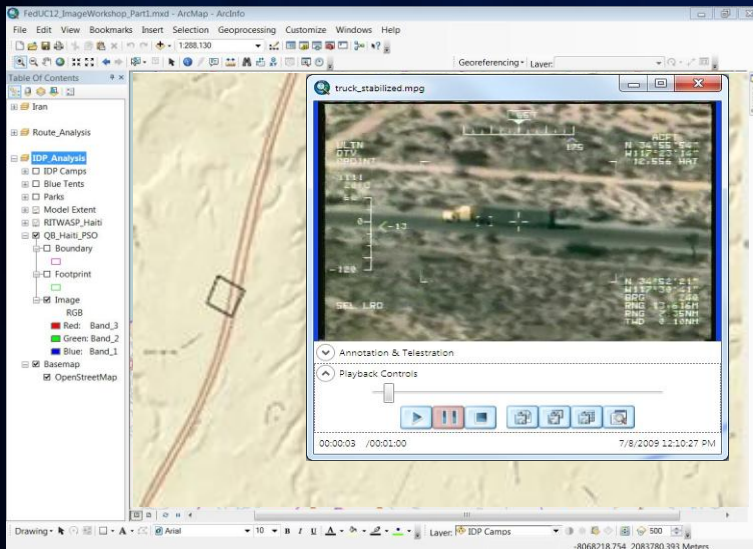
MAP INFORMATION

- Description
- Content
- Legend



# Support for Emerging Sources – WAMI & LiDAR

*New expansions to ArcGIS will provide additional AGI capabilities*

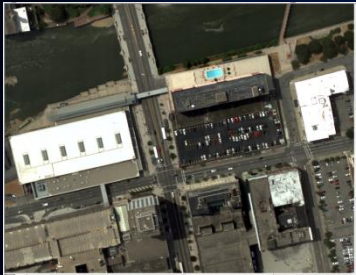


- New Video Tools works for ArcGIS to view and manipulate full-motion video and WAS (wide area surveillance) within ArcMap and ArcGlobe.
- MISB compliant positional metadata - camera position, target position, roll, pitch, yaw, and speed – display georeferenced video on a map.
- Tools consist of a video browser & video player windows, and annotation and telestration tools.
- Point Clouds (LAS & ASCII Point) are readily converted and stored as multipoint data in the geodatabase for analysis by ArcGIS.
- First return and last return to generate offer a variety of analysis strategies.
- Continued improvement in feature extraction from Lidar data will support more AGI analysis.

# Feature Extraction Using Image Segmentation

It is easier to classify components of an object based on their logical segments

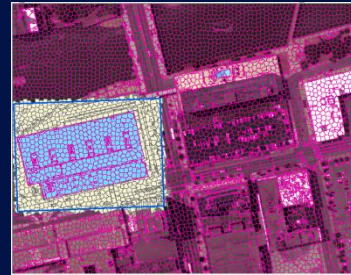
(1)



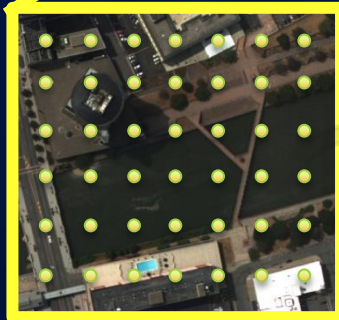
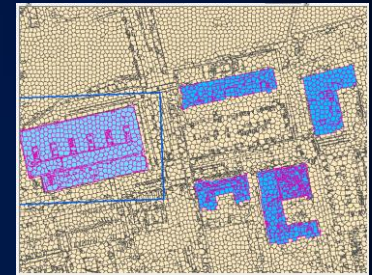
(2)



(3)



(4)



1. Original Image
2. Superpixel Segmentation
3. Extract geometry within user-defined region
4. Propagate classification to rest of image

# Implementing Structure from Motion – Finding Objects

Segmentation Opens the door for more advanced image processing capabilities

*Multiple Registered or Unregistered Images*



*Photogrammetric, Probabilistic and Computer Vision Methods*

- Structure from Motion Tools
- Continuous/Probabilistic Method
- Shadow detection and removal
- Methods to correlate pixels in images to points in dense point clouds
- “Pulling” out primitives from a variety of geometries
- Image segmentation (ScISR Method) and classification
- Color Models
- Ray Casting
- etc...



