The Importance of Cadastral Systems

Brent A. Jones, PE, PLS
ESRI
Survey/Engineering/Cadastre
Industry Manager
bjones@esri.com
Twitter – BrentJones_ESRI

ESRI at 40

Our Purpose Is Unchanged – Serving Our Users

Status

- Financially Strong & Growing
- Many Strong Relationships

Goals

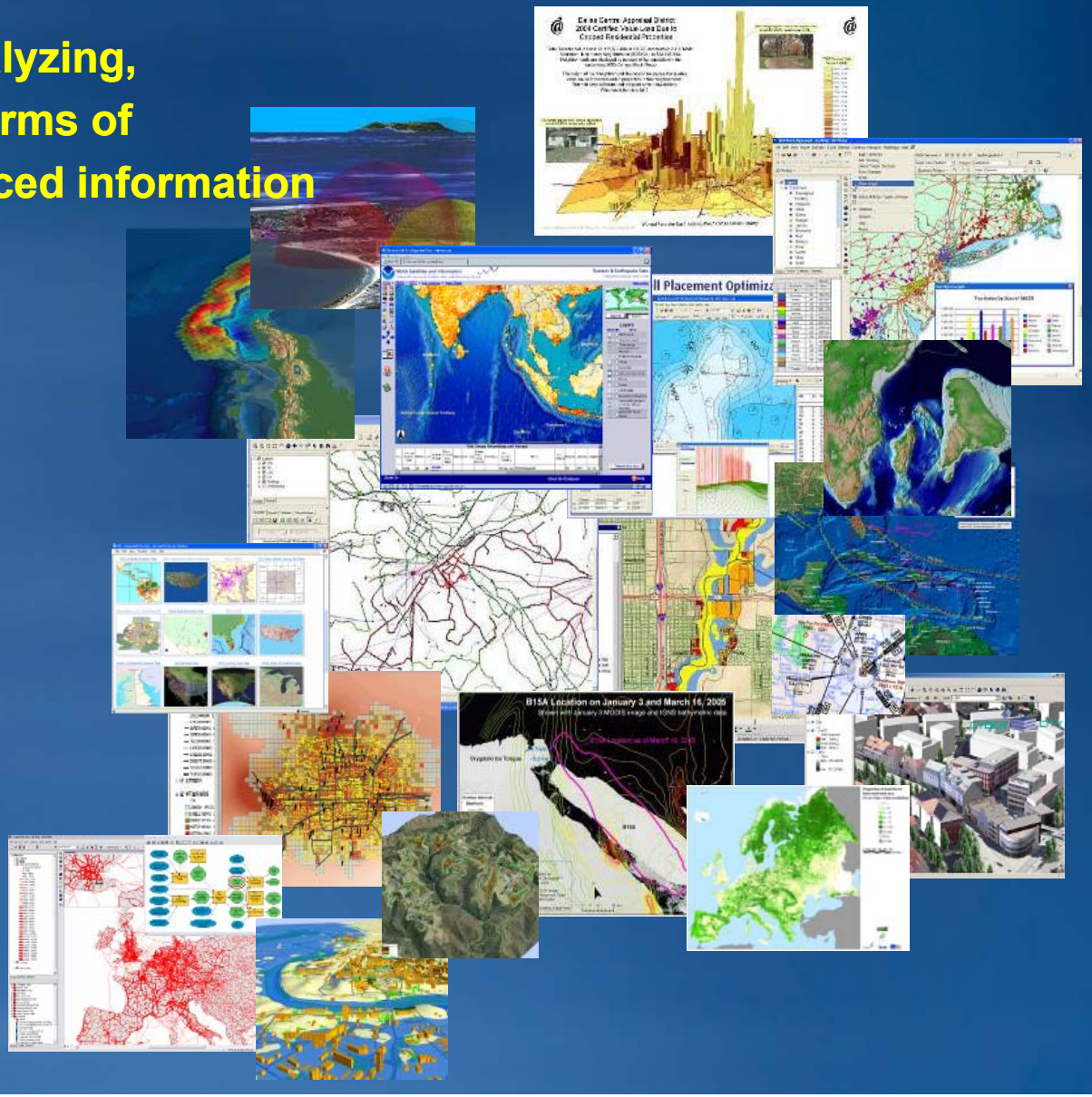
- Advancing GIS & Geographic Science
- Promoting Spatial Thinking
- Supporting Our Employees

Making a Difference

. . . And Contributing to Society

GIS is a collection of computer hardware, software, and geographic data for . . .

Capturing, Managing, Analyzing, and Disseminating all forms of geographically referenced information

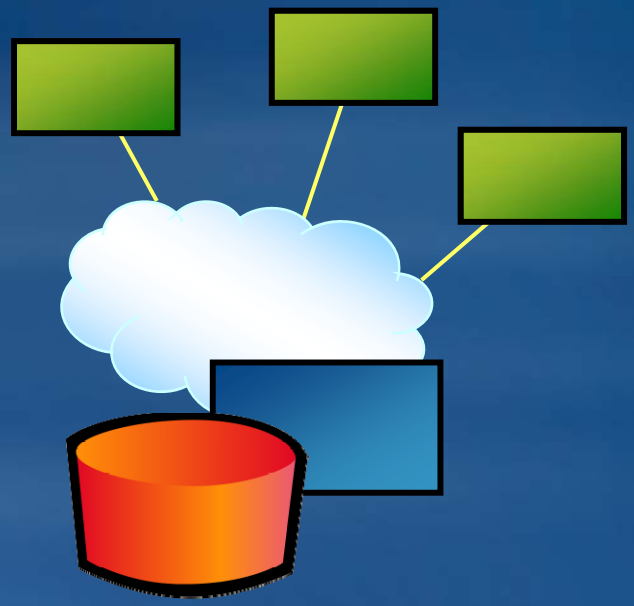


GIS

Software Technology for Managing and Applying Geographic Information

Supporting:

- Rich Data Model
- Data Management
- Strong Tools
  - Data Compilation
  - Data Integration
  - Analysis / Modeling
  - Mapping / Visualization
- Applications and Workflows

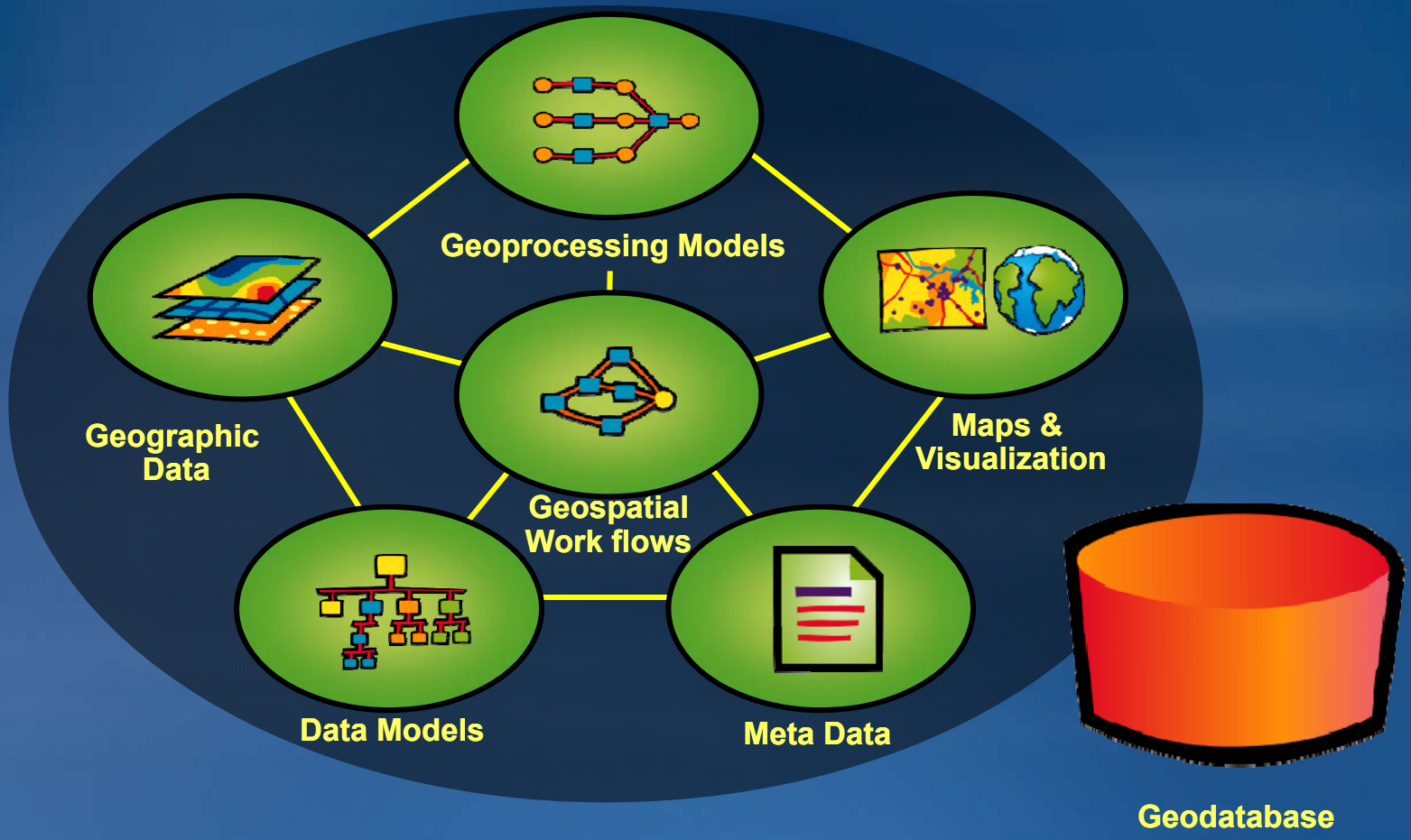


On a Technology Platform (Architecture, Hardware, Networks . . .)

. . . And Knowledgeable Users

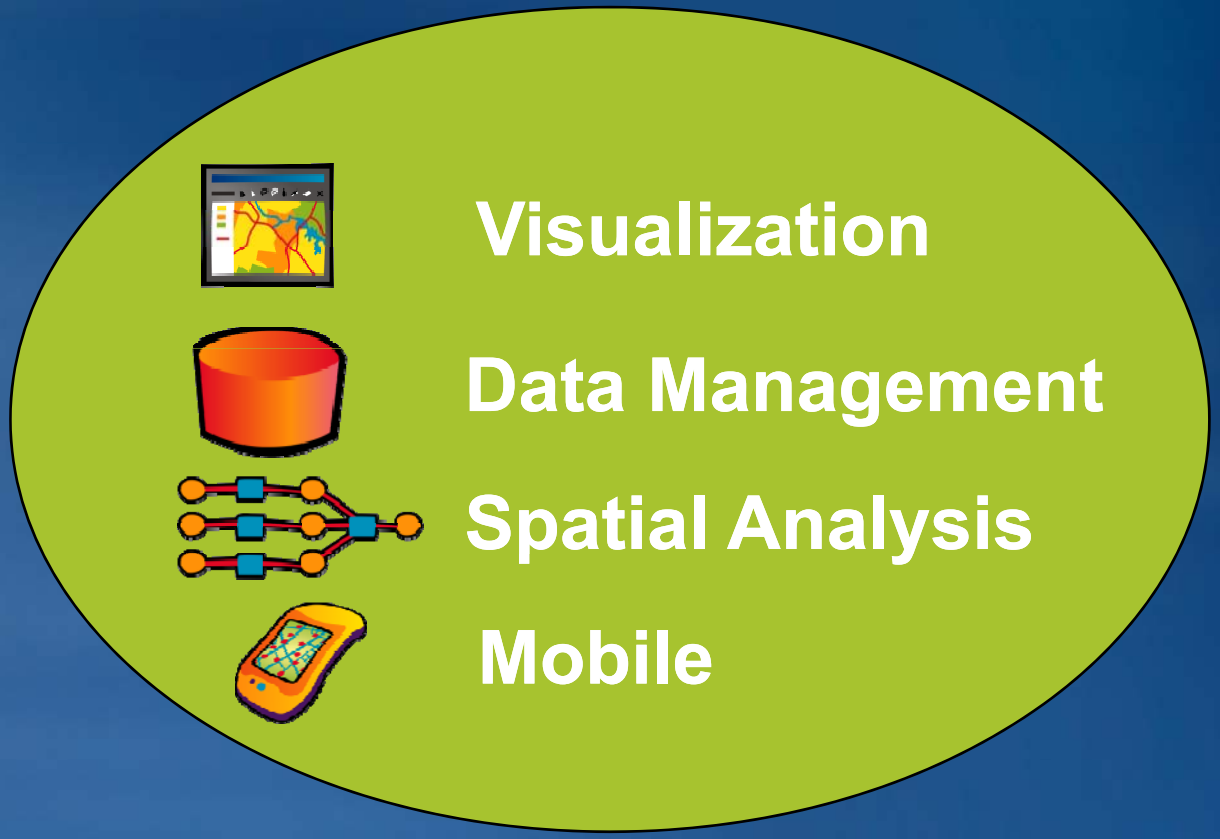
GIS Organizes and Manages Geographic Knowledge

Six Basic Types



. . . Useful Building Blocks that Can Be Shared and Applied

GIS is -



Extracting value from geographic data

Requires modeling, management & georeferencing. . .

MAPS

DATA

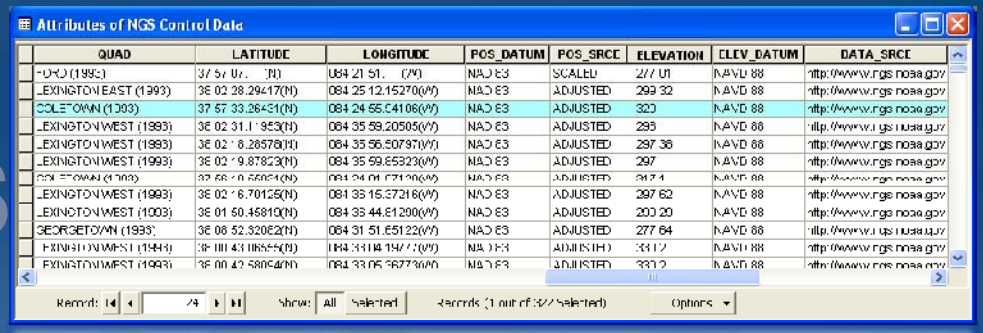
INFORMATION

KNOWLEDGE

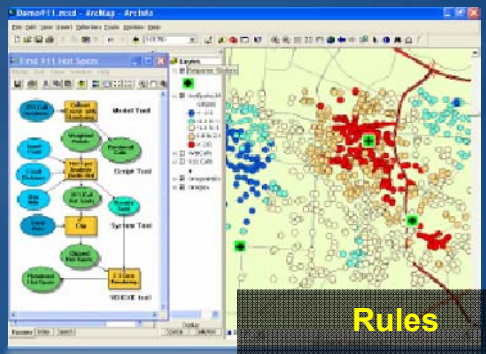
Components of geographic data

Properly structuring data powers new uses. . .

ATTRIBUTES



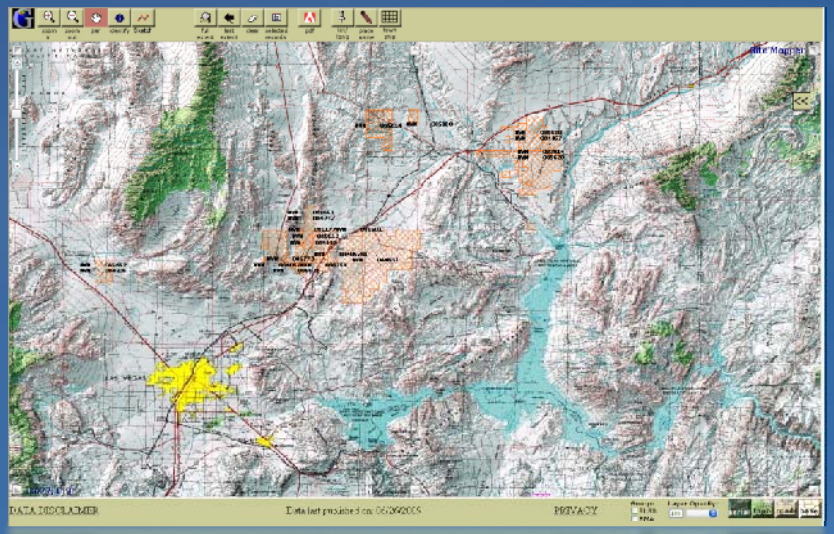
BEHAVIOR



Rules

Local streets and highways may not intersect

GEOMETRY

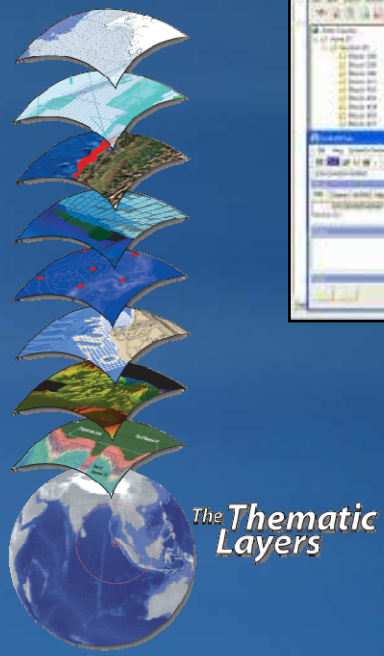


GIS Provides the Platform

Modeling the Land Information Environment

Providing

- An Integrative (Geospatial) Framework
- Analytic Methods
- Advanced Visualization



. . . Providing Many Tools and Methods
. . . And Comprehensive Information Management

GIS for Land Administration

All elements of land administration benefit from GIS

Cadastre
Land Registration
Mapping
Valuation
Planning
Land management
Land Information Systems
Spatial Data Infrastructures

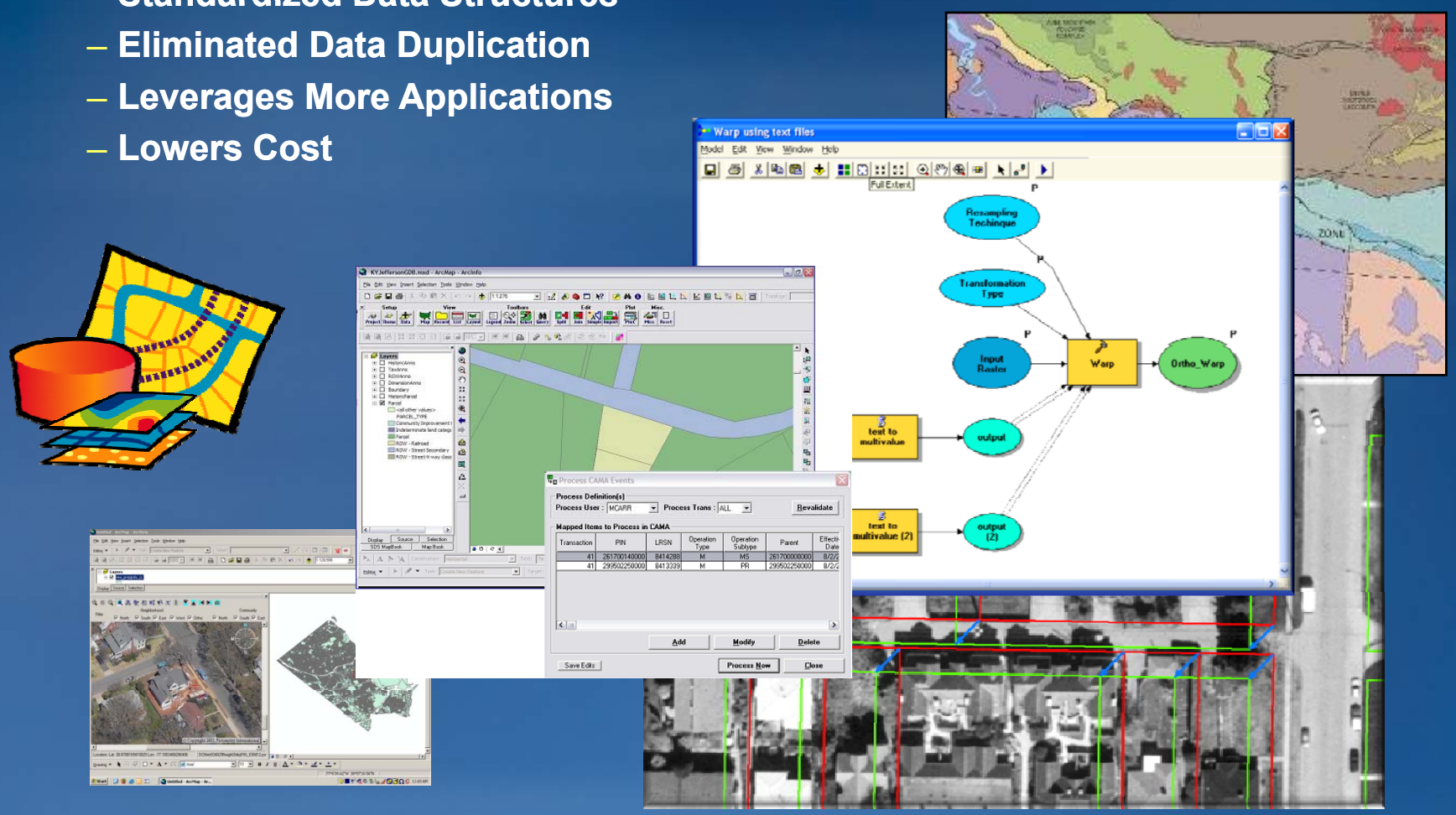
. . .GIS is the Technology Platform

GIS Provides Centralized Data Management

Leveraging the value of data throughout the Enterprise. . .

