Changing World of GIS

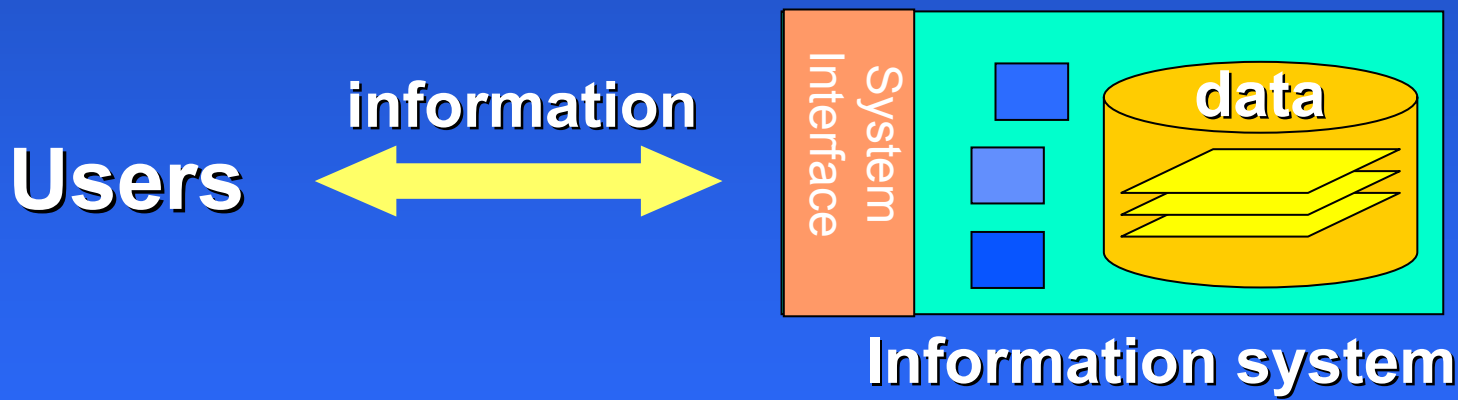
DOI Executive Workshop
July 14, 2004

Clint Brown, ESRI

What is an information system?

Driven by mission and business needs

- An information system is a tool for providing useful **information** through management and analysis of **data**.



- The design of the system is based on the information we want the system to provide and manage.

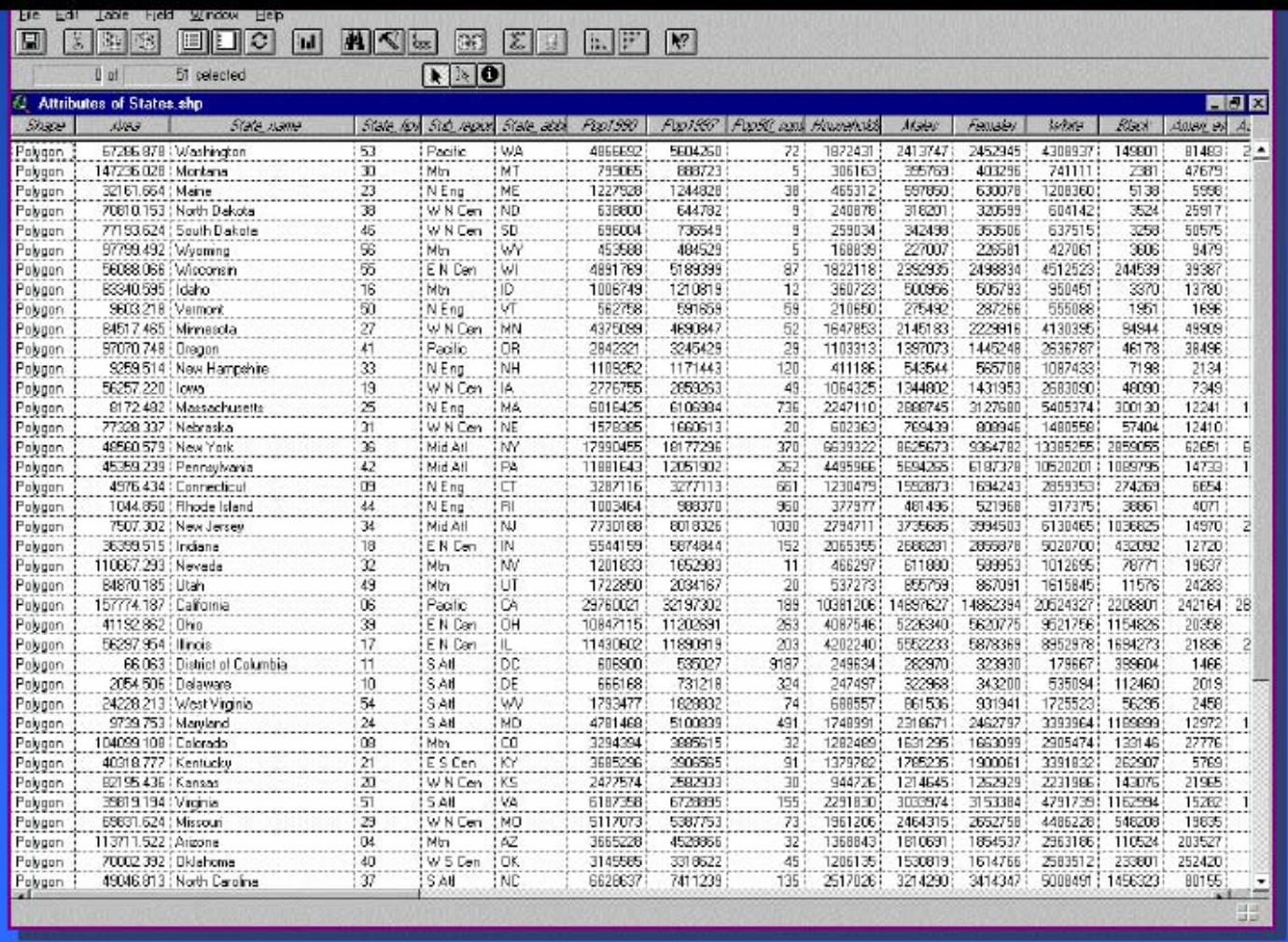
Outline

- Quick Intro to GIS
- GIS is evolving
- GIS and IT
- GIS Interoperability

A Quick Intro to GIS

Database

"Not Easy to Interpret"



File Edit Table Field Window Help

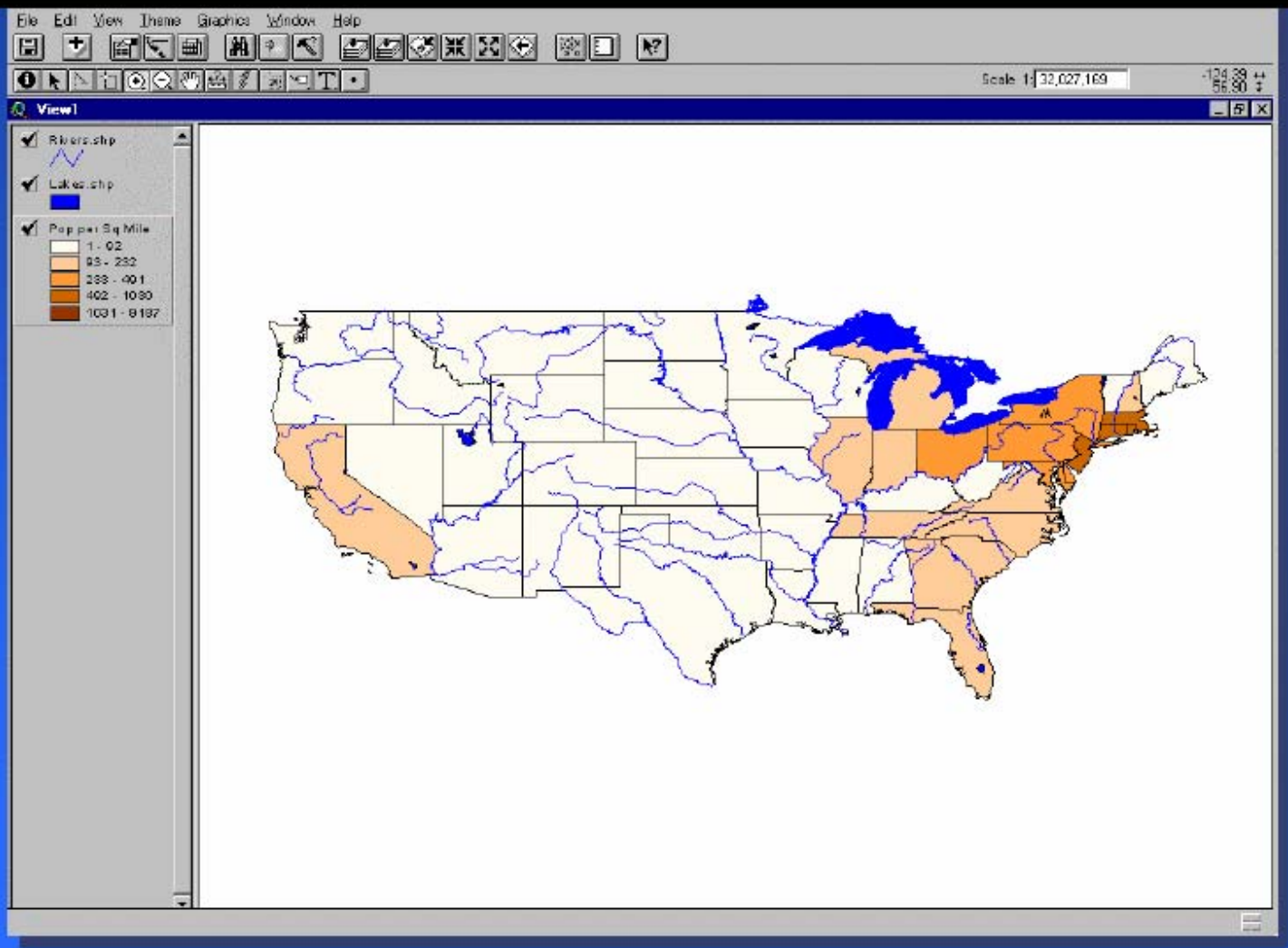
0 of 51 selected

Attributes of States.shp

Shape*	Area	State_name	State_fips	Sub_region	State_abbr	Pop1990	Pop1997	Pop90_sqmi	Households	Males	Females	Whites	Blacks	Amer_Ind	A
Polygon	67286.978	Washington	53	Pacific	WA	4866692	5604250	72	1872431	2413747	2452945	4308937	149801	81483	2
Polygon	147236.028	Montana	30	Mtn	MT	799065	880723	5	306163	395769	403296	741111	2381	47679	
Polygon	32161.664	Maine	23	N Eng	ME	1227928	1244828	38	465312	597850	630078	1208360	5138	5998	
Polygon	70810.153	North Dakota	38	W N Cen	ND	638800	644782	9	240878	316201	320599	604142	3524	25917	
Polygon	77153.624	South Dakota	46	W N Cen	SD	696004	736549	9	259034	342498	353506	637515	3258	50575	
Polygon	97799.492	Wyoming	56	Mtn	WY	453588	484529	5	168039	227007	226581	427061	3606	9479	
Polygon	56088.066	Wisconsin	55	E N Cen	WI	4891769	5189399	87	1822118	2392935	2498834	4512523	244539	39387	
Polygon	83340.595	Idaho	16	Mtn	ID	1006749	1210819	12	360723	500966	505793	950461	3370	13780	
Polygon	9603.218	Vermont	50	N Eng	VT	562758	591859	59	210650	275492	287266	555088	1951	1696	
Polygon	84517.485	Minnesota	27	W N Cen	MN	4375099	4690847	52	1647853	2145183	2229916	4130395	94944	49909	
Polygon	97070.748	Oregon	41	Pacific	OR	2842321	3245429	29	1103313	1397073	1445248	2636787	46178	38496	
Polygon	9269.514	New Hampshire	33	N Eng	NH	1109252	1171443	120	411186	543544	565708	1087433	7198	2134	
Polygon	56257.220	Iowa	19	W N Cen	IA	2776755	2853263	49	1064325	1344802	1431953	2683090	48090	7349	
Polygon	8172.492	Massachusetts	25	N Eng	MA	6016425	6106994	736	2247110	2868745	3127690	5405374	300130	12241	1
Polygon	77328.337	Nebraska	31	W N Cen	NE	1578385	1660613	20	602363	769439	808946	1480558	57404	12410	
Polygon	49560.579	New York	36	Mid Atl	NY	17990455	18177296	370	6639322	8626673	9364782	13385255	2859055	62651	6
Polygon	45359.239	Pennsylvania	42	Mid Atl	PA	11881643	12051902	262	4495966	5694255	6187378	10520201	1089795	14733	1
Polygon	4976.434	Connecticut	09	N Eng	CT	3287116	3277113	661	1230479	1552873	1634243	2855353	274269	6654	
Polygon	1044.850	Rhode Island	44	N Eng	RI	1003464	988370	960	377977	481496	521968	917375	38861	4071	
Polygon	7507.302	New Jersey	34	Mid Atl	NJ	7730188	8018326	1030	2794711	3735685	3994503	6130465	1036825	14970	2
Polygon	36359.515	Indiana	18	E N Cen	IN	5544159	5874844	152	2065355	2688231	2855978	5020700	432092	12720	
Polygon	110067.293	Nevada	32	Mtn	NV	1201833	1652393	11	466297	611880	589953	1012695	78771	19637	
Polygon	84870.185	Utah	49	Mtn	UT	1722850	2034167	20	537273	855759	867091	1615845	11576	24283	
Polygon	157774.187	California	06	Pacific	CA	29760021	32197302	189	10381206	14897627	14862394	20624327	2208801	242164	28
Polygon	41152.962	Ohio	39	E N Cen	OH	10847115	11209891	263	4087546	5226340	5620775	9521756	1154826	20358	
Polygon	56287.954	Illinois	17	E N Cen	IL	11430602	11890819	203	4202240	5552233	5878369	8852978	1694273	21896	2
Polygon	66.063	District of Columbia	11	S Atl	DC	606900	535027	9187	249634	282970	323930	179667	399604	1466	
Polygon	2054.506	Delaware	10	S Atl	DE	666168	731218	324	247497	322968	343200	535084	112460	2019	
Polygon	24228.213	West Virginia	54	S Atl	WV	1793477	1828332	74	688557	861536	931941	1725523	56295	2458	
Polygon	9739.753	Maryland	24	S Atl	MD	4781468	5100939	491	1748991	2316671	2462797	3393964	1189999	12972	1
Polygon	104099.108	Colorado	08	Mtn	CO	3294394	3995615	32	1282469	1631295	1663099	2905474	133146	27776	
Polygon	40318.777	Kentucky	21	E S Cen	KY	3685296	3908565	91	1379782	1795235	1900061	3391832	262907	5769	
Polygon	82195.436	Kansas	20	W N Cen	KS	2477574	2682933	30	944726	1214645	1262929	2231986	143076	21965	
Polygon	39819.194	Virginia	51	S Atl	VA	6187358	6728895	155	2291830	3033974	3153384	4791735	1162994	15262	1
Polygon	69631.624	Missouri	29	W N Cen	MO	5117073	5387753	73	1961206	2464315	2652758	4486228	548208	19635	
Polygon	113711.522	Arizona	04	Mtn	AZ	3665228	4528866	32	1368843	1810691	1854537	2963186	110524	203527	
Polygon	70002.392	Oklahoma	40	W S Cen	OK	3145585	3318522	45	1206135	1530819	1614766	2583512	233801	252420	
Polygon	49046.813	North Carolina	37	S Atl	NC	6628637	7411239	135	2517026	3214290	3414347	5008491	1456323	80155	

Visualization

"Worth a Thousand Words"

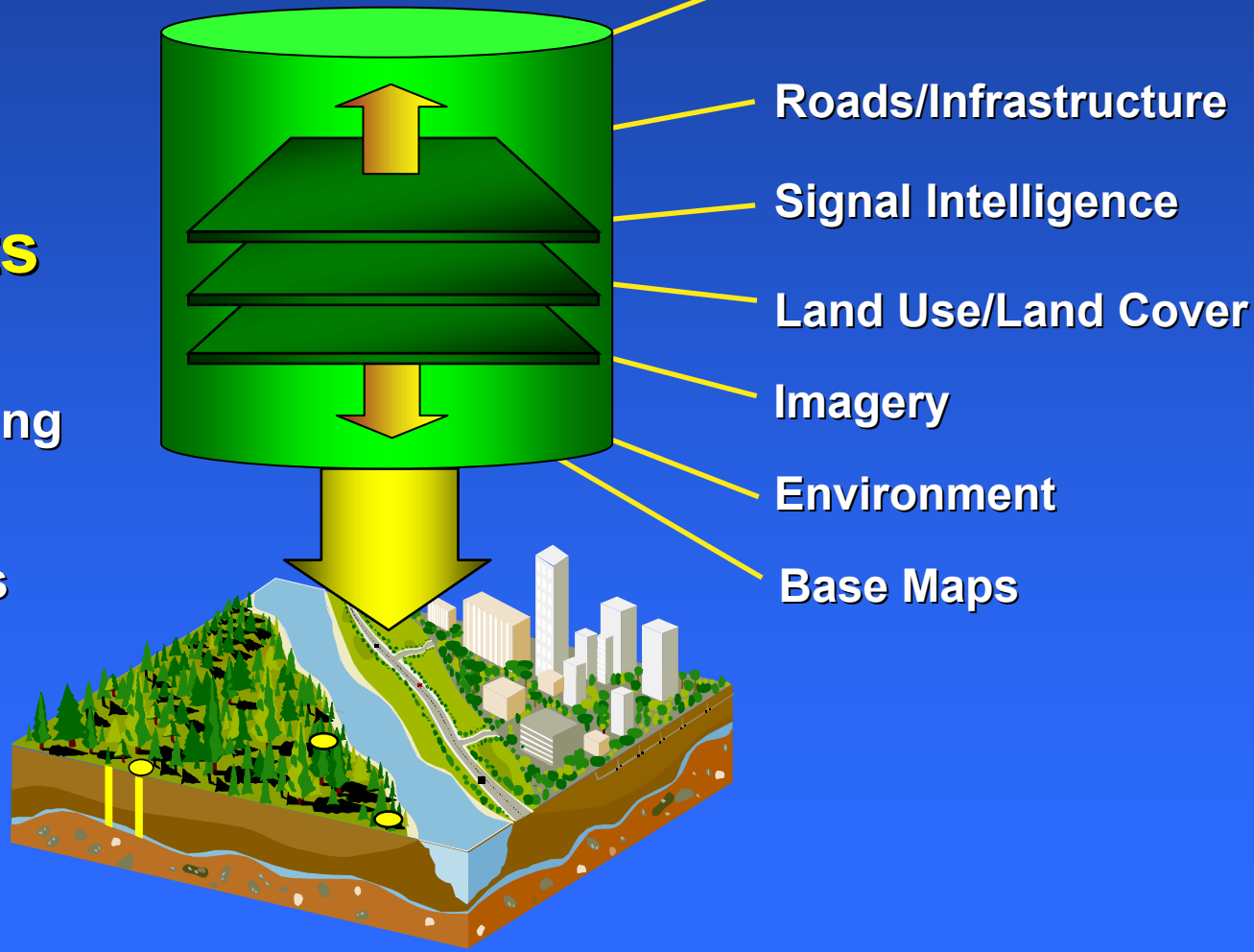


GIS Integrates All Types of Data

Geography is a "Key"