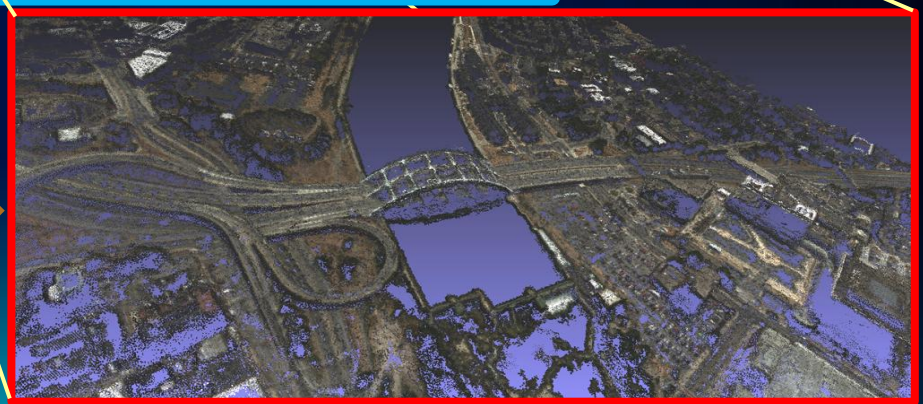
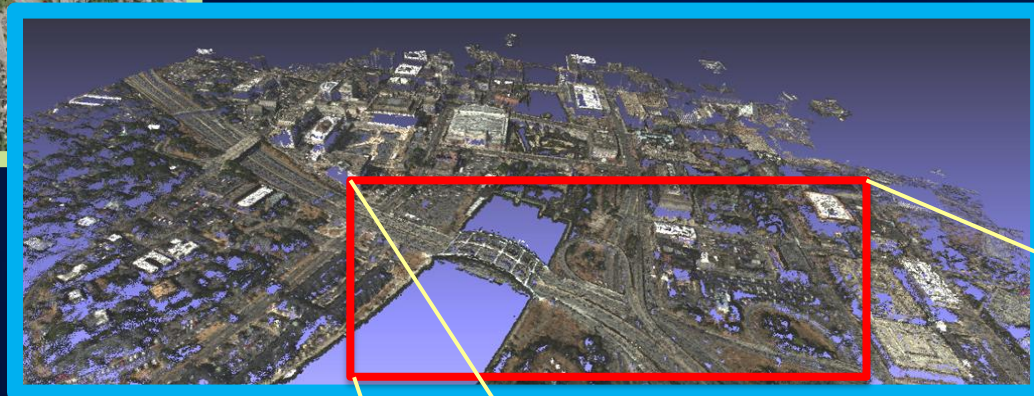
*True 3D Object Models*



# Applying SfM for Urban Area Extraction

Motion Imagery becomes an ideal source for large area extractions

Find the three-dimensional structure of an object by analyzing local and global object movement over time



Images

To

Geometry Models  
(dense point cloud)



# ArcGIS Online is a New Approach

An easy, open Cloud based platform for maps and geographic information

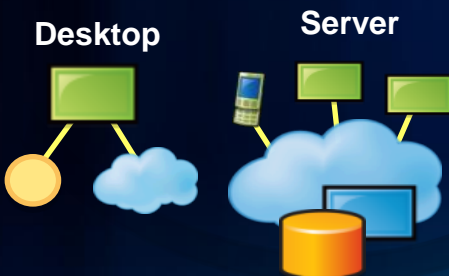
## Templates & Services

Discover Data, Maps and Apps; Share & Collaborate; Create Maps; Manage Content ; Social Grouping and Sharing