Benefits

- **Standardized Workflows**
- **Standardized Data Structures**
- **Eliminated Data Duplication**
- **Leverages More Applications**
- **Lowers Cost**

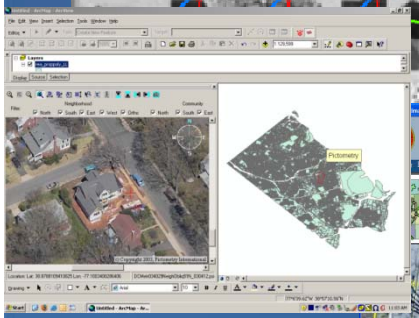


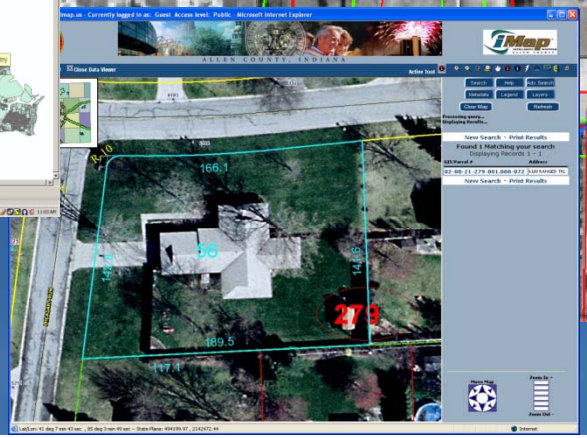
Integrating Imagery

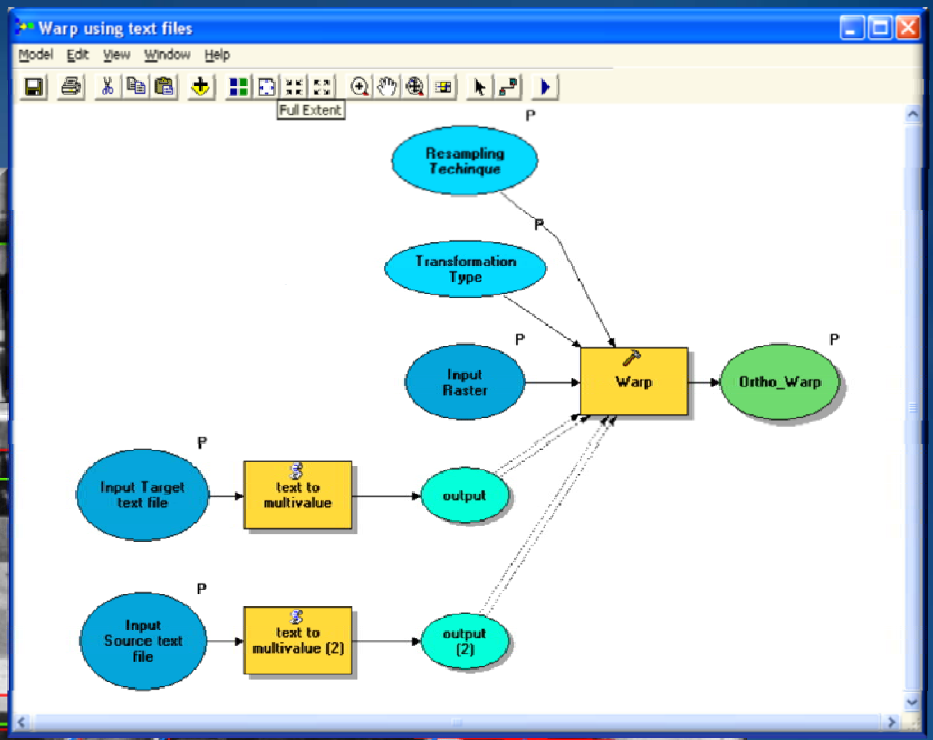
Leveraging the Imagery throughout the Enterprise. . .

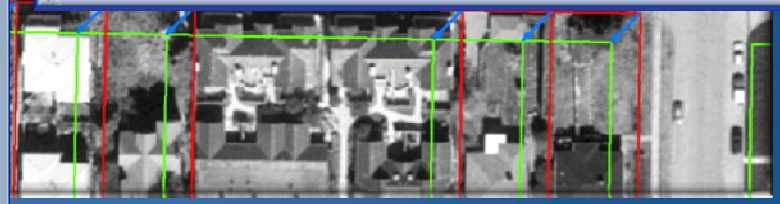
High Resolution Imagery

- Change Detection
- Data Adjustment
  - Raster to Vector
  - Vector to Raster





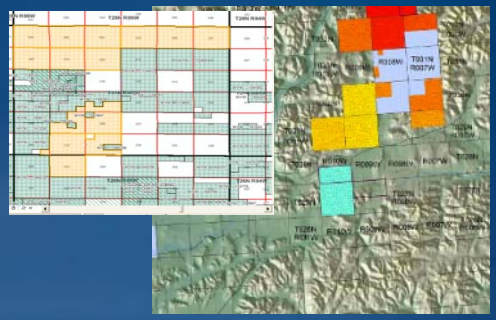




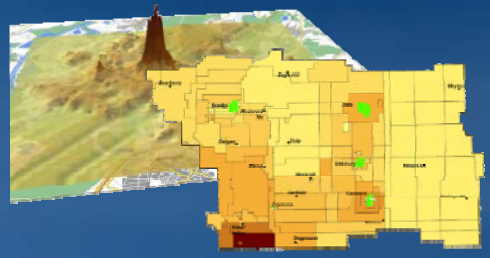
Land Information Systems

Integrating and Managing Land Information

Integrated Land Management
BLM



Property Valuation
Germany



Canada

Tax Mapping

Adapx Pen-Based Sketching
USAID-Timor Leste

Analyzing Transactions

National Data Portal

Oil & Gas Leases

Planning

GIS provides advanced analysis and visualization . . .

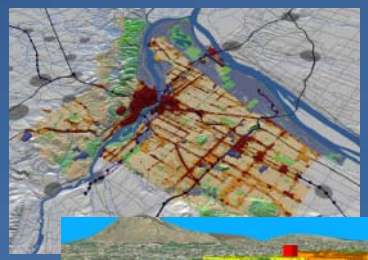
Land Use Suitability
Montana

Urban Planning
California

Urban Design
San Jose, California

Web Based Suitability
North Carolina

3D Zoning
Portland, Oregon



Arizona

Urban Redevelopment
Bakersfield, California

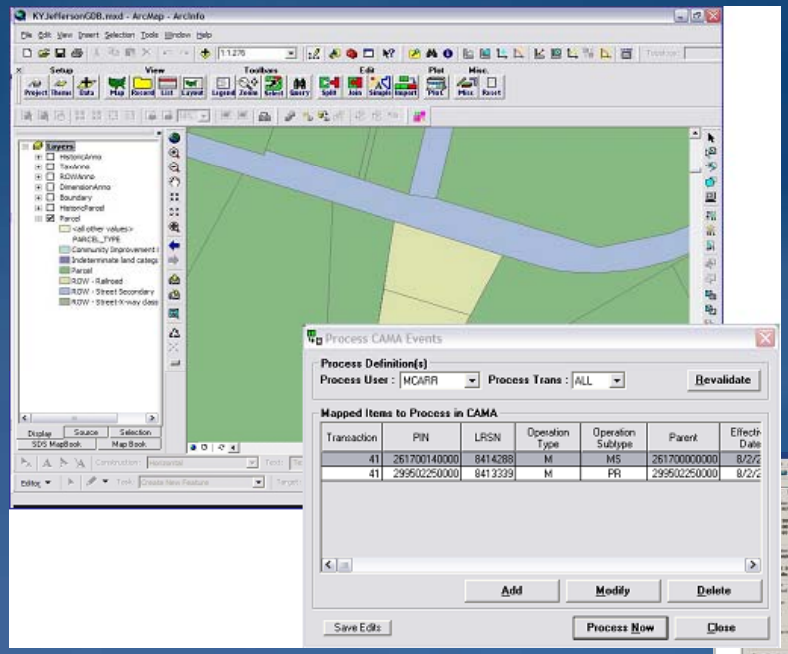
Virtual City
Bangkok

Online Community Planning
U.K.

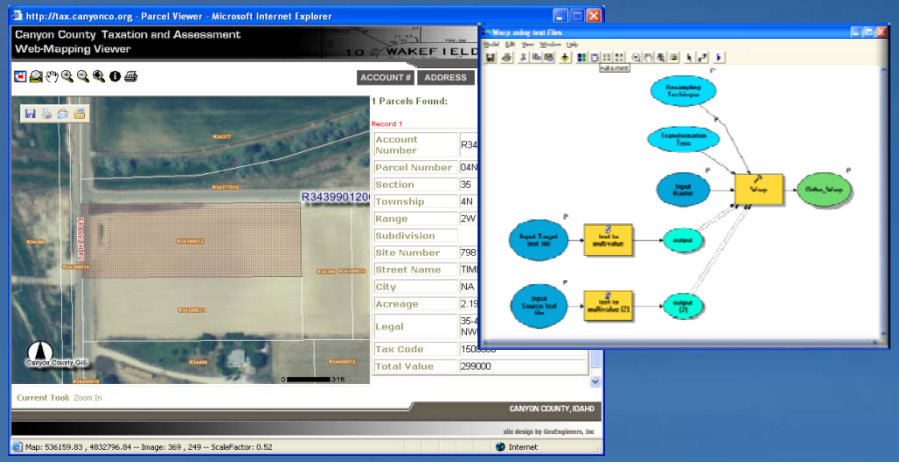
Regional Planning
Puerto Rico

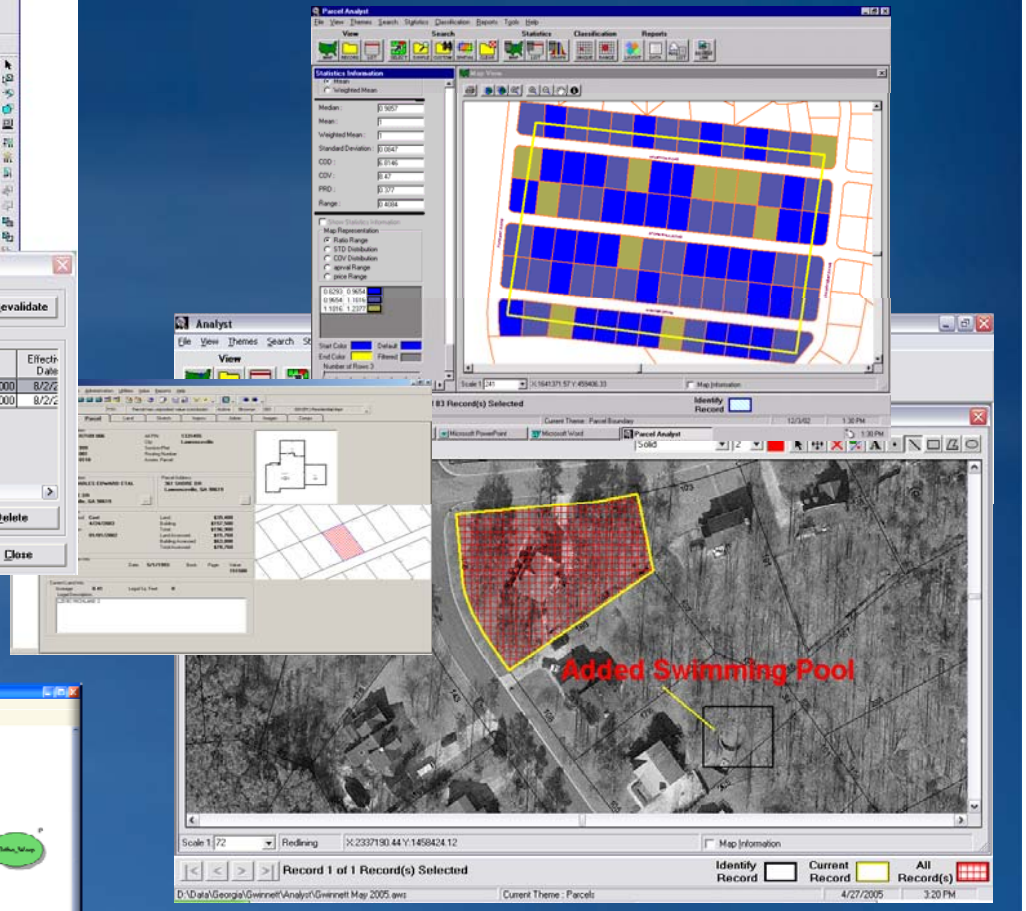
Integrating GIS and Valuation Systems

Modeling trends, improving revenue projections



Louisville/Jefferson County



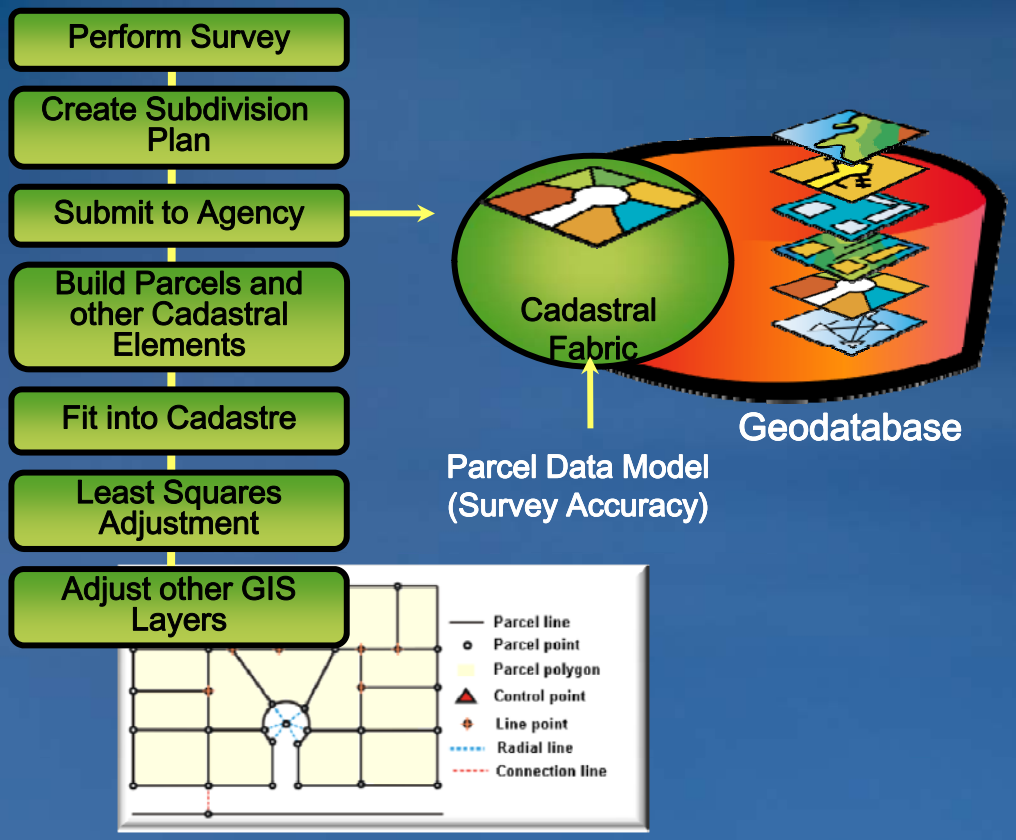


Snohomish County

Specialized Cadastral Workflow

Parcel manager provides new data structures for survey data. . .

Workflow



Benefits

- **Incremental updates in accuracy**
- **Integration of Surveyors work**
- **Standardized procedures**

. . . Supporting Complex Workflows

Ownership Parcel/Property Information

Not Single Use/Single Source Anymore

Note: This is a workshop. . .
Your participation is required!

Enterprise-wide GIS

What's this all about?

en·ter·prise -

Pronunciation: \□en-tə(r)-□prīz\ **Function:** *noun*

Etymology: Middle English, from Anglo-French, from *entreprendre* to undertake, from *entre-* inter- + *prendre* to take — **Date:** 15th century

1 : a project or undertaking that is especially difficult, complicated, or risky

2 : readiness to engage in daring or difficult action : <showed initiative great enterprise in dealing with the crisis>

3 a : a unit of economic organization or activity; especially : a business organization b : a systematic purposeful activity <agriculture is the main economic enterprise among these people>

Wikipedia –
An enterprise GIS is a geographic information system that is -

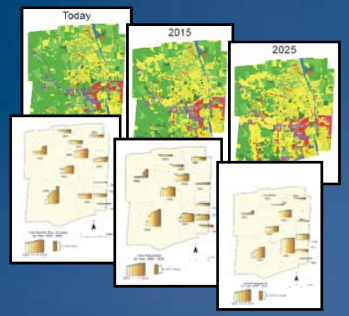
- **Integrated through an entire organization**
  - **Manage**
  - **Share**
  - **Use spatial data and related information**

- **Address a variety of needs**
  - **Data creation**
  - **Modification**
  - **Visualization**
  - **Analysis**
  - **Dissemination**

Traditional Role of GIS in Government

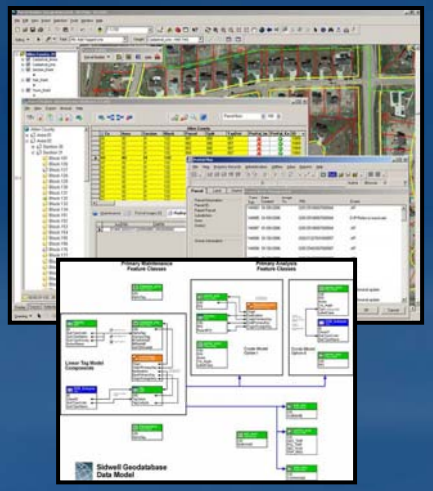
Single silo applications. . .

Scenario Planning

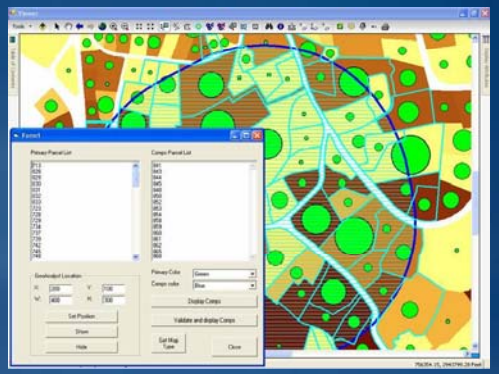


Urban Design

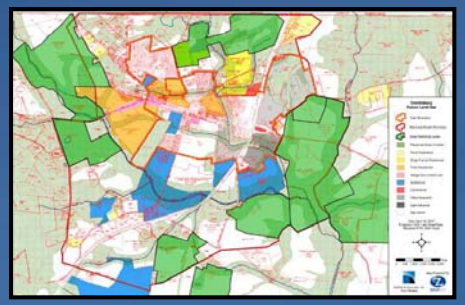
Integrated Assessment

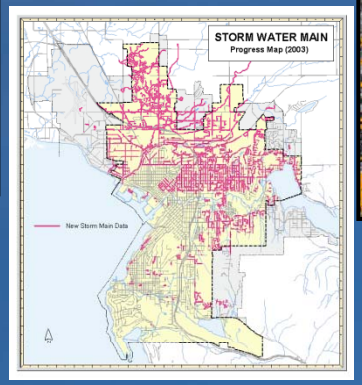


Property Valuation



Land Use Planning

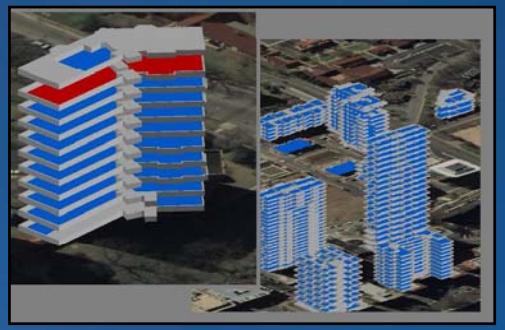




Sustaining Infrastructure
Public Works/Engineering

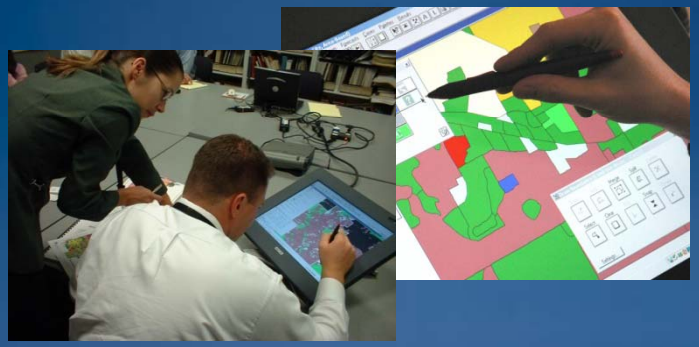
Transportation Modeling

Stratified Tax Appraisal



Traditional Role of GIS in Government

Single silo applications. . .