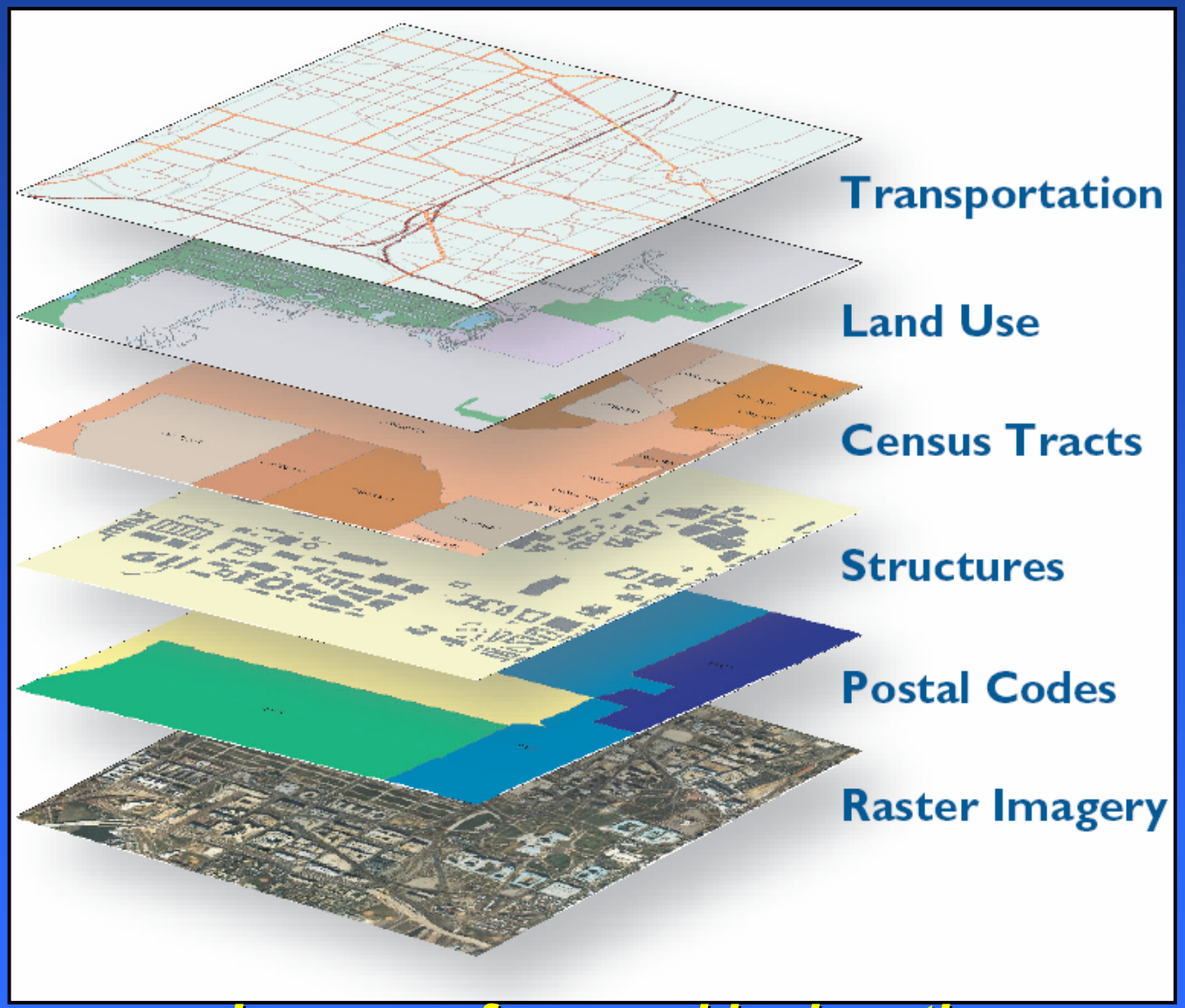
Key Concepts

- Georeferencing
- Digital Processing
- Map Overlay
- Spatial Analysis
- Visualization



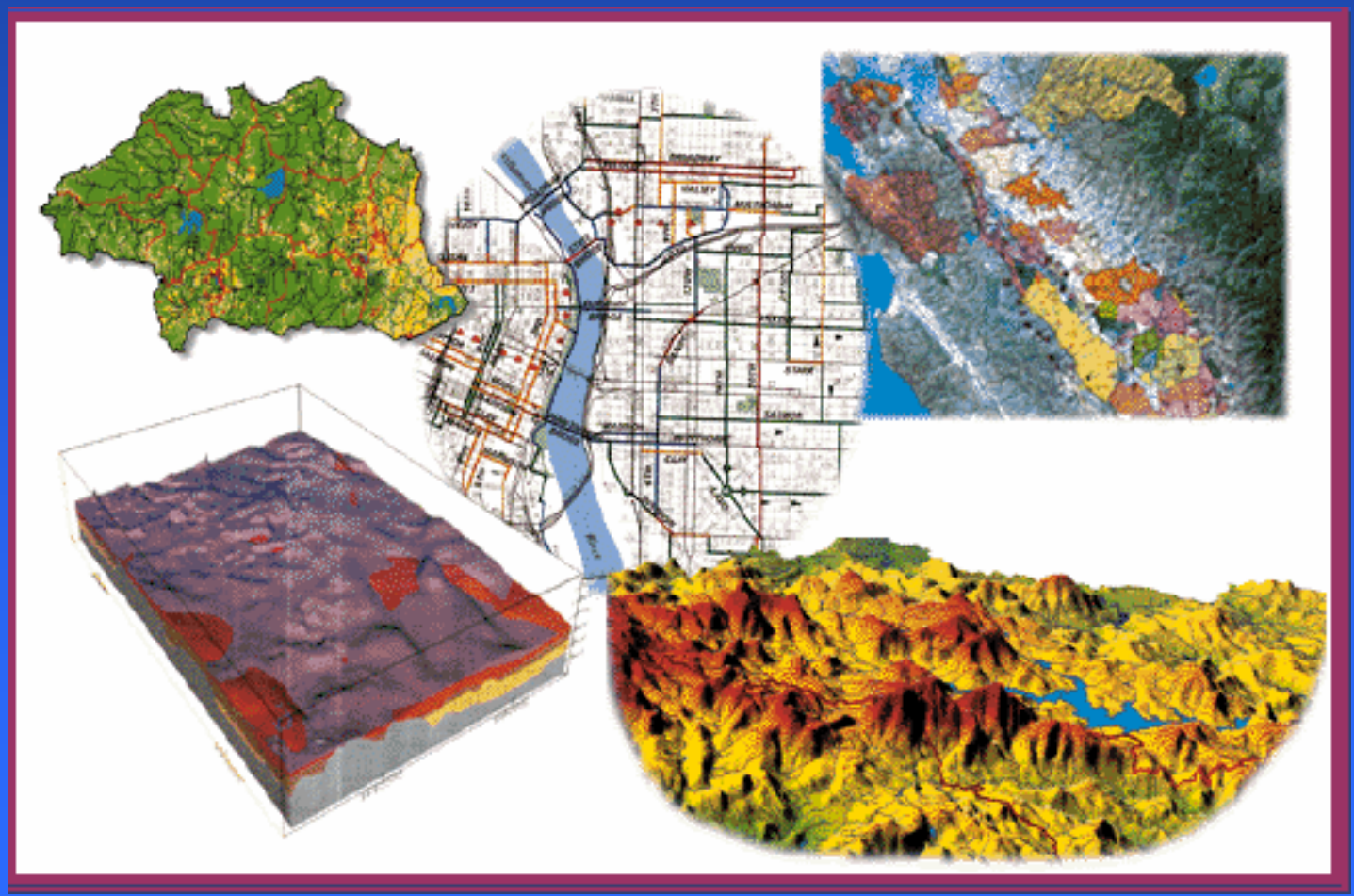
. . . Integrating Disciplines, Organizations and Activities

GIS is Layer-Centric



…Layers referenced by location

Combine Data from Many Sources



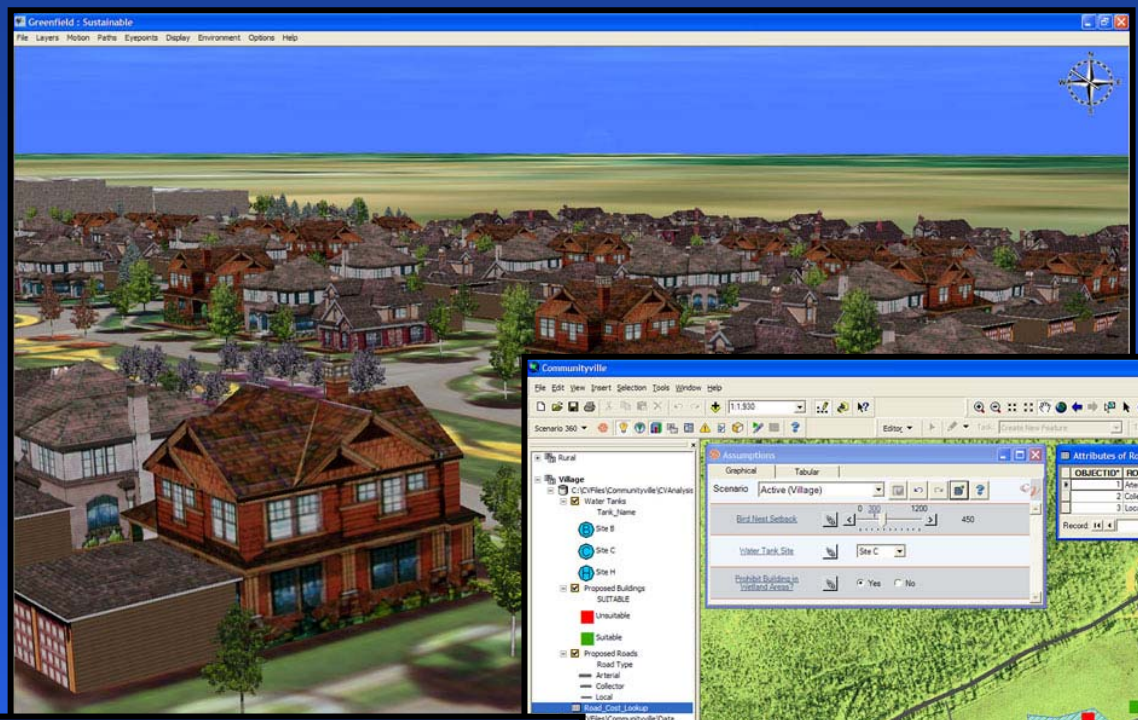
GIS Applications

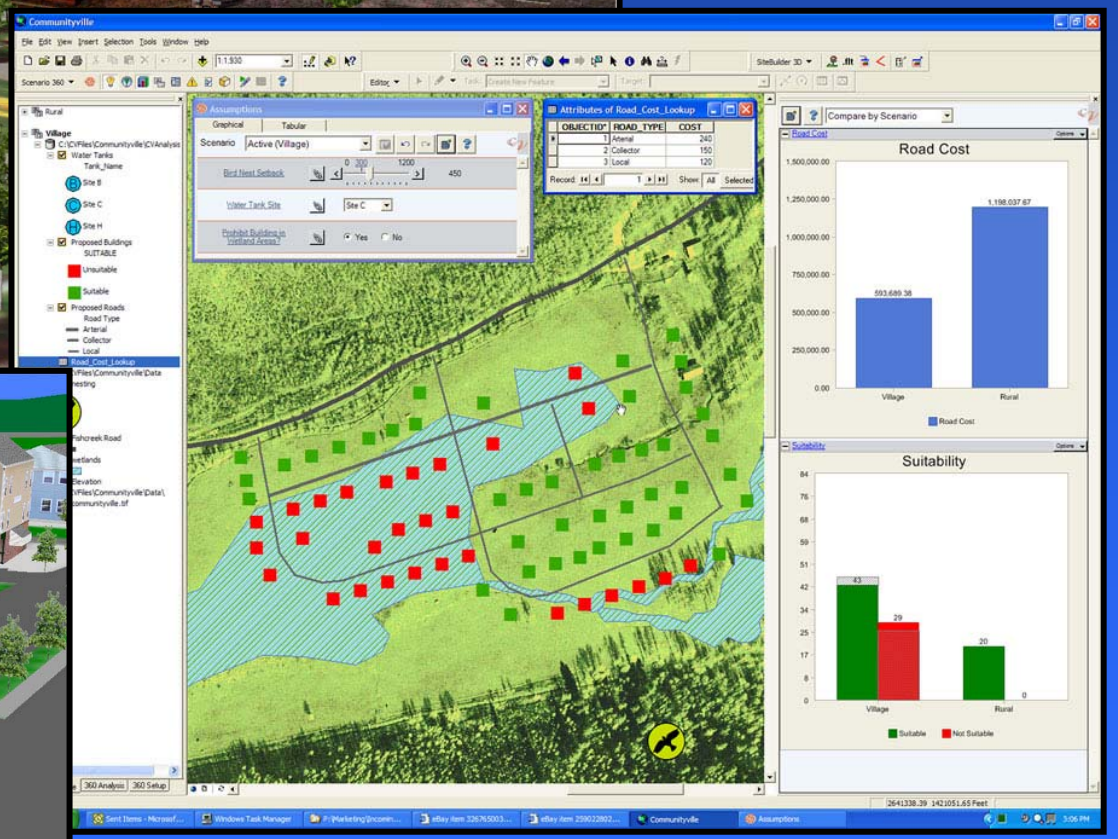
- Population
- Bio-Diversity
- Global Warming
- Facilities
- Urbanization
- Pollution
- Congestion
- Conservation
- Land Use
- Oceans
- Business Efficiency
- Water
- Economic Development
- Crime
- Health
- Education
- Logistics
- Energy
- Defense/Security
- Environment
- eGovernment
- Globalization
- Agriculture/Forestry
- Public Safety
- Transportation