**Non Geospatial Content**  
Charts & Graphs, Photos,  
Reports, Tabular Data

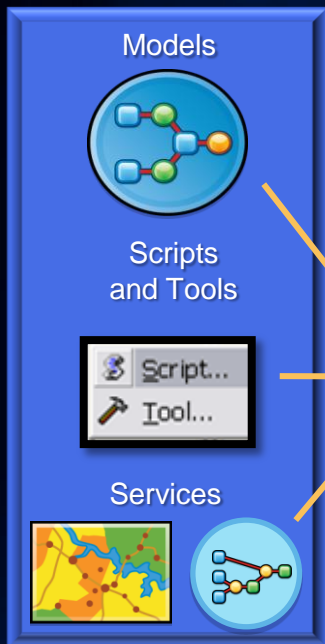
*...Public, Private & Hybrid Versions*



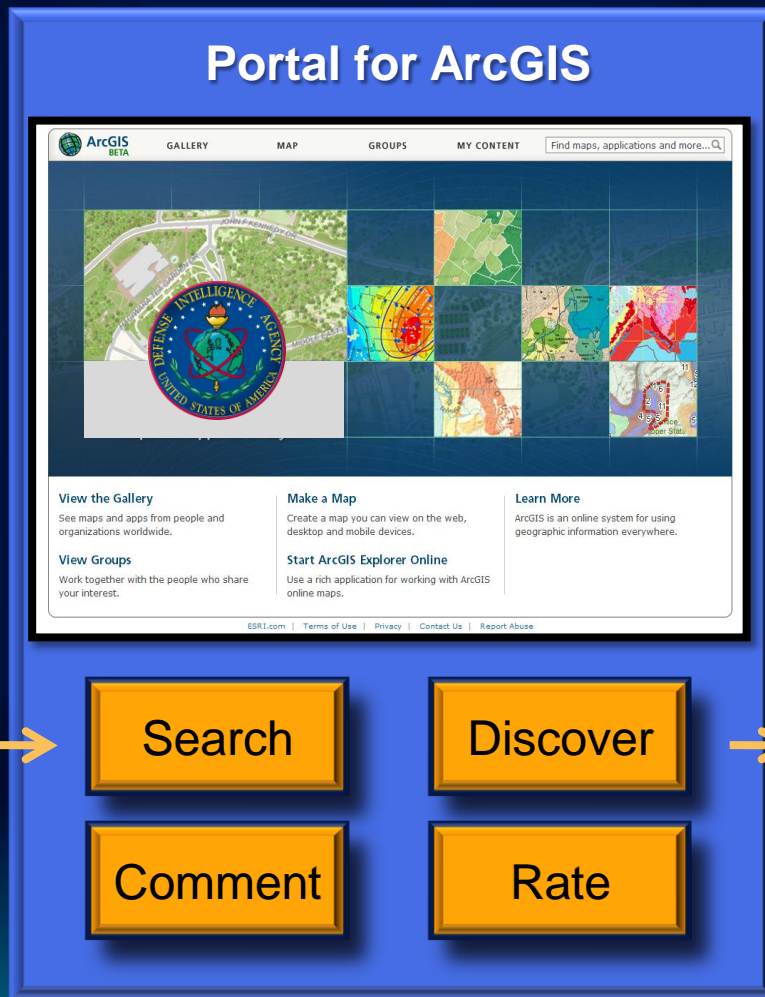
# DIAGRAM – Capturing Tradecraft in the Cloud