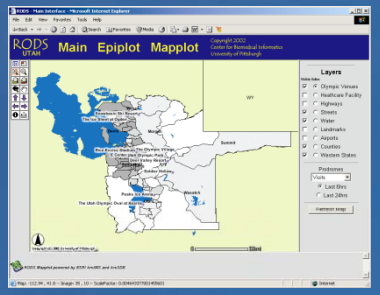


Public Works

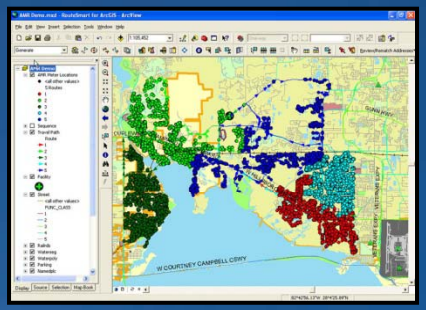
Public Safety

Emergency Management

Crime Mapping



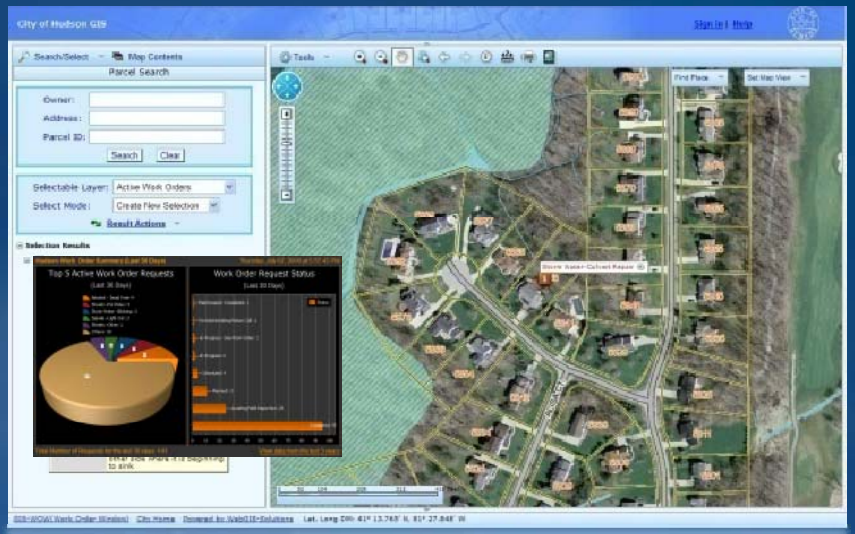
Health Surveillance

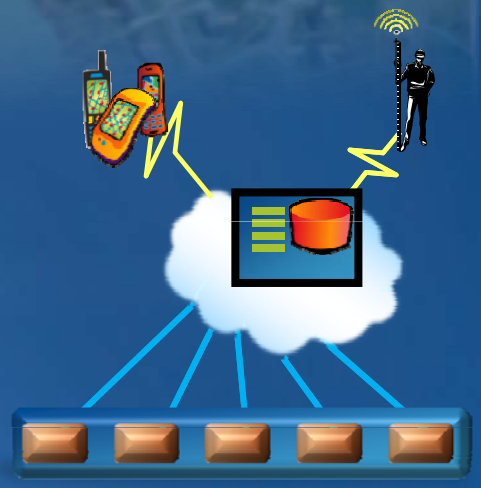


Meter Reading Optimization

New Roles for GIS in eGovernment

- Transparency
- Citizen Participation
- Web Portals
- Dashboards
- Census
- Demographics
- Mobile
- . . .





Government Enterprise GIS

GIS is at the center of eGovernment implementations. . .

Data Creation

Mapping and Reporting

Internet

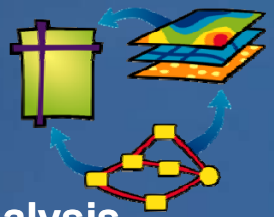
Data Access

Citizen Portals

Logistics

Navigation

Mobile Field Workers



Analysis

Data Center

Visualization

Maps

Data

Information

Knowledge

Enterprise GIS

Standards-based Interoperability – SOA

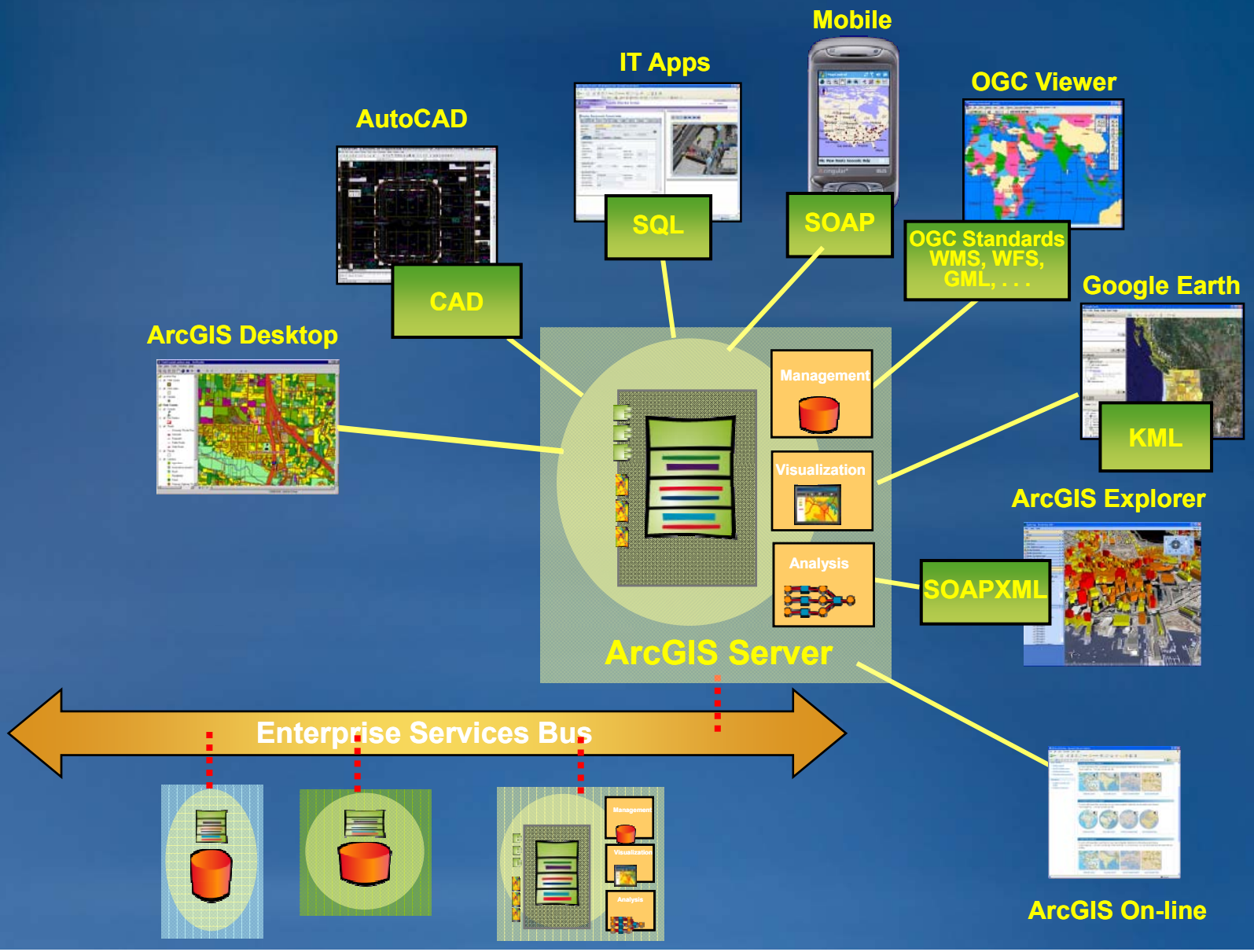
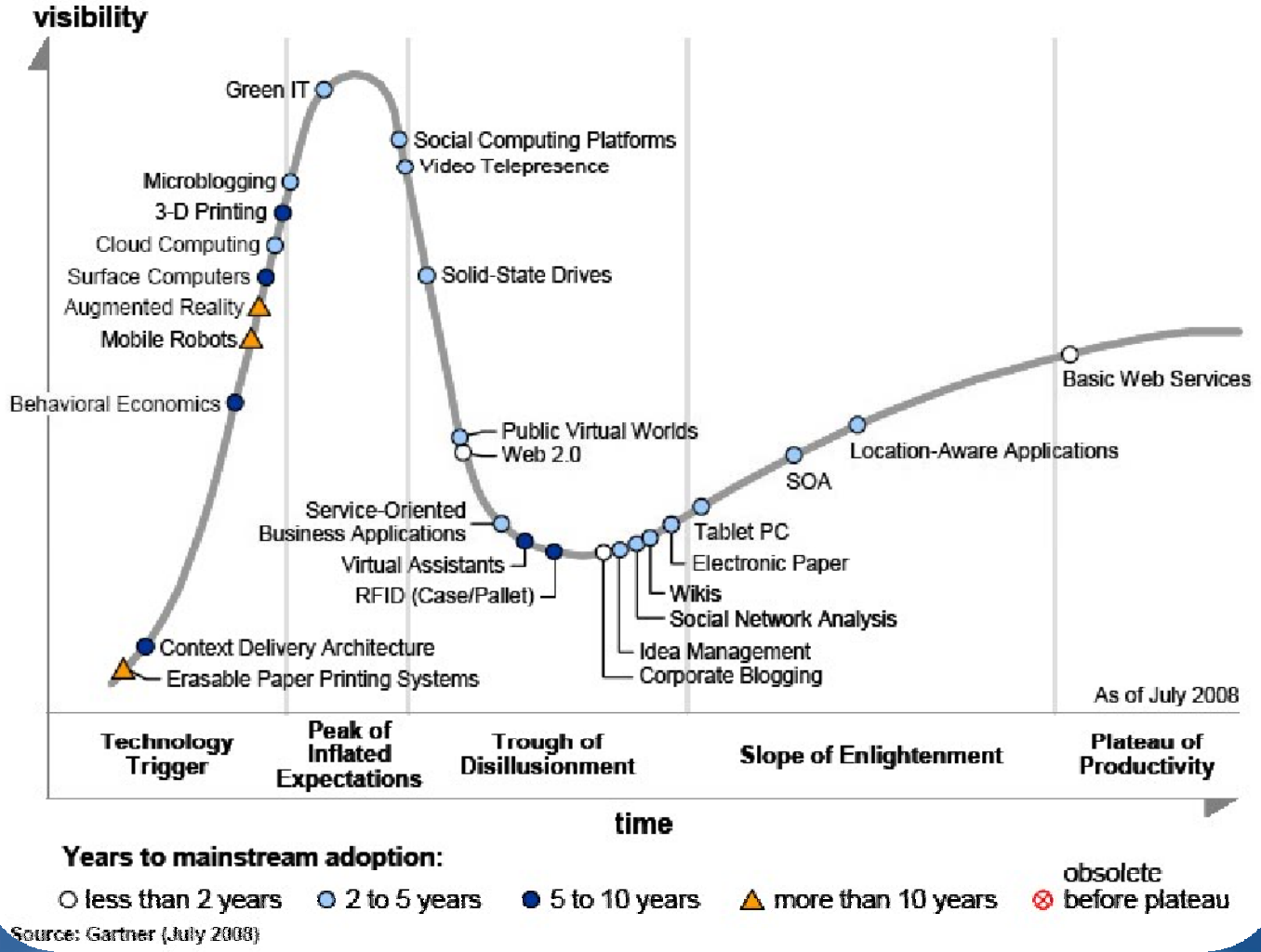
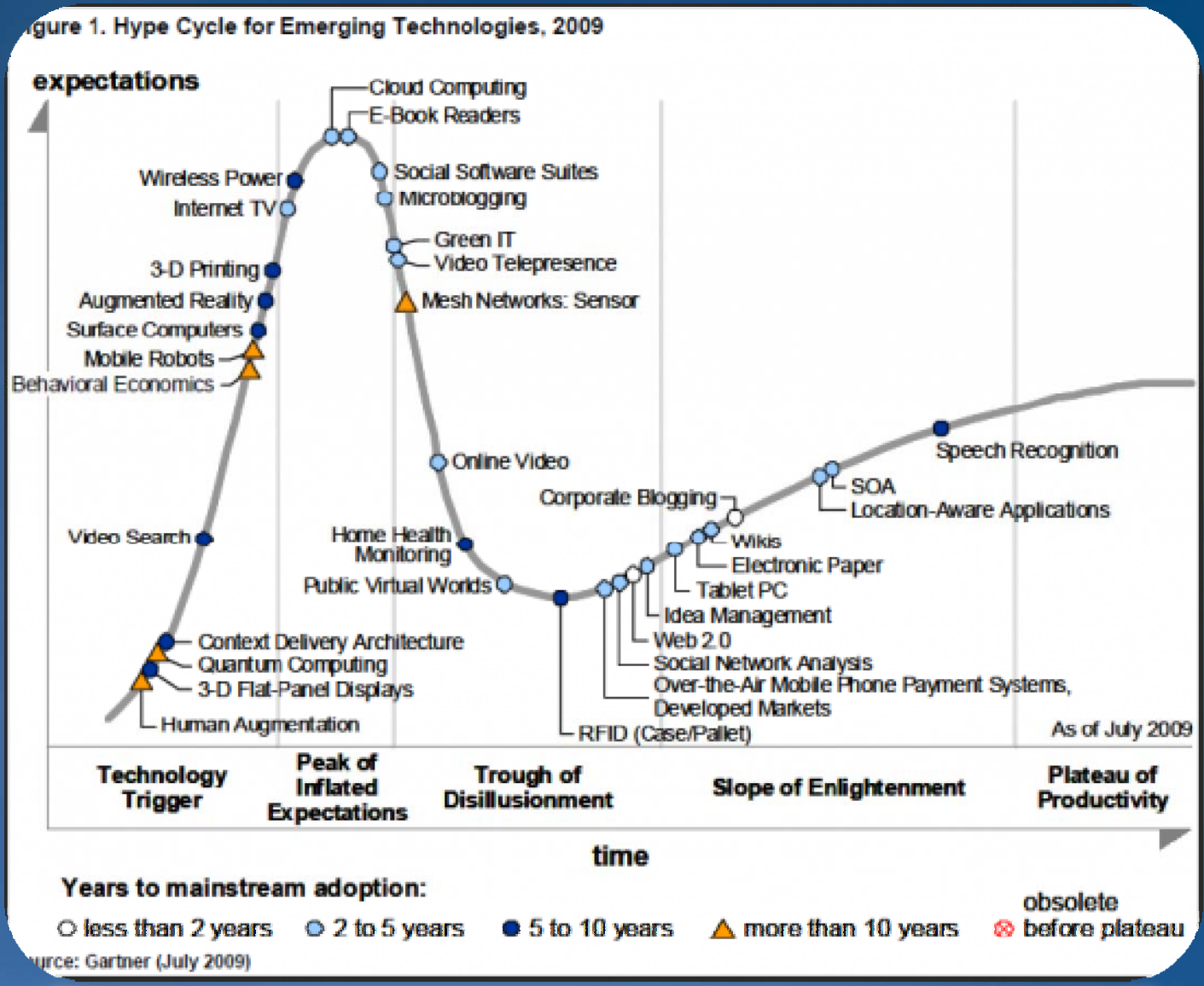
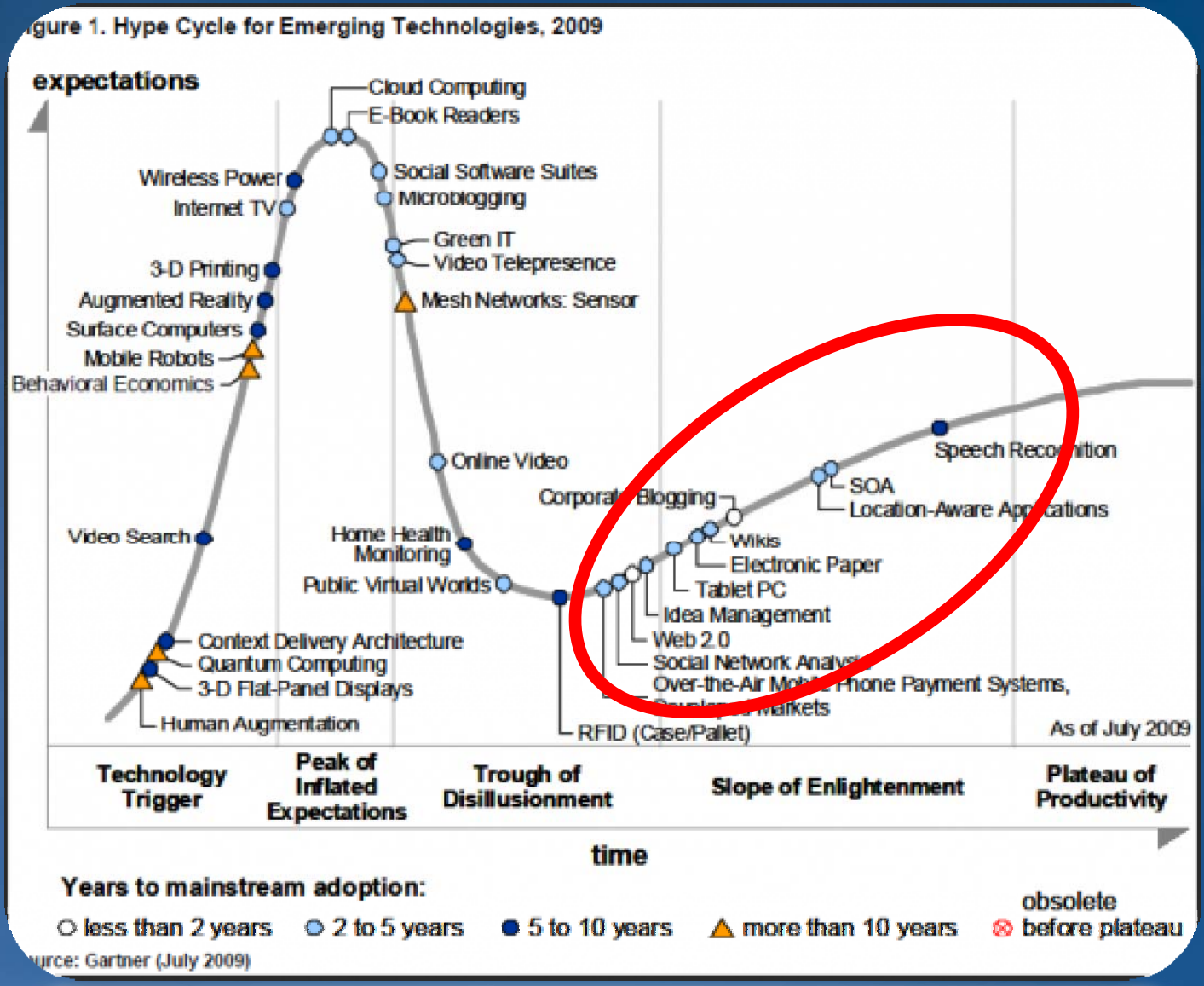


Figure 1. Hype Cycle for Emerging Technologies, 2008



Source: Gartner (July 2008)


gure 1. Hype Cycle for Emerging Technologies, 2009
expectations
Cloud Computing
E-Book Readers
Wireless Power
Internet TV
Social Software Suites
Microblogging
Green IT
Video Telepresence
3-D Printing
Augmented Reality
Surface Computers
Mobile Robots
Behavioral Economics
Mesh Networks: Sensor
Online Video
Speech Recognition
Corporate Blogging
SOA
Location-Aware Applications
Video Search
Home Health Monitoring
Wikis
Electronic Paper
Public Virtual Worlds
Tablet PC
Idea Management
Context Delivery Architecture
Quantum Computing
Web 2.0
Social Network Analysis
3-D Flat-Panel Displays
Over-the-Air Mobile Phone Payment Systems, Developed Markets
Human Augmentation
RFID (Case/Pallet)
As of July 2009
Technology Trigger
Peak of Inflated Expectations
Trough of Disillusionment
Slope of Enlightenment
Plateau of Productivity
time
Years to mainstream adoption:
less than 2 years
2 to 5 years
5 to 10 years
more than 10 years
obsolete before plateau
urce: Gartner (July 2009)


gure 1. Hype Cycle for Emerging Technologies, 2009
expectations
Cloud Computing
E-Book Readers
Wireless Power
Internet TV
Social Software Suites
Microblogging
Green IT
Video Telepresence
3-D Printing
Augmented Reality
Surface Computers
Mobile Robots
Behavioral Economics
Mesh Networks: Sensor
Online Video
Speech Recognition
SOA
Location-Aware Applications
Corporate Blogging
Wikis
Electronic Paper
Tablet PC
Idea Management
Web 2.0
Video Search
Home Health Monitoring
Public Virtual Worlds
Context Delivery Architecture
Quantum Computing
3-D Flat-Panel Displays
Human Augmentation
RFID (Case/Pallet)
As of July 2009
Technology Trigger
Peak of Inflated Expectations
Trough of Disillusionment
Slope of Enlightenment
Plateau of Productivity
time
Years to mainstream adoption:
less than 2 years
2 to 5 years
5 to 10 years
more than 10 years
obsolete before plateau
urce: Gartner (July 2009)

Parcels – why the big deal?

Secure property is the foundation to a successful economy. . .