…Are Serving Our World

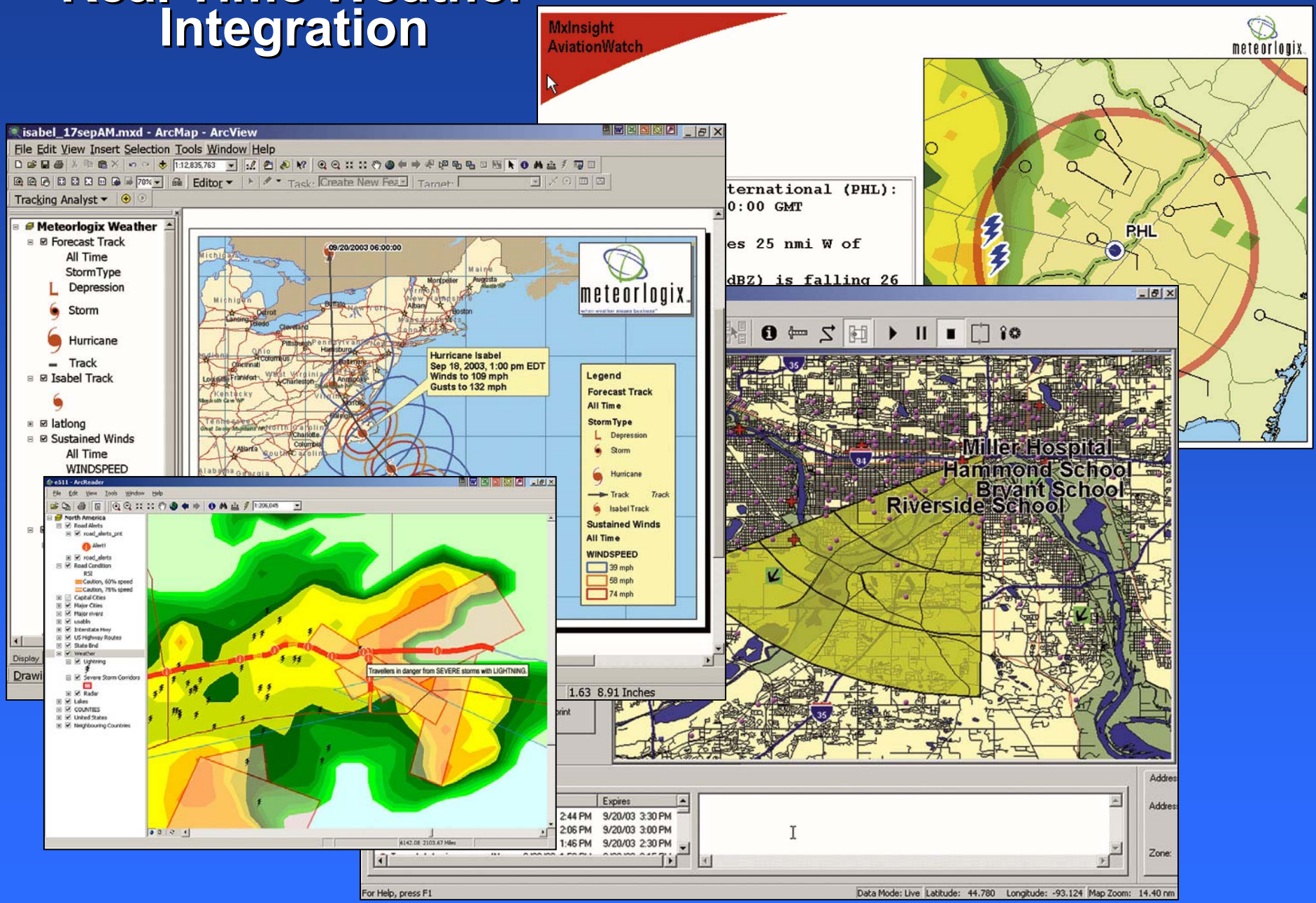
Risk Analysis

Community Planning

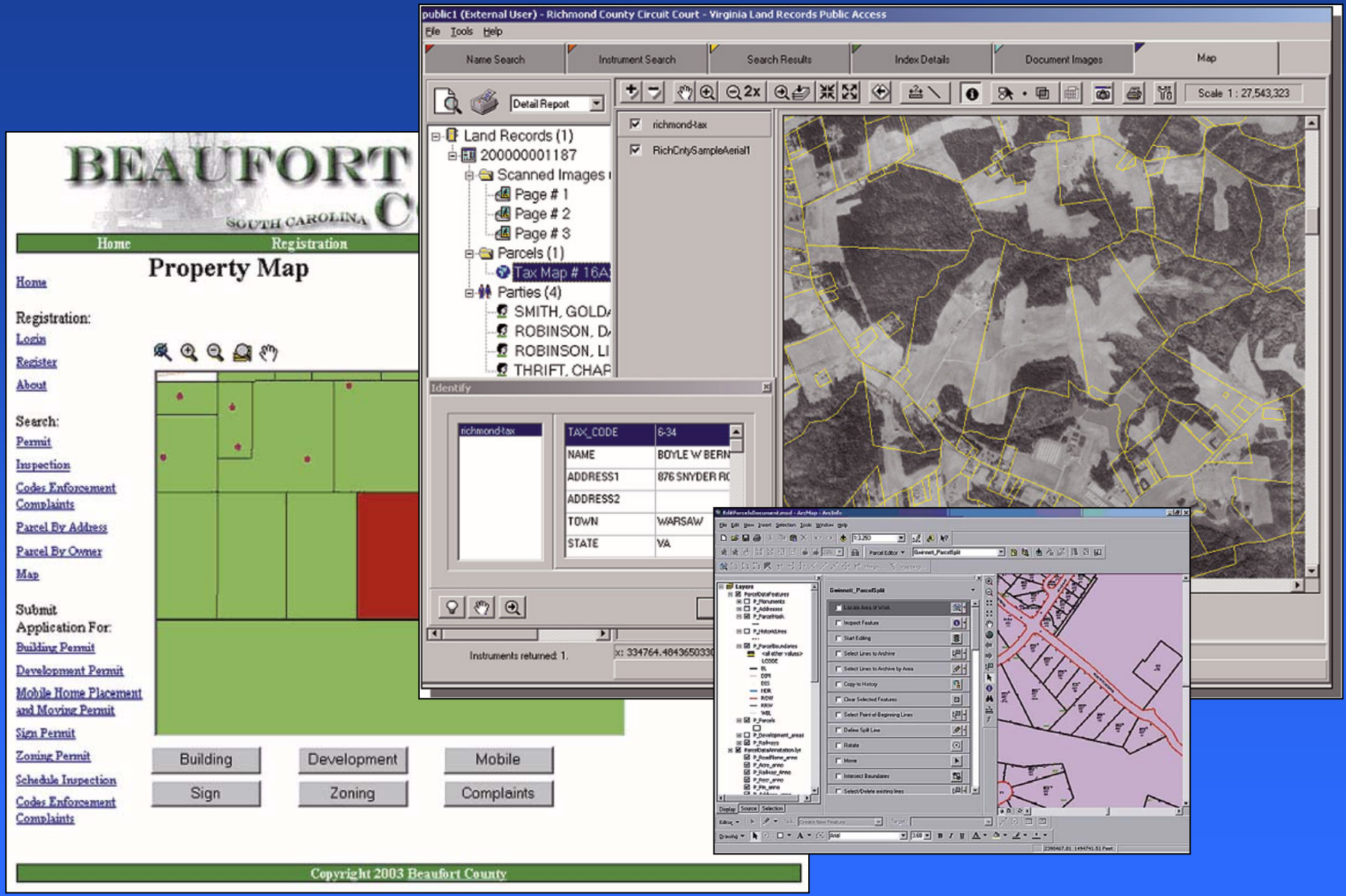




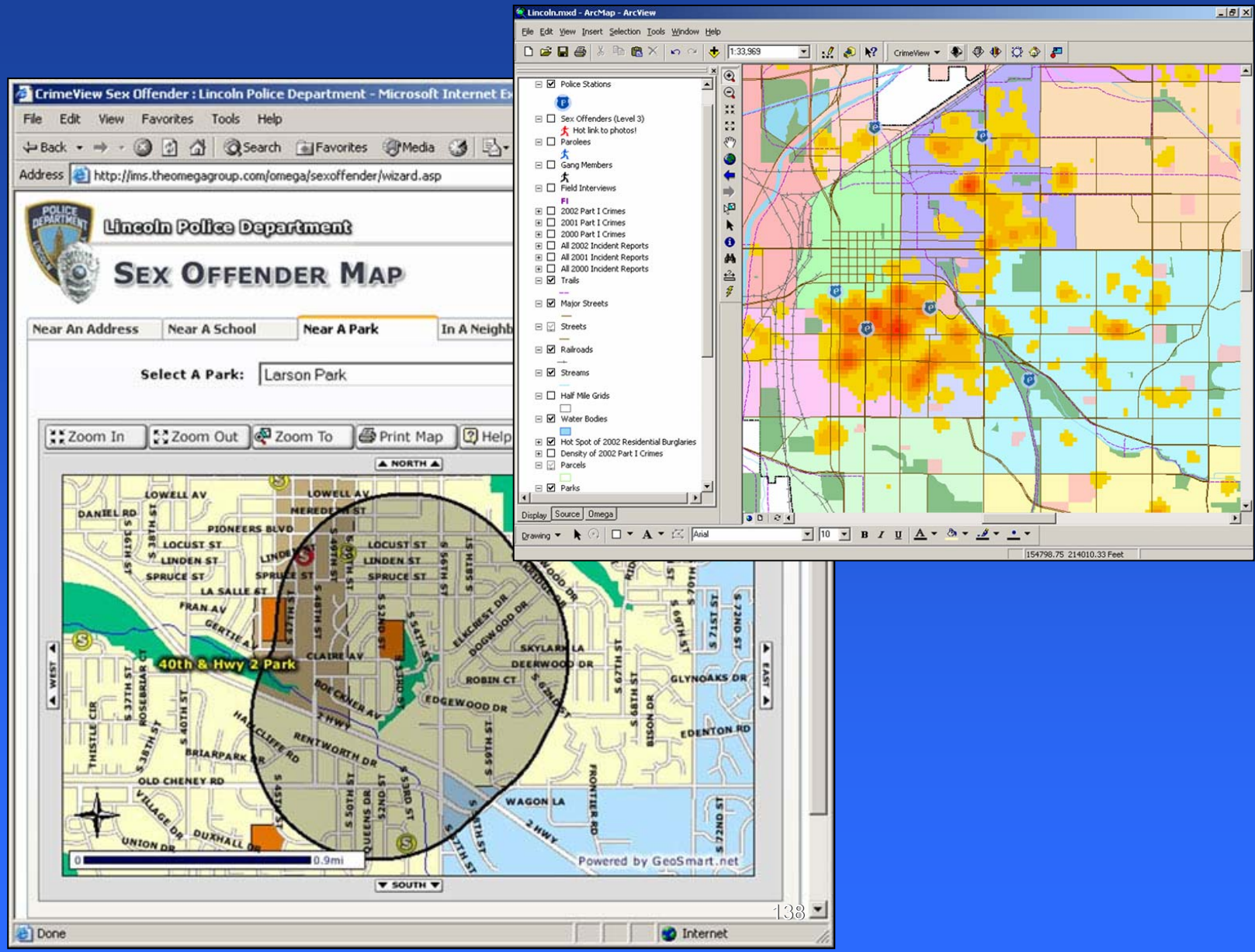
Real Time Weather Integration



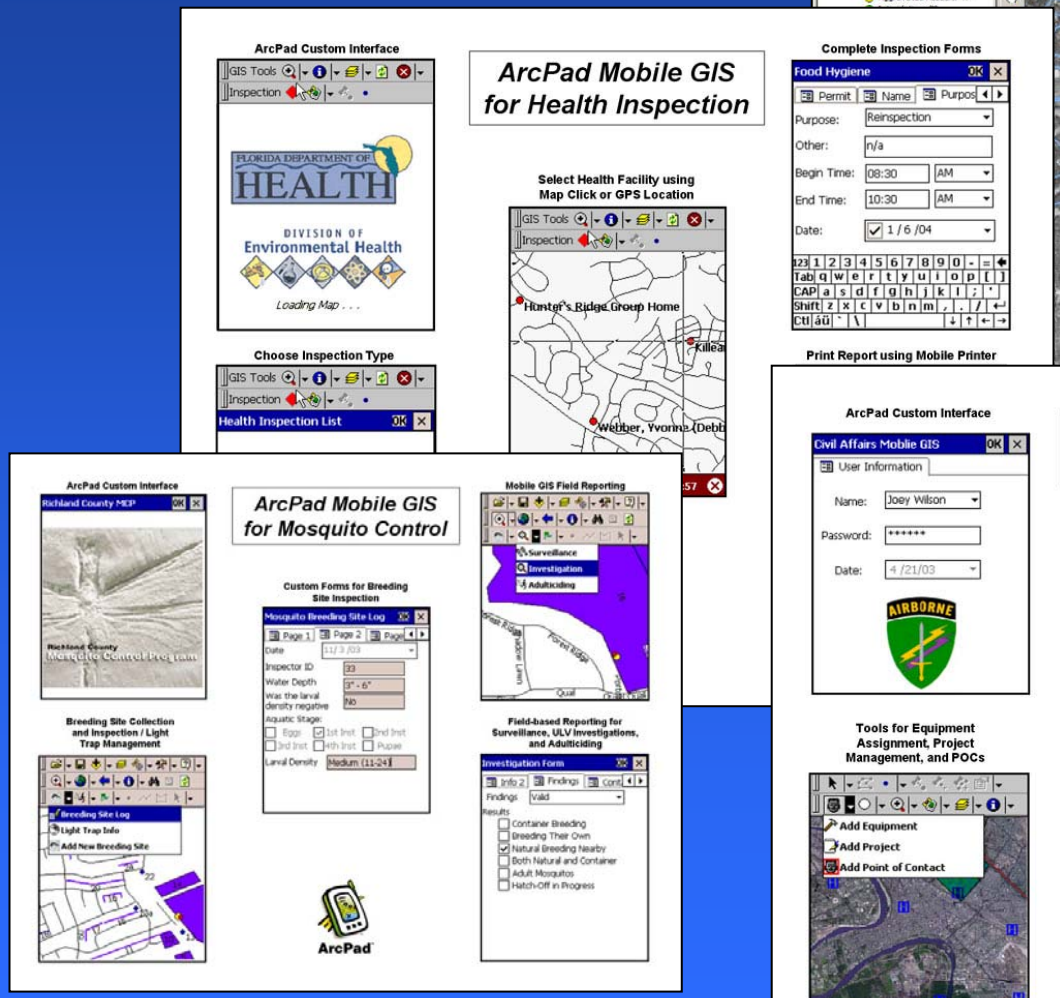
Land Records Management



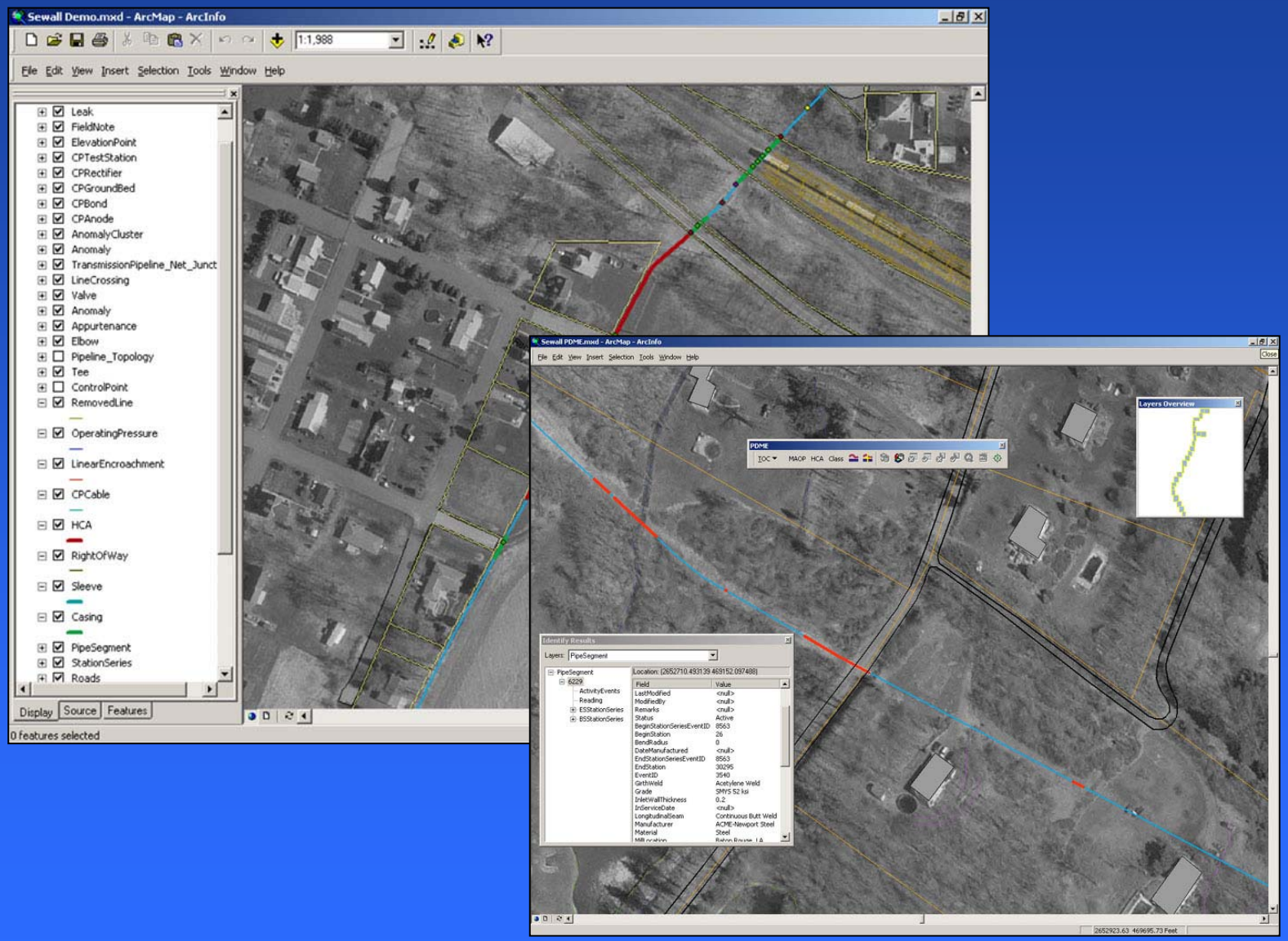
Crime Analysis



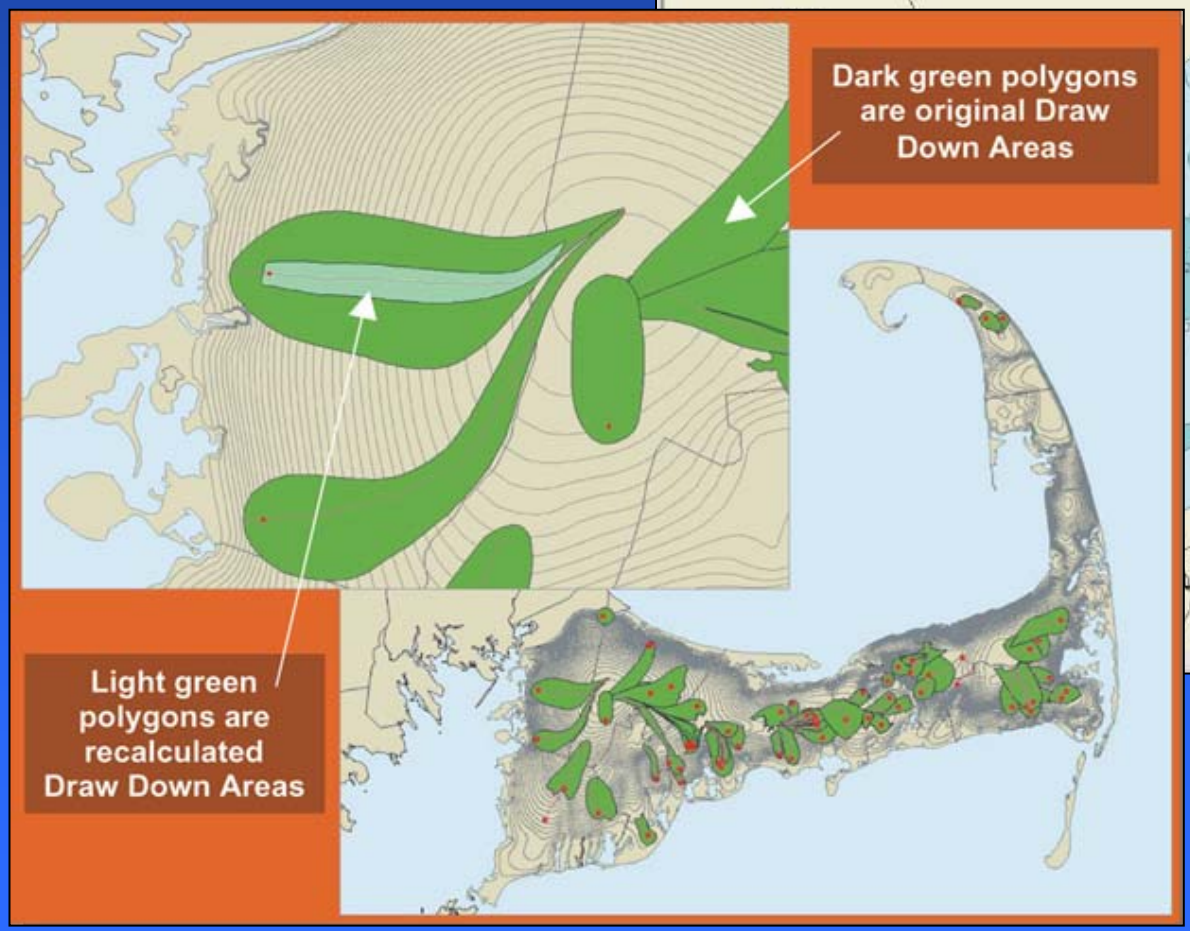
Health And Public Safety Systems

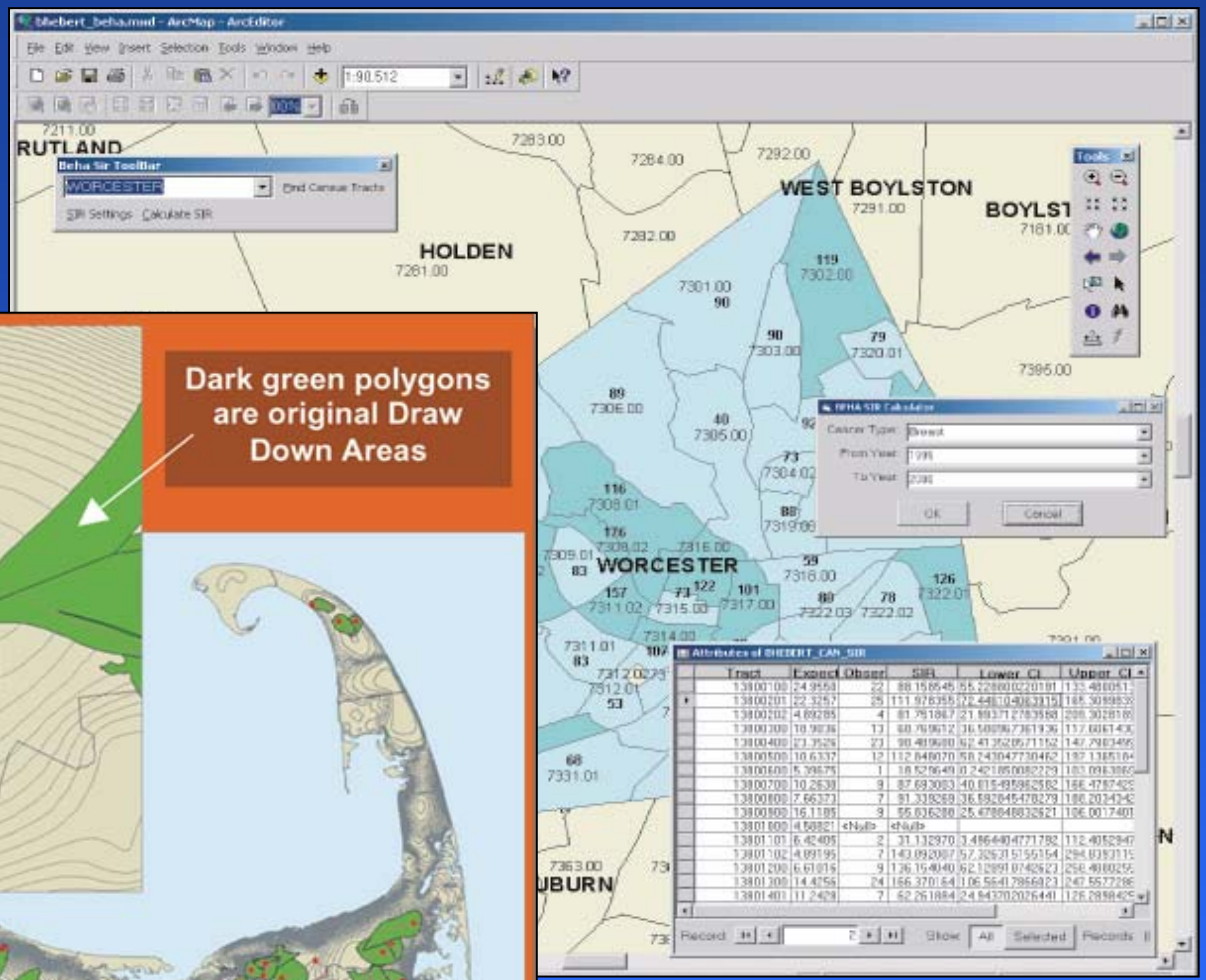


Pipeline Analysis

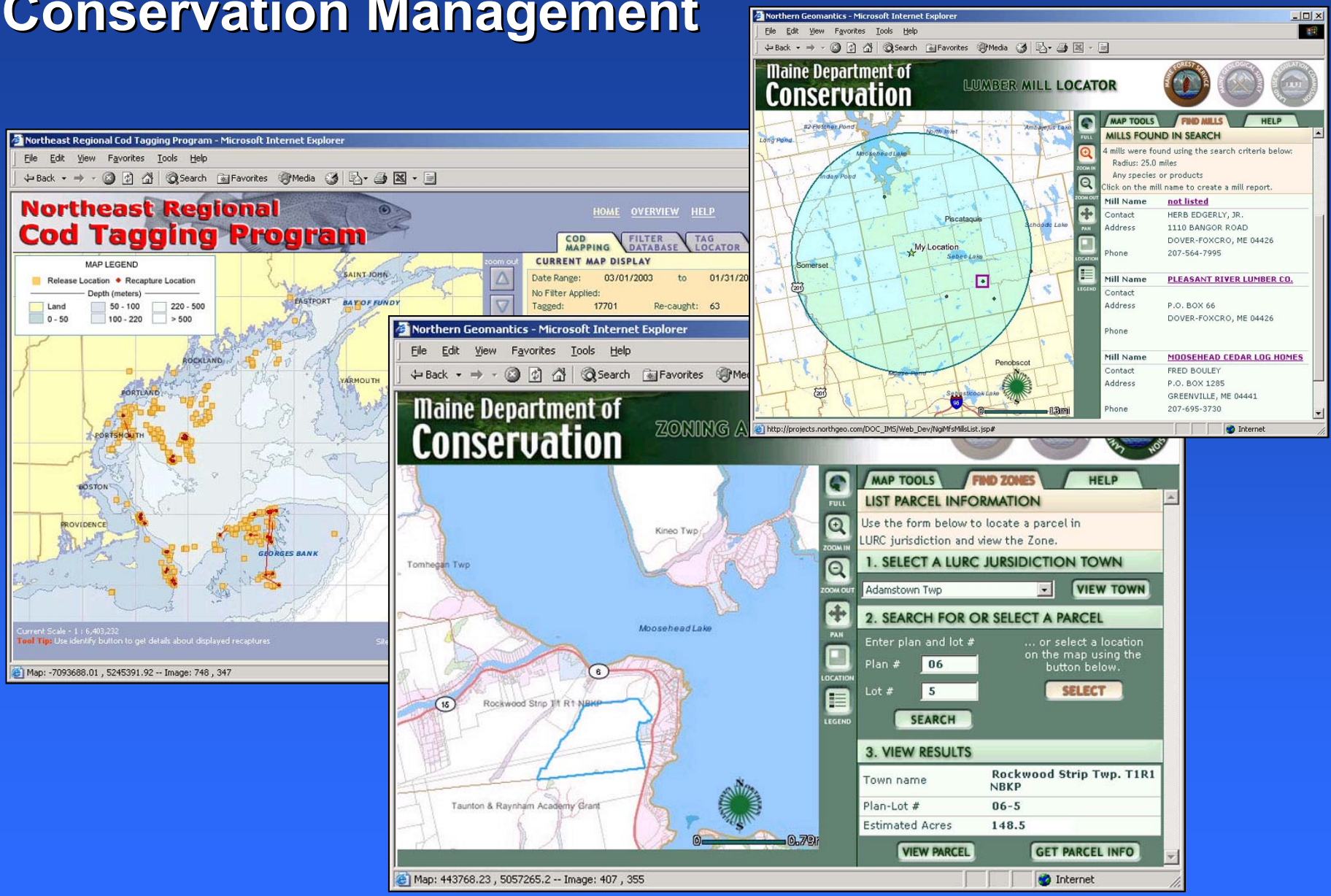


Cancer Probability & Research Application

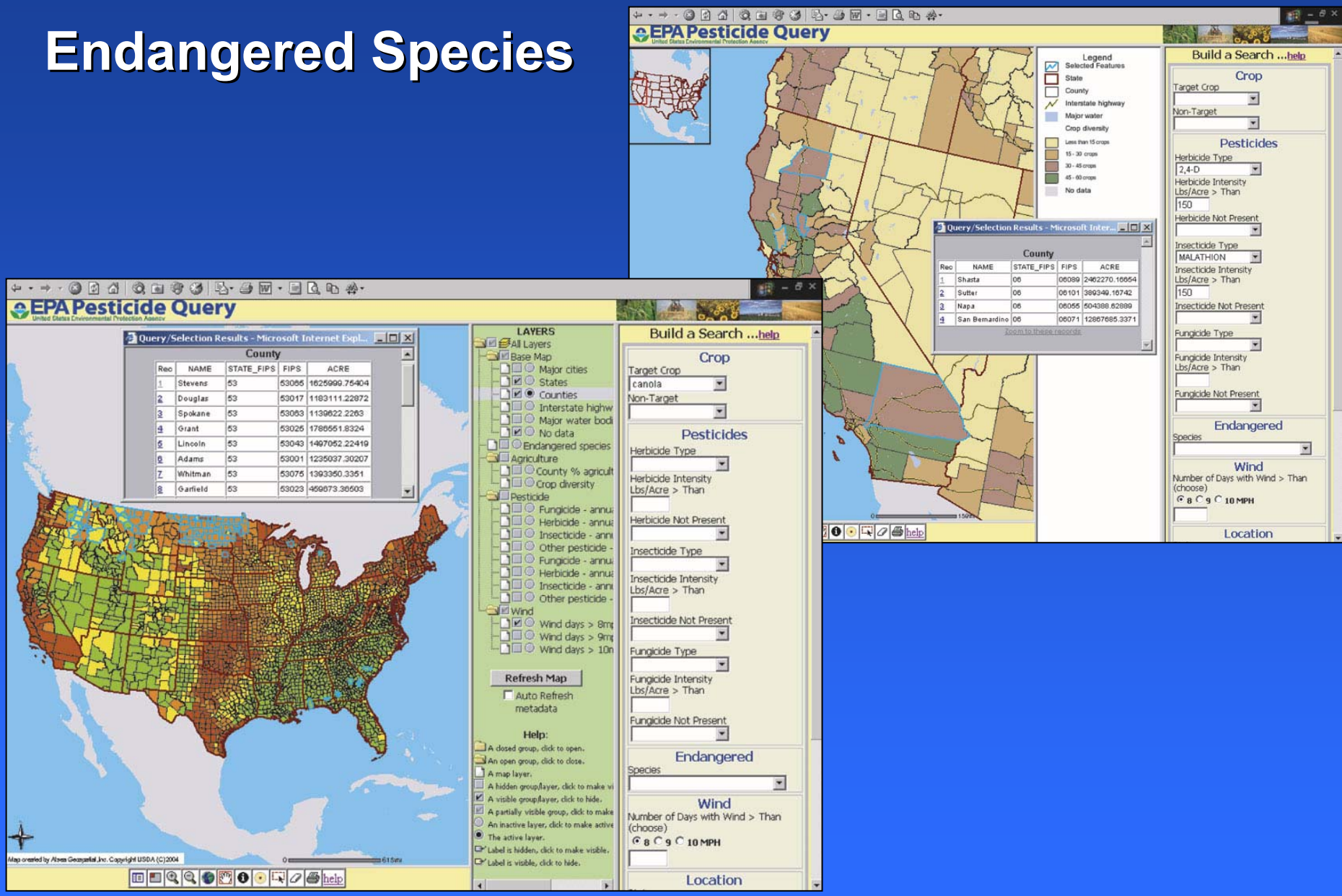




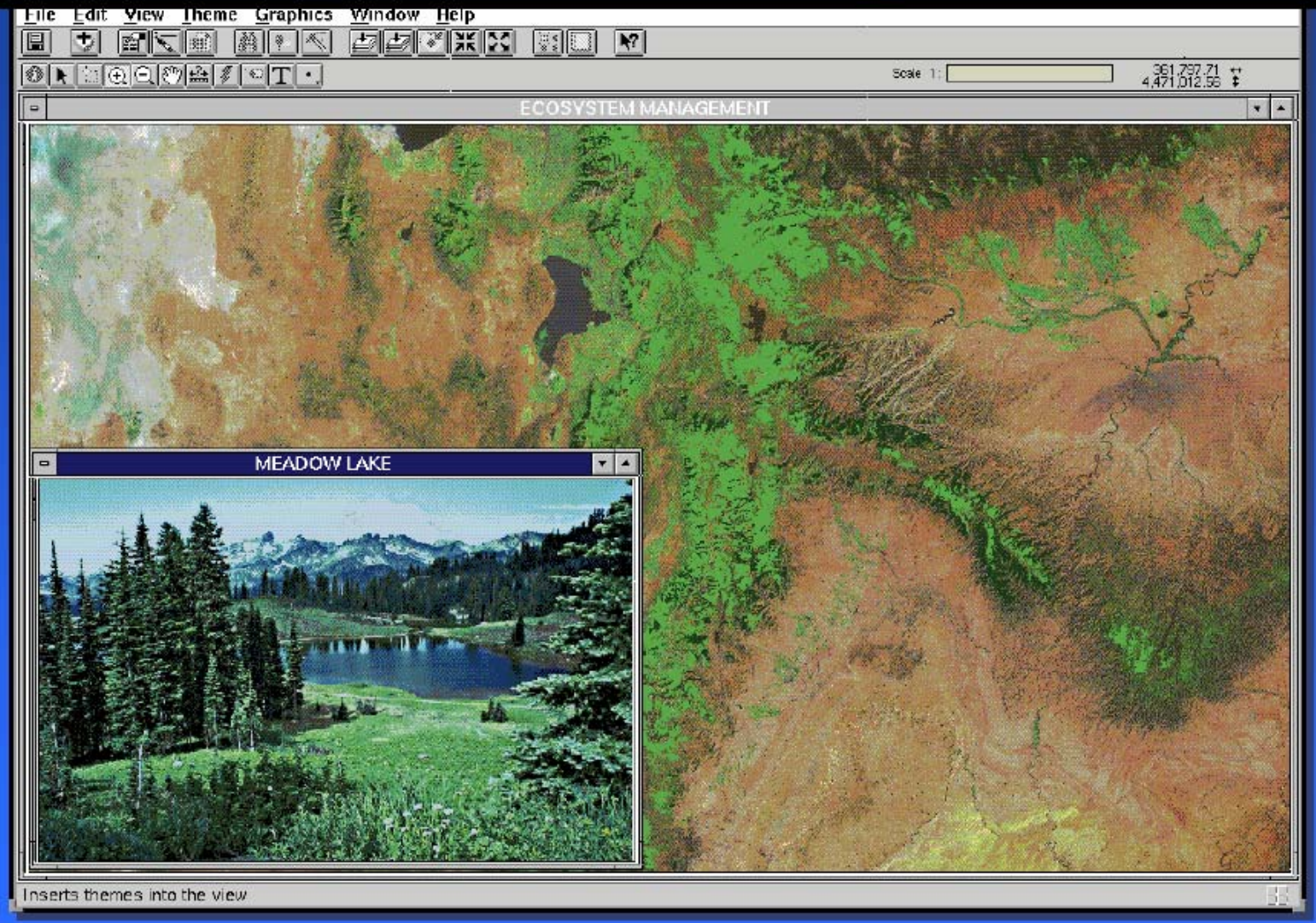
Conservation Management



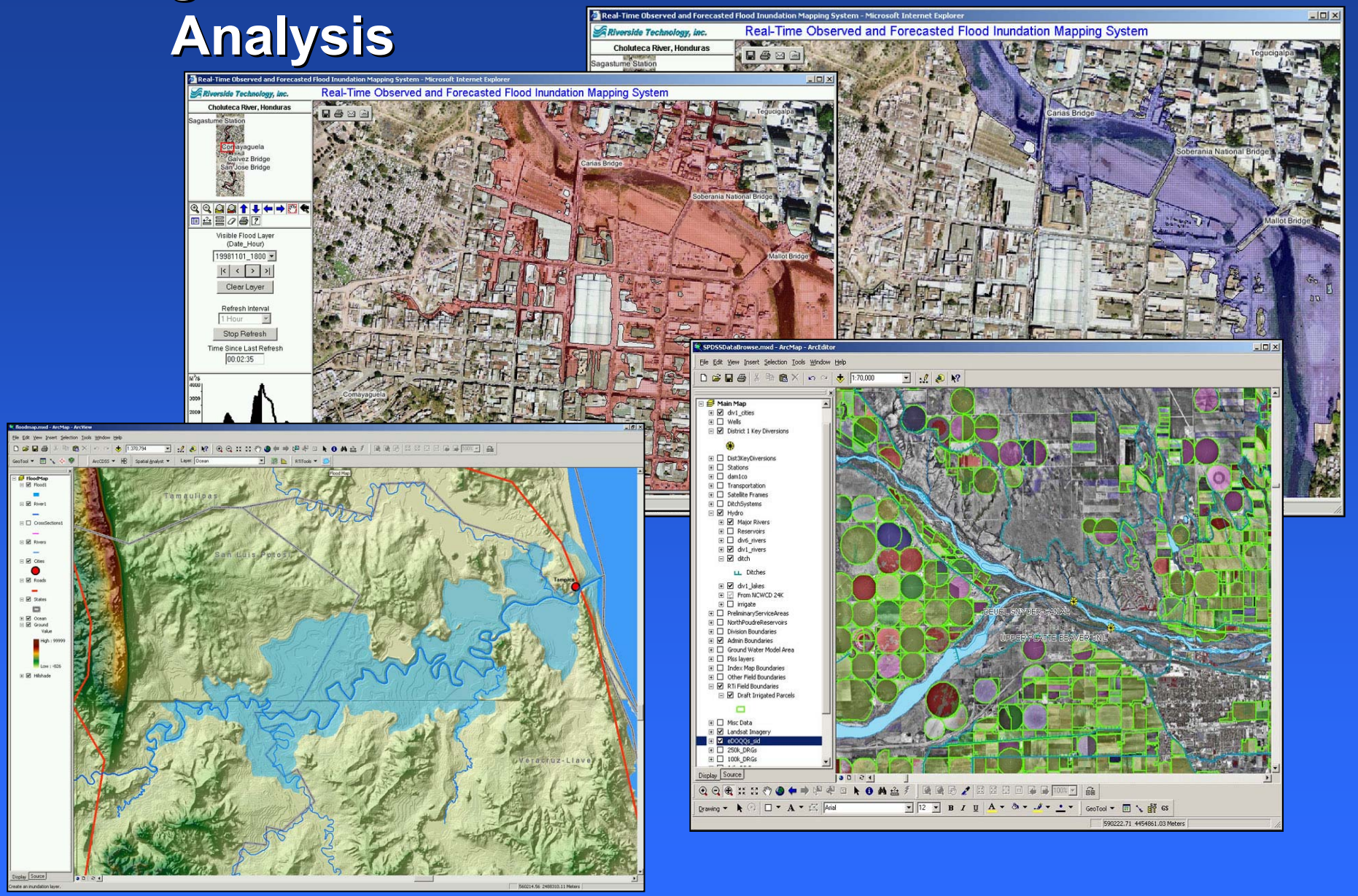
Endangered Species



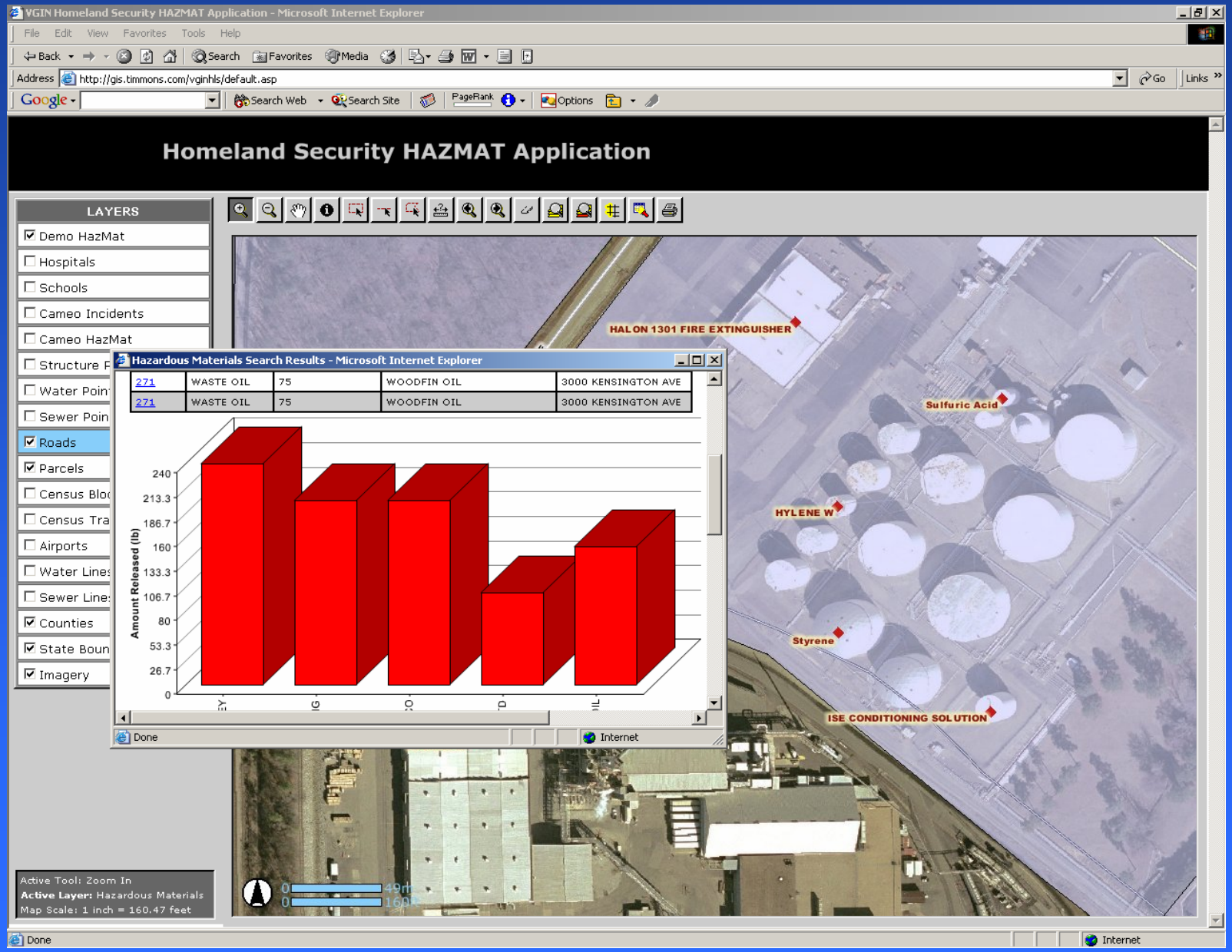
Ecosystem Management



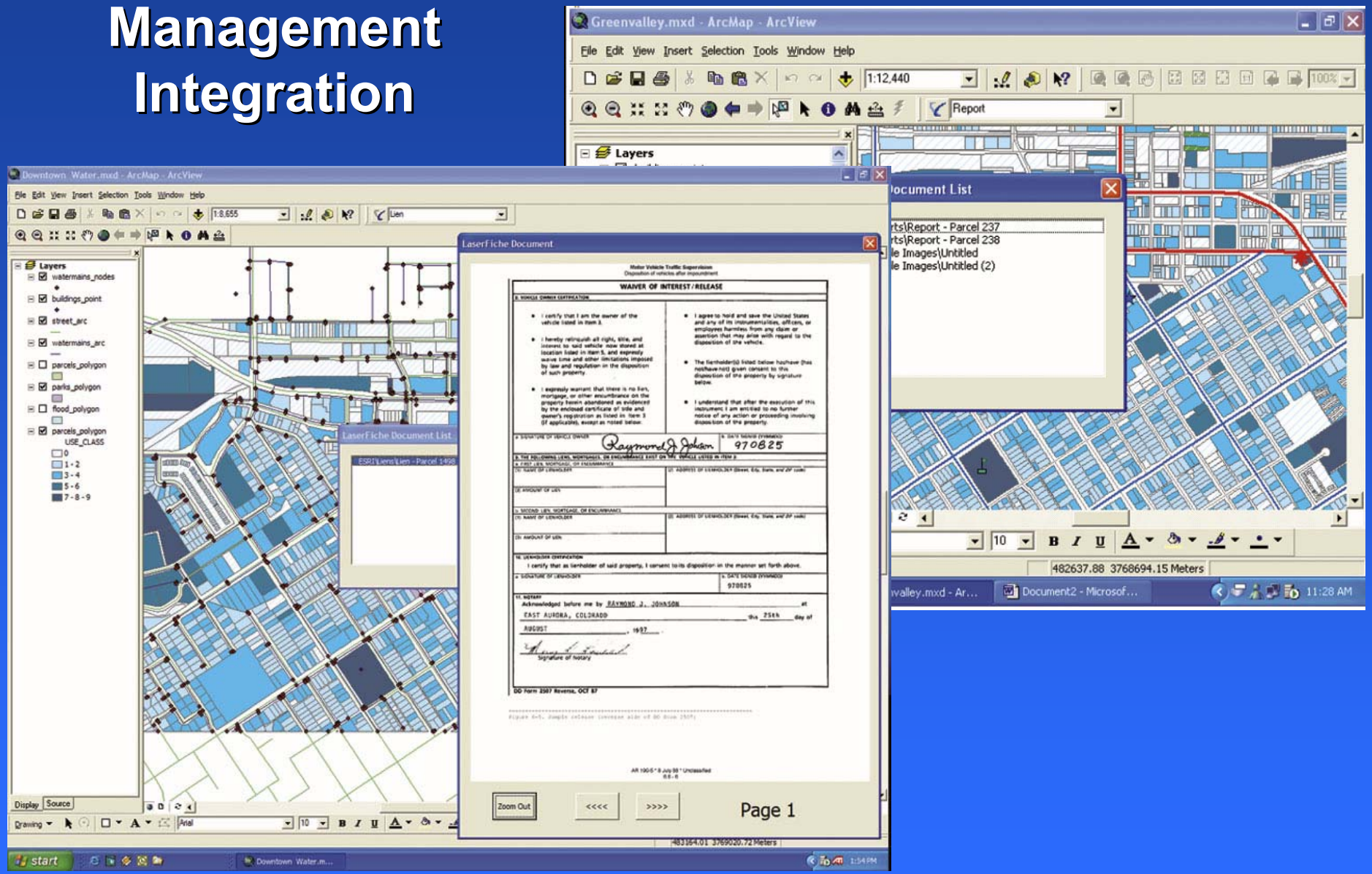
Drought and Flood Analysis



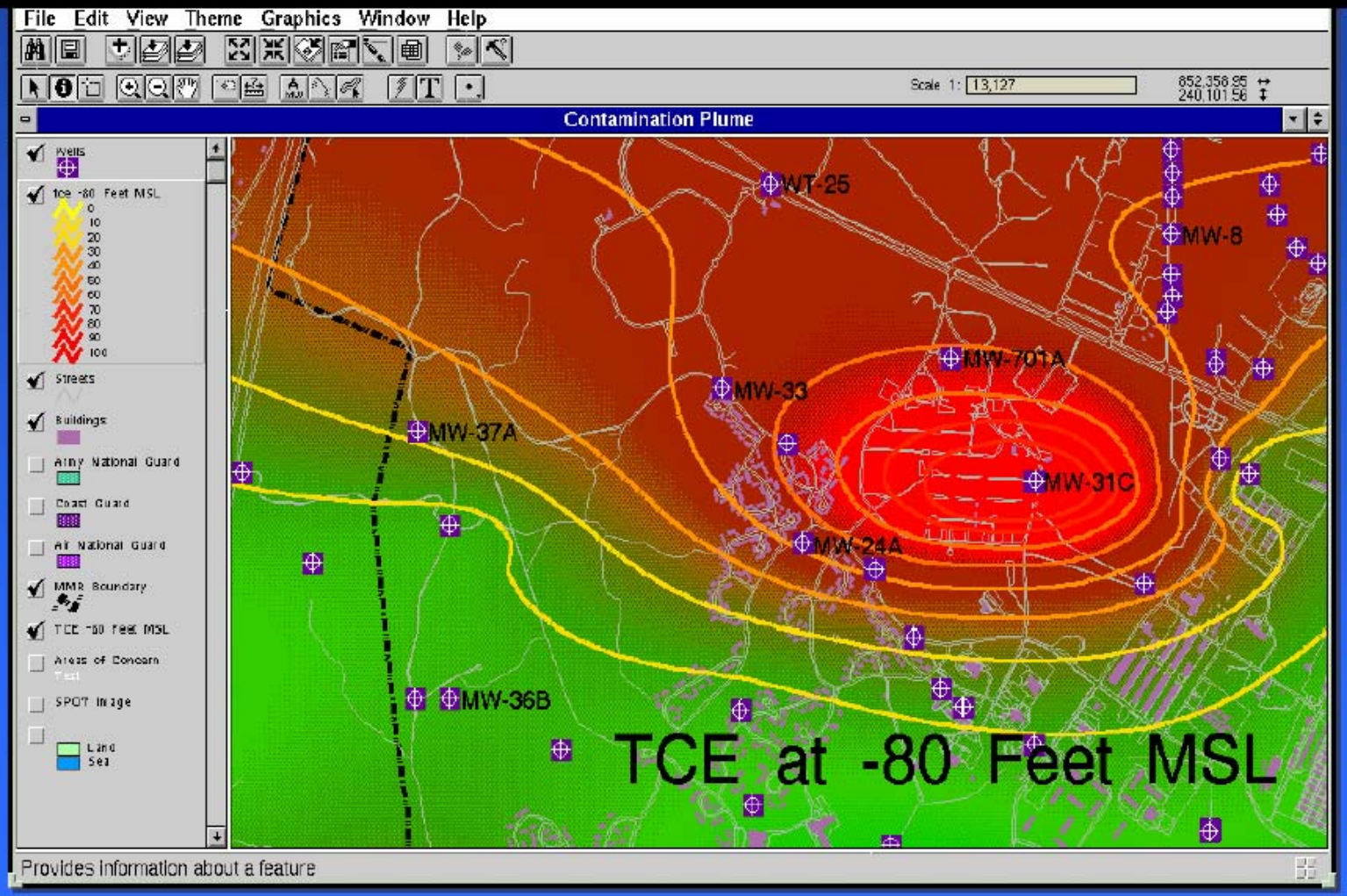
Hazardous Materials Assessment



Document Management Integration



Environmental Monitoring Toxic Plume



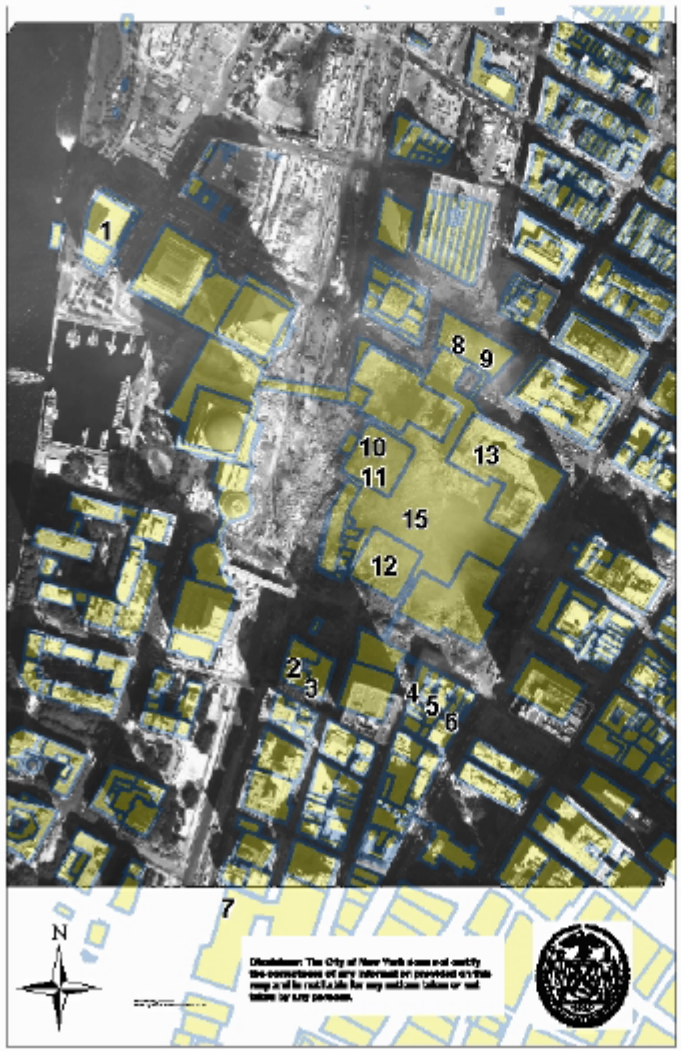
Fuel Tanks Near the World Trade Center Within Secured Area

1) PBS# 2-601825
250 Vesey Street
400 gallons
Fuels: #1, 2, or 4
Steel Storage Tank, Above Ground

2) PBS# 2-200212
90 West Street