*Defense Intelligence All-Source Geospatial Repository for Analytical Models*

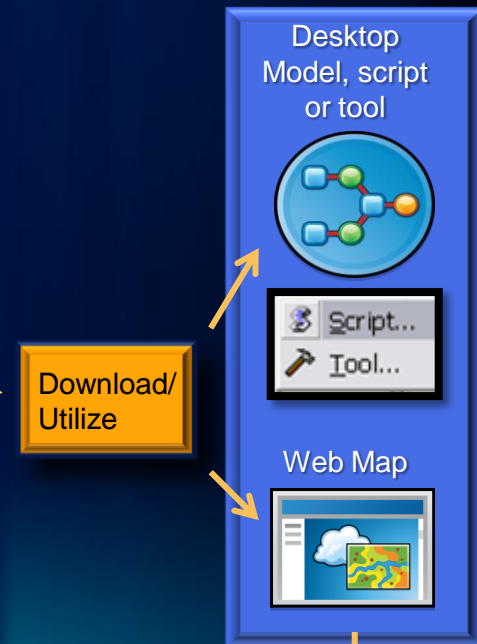
**Subject Matter Experts develop and publish models**



**Register**



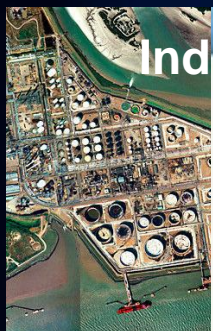
**Lead Analysts implement models within exploitation templates**





# Target Specific Exploitation



Exploitation tools are exposed based on target specific criteria



Share

### Make a Web Application

Click a template's thumbnail to preview it or click its links to download it to your computer or publish it to the web.

<b>Multiviewer Storytelling</b>  Download Publish	<b>One Pane</b>  Download Publish	<b>Search maps</b>  Download Publish	<b>Side by Side Viewer</b>  Download Publish
<b>Storytelling - Sidepanel</b>  Download Publish	<b>Storytelling - Tabbed</b>  Download Publish	<b>Storytelling Basic</b>  Download Publish	<b>Swipe Tool</b>  Download Publish

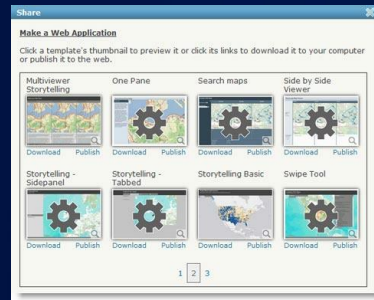
1 2 3

## Default Exploitation Rates



# Mission On Demand – Putting it all Together

## Multiple Sources



## User Template Library

## DIAGRAM & Other Authored Services



## Tradecraft:

- Change Detection
- Target Analysis
- Feature Extraction

## Imagery Data Management (IDM):

- Panchromatic
- Spectral
- LIDAR
- FMVideo\*



## Intelligent APPs Operators & Warfighters

# A New Pattern for GeoINT has Emerged

An Intuitive Platform For Mission on Demand Analysis and Production

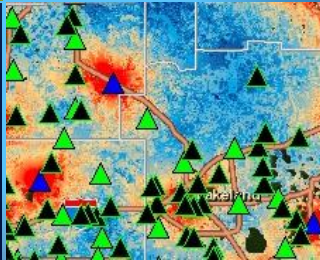
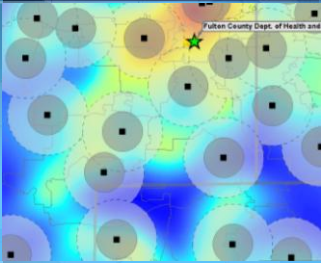