Capital

Collateral

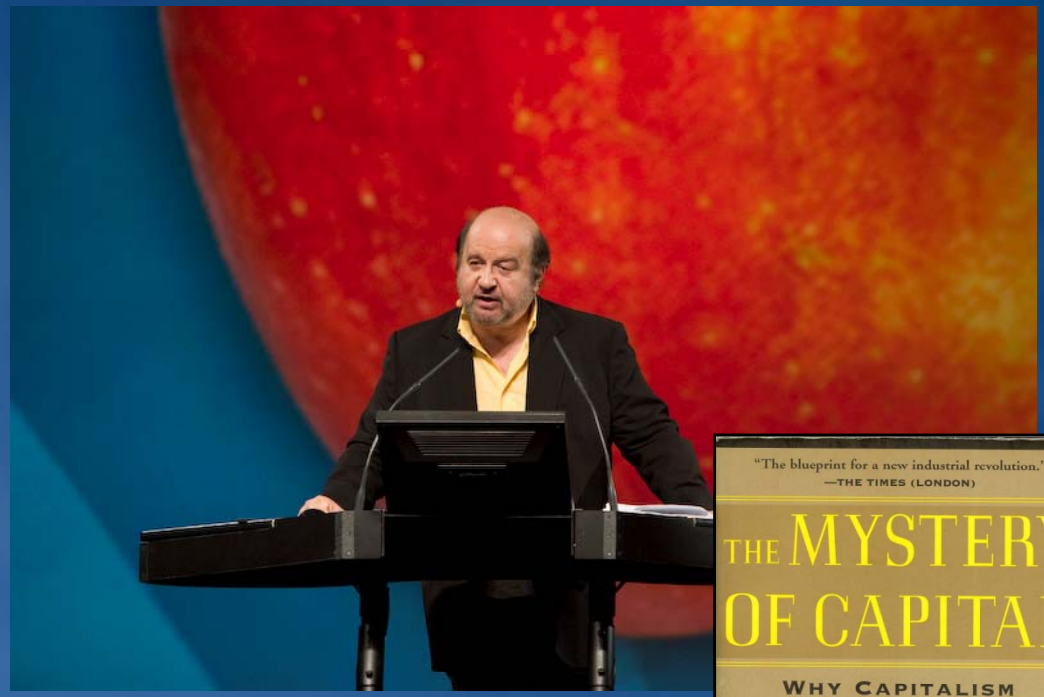
Stability

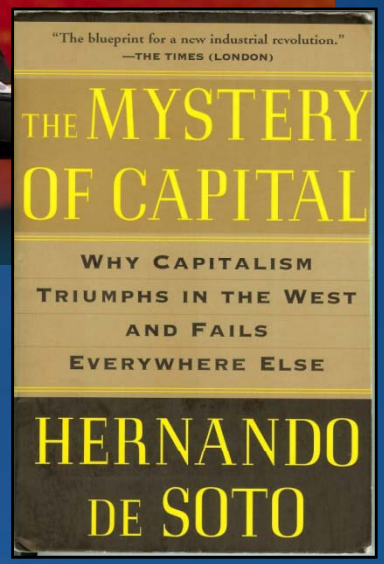
Taxation

Heir

Assign

Wealth accumulation





http://www.esri.com/events/uc/agenda/plenary.html

Parcels -

- **A parcel is an unambiguously defined unit of land within which a bundle of rights and interests are legally recognized in a community.**

- **A parcel encloses a contiguous area of land for which location and boundaries are known, described, and maintained, and for which there is a history of defined, legally recognized interests.**

National Land Parcel Data: A Vision for the Future
2007, NRC Mapping Sciences Committee

Parcels –

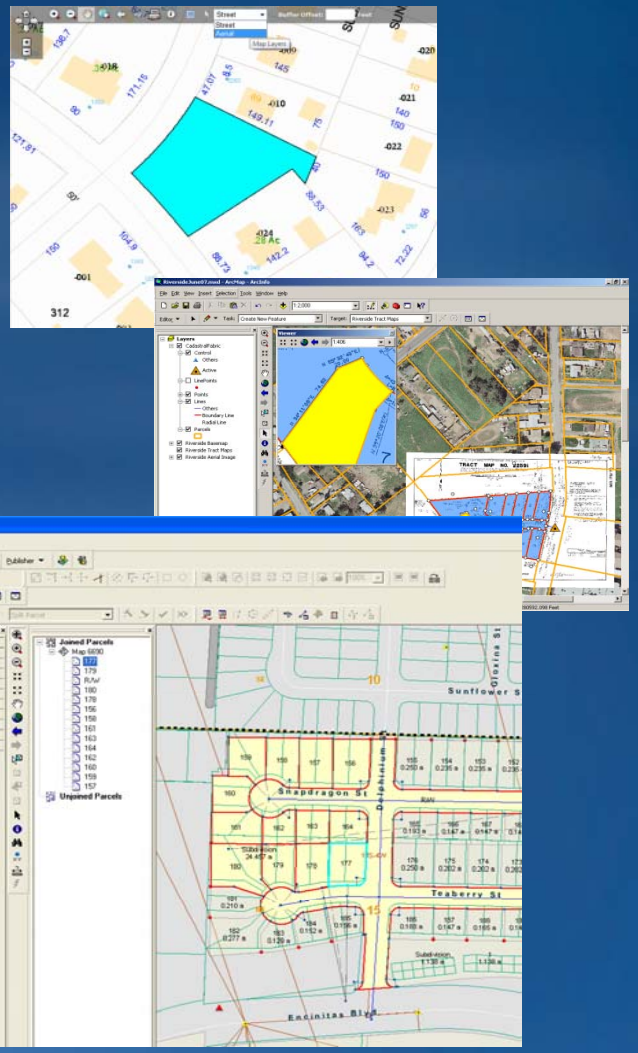
Provides intelligence to maps and imagery

- **Users view and use parcels differently**
- **Land owners**
  - **Know little of GIS**
- **Surveyors**
  - **Individual parcel accuracy**
- **Enterprise Professional Users**

Parcels –

A representation of the limits of rights. . .

- **Property lines**
- **PID**
- **Description (Legal Record)**
- **Bearings/Distances**
- **Monuments**
- **Zoning**
- **Area**
- **Ownership**
- **Interests**
- **Address**
- **Tax parameters**
- **. . . .**



Parcels – who needs 'em? (your local gov't)

And what are they doing with them?

- County Engineer
- Emergency Responders
- Law Enforcement
- Logistics
- Census
- Demographer
- DOT
- Welfare Services
- Register of Deeds
- Health Officer
- Code Enforcement
- Treasurer
- Sheriff
- Assessors
- County Surveyors
- Auditor
- Public Works
- Parks & Recreation
- Permits
- Epidemiologist
- Planner
- Environmental Analyst
- Zoning Administrator
- Real Property Lister
- E 911 Coordinator
- . . . .

Parcels – who needs ‘em? (your community)

Part 2

- **Realtors**
- **Home buyers**
- **Insurance companies**
- **Utilities**
- **Pipelines**
- **Railways**
- **Engineers**
- **Developers**
- **Broadband providers**
- **Environmental groups**
- **Historians**
- **Call before you dig**
- **Reverse 911**
- **Land surveyors**
- **Waste management**
- **Elected officials**
- **Facility managers**
- **Carbon traders**
- . . . .

Parcels – who needs 'em? (the Feds)

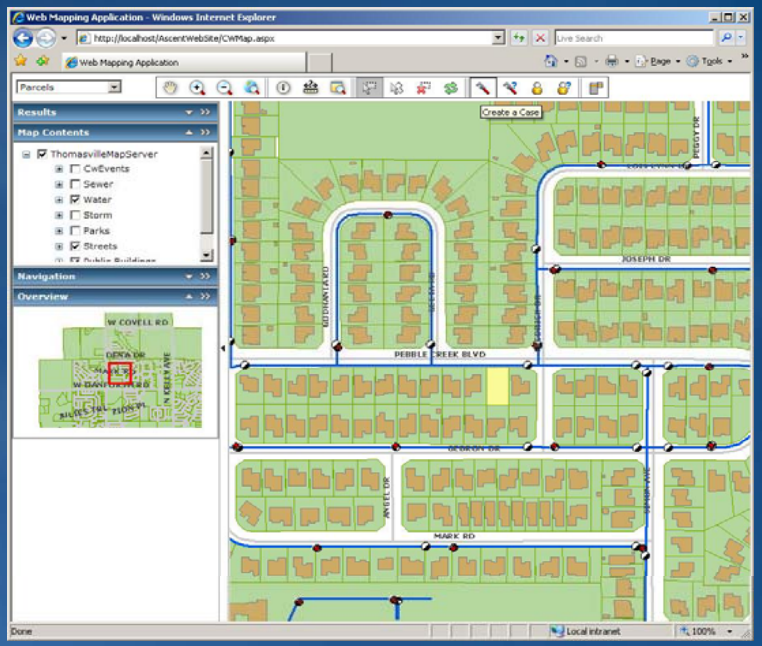
Part 3

- **Federal Government**
  - **Federal Maps**
  - **Statistics**
  - **Census**
  - **Agriculture/Land Use**
  - **Foreign ownership of real estate**
  - **Federal lands**
  - **Assistance programs – standardize records (housing, community development, historic preservation, HUD)**
  - **DHS – i.e. Katrina, wildfires**
  - **EPA**
  - **NOAA**
  - **. . .**

Parcels – who needs ‘em?(put state name here)

Part 4

- **State Government**
  - **Equitable assessment**
  - **Department of Revenue**
  - **DOTs**
  - **State owned lands**
  - **Statistics**
  - **Census**
  - **Agriculture/Land Use**
  - **Foreign ownership of real estate**
  - **Federal lands**
  - **Emergency response**
  - **Environmental protection**
  - **. . .**



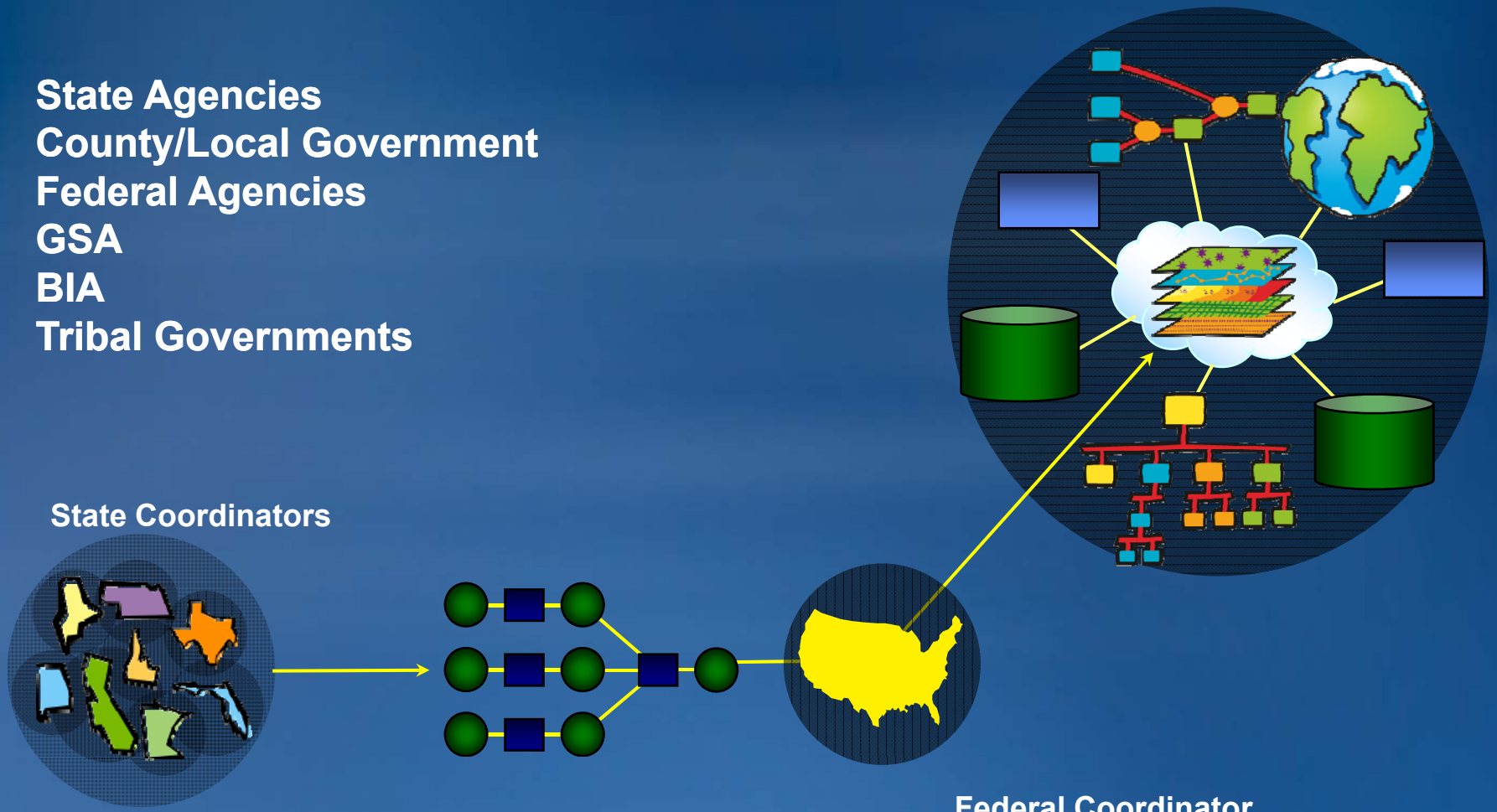
Parcels – why don't we want to share 'em

They're mine. . .

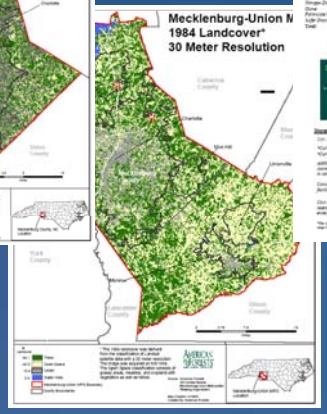
- **Cost**
- **Liability**
- **"Once you get these, what will you want next?"**
- **"How much work do I need to do to share?"**
- **"What's in it for me?"**
- **Hard to manage expectations**
- **Data models**
- **Currency**
- **Quality**
- **Barter Value**
- **. . .**

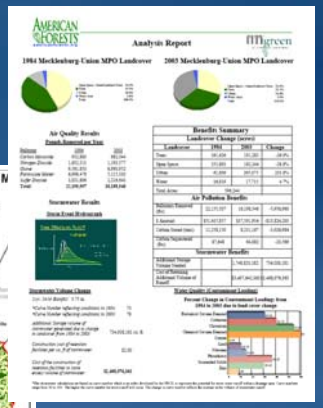
Federated Parcels

State Agencies
County/Local Government
Federal Agencies
GSA
BIA
Tribal Governments

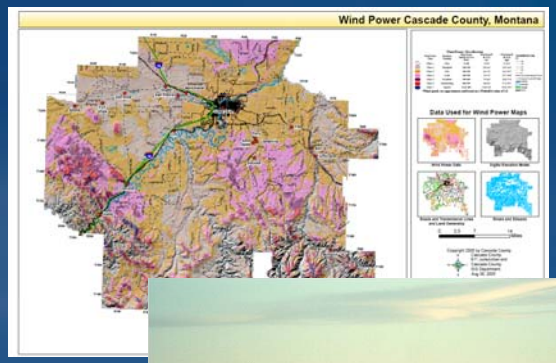


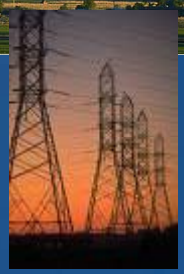
Parcels for Green Government



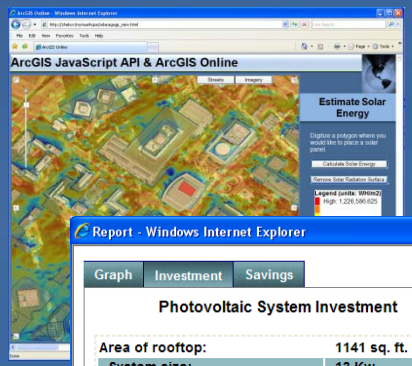


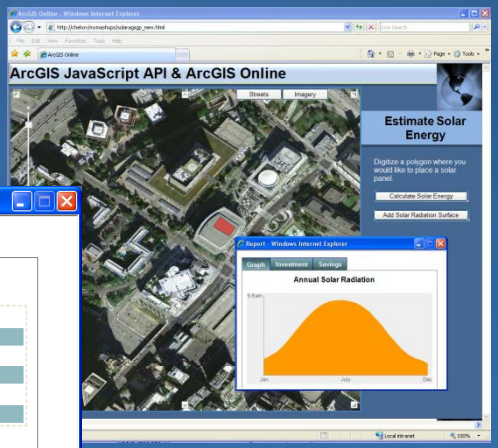
Carbon Footprint analysis

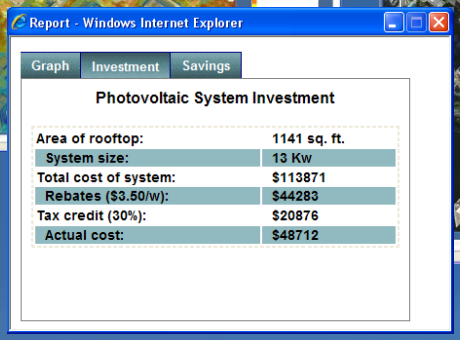




Alternative Energy



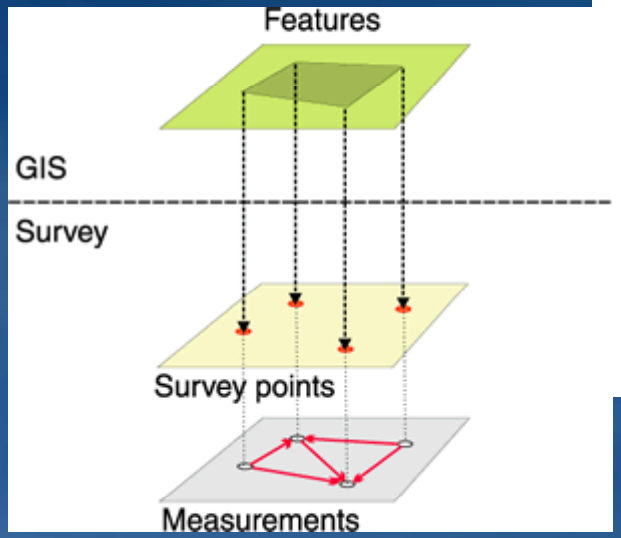


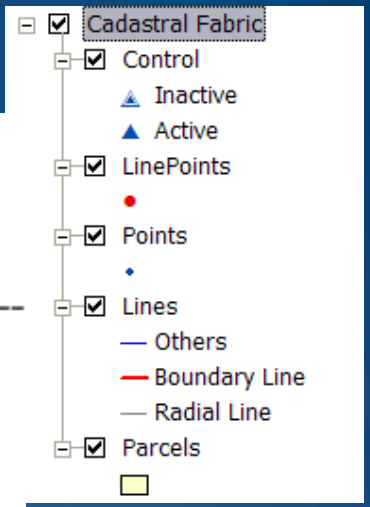


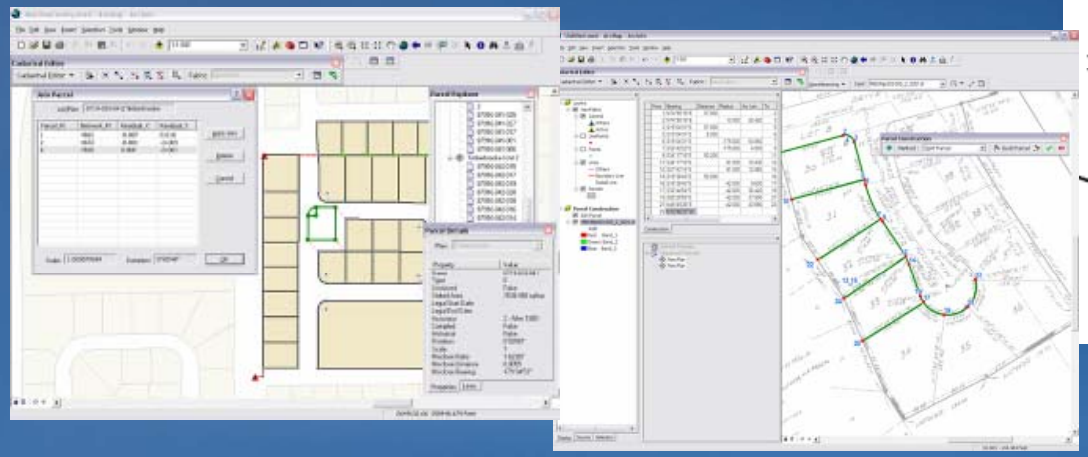
Parcels – for Accuracy Control

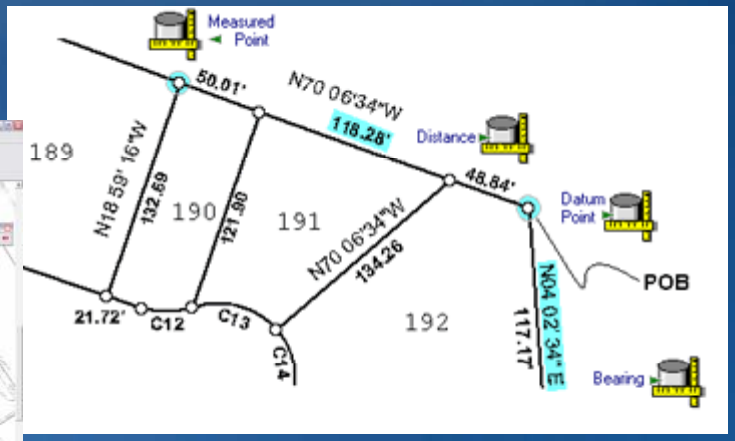
A new way to manage spatial accuracy of GIS data

- **Parcels are the fundamental land element**
- **Parcels are created by measurements**
- **Measurements can be maintained (improved) over time**
- **GIS data based on parcels can be spatially maintained**









The Importance of Cadastre

Capital to drive economies

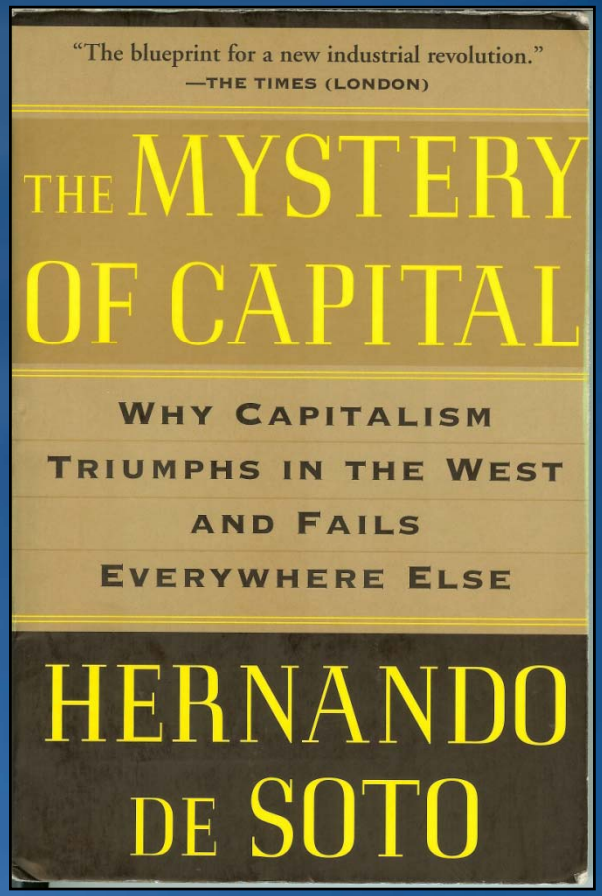
Formalizing Land Ownership/Occupation is the first step in "unlocking" the capital in land

Collateral

Stability

Accumulation of Wealth

Pass Property onto Heirs



The Importance of Cadastre

Modernization of Financial Sectors. . . .