2 x 10,000 gallons
Fuels: #5 or 6
Steel Tanks, Above Ground

3) PBS# 2-511536
130 Cedar Street
8,500 gallons, #5 or 6,
Underground, Vaulted Access
3,000 gallons, #1, 2, or 4
Steel Tank

4) PBS# 2-357885
124 Liberty Street
330 gallons, Above ground, Steel tank
1,000 gallons
Below ground, Fiberglass reinforced plastic
Diesel Fuel



5) PBS# 2-604662
120 Liberty Street
4,000 gallons
Fuels: #1, 2, or 4
Steel Tank, Above ground

6) PBS# 2-332941
114 Liberty Street
5,000 gallons
Fuels: #5 or 6
Steel Tank, Above Ground

7) PBS#2-259822
47 West Street
3,000 gallons
Fuels: #5 or 6
Steel Storage Tank, Above Ground

8) PBS# 2-601553
7 World Trade Center
2 x 6,000 gallons
Diesel Fuel
Underground Storage Tank

9) PBS# 2-602283
7 World Trade Center
2 x 11,690 gallons
Fuels: 1, 2, or 4
Fiberglass reinforced plastic tanks, Underground

10) PBS# 2-602234
1 World Trade Center
10,000, 3 x 275, & 100 gallons
Fuels: #1, 2, or 4
Steel Storage Tank

11) PBS# 2-293563
1 WORLD TRADE CENTER
10,000, 5,000, 1,800, & 3 x 275 gallons
Fuels: 1, 2, or 4
Above Ground, Stainless Steel Tanks

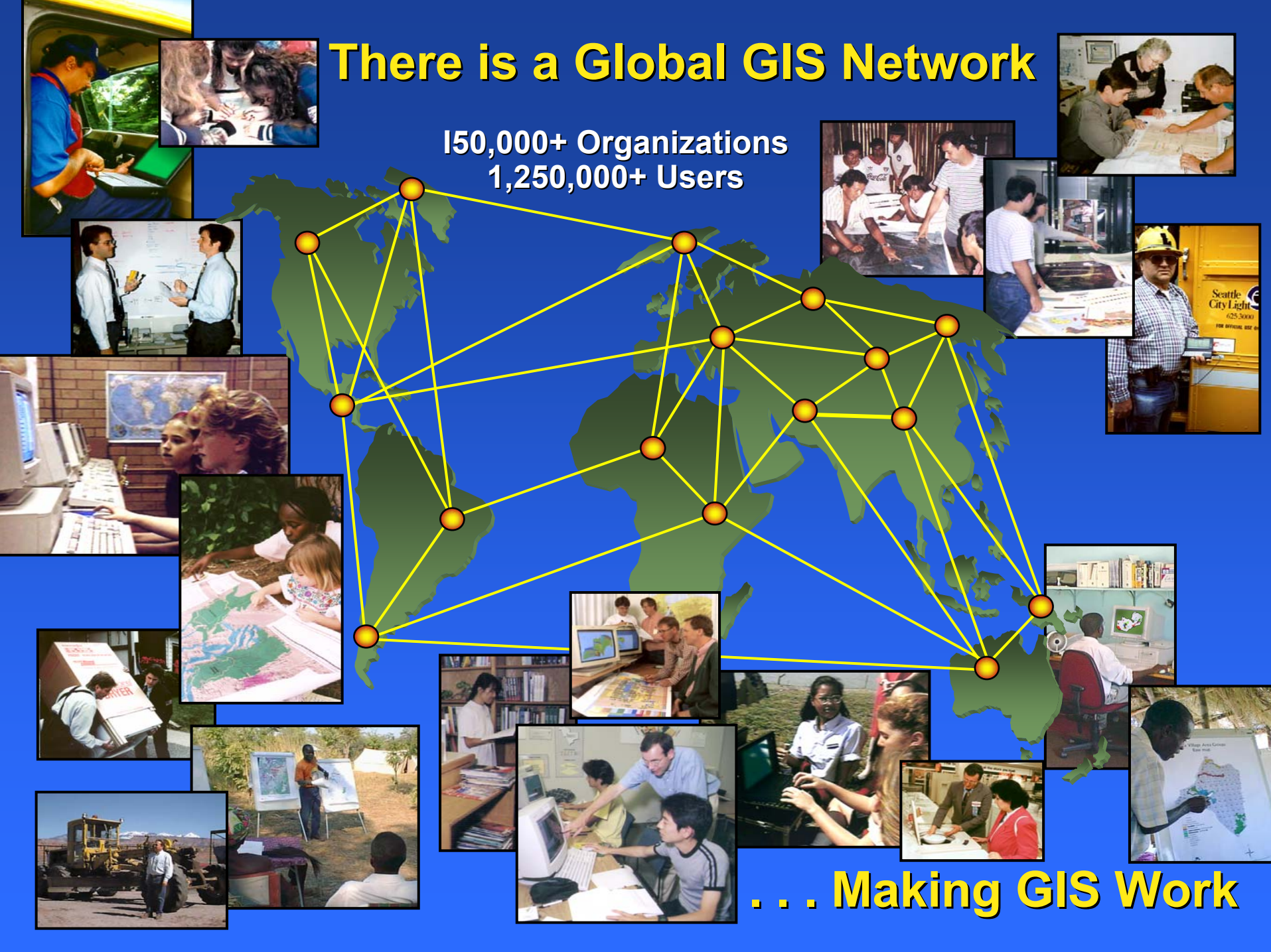
12) PBS# 2-344737
2 World Trade Center
2 x 2,500 gallons
Fuels: #1, 2, or 4
Steel Storage Tanks, Above Ground

13) PBS# 2-604231