*Creating An Online Collaboration Framework*

DeKalb County Board

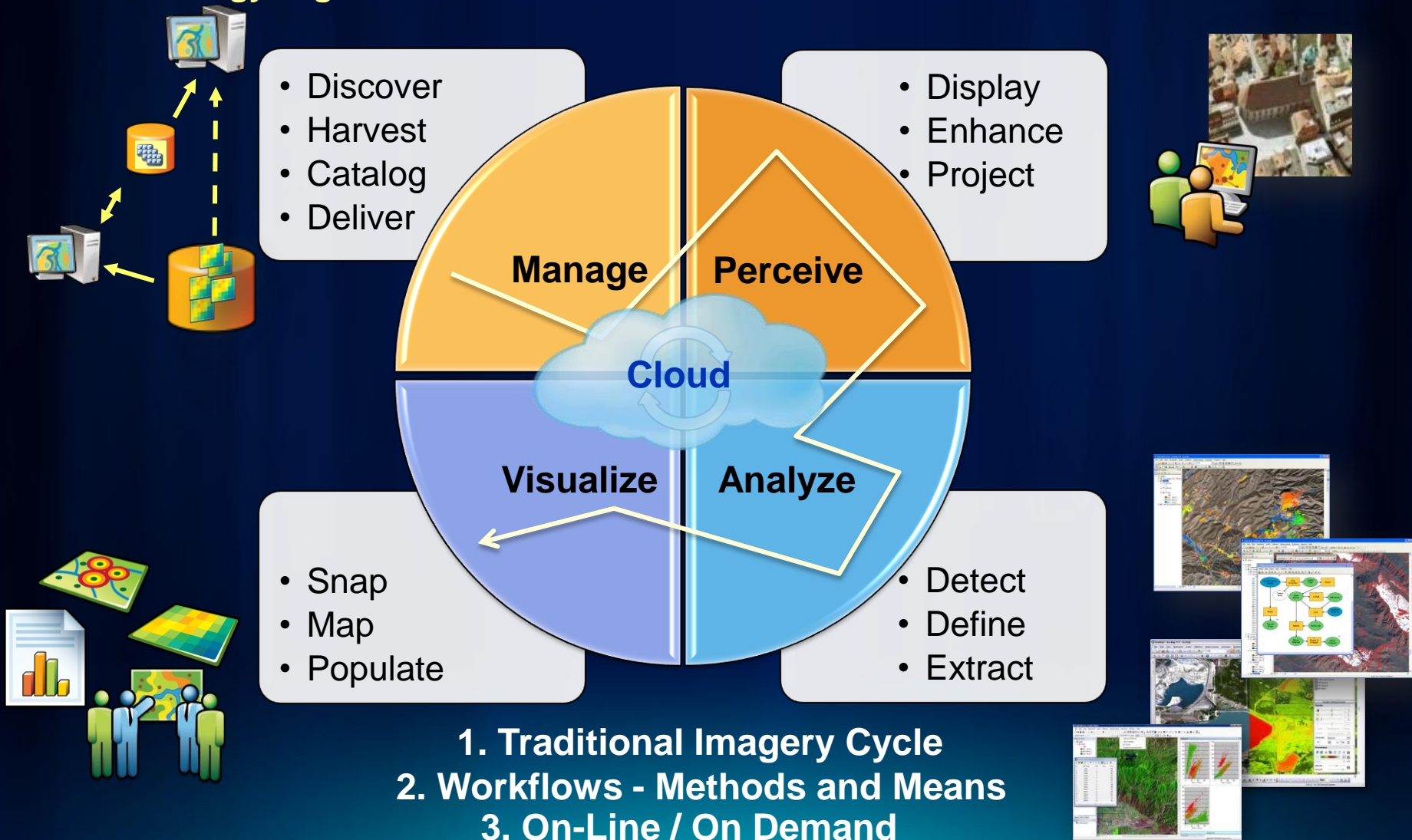
Fulton County Dept. of Health and Wellness/District 3, Unit 3, G