Create Land Markets

Transactions Tracked

Markets Mature –

Confidence in Land Administration

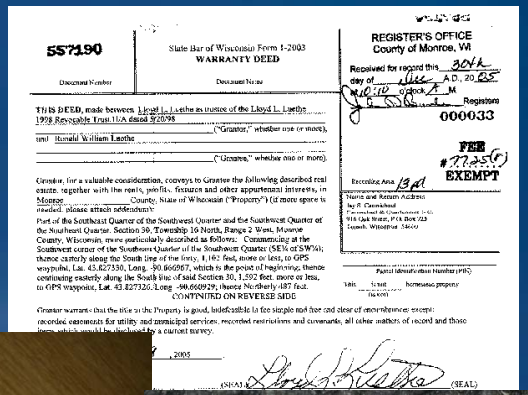
Creative Financial Instruments

Securitization of Commercial Interest in Land Mobilizes Funding

Elements of Property Title

Organized, managed, accessible land records. . .

- Transparency
- Public Recognition
- Recognition by Authority
- Stable Occupancy
- Address


557190

State Bar of Wisconsin Form 1-2003
WARRANTY DEED

Document Number

Document Name

REGISTER'S OFFICE
County of Monroe, WI

Received for record this 30th day of June A.D., 20 05 at 1:10 o'clock P M and recorded as Document 000033

FEE $7.25(R)
EXEMPT

THIS DEED, made between Lloyd L. Luethe as trustee of the Lloyd L. Luethe 1998 Revocable Trust U/A dated 9/20/98 ("Grantor," whether one or more), and Ronald William Luethe ("Grantee," whether one or more).

Grantor, for a valuable consideration, conveys to Grantee the following described real estate, together with the rents, profits, fixtures and other appurtenant interests, in Monroe County, State of Wisconsin ("Property") (if more space is needed, please attach addendum):

Part of the Southeast Quarter of the Southwest Quarter and the Southwest Quarter of the Southeast Quarter, Section 30, Township 16 North, Range 2 West, Monroe County, Wisconsin, more particularly described as follows: Commencing at the Southwest corner of the Southwest Quarter of the Southeast Quarter (SE¼ of SW¼); thence easterly along the South line of the forty, 1,162 feet, more or less, to GPS waypoint, Lat. 43.627330, Long. -90.660967, which is the point of beginning; thence continuing easterly along the South line of said Section 30, 1,592 feet, more or less, to GPS waypoint, Lat. 43.627326, Long. -90.660929; thence Northerly 487 feet.

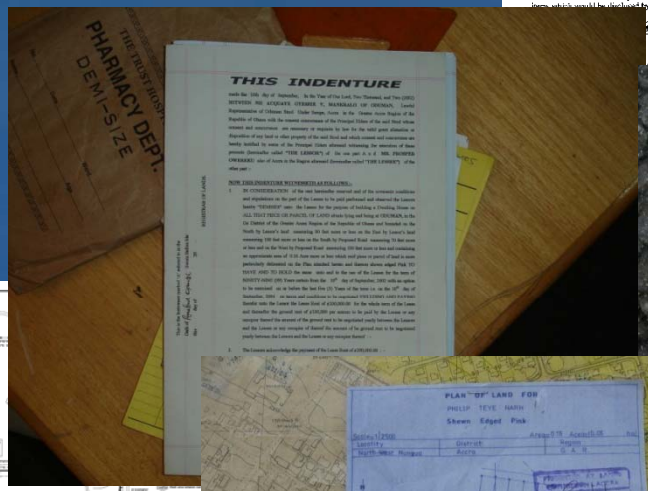
CONTINUED ON REVERSE SIDE

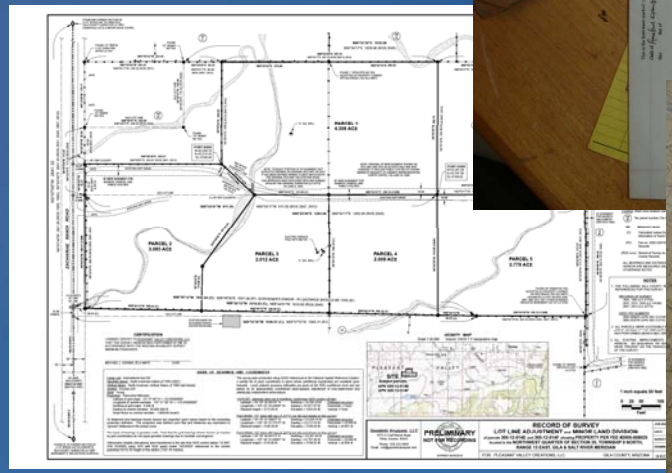
Grantor warrants that the title to the Property is good, indefeasible in fee simple and free and clear of encumbrances except: recorded easements for utility and municipal services, recorded restrictions and covenants, all other matters of record and those facts which could be disclosed by a current survey.

, 2005

(SEAL)

(SEAL)



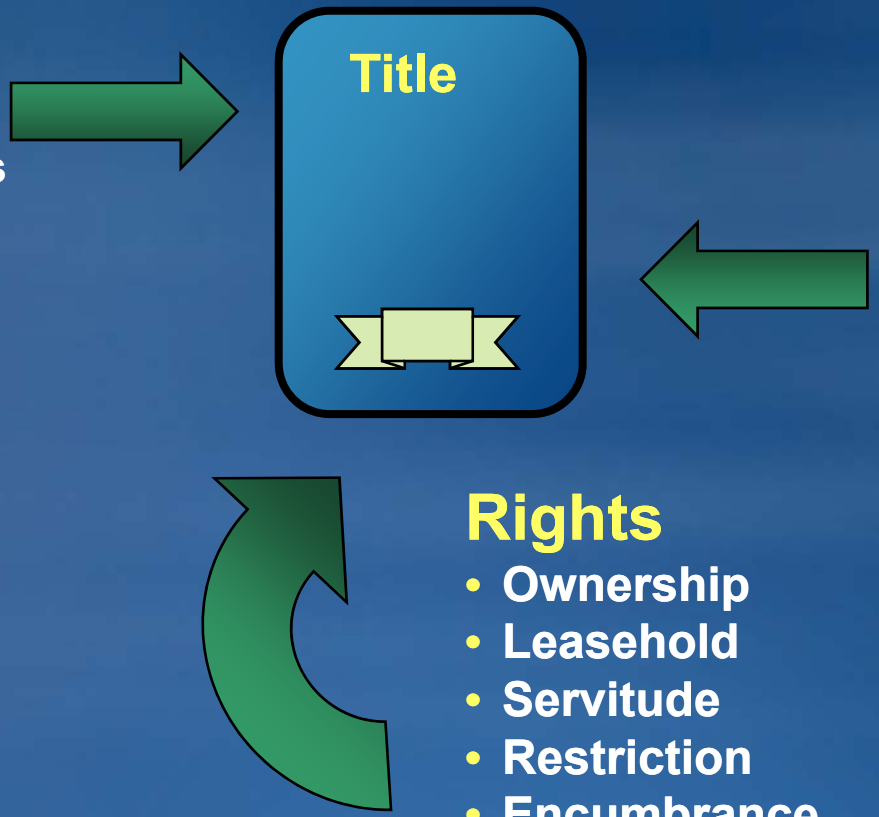


Using GIS to Integrate Registry and Cadastral Systems

. . .The Union of All Elements which constitute Ownership. . .

Parties

- Owners
- Tenants
- Mortgagors
- Trustees
- Attorneys
- others



Property

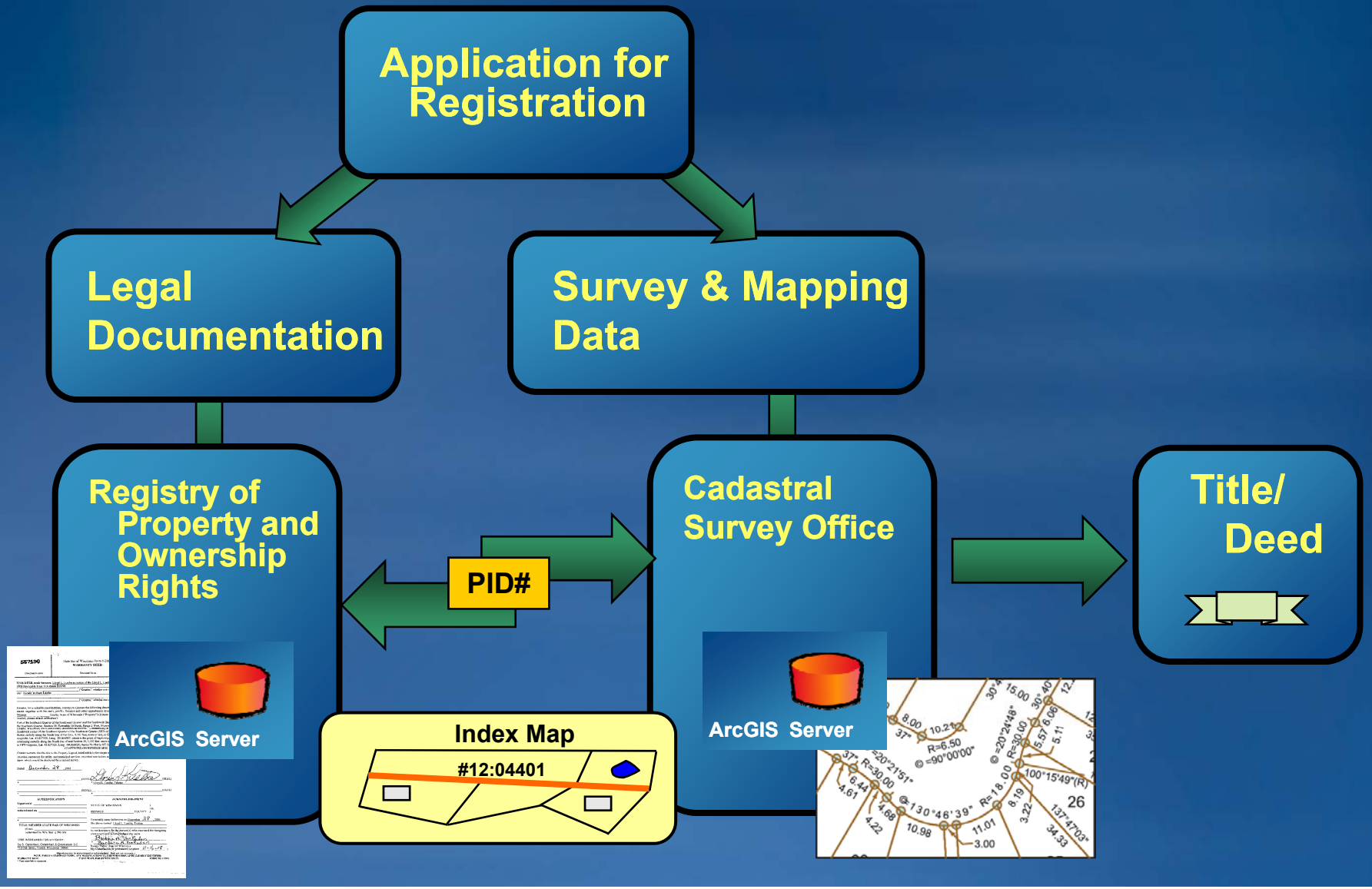
- Physical Description
- Cadastral Survey
- Parcels
- Buildings
- Improvements
- Apartments

Rights

- Ownership
- Leasehold
- Servitude
- Restriction
- Encumbrance
- Sale
- Heir
- others

Cadastral Mapping/Surveying

Ensures rights and restrictions are identified and transparent

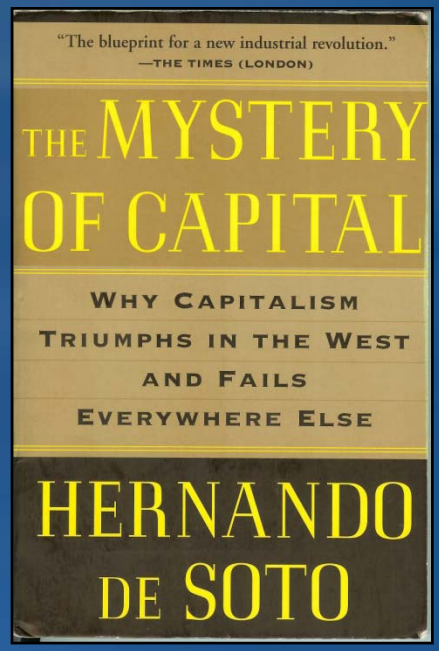


Ghana Land Titling and Registration

Case Study of Ongoing GIS-Based Land Registration Project

"The exciting and unique part of your approach is that you are truly building the shoes to fit the poor"

- Dr. Hernando de Soto

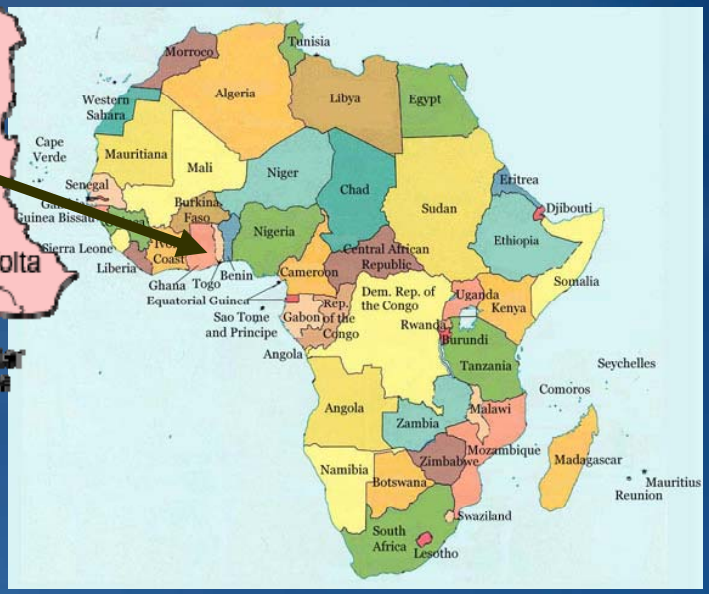


. . . Practical implementation of land economic theory

Ghana

Independent west African nation since 1960

- Population – 23 Million
- 93 people/km^2
- GDP $690 per capita
- Presidential republic
- Capital – Accra
  - Population 2 Million
- Ashiaman, Tema – Project
  - Population 250,000



Ashiaman, Tema

Conditions in Ghana

Informal settlements

Conditions in Ghana

Informal settlements

Conditions in Ghana

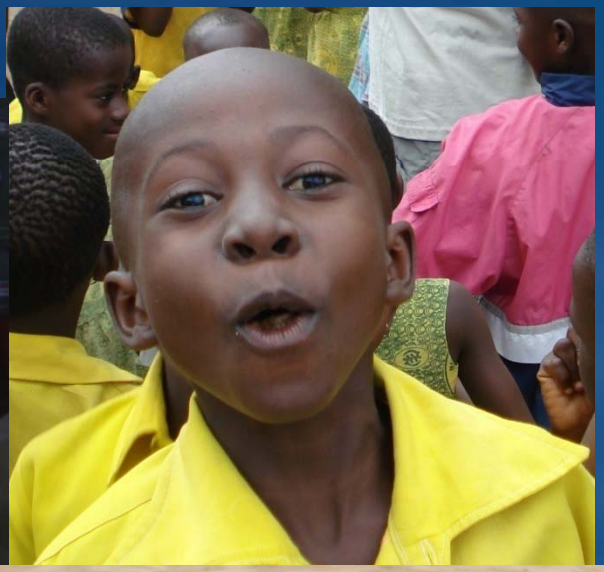
Entrepreneurial culture

Conditions in Ghana

Entrepreneurial culture

Conditions in Ghana

Active, optimistic society



Existing Land Registration Situation

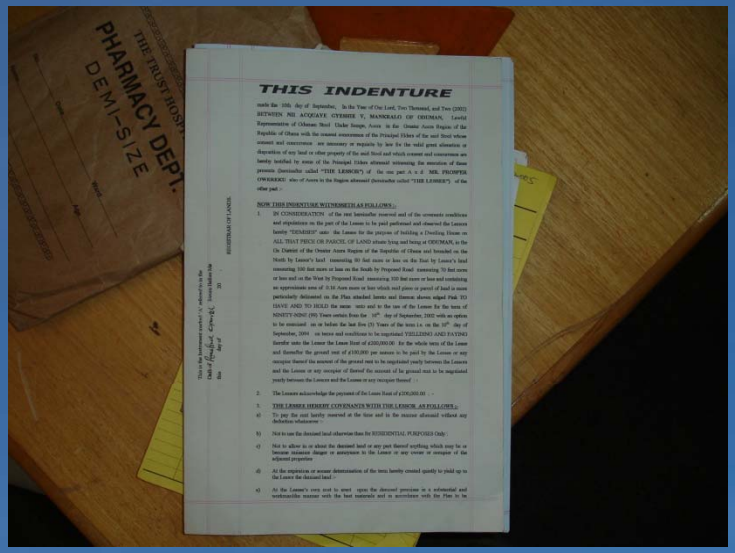
Costly, complex, under utilized land registration system

- Application – 6 Months, fees too high
  - Travel and time to Accra and associated costs, multiple trips
- Consult Land Registrar for Title Processing
  - 3 days
  - 1% stamp duty (implies valuation, separate agency)

Existing Situation (con't)

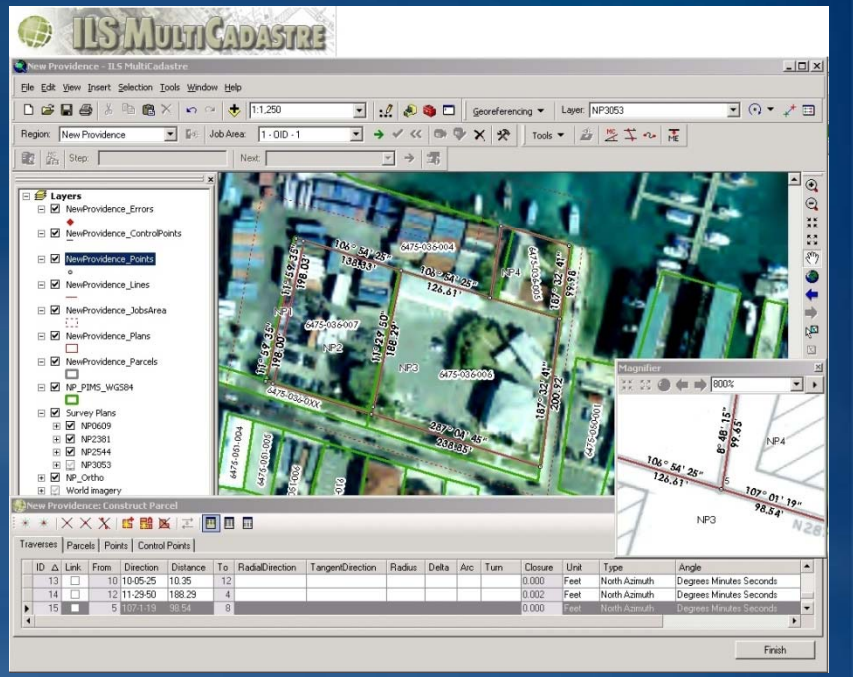
A "top-down" process for those with means

- Secure Property Description – requires high precision
  - Obtain land survey and formal plat
    - $300-$1000
    - 30 days
  - Obtain Legal Description based on land survey
    - 3 days
- Verify survey with Land Survey Office
  - 7 days



Our New Methodology - Medeem

Streamlined approach to land registration

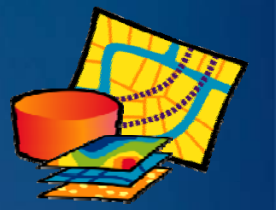


- Use consolidated onsite interview, survey and document review process
  - We go to the clients
- Leverage Technology
  - GIS
  - GPS
  - Titling software
  - Imagery
- Use data to derive a para-legal title certificate
  - "Provisional Title" is part of law
  - Paralegal title conforms to provisional title parameters

Pre-approved approach – Registrar to issue provisional titles based on paralegal certificate