5 World Trade Center
2 x 10,000 gallons
Fuels: #1, 2, or 4
Steel Storage Tanks, Above Ground, Level B2

14) PBS# 2-000204
River Water Pump Station
(Actual Location Unknown)
2 x 4000 gallons
Sodium HypoChlorite
Fiberglass Reinforced Plastic Tank

15) Large Freon Tank

There is a Global GIS Network

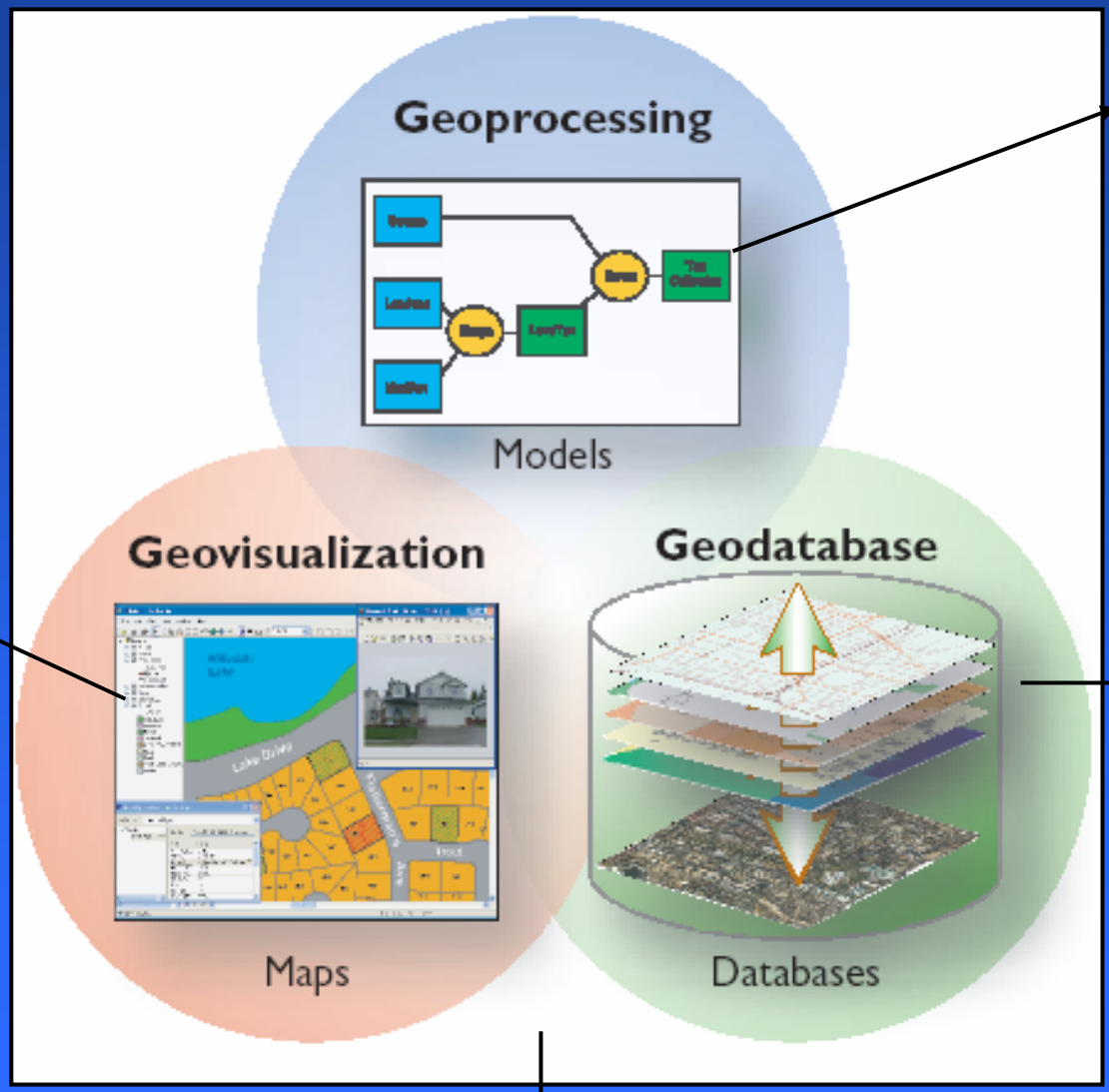


. . . Making GIS Work

Emerging GIS Technologies Will Improve Implementations

- Intelligent GIS
- Web Services
  - GIS Services
  - Networks
  - GIS Portals
- Distributed GIS
  - Server
  - Embedded
  - Desktop
  - Mobile
- Component Software
- New GIS Functionality
  - Geoprocessing Models
  - Global Visualization
  - Cartography & Labeling
  - Image Integration
  - Real Time
  - Mobile GIS/LBS
- Interoperability

Three views of GIS



Geoprocessing Models

Maps and Globes

Datasets

Data Models

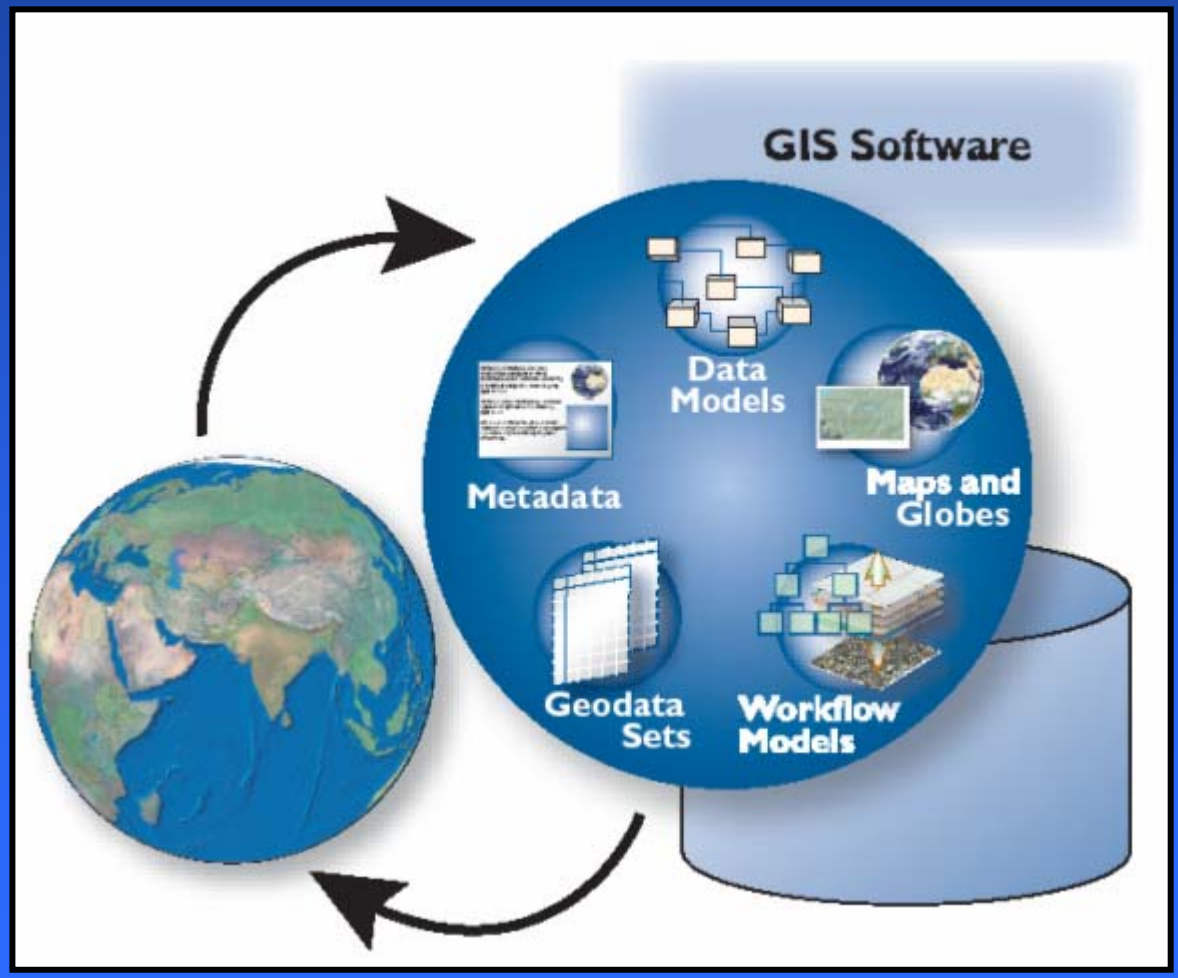
Metadata Documents

GIS is evolving from a database approach to a knowledge approach

GIS Is Becoming More Intelligent

Managing Datasets, Workflows in a Common Environment

…Encapsulating Five Basic Elements

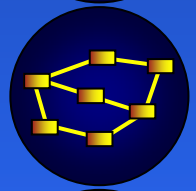


…Abstracting Geographic Knowledge

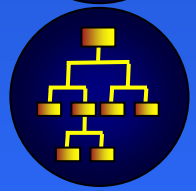
GIS "Abstracts" Geography Into Five Basic Elements