# Questions



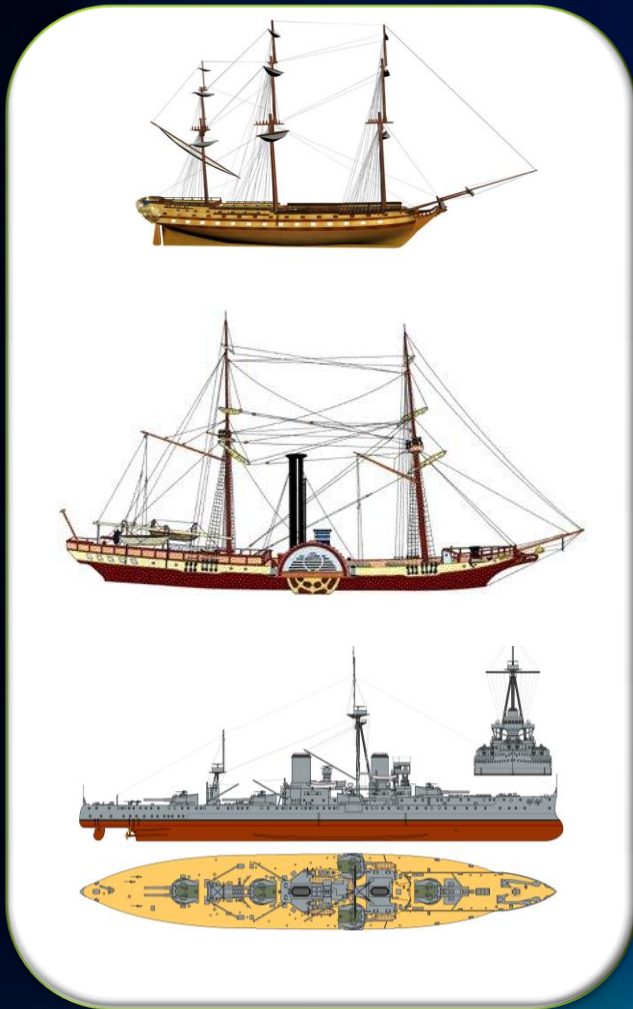
# Evolution of Imagery Exploitation

As Technology Migrates towards the Cloud

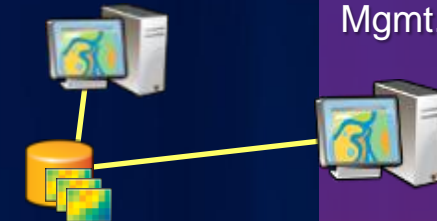


# Development of Imagery Data Management (IDM)

Migration of image processing expertise into the cloud