Our New Methodology

Streamlined approach to land registration



Interview Questionnaire

Site Survey

GIS Data Entry

Photos
Video
Documents

MultiCadastre

10 Days!

New Land Markets Begin
Capital in Land Leveraged

Paralegal Title

Traditional Land Markets
10+ Years

Formal Title

Provisional Title

Batch Process

Additional Unique Elements

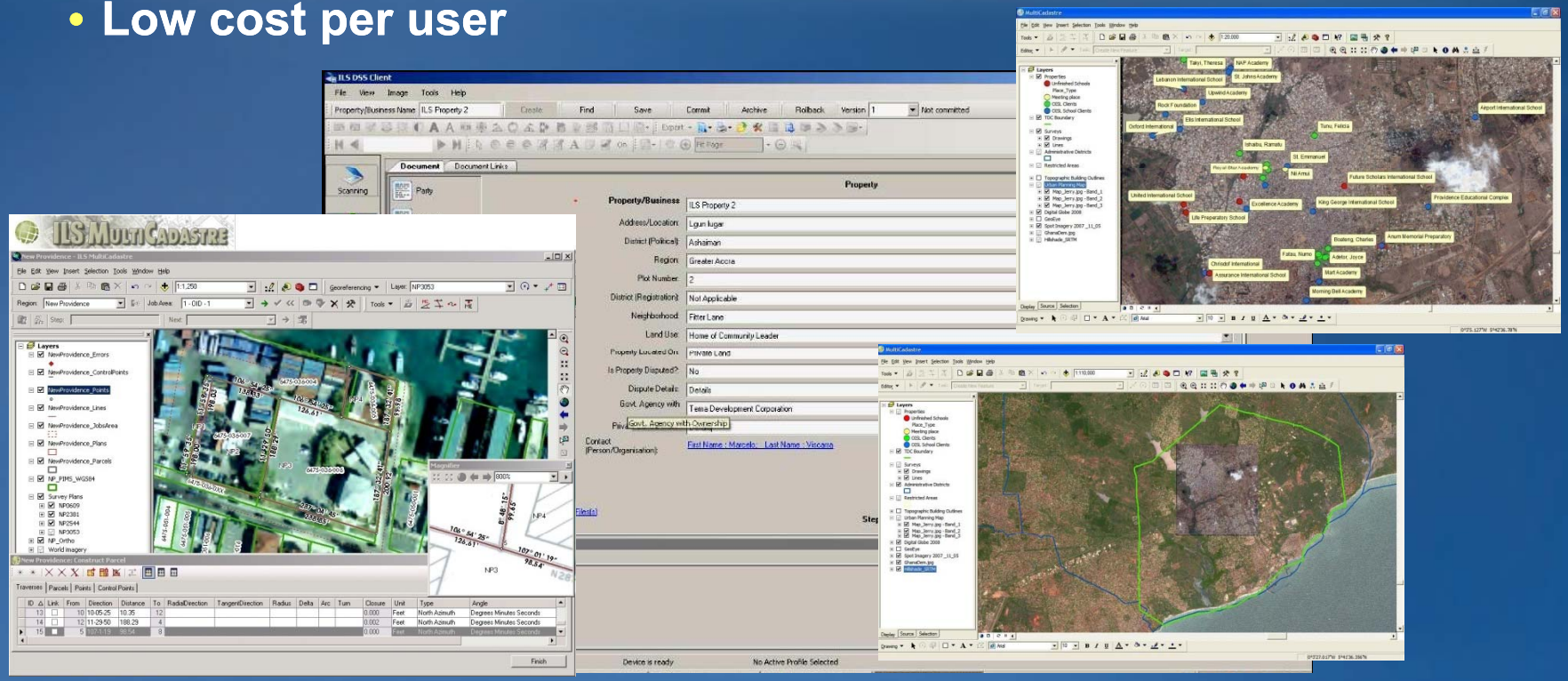
Many benefits to GIS based land registration

- **Coupled to microfinance lending leveraging the microfinance lender as the "trusted broker"**
  - **Loans *and land registration***
- **Leveraging paralegal title process**
  - **Microfinance lender can accept land as collateral**
  - **Begins to establish market value for land**
- **Opens floor to formalizing property rights for women**
  - **Encourages land ownership where joint obligor on loan**
- **Centralized GIS and Title Data**
  - **Many other uses (i.e. planning, health, etc.)**
  - **Provides means for third part repository in case of conflict, natural disaster, change of government, etc.**

Technology

ESRI ArcGIS Server based system

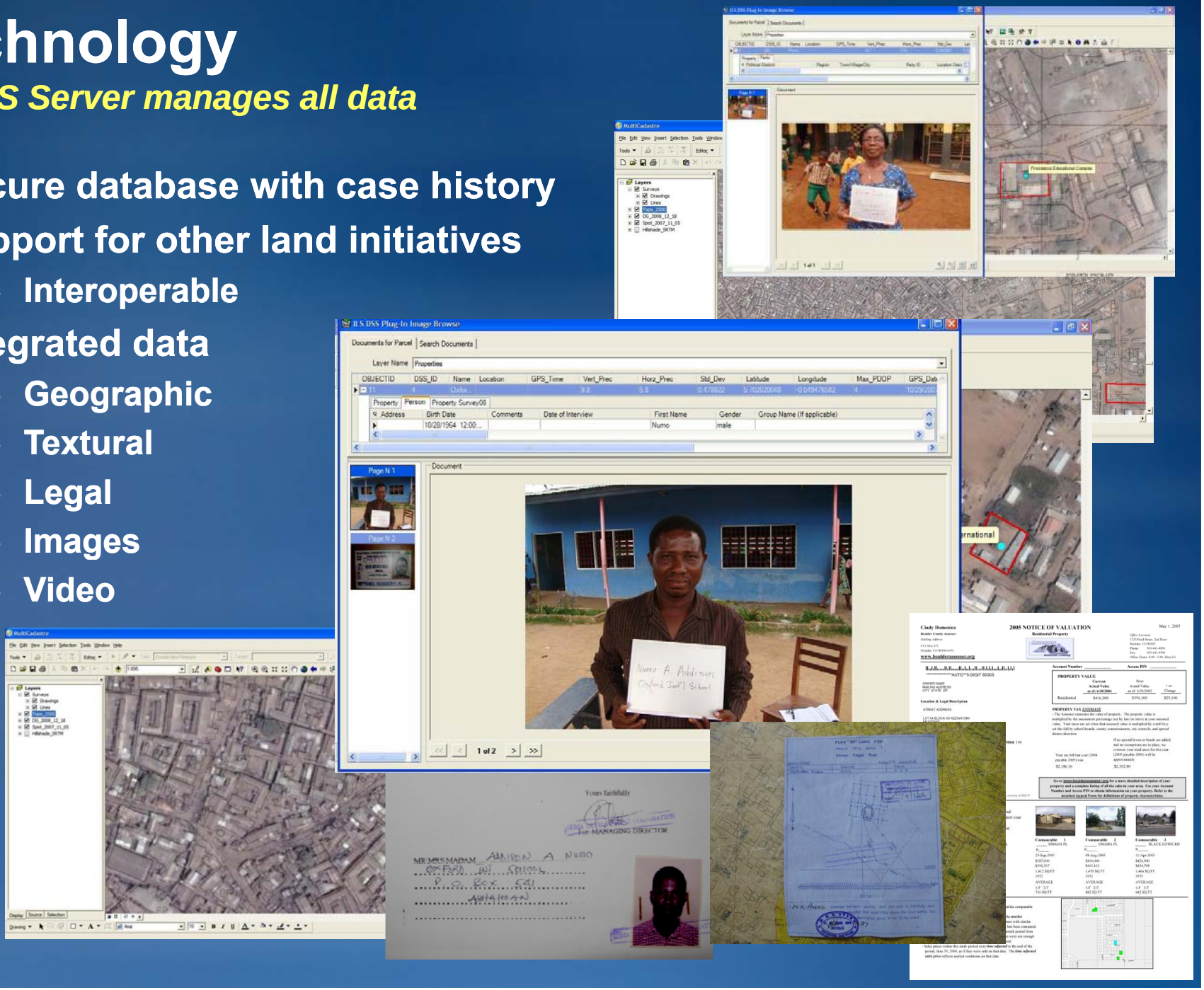
- **ArcGIS Server-based ILS MultiCadastre Titling Software manages all data and documents**
  - **Property documents**
  - **Photographs**
  - **Video**
- **Low cost per user**



Technology

ArcGIS Server manages all data

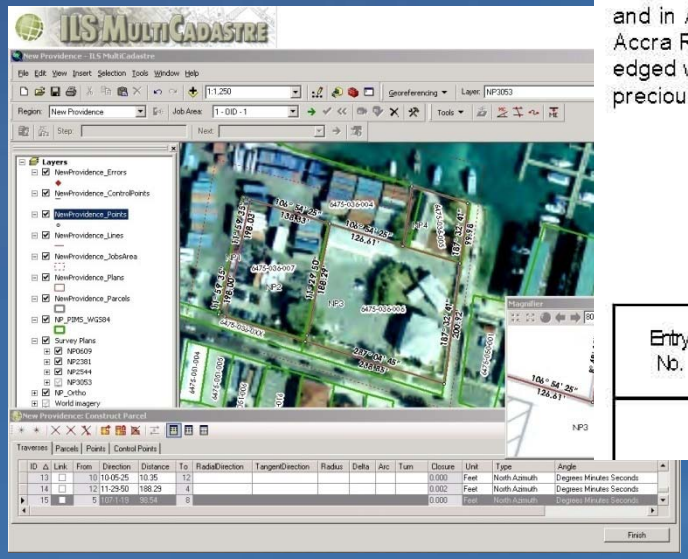
- Secure database with case history
- Support for other land initiatives
  - Interoperable
- Integrated data
  - Geographic
  - Textural
  - Legal
  - Images
  - Video



Technology

ILS MultiCadastre leveraging ESRI ArcGIS Server

- **Automated generated documents**
  - **Lease request**
  - **Paralegal title**
  - **Lease forms**



Opportunity International
GIVING THE POOR A WORKING CHANCE

Next to Ghana Water Company
Opposite Fire Service Station
Tel:+233 (0) 20 2016003-6

LAND TITLE REGISTRY

REPUBLIC OF GHANA

LAND TITLE REGISTRATION LAW, 1986

NO.....

LAND REGISTER
VOL..... FOLIO.....

PARALEGAL REAL PROPERTY CERTIFICATE

THIS IS TO CERTIFY THAT NUMO ADDISON of in the Tema Region in the Republic of Ghana, husband and wife,is registered as tenant or lessee for a term of 60 years from the 1 of January 1997 (less the last one day) (the lessee has an option with a possibility to renew for a further term of 20 restrictions, encumbrances, liens and interests as are notified by memorial u and in ALL THAT piece or parcel of land in extent 0.105 hectare(s) more or Accra Region of the Republic of Ghana aforesaid which said piece or parce edged with pink colour on Survey Plan No.105 annexed to this Certificate ex precious stones and timber whatsoever upon or under the said piece or parce

.....
CHIEF REGISTRAR OF LANDS

Entry No.	Date of Instrument	Date of Registration	Registered No.	MEMOR

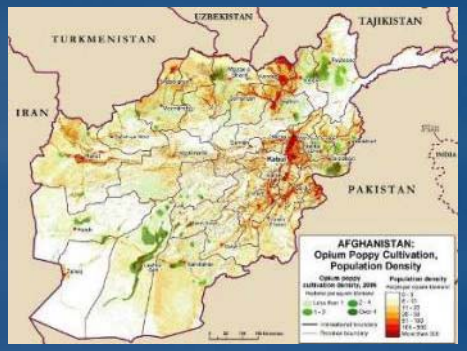
GIS-Based Land Registration Adds Value

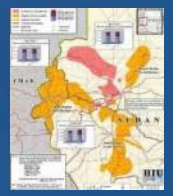
Geographic information is the key. . .

- Cadastre
- Land Registration
- Mapping
- Valuation
- Planning
- Survey
- Development
- Land Management
- Land Information Systems
- Spatial Data Infrastructures
- Urban Planning
  - Slum upgrading
  - Sanitation
  - Transportation
  - Safety
  - Flood zones
  - Hazardous areas
  - Illegal occupation
- Health & Human Services
  - Access to facilities
  - Illness tracking/Mapping
  - Managed care

Reconstruction
Iraq

Opium Cultivation
Afghanistan





Humanitarian Aid
Darfur

Children Out Of School
Ethiopia

Types of Data Accuracy

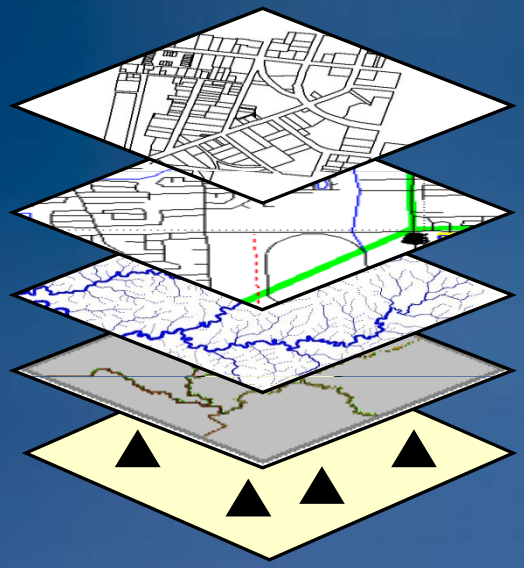
Measures of data correctness

- ***Topological*** *– how features relate to each other*
- ***Attribute*** *– non-graphical information about features*
- ***Absolute Spatial*** *– nearness to the true position*
- ***Relative Spatial*** *– how accurate relative to each other*
- ***Temporal*** *– how current is it*
- ***Feature Identification*** *– is it what we say it is*

. . . .data maintained in a structured environment

GIS data

Vector Data Layers



Land Ownership

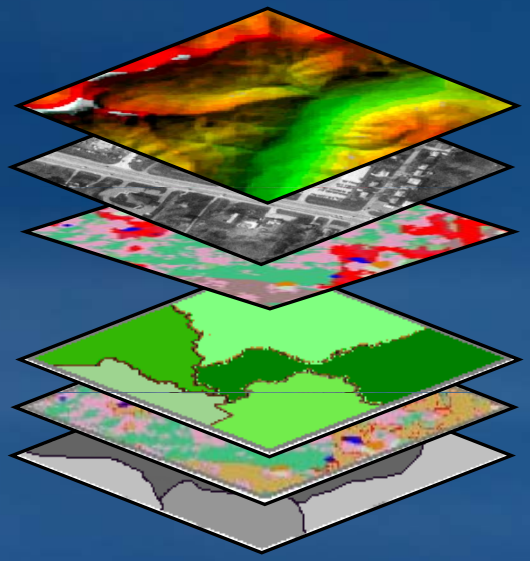
Transportation

Surface Waters

Boundaries

Geodetic Control

Raster Data Layers



Elevation

Imagery

Land cover

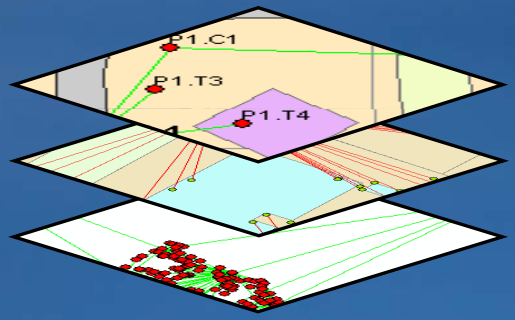
Soils

Vegetation

Slope

Others …

Survey Data Layers (Projects)



Cadastral Fabric

Buildings

Total Station Survey

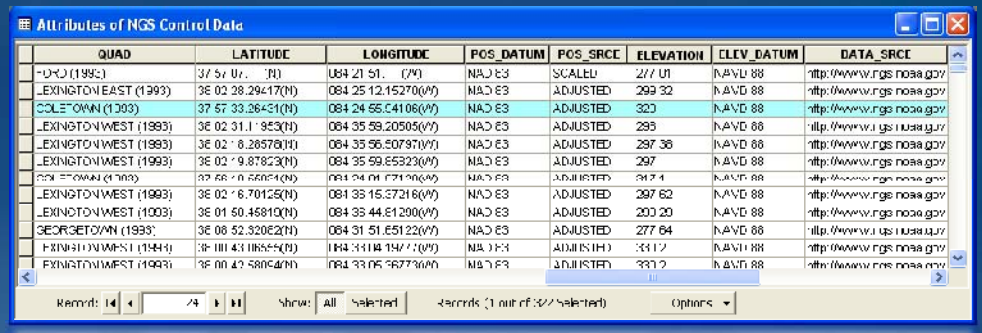
GPS Survey

Special editing tools for each data type

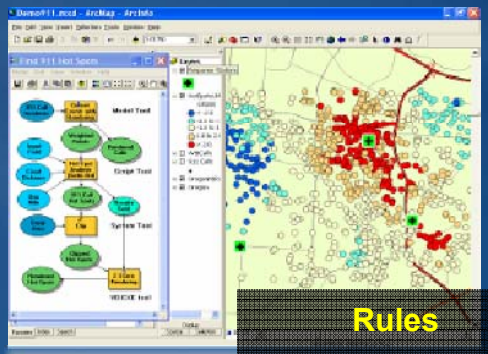
Components of geographic data

Properly structuring data powers new uses. . .

ATTRIBUTES

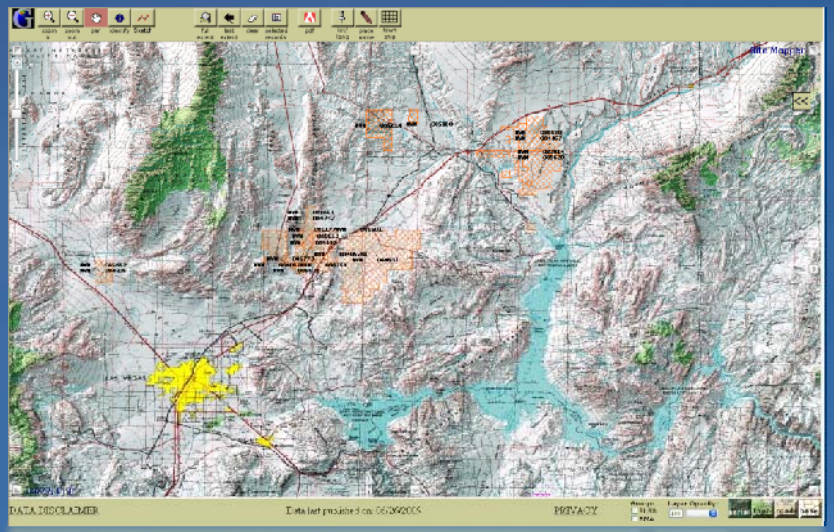


BEHAVIOR



Rules

Local streets and highways may not intersect

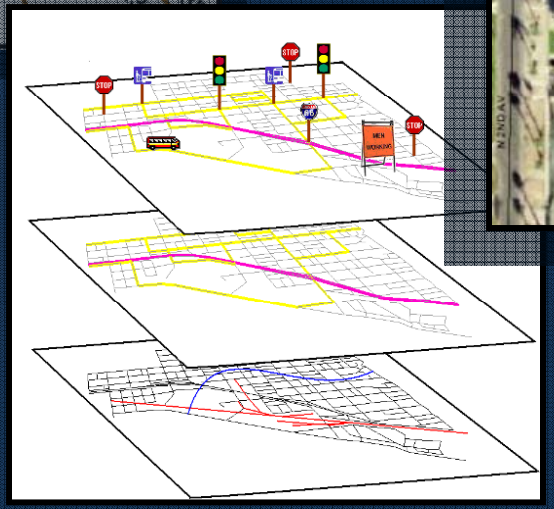


GEOMETRY

Most GIS layers register to:

Parcels

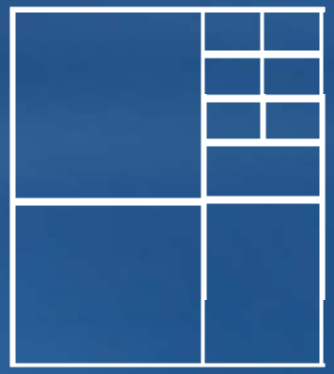
Photogrammetry/Ortho Base



Transportation

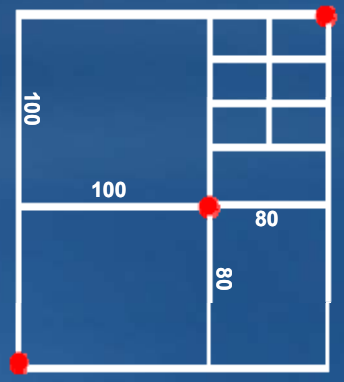
Three tiers of parcel data management

- Ink on mylar – scan/digitize
- COGO/CAD
- Survey controlled parcel fabric



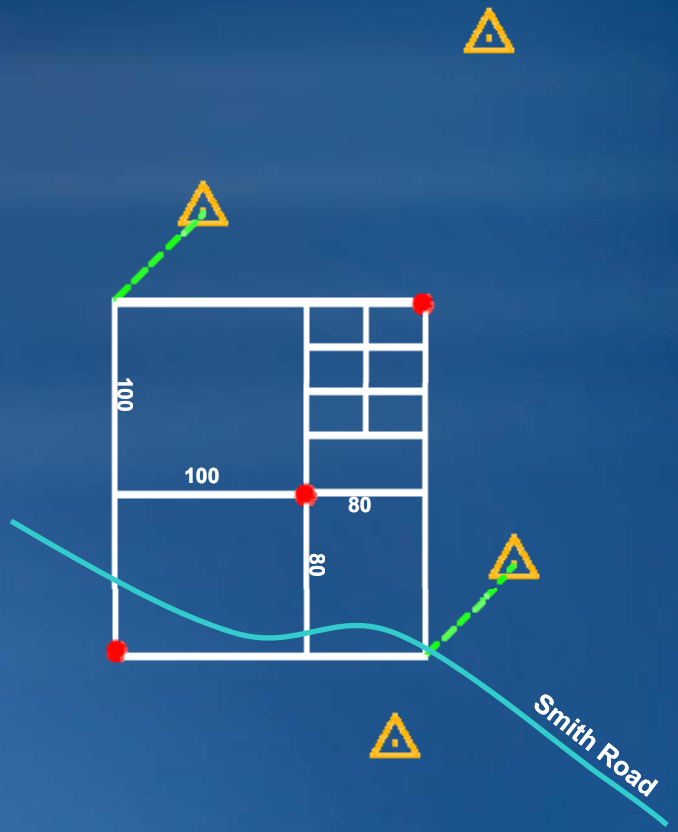
Three tiers of parcel data management

- Ink on mylar
- COGO/CAD – dimensions used for data entry
- Survey controlled parcel fabric