Maps and Globes

Geodata Sets



Workflow Models



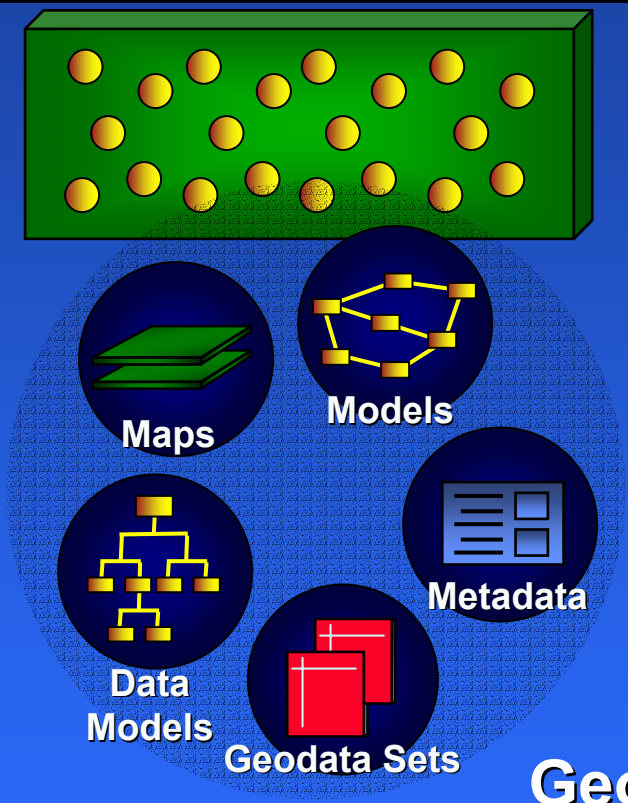
Data Models

Metadata

. . . Together They Represent Geographic Knowledge

These Five Basic Elements

Plus GIS Software Objects



. . . Provide the Building Blocks for *Intelligent GIS*

GIS users work with many databases and datasets in many schemas and produce and share results

Requires a unique combination of "scientific computing" and, increasingly, "business computing"

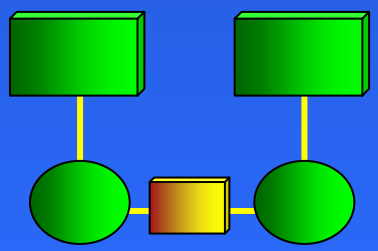
GIS is distributed

- Each GIS must access and use many datasets
- Geodata compilation is an expensive, specialist activity that requires
  - Comprehensive tools and systems
  - Mechanism to share data
- Compiled & maintained by many organizations
- Distributed update and sharing

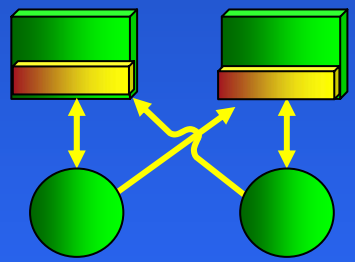
Implications …

Interoperability is Important

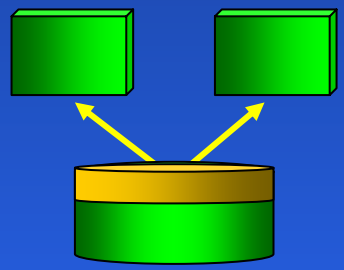
We Support Many Standards . . .



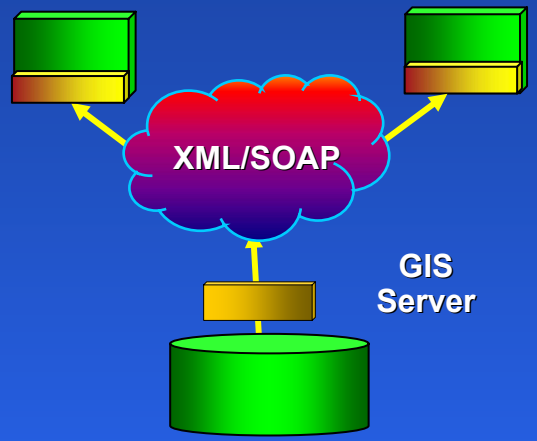
Conversion



Direct Read (API)



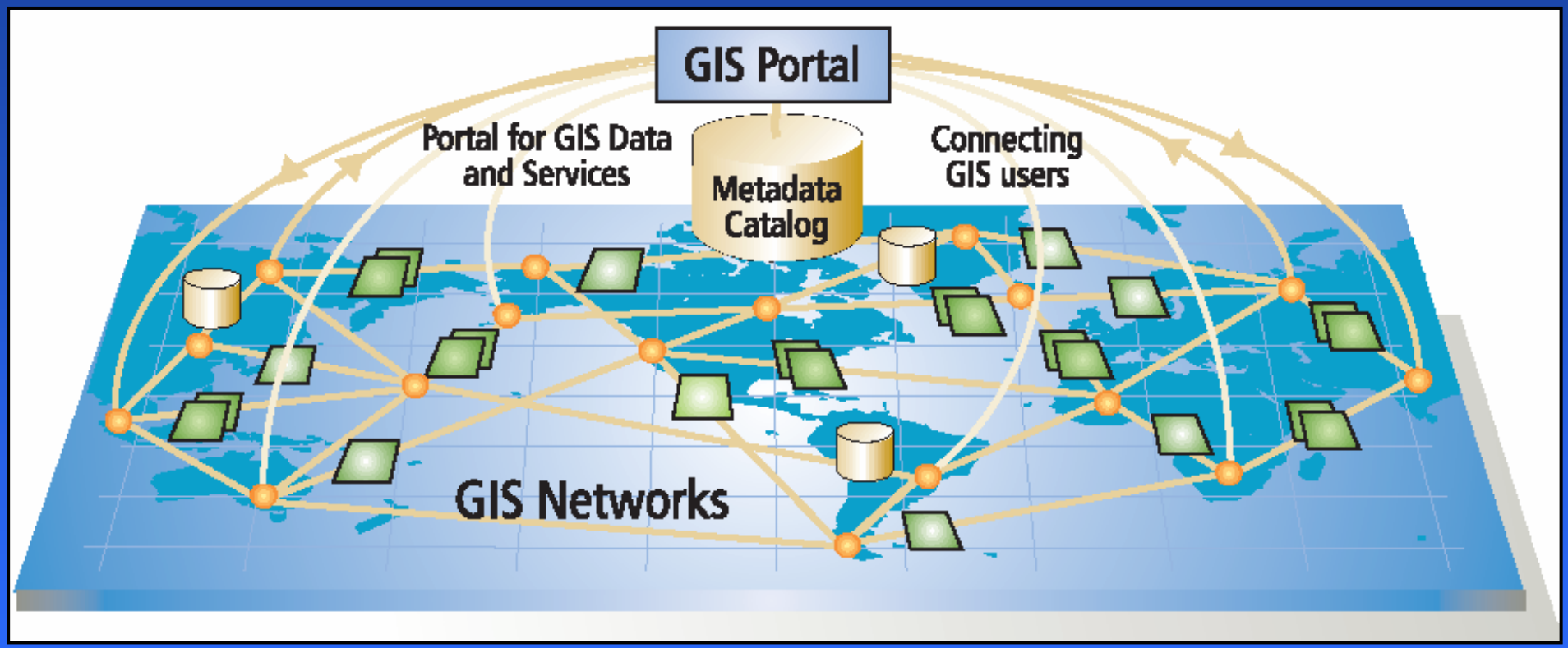
DBMS Integration



Web Services

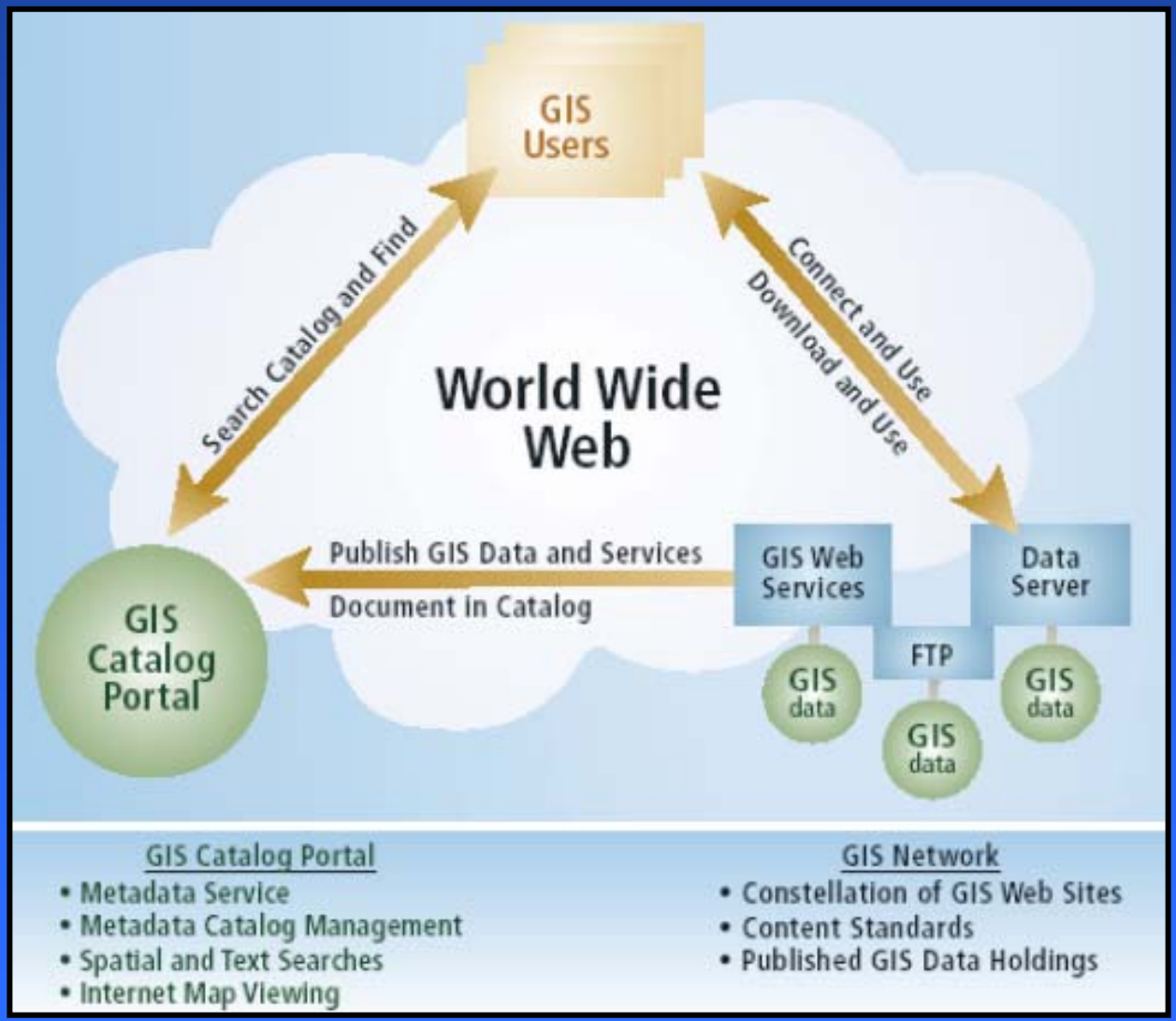
. . . Our Focus Is On Simple and
Practical Approaches That Work

GIS Networks



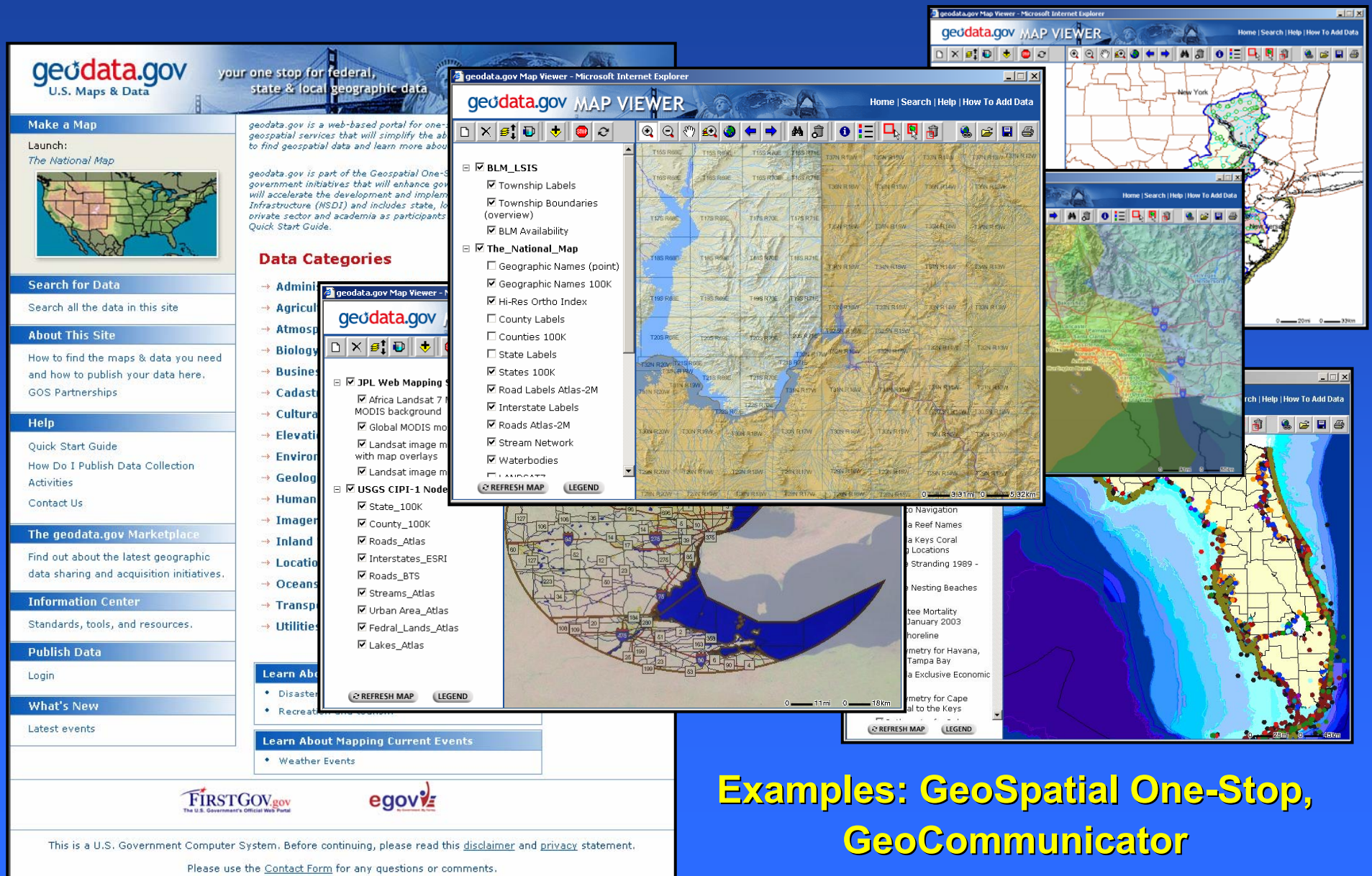
GIS Catalog Portals centralize access to distributed information nodes

Three Key Building Blocks



GIS Portals

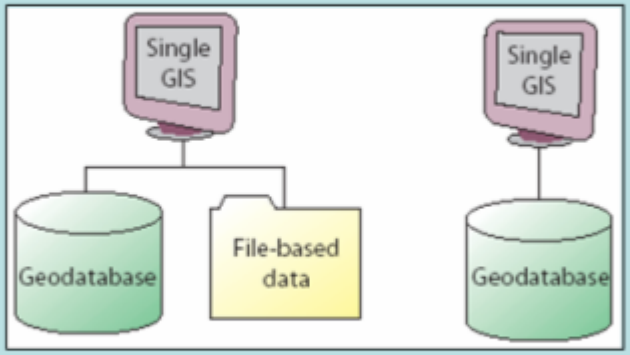
Access to Distributed Information & Web Services