**Basic Image Serving**



**Cataloging and Web Services**

*Cloud Storage Only*

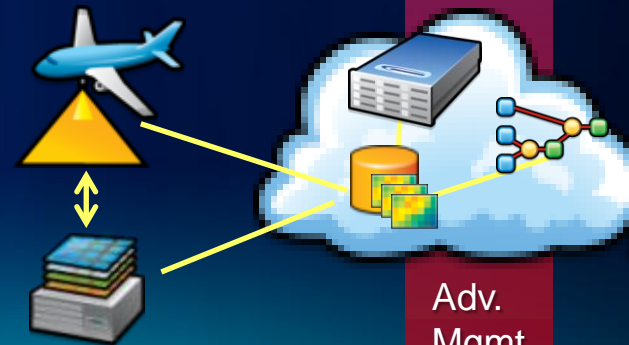


Expert



**Cloud Based Processing**

**Online / On Demand**

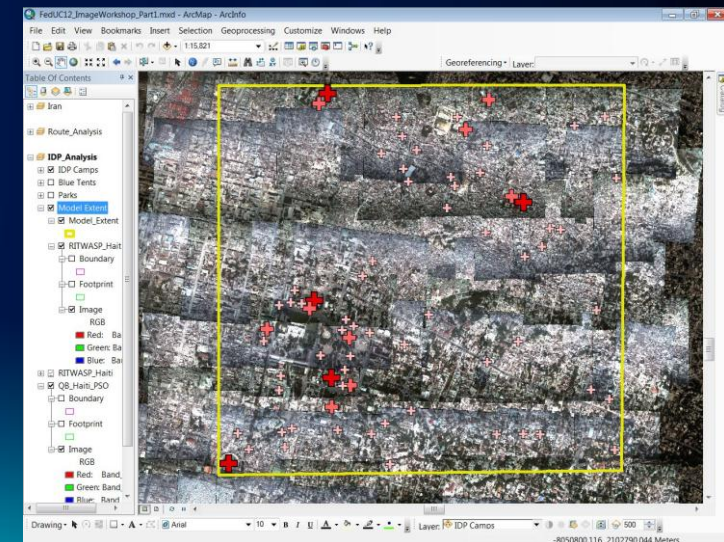
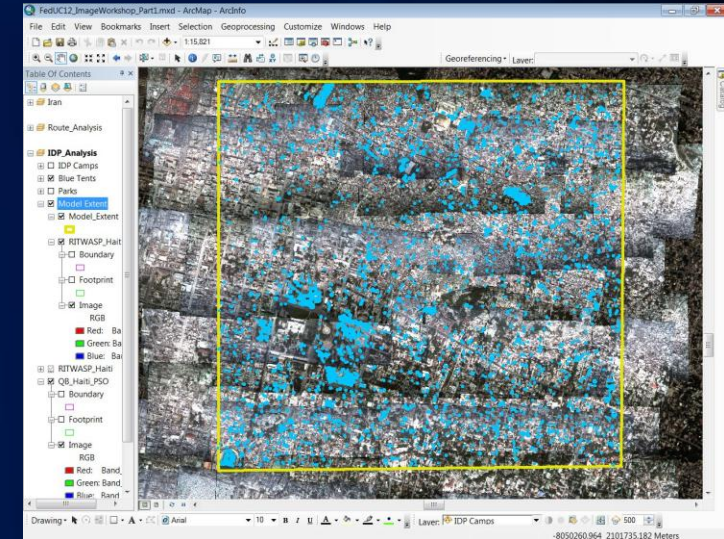
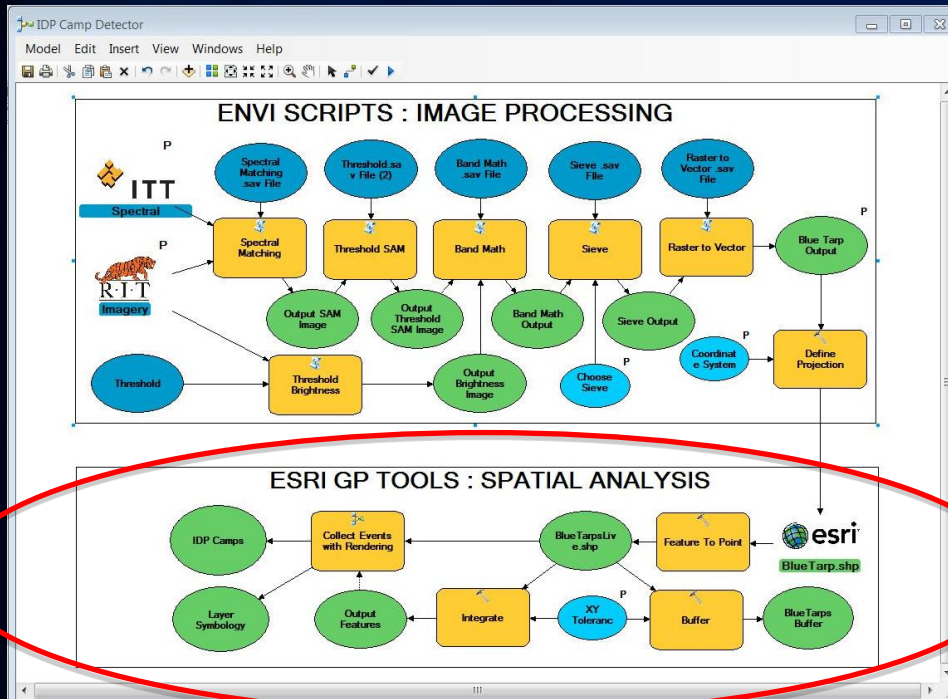