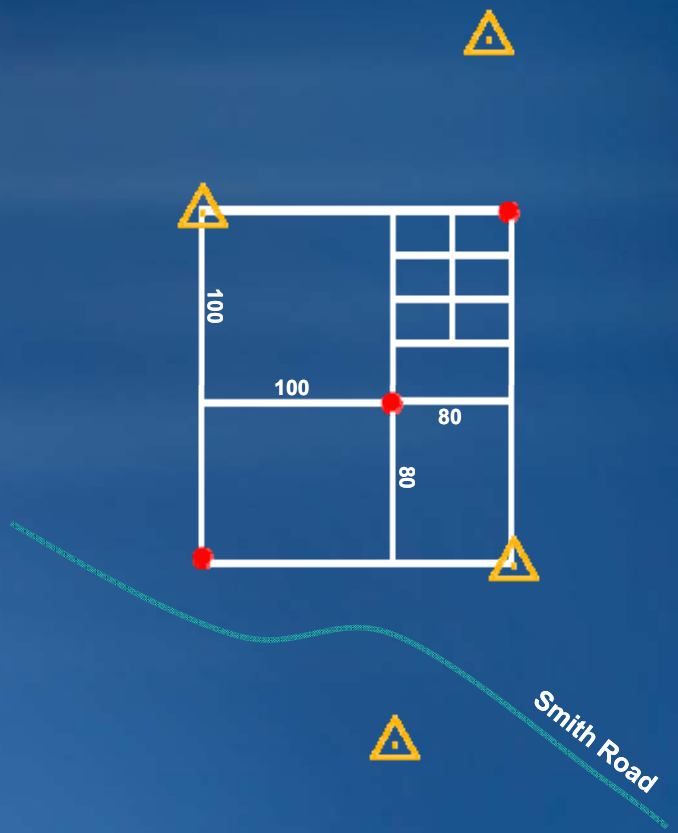
Three tiers of parcel data management

- Ink on mylar
- COGO/CAD
- **Parcel Fabric**
  - Plan Dimensions (COGO)
  - Control points
  - LSA
  - Associated Data Layers Adjusted



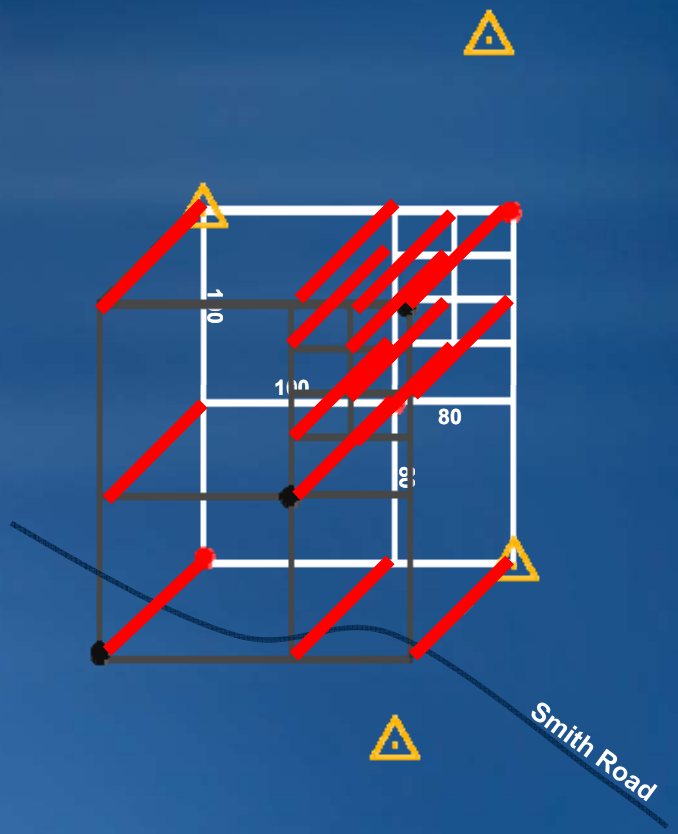
Three tiers of parcel data management

- Ink on mylar
- COGO/CAD
- **Parcel Fabric**
  - Plan Dimensions (COGO)
  - Control points
  - LSA
  - Associated data layers



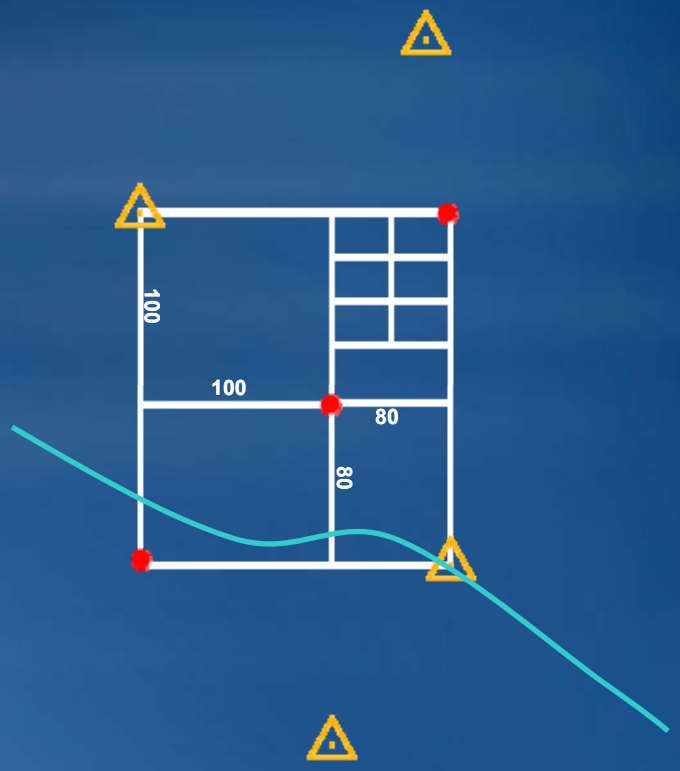
Three tiers of parcel data management

- Ink on mylar
- COGO/CAD
- **Parcel Fabric**
  - Plan Dimensions (COGO)
  - Control points
  - LSA
  - Associated data layers



Three tiers of parcel data management

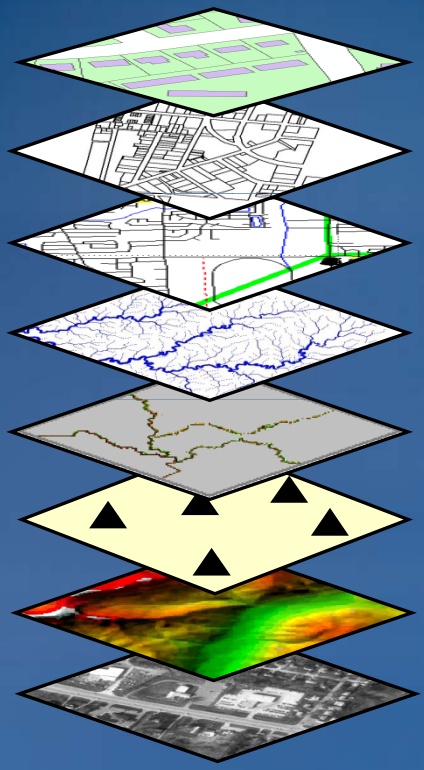
- Ink on mylar
- COGO/CAD
- **Parcel Fabric**
  - Plan Dimensions (COGO)
  - Control points
  - LSA
  - Associated data layers

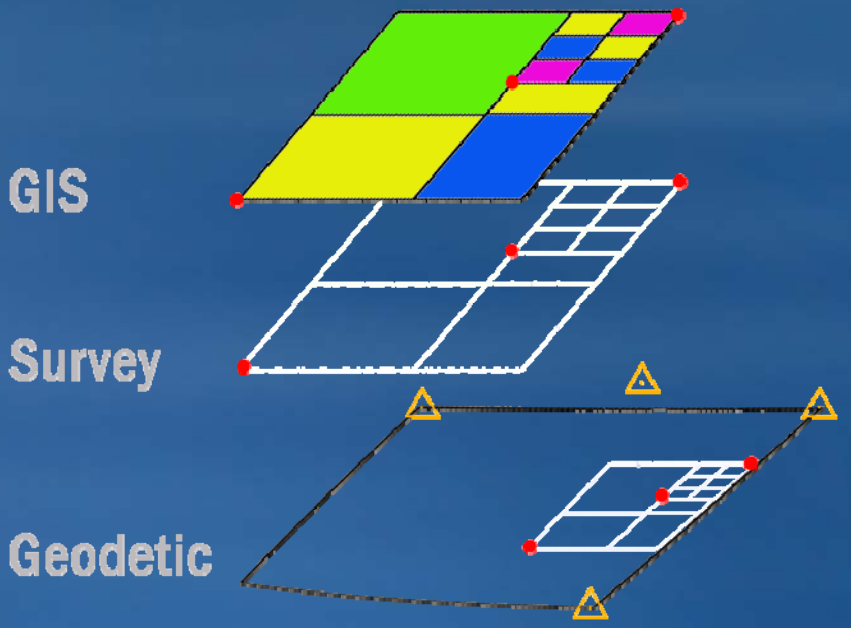


Before and After LSA

Survey-based parcel adjustment aligns parcels on orthos

GIS Data *Connected* to Survey Control Network
GIS Data *Incrementally Improves* with Record Measurements

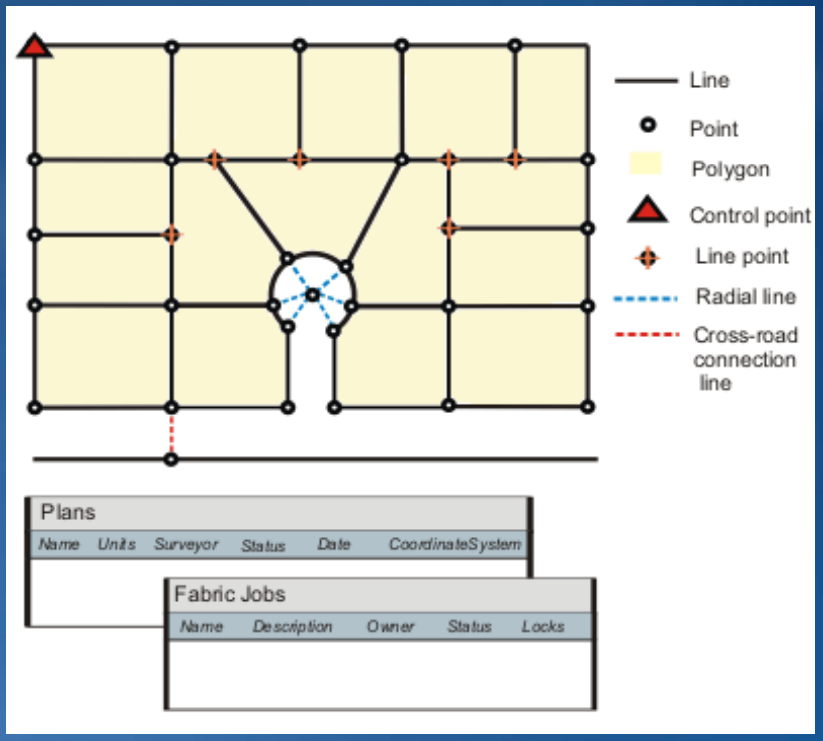




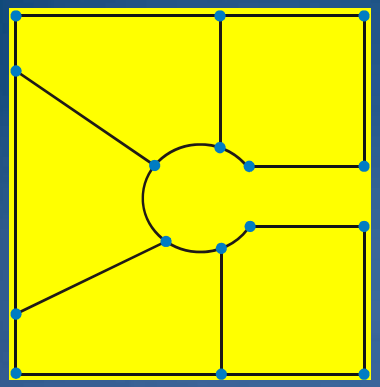
What is Parcel Fabric?

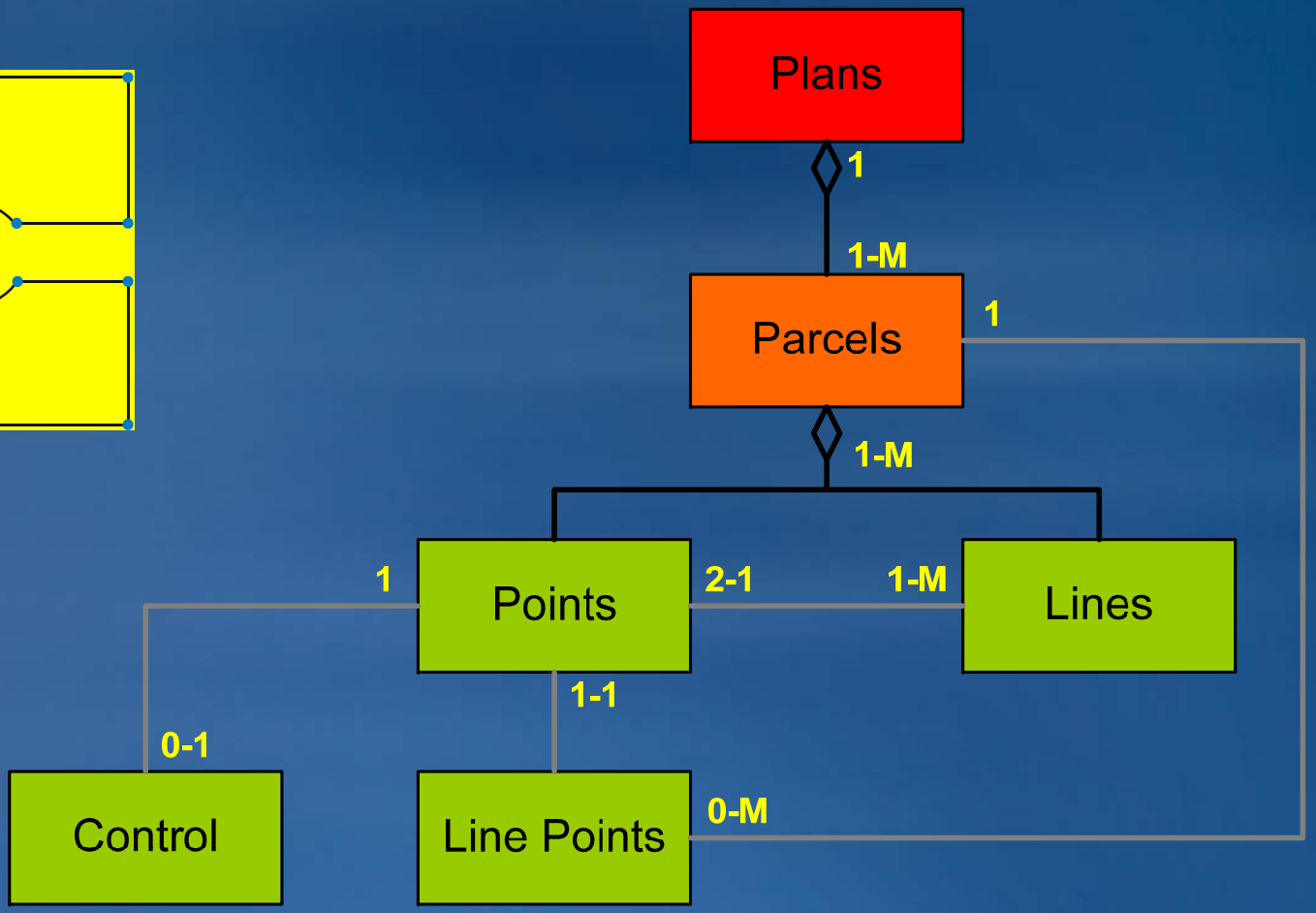
Parcel Fabric is a new dataset

- A continuous surface of connected parcels
- A dimensioned boundary network
- Internal Topology defined by common parcel corners
- Adjusted by Least-Squares



Parcel Fabric Data Model





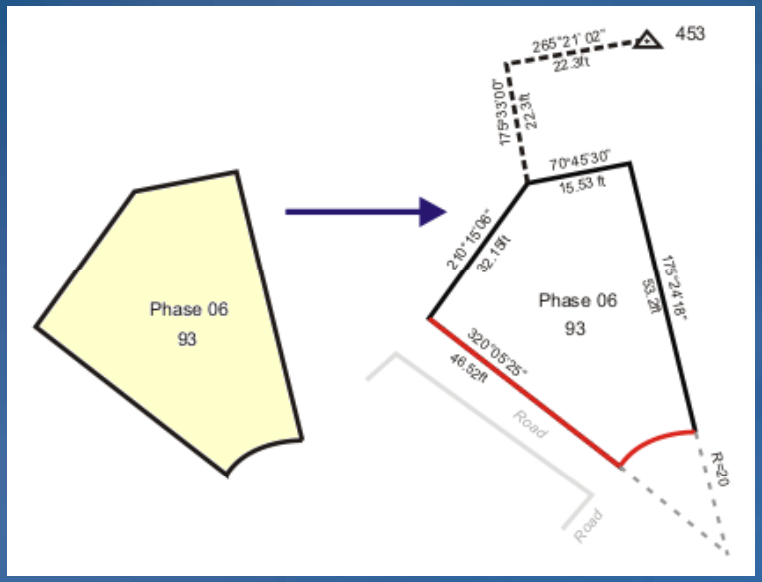
Parcel Data Model

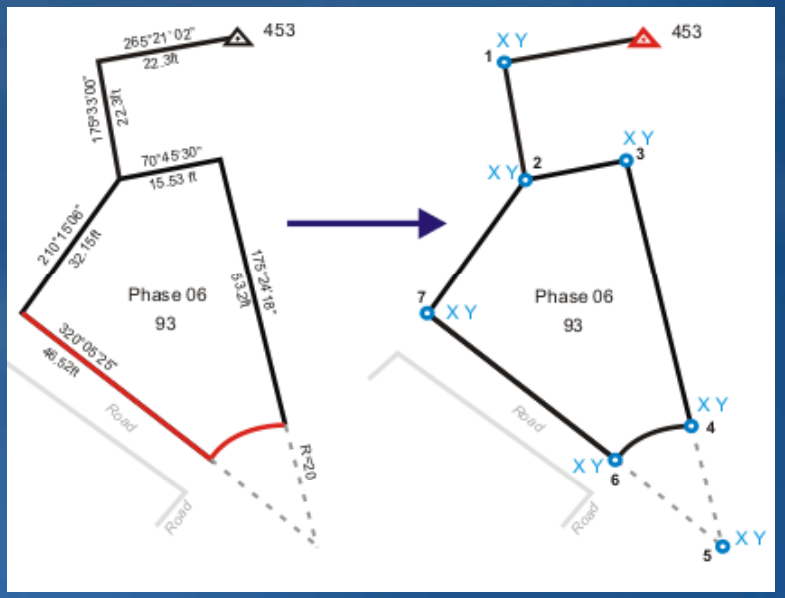
Parcel polygon

has 1 – M Lines

Parcel Line

has 2 Points

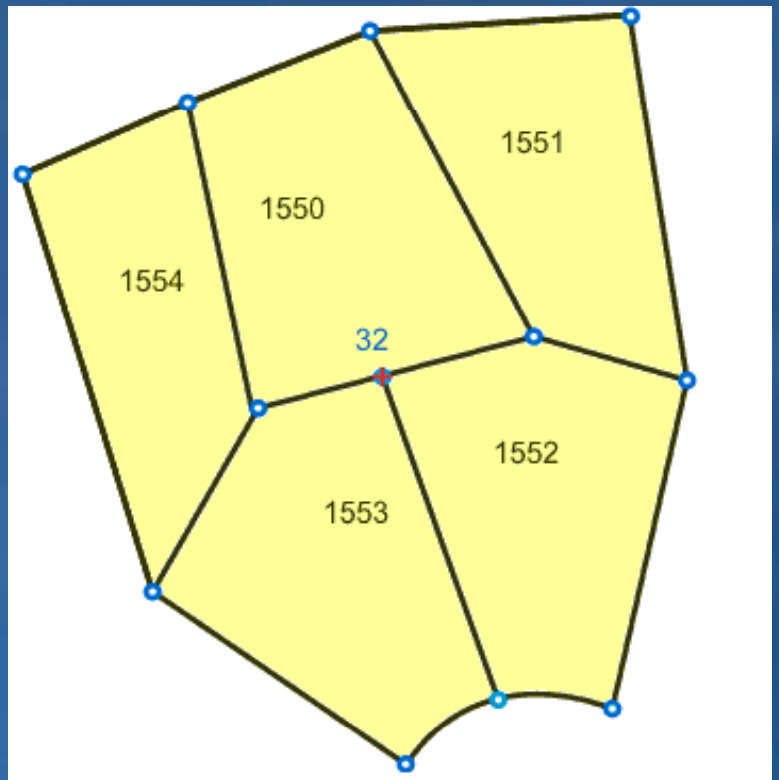




Lines store recorded dimensions. . . Points are common

Line points

- A parcel point becomes a ***Line Point*** when it sits on the boundary of an adjacent parcel, but does not split the boundary line.

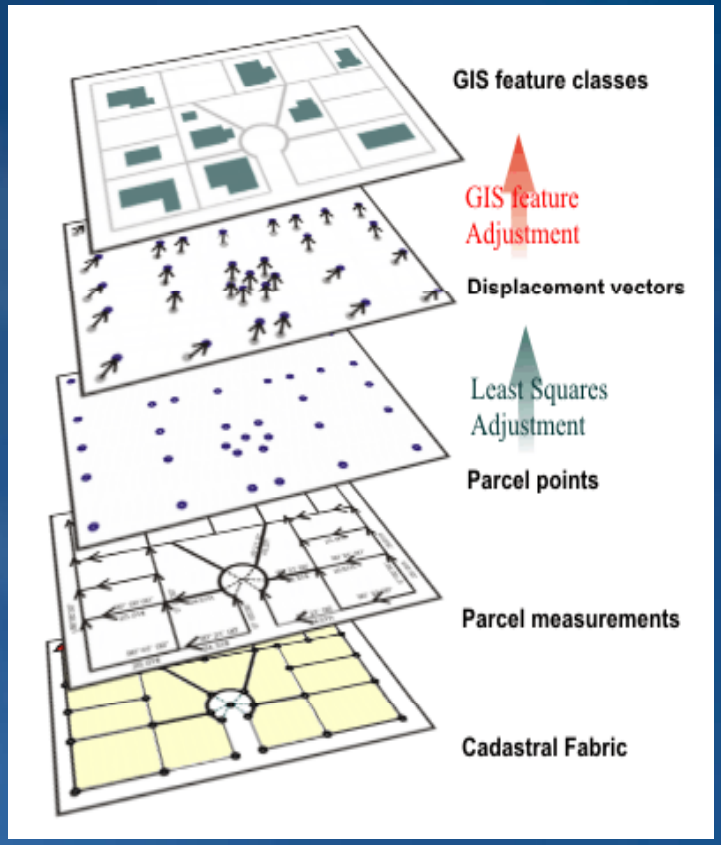


Point 32 is a line point on parcel 1550

GOAL of the Parcel Manager

Build a simple system to:

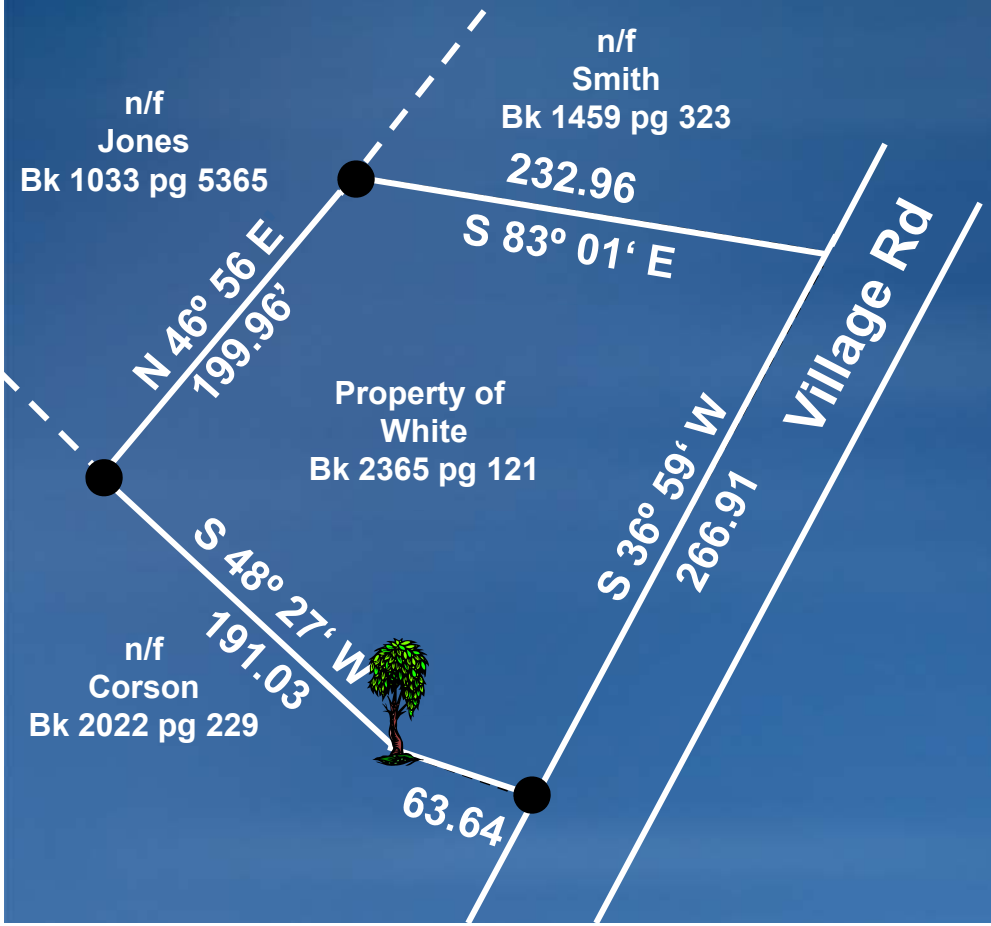
- Represent land record information in the GIS
- Provide a core model for a Land Information System (LIS)
- Process GPS coordinates and land records together in a productive editing environment
- Improve and maintain the accuracy of boundary geometry and associated GIS layers



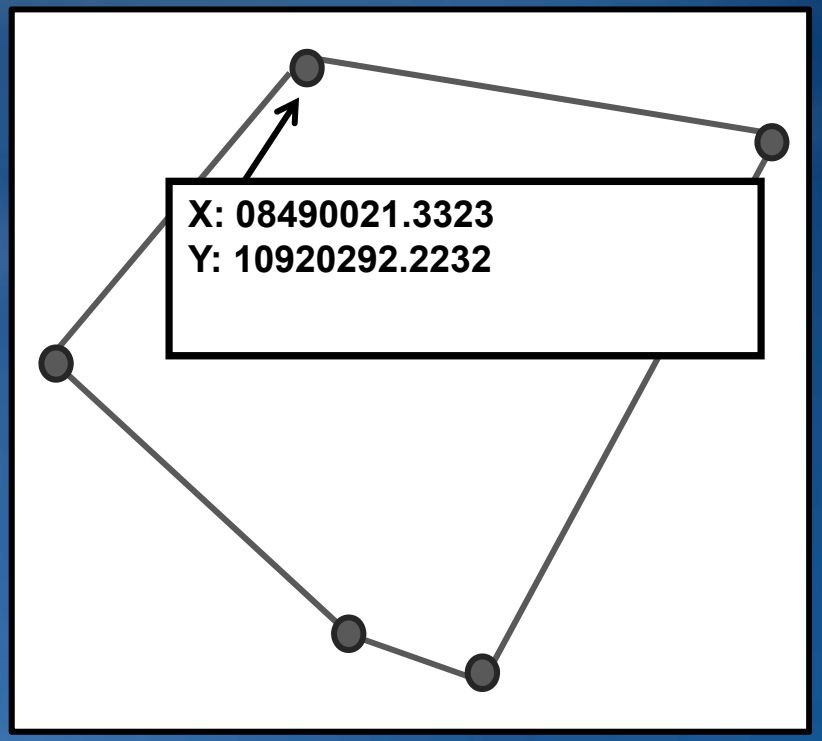
What is different about a parcel fabric?

Two layers of data, and history preserved

A Legal Representation



A GIS Representation

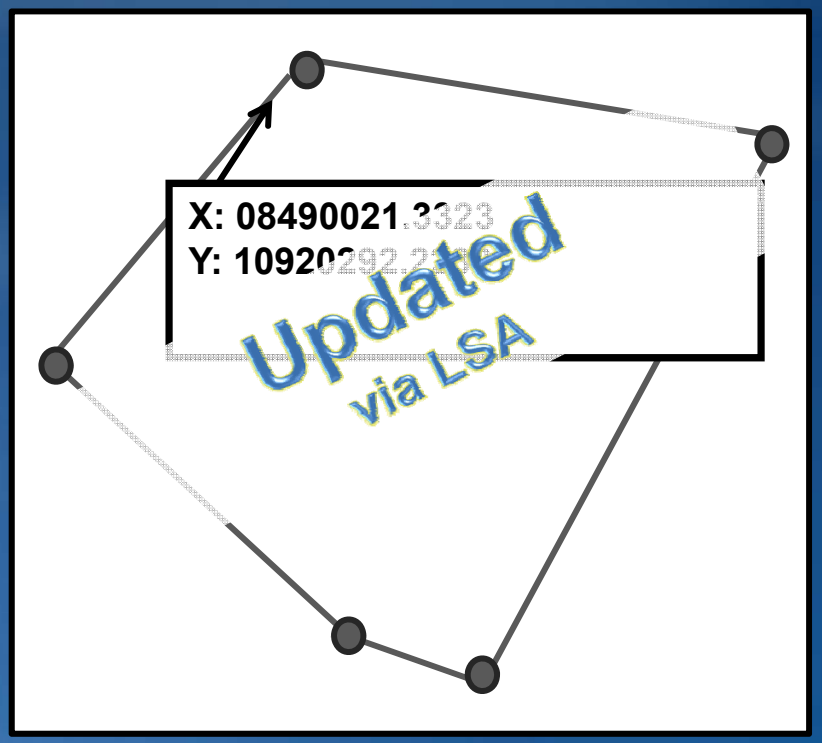


What is a parcel fabric?

Two layers of data, and history preserved

A Legal Representation

A GIS Representation



Why go through this effort?

- Represent land record information GIS
- Process precise coordinates and land records together in a productive editing environment
- Improve and maintain the accuracy of boundary geometry and associated GIS layers
- Integration of survey plans deeds
- Standardized procedures
- Eliminate duplicate data
- Enterprise system use – best data from the record

Enterprise GIS in Local Government

Successful Enterprise GIS sites follow common patterns. . .

OUR WORK

ArcGIS

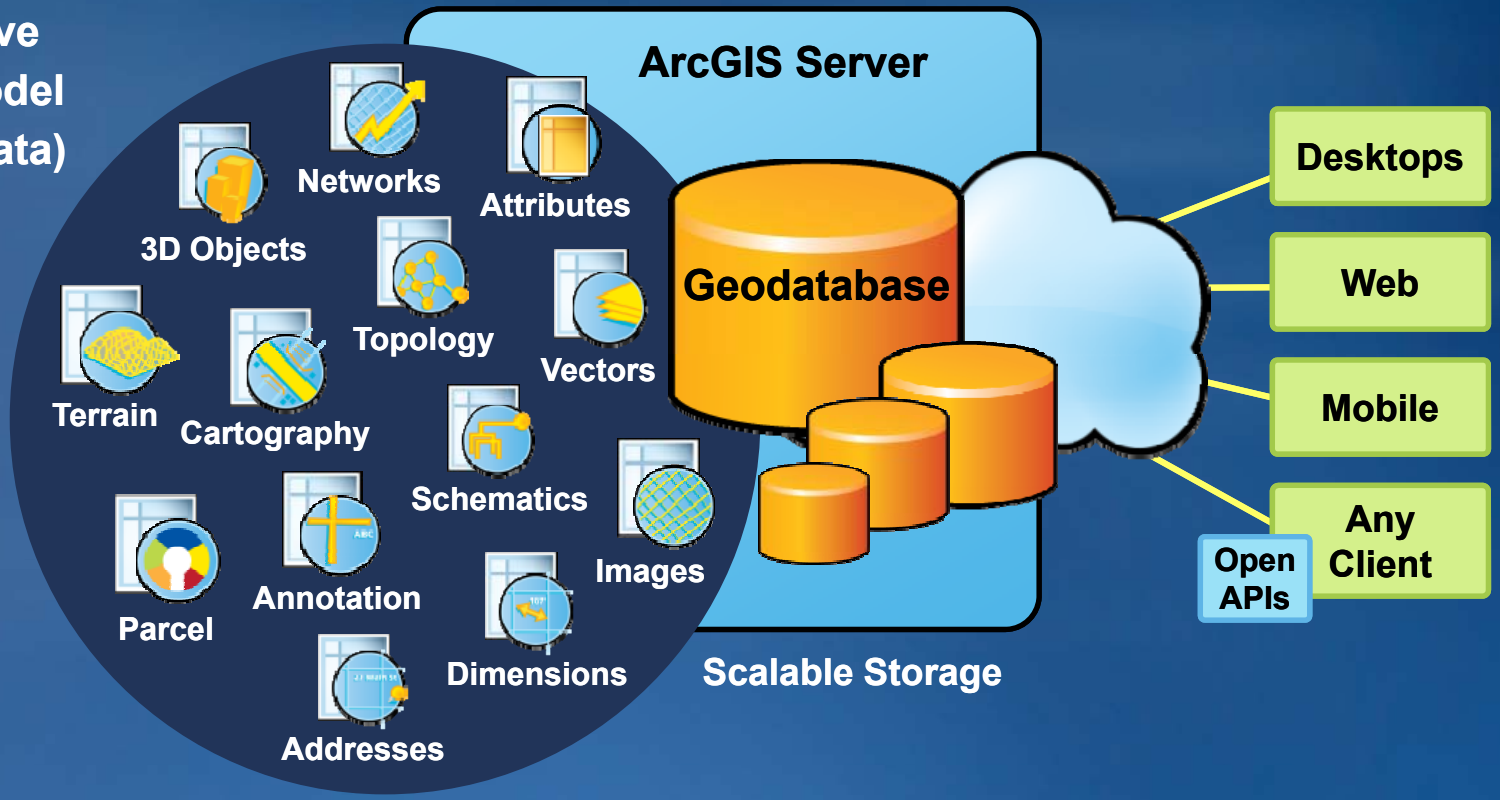
Desktop	Server	Mobile	Online
A Complete Integrated System			
• ArcReader • ArcView • ArcEditor • ArcInfo • Engine	• Workgroup • Enterprise	• ArcGIS Mobile • ArcPad	• Content • Services • Sharing

. . . For Authoring, Serving & Using Geography Everywhere

ArcGIS GEODATABASE

Organizes Your Geographic Information

Comprehensive Information Model (Any Type of Data)

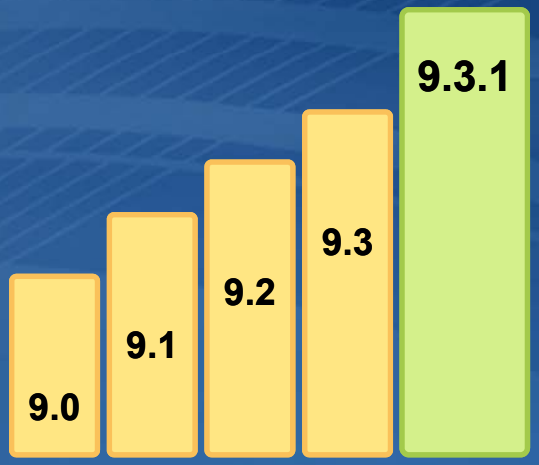


Essential for Leveraging the Full Capabilities of ArcGIS

ArcGIS 9.3.1

Has Substantially Improved Our Platform

- Quality
- Performance & Scalability
- Fast Dynamic Maps
- Rich Clients (Web 2.0)
- Easy Data Sharing
- Expanding Online Content
- Simplified Licensing

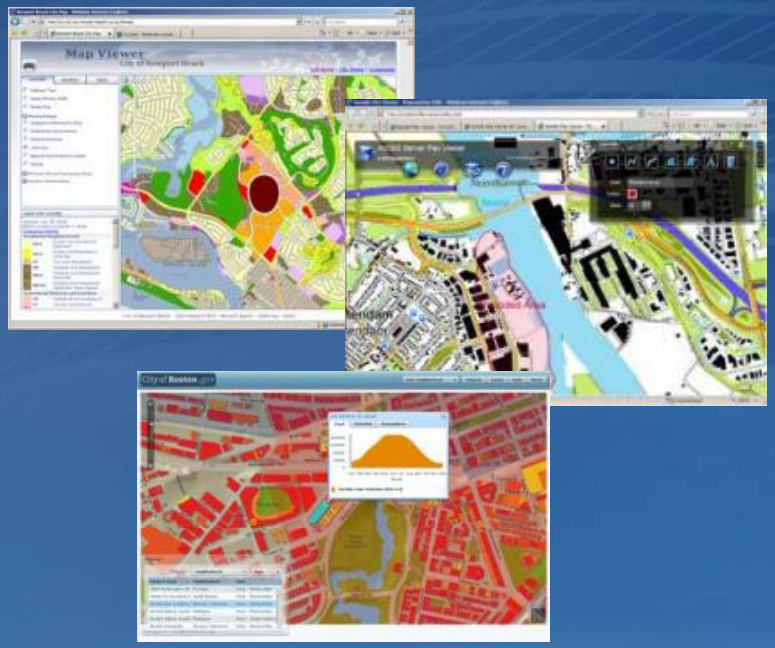


Providing a Great Platform for Web GIS

Rich Internet Applications (RIAs) Are Growing Rapidly

Providing a Powerful Way To Access & Integrate GIS Services

- Highly Interactive
- Lightweight
- Integrating Multiple Services



- JavaScript
- Flex
- Silverlight

Part of ArcGIS Server . . .
. . . Free for Noncommercial Use

Online Services are a Key Component of ArcGIS

Ready-to-Use Maps & Imagery

Streets

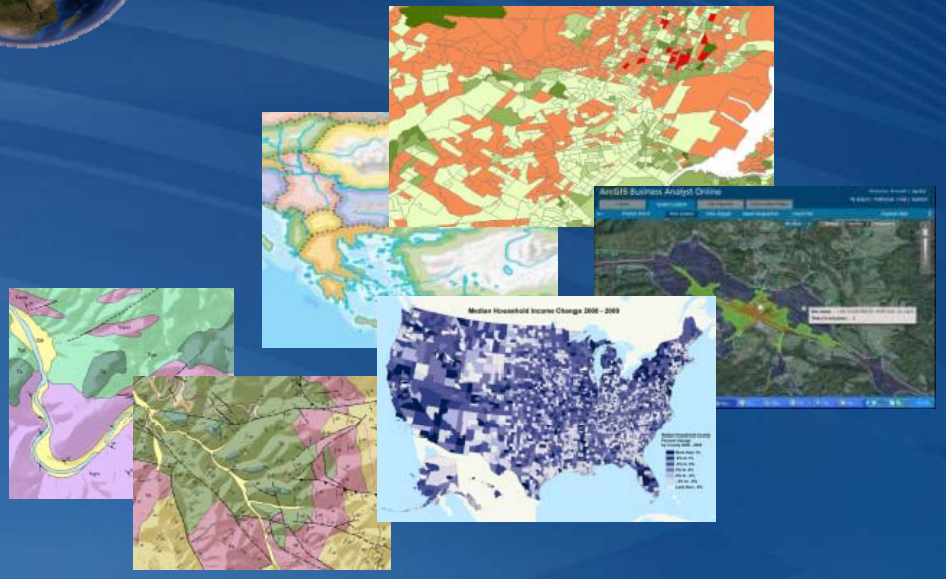
Imagery

Delivered to Users

- Online
- DVD Media
- Appliance

Topographic

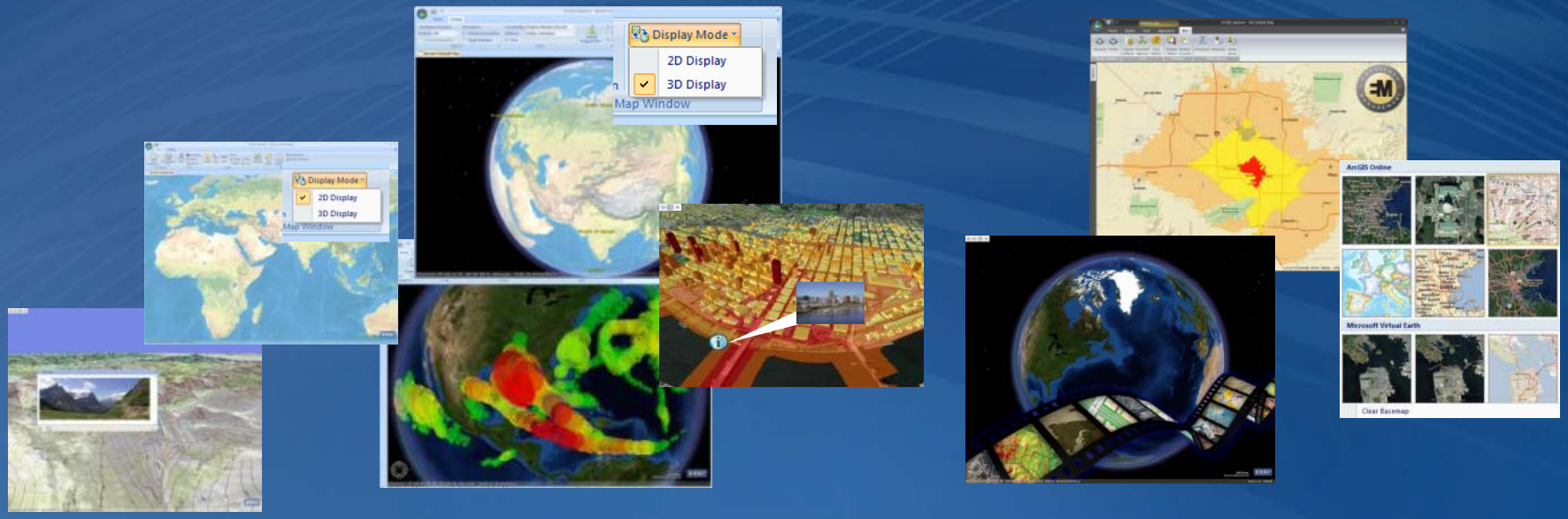
Demographic & Thematic



The New ArcGIS Explorer Is a Big Step Forward

Free, Easy & Exciting GeoVisualization

- 2D & 3D Mapping
- **Integrates Local Data**
- Supports Presentations
- Customizable

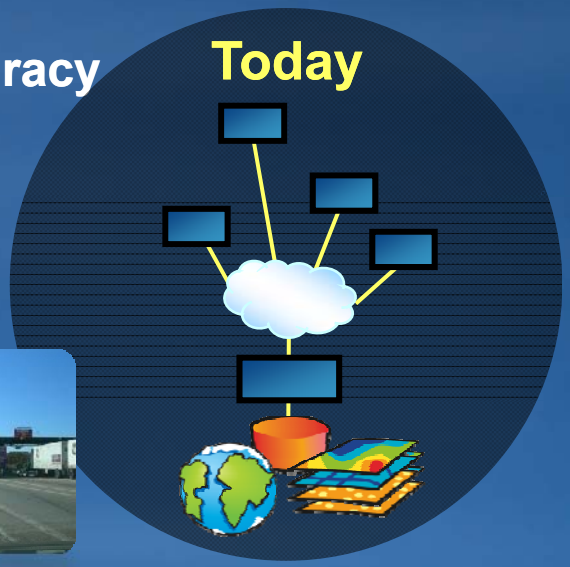


A Whole New Way to Understand & Make Decisions

Final Thoughts

Gettin' on the enterprise bus. . .

- **You may need to maintain data differently in the past**
  - **New uses**
  - **New dependencies**
- **Requirements will continue to evolve**
  - **New users, new requirements**
- **Parcel data is key for many reasons**
  - **Large user community**
  - **Many uses**
  - **Framework for accuracy**



Thanks!

Brent A. Jones, PE, PLS
ESRI
Survey/Engineering/Cadastre
Industry Manager
bjones@esri.com
Twitter – BrentJones_ESRI