Examples: GeoSpatial One-Stop, GeoCommunicator

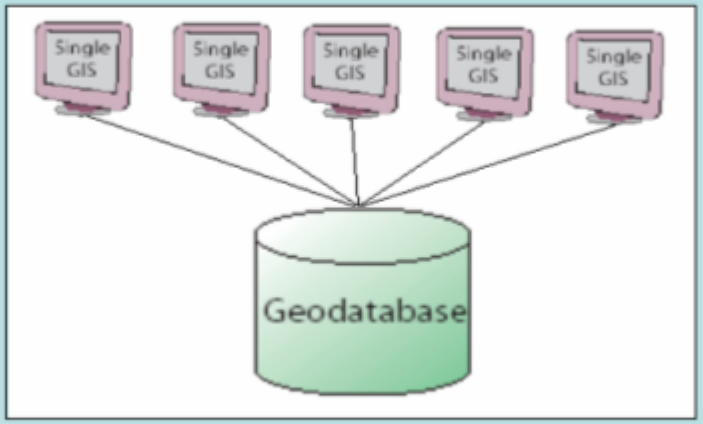
GIS Is Deployed In Many Ways

Traditional GIS Workstations



Client-Server GIS

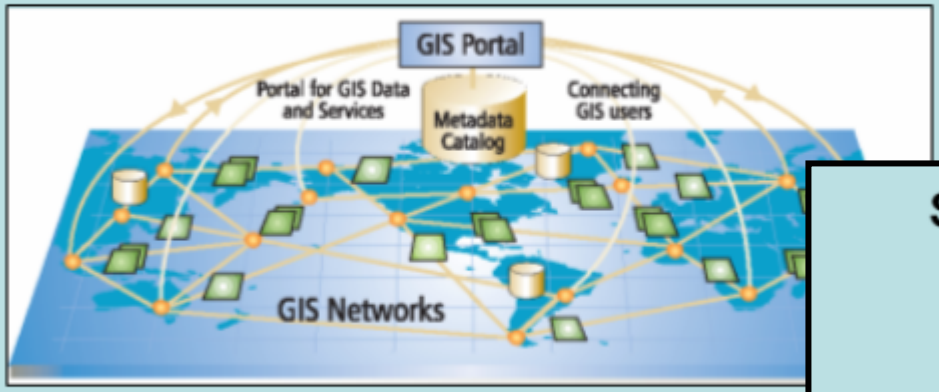
Central GIS



Central DBMS with Multiple Users

Emerging GIS Deployments

Federated GIS

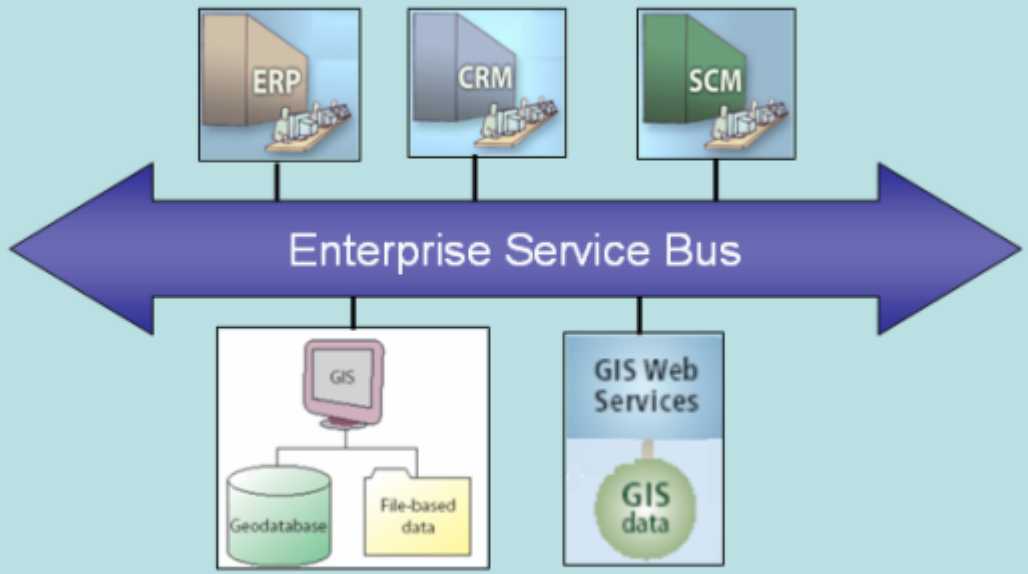


Spatial Data Infrastructures

Stovepipe GIS Integration

IBM

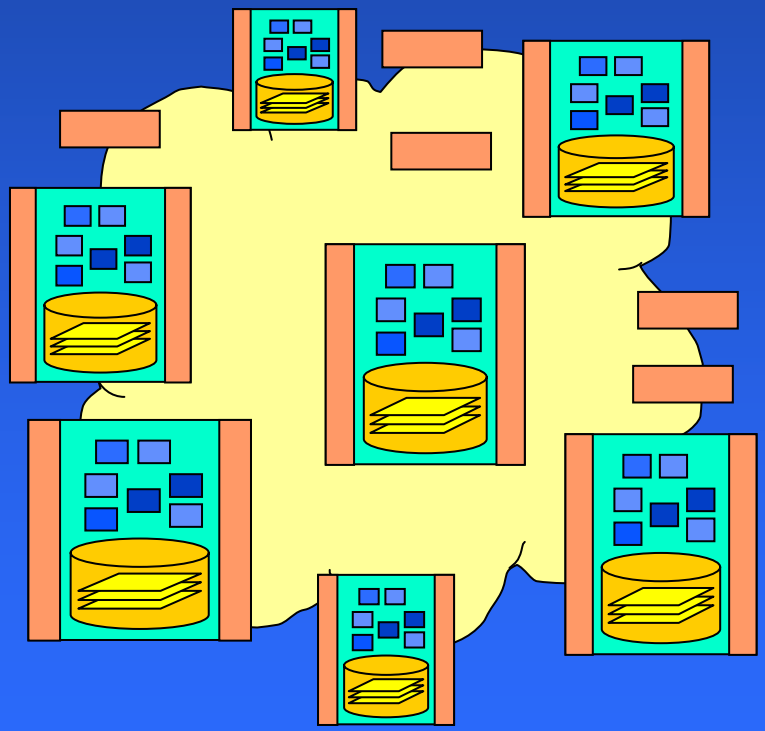
Services-Oriented Architecture

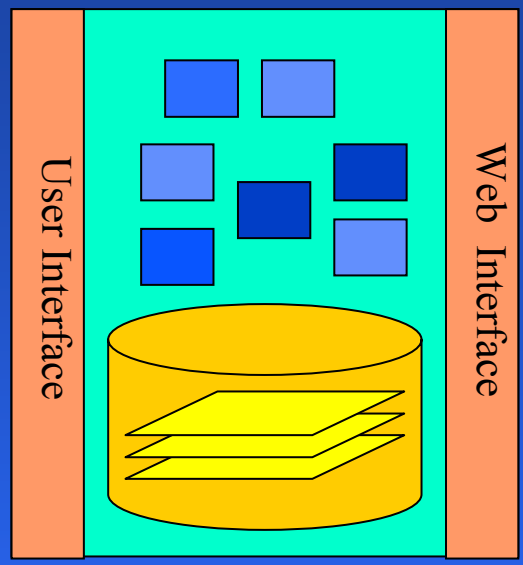


Workflow integration via web services and messaging

Federated GIS

A web of loosely-coupled
Information system nodes





Each node has:

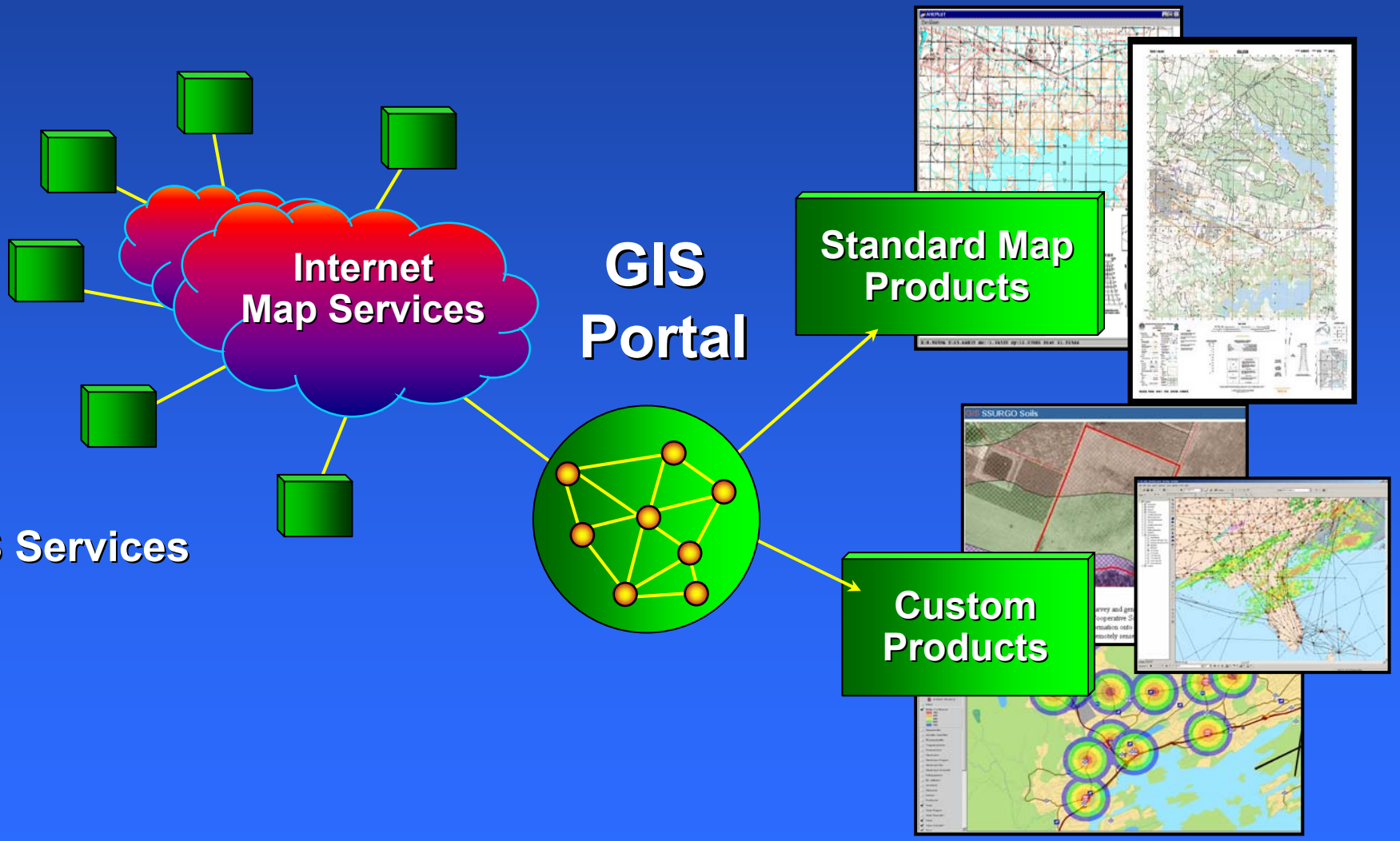
- data & functionality
- a user interface
- a web interface

A network of heterogeneous systems

Federated GIS Requirements

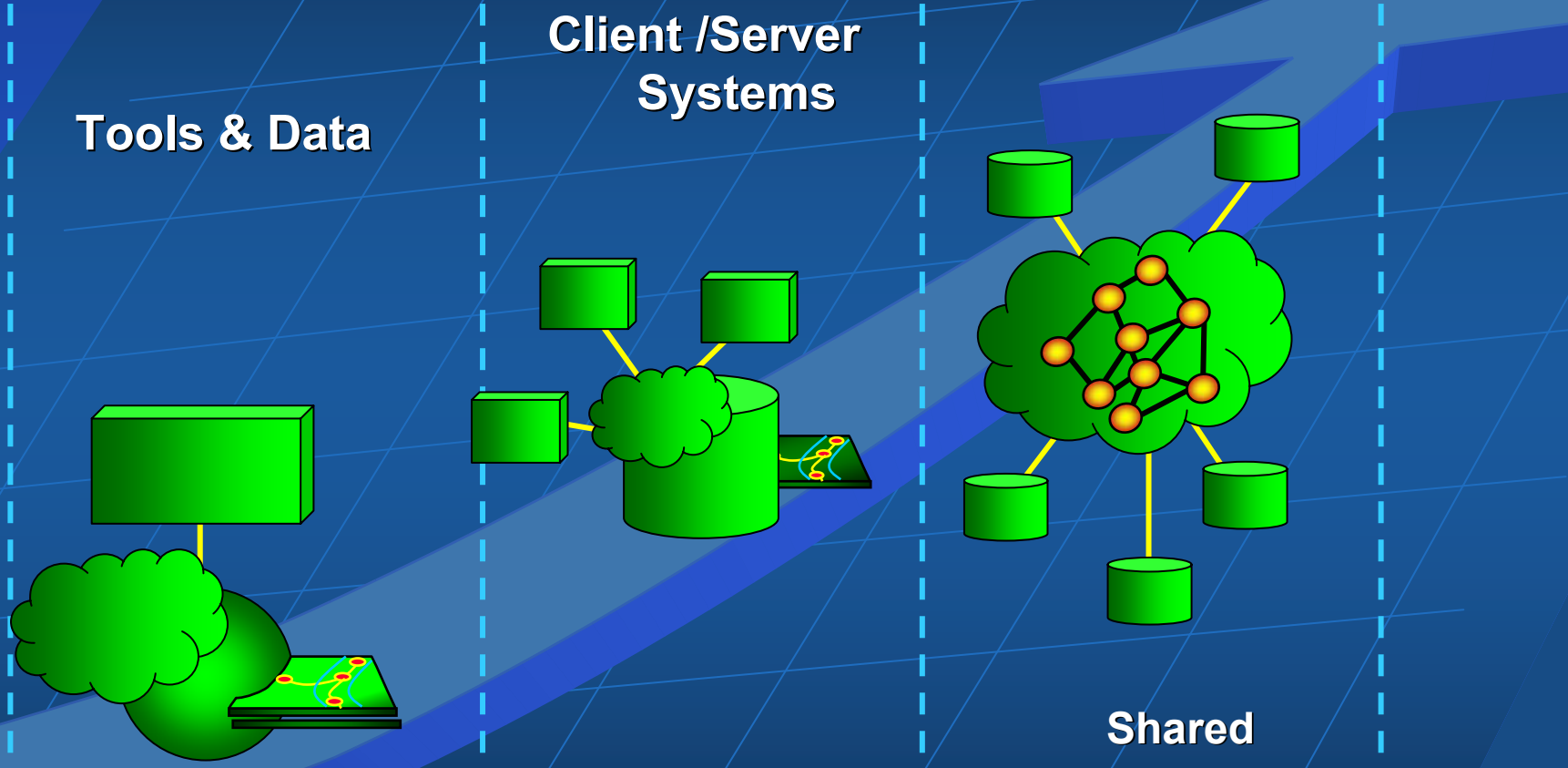
- Ad-hoc combination of information maintained in separate data stores
- Complex information models
  - Geometry and imagery
  - Relationships and integrity constraints
    - Semantic relationships
    - Connectivity (graph) relationships
    - Shared geometry (topology) relationships
- Distributed data compilation (collaboration)
- Large datasets
  - Number of elements
  - Size of elements
- Open, standards-based architecture

Web Services Provide A New Architecture For GIS



. . . They Dynamically Integrate Many Distributed Services

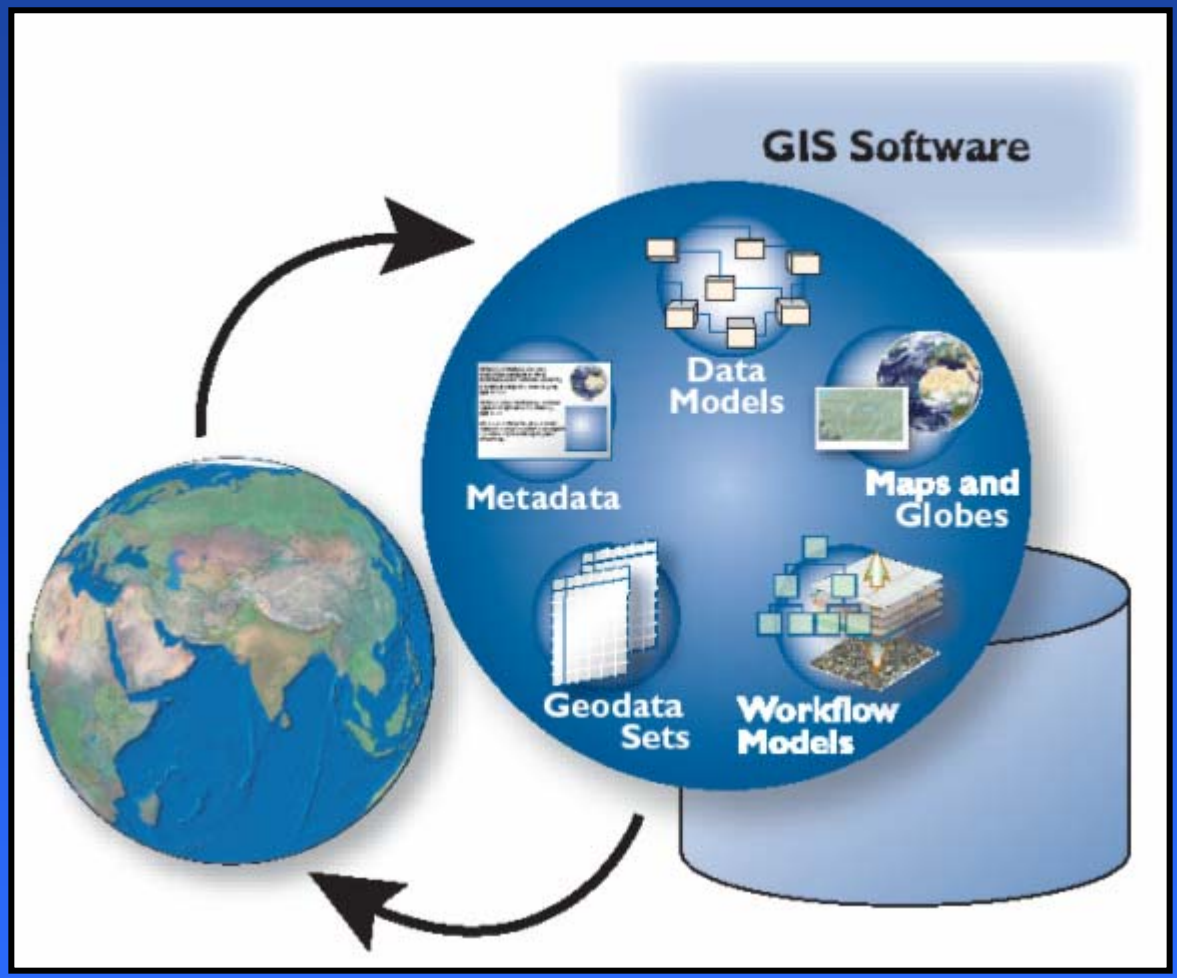
GIS Architectures Are Expanding



. . . Web Services Provide A New Platform

Some important initiatives for DOI

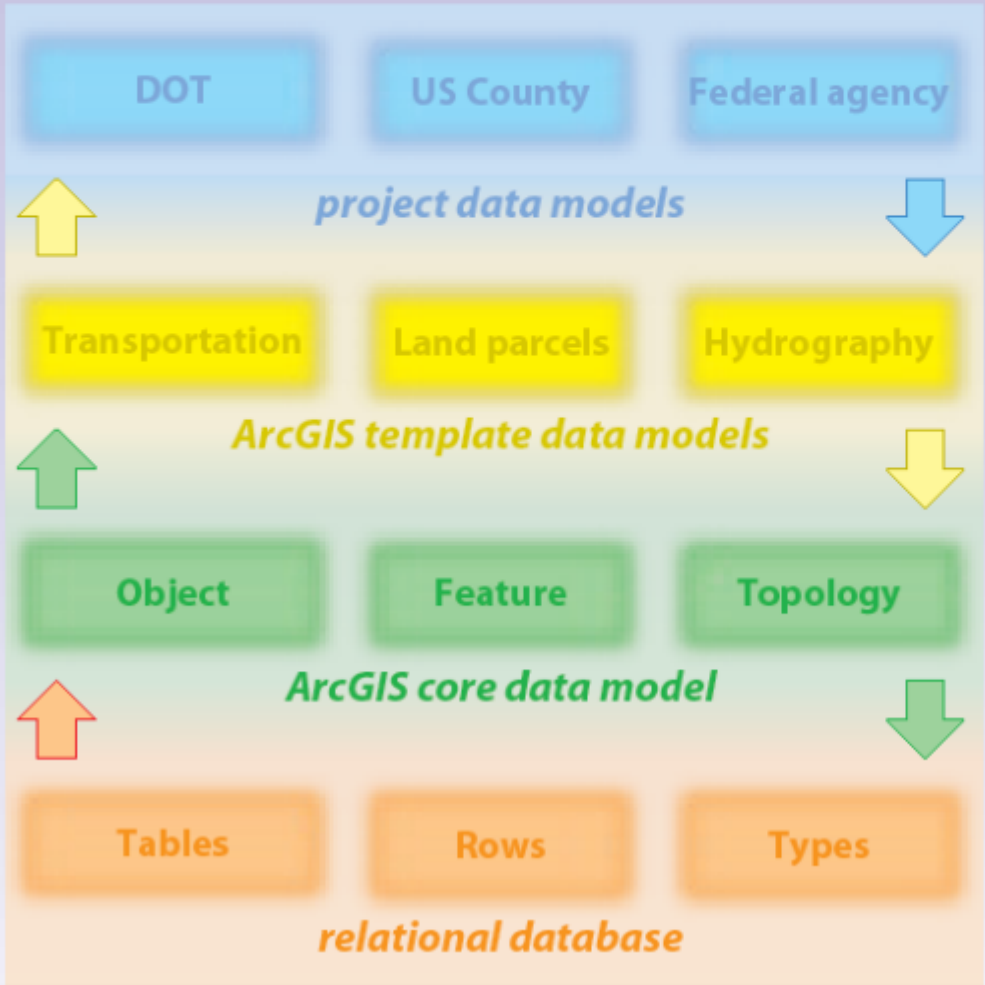
Enterprise Data Management



NILS,
TNM, NHD,
GOS, etc.

Requires a schema, stewardship responsibilities, and implementation

There are important relationships that exist between the ArcGIS data model, existing GIS and IT concepts, and related standards efforts. The ArcGIS data models implement fundamental DBMS and GIS data concepts. In turn, the templates build on those concepts to provide a useful starting point for each user's GIS database design. In addition, the GIS and IT design techniques used in each data model support, as well as influence, a number of important standards efforts. ESRI will continue to evolve its designs in support of these on-going efforts.



A hydrographic template data model provides a water agency with a good starting design

Topology provides spatial integrity for land parcel applications

Developments in RDBMS technology enable storing massive raster datasets.

The TIGER database directed the Census model and topology simplified storage of nested features

In the land parcel model, we came up with several new topology rules for developers

GIS requirements (such as long transactions) are influencing DBMS development

ISO

FGDC

OGC

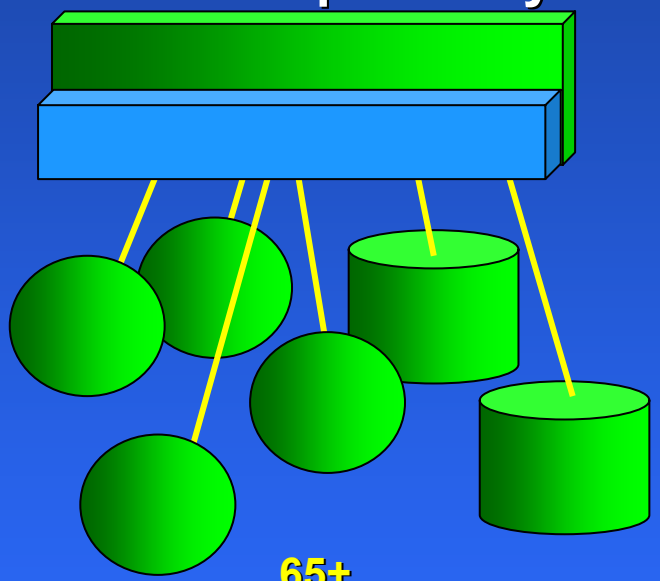
Industry

The Arc Hydro and the Land Records data models are examples of designs that are closely tied to standards efforts

GIS/IT standards

Interoperability

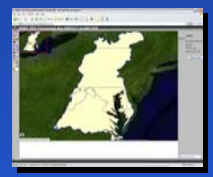
Direct Read
Data Interoperability



65+
Formats

. . . Clip/Zip/Ship

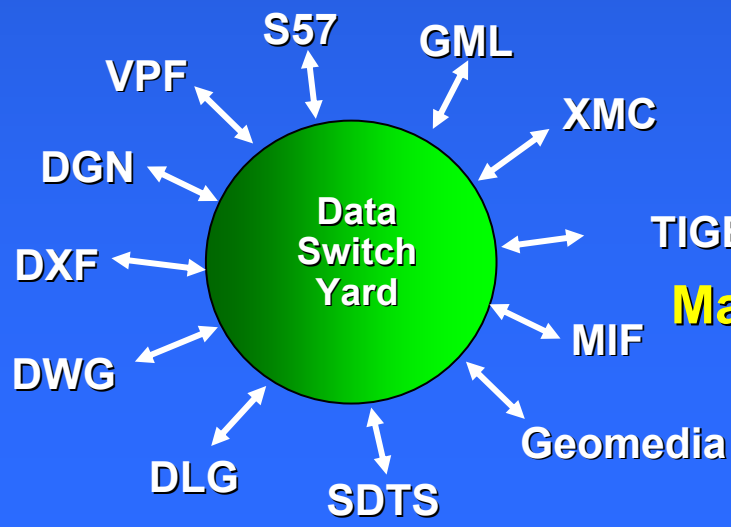
Zoom to Extent



Select Format

Export to File

Data Conversion



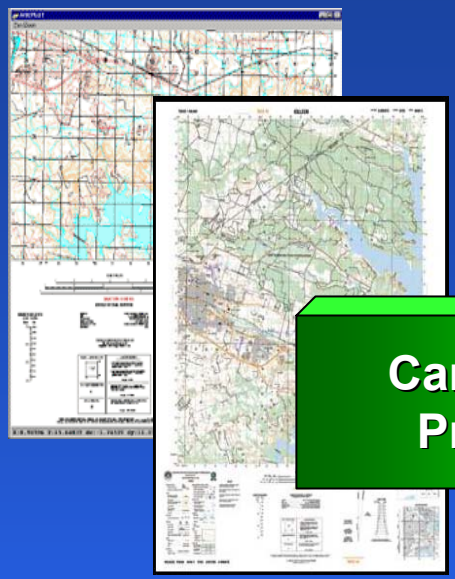
Many formats

ESRI will support all practical IT and GIS Standards
Responding to User Base

Examples

- FGDC / ISO
  - FGDC Metadata Content, ISO Metadata Content
- OGC
  - Simple features (The basis of Geodatabase Storage in RDBMS)
  - OGC Catalog Services
  - Support for Z39.50
  - WMS, WCS, WFS, GML
- Information Technology
  - XML Web Services (ArcXML), SOAP, HTTP
  - Open DBMS (Spatial types in Oracle, DB2, Informix)
  - Open Programming (C++, COM, JAVA, .NET)
  - Open Platforms (Windows, Unix, Linux)
  - Direct IS interfaces (SAS, SAP, Bentley, GPS, Image, Survey, Government Data formats, VPF, CAD, more . . .)

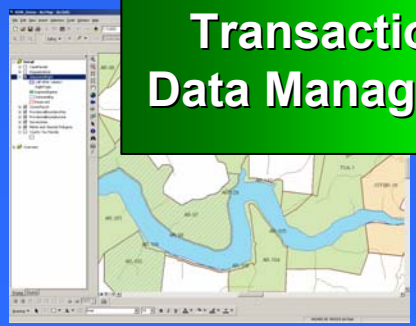
National Map Deployment



Cartographic Production

Internet Map Services

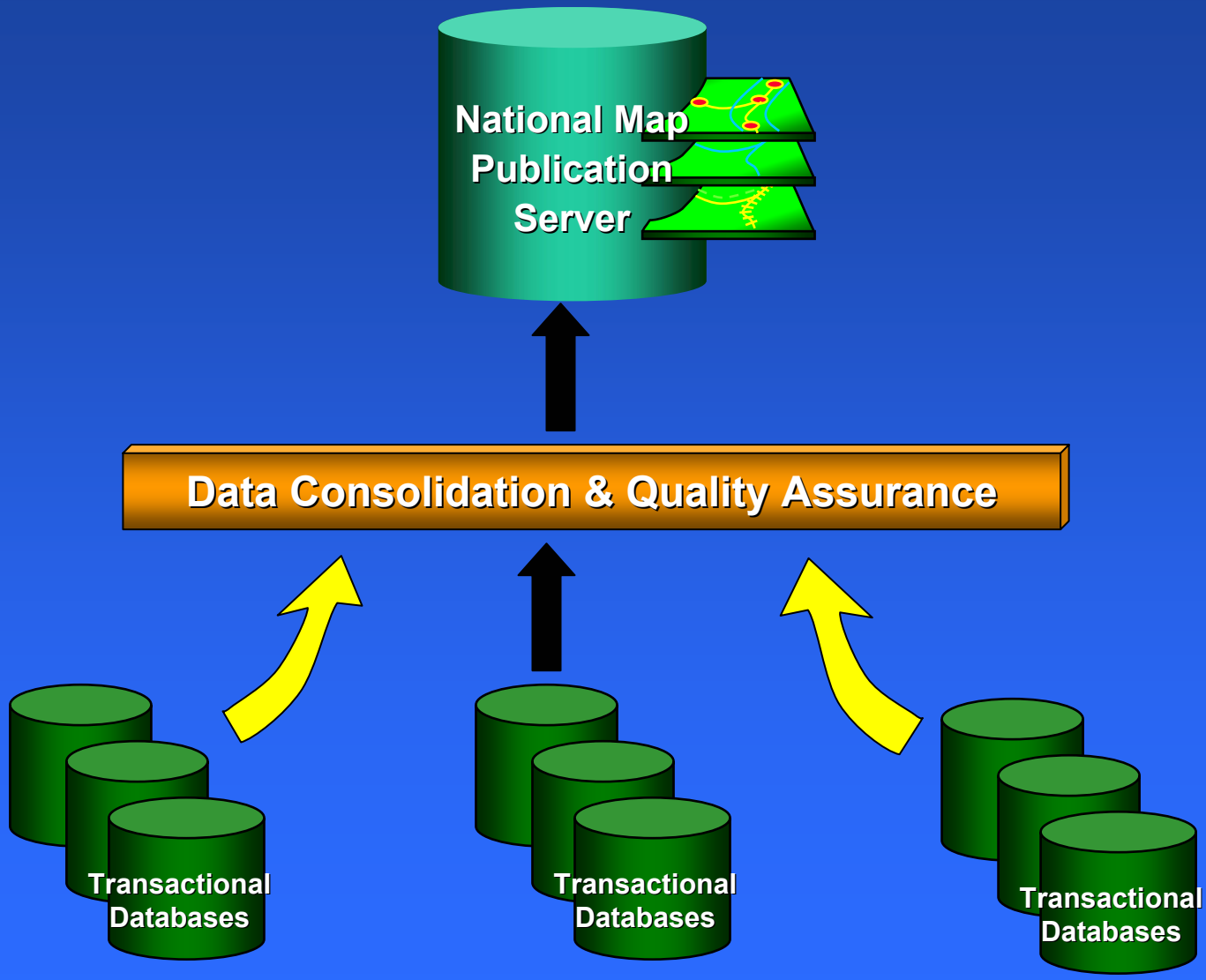
Transactional Data Management



National Map Publication Server

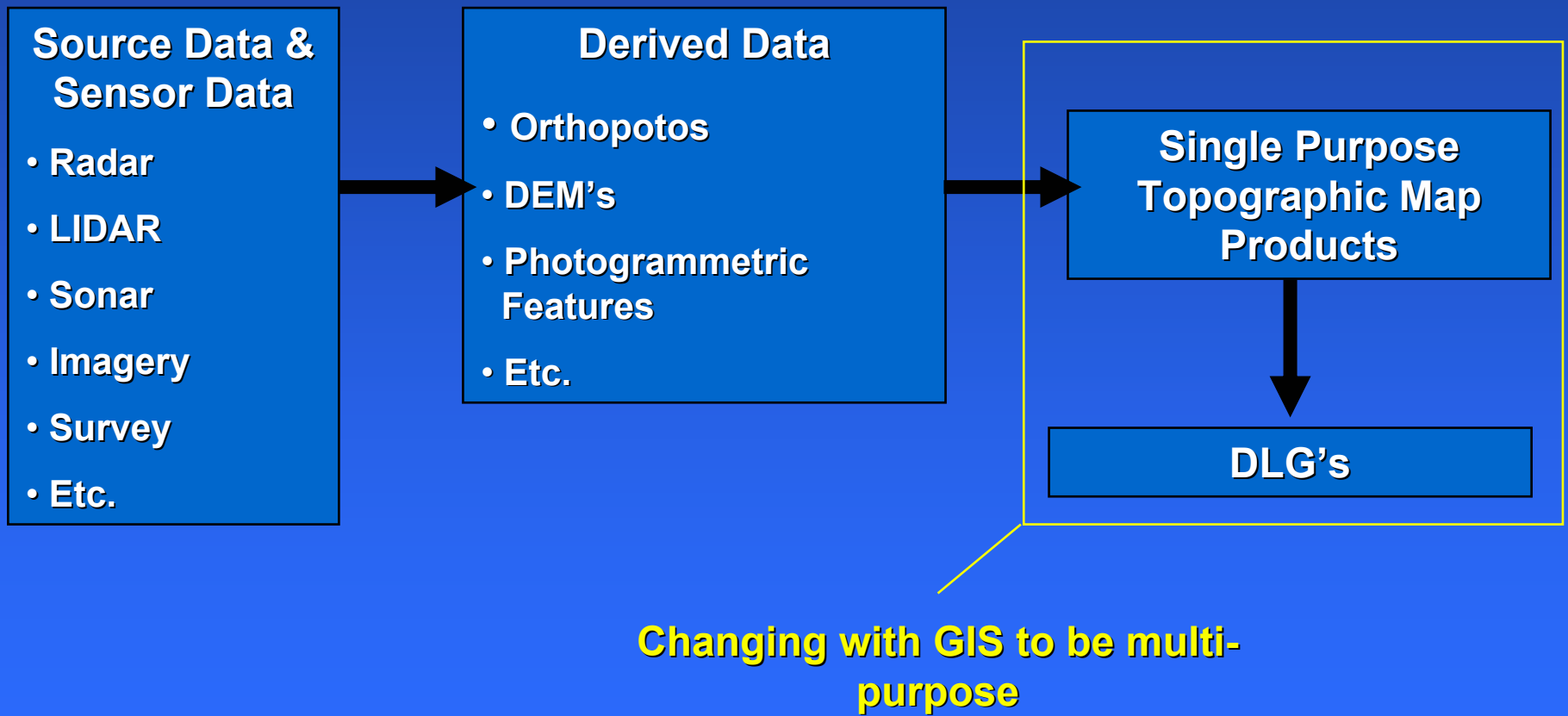
- Imagery
- Elevation
- Names
- Land Cover
- Vector Data
  - Hydrography
  - Transportation
  - Boundaries
  - Structures

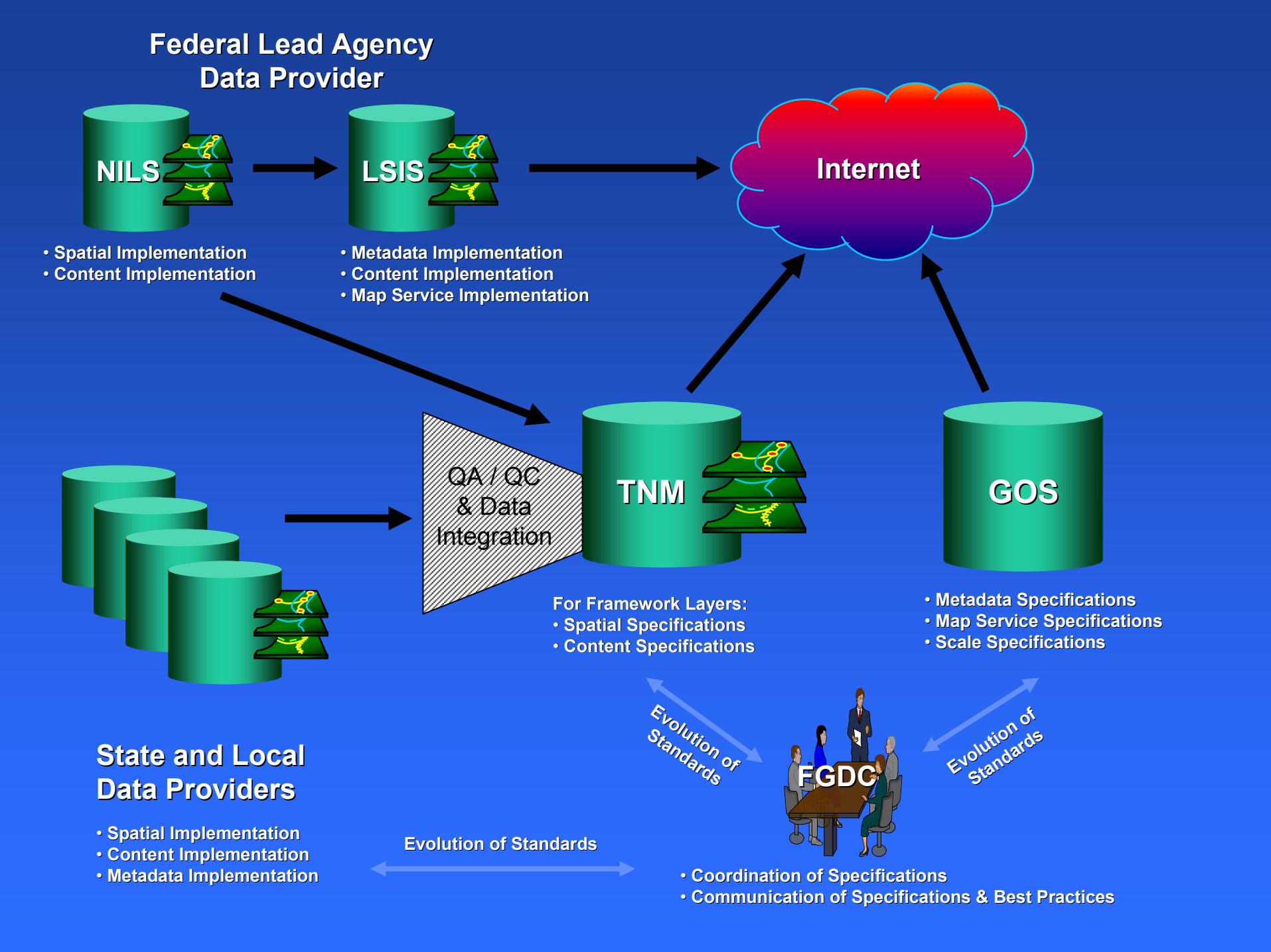
National Map Development



Framework Databases

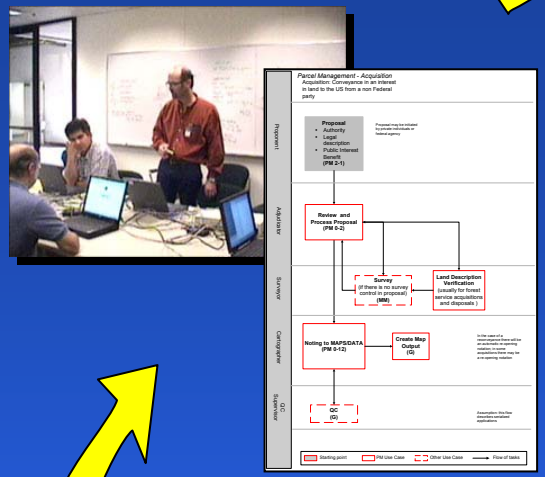
Multi-purpose & Multi-scale



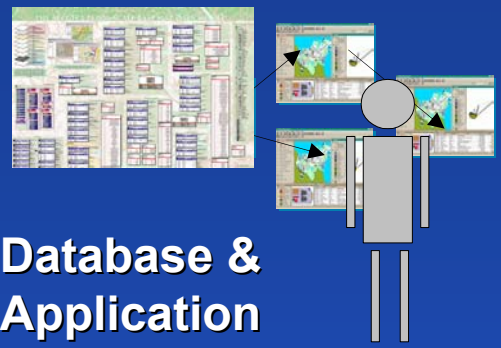

Federal Lead Agency
Data Provider
NILS
LSIS
Internet
• Spatial Implementation
• Content Implementation
• Metadata Implementation
• Content Implementation
• Map Service Implementation
QA / QC
& Data
Integration
TNM
GOS
For Framework Layers:
• Spatial Specifications
• Content Specifications
• Metadata Specifications
• Map Service Specifications
• Scale Specifications
Evolution of
Standards
FGDC
Evolution of
Standards
State and Local
Data Providers
• Spatial Implementation
• Content Implementation
• Metadata Implementation
Evolution of Standards
• Coordination of Specifications
• Communication of Specifications & Best Practices

National Map Implementation

Business Requirements Analysis



Database & Application Design



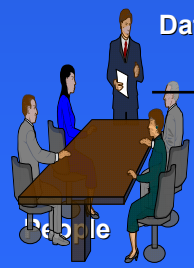
Project Planning

Hardware

Applications

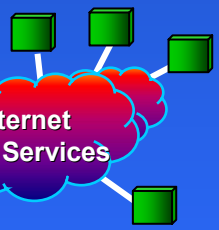
Data Resources

Network Design

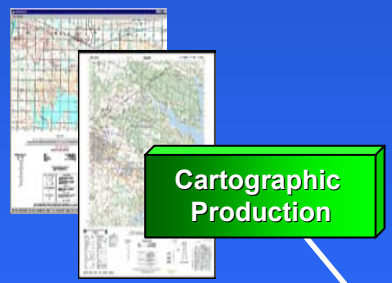


System Architecture Design

Internet Map Services

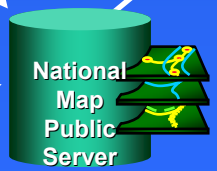


Cartographic Production