Adv. Mgmt



# Integrated AGI & GIS Models – Spatial Analytics

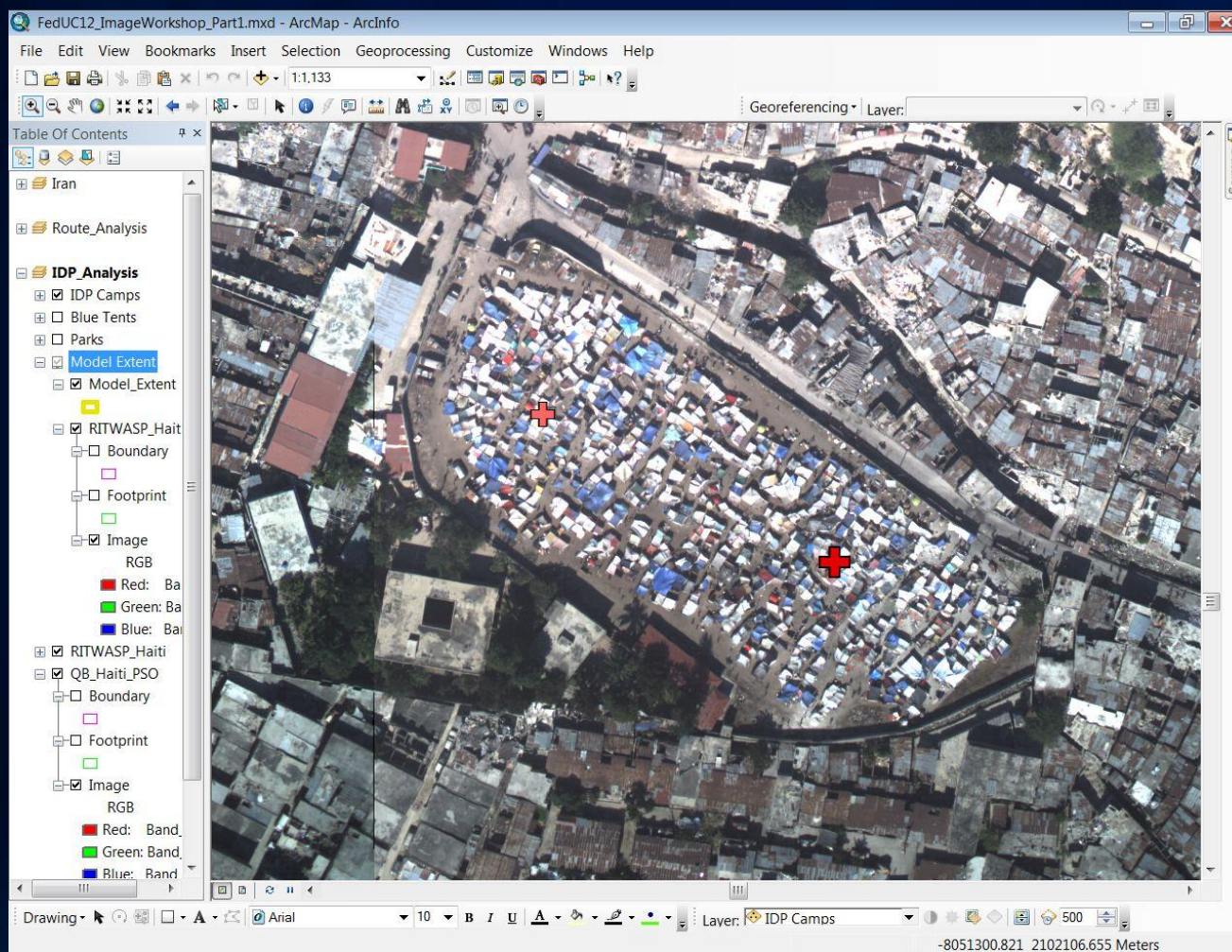
Density and Proximity Tools aggregate extracted features into logical groupings.



Groupings are symbolized based on their density and displayed on the map.

# Solution to Facilitate Activity Based Intelligence (ABI)

Human geography automatically found, categorized and mapped from Imagery



GIS Tools are able to both assist and enhance AGI Analysis

Applications are practical and easy to implement

All desktop models can be published as a web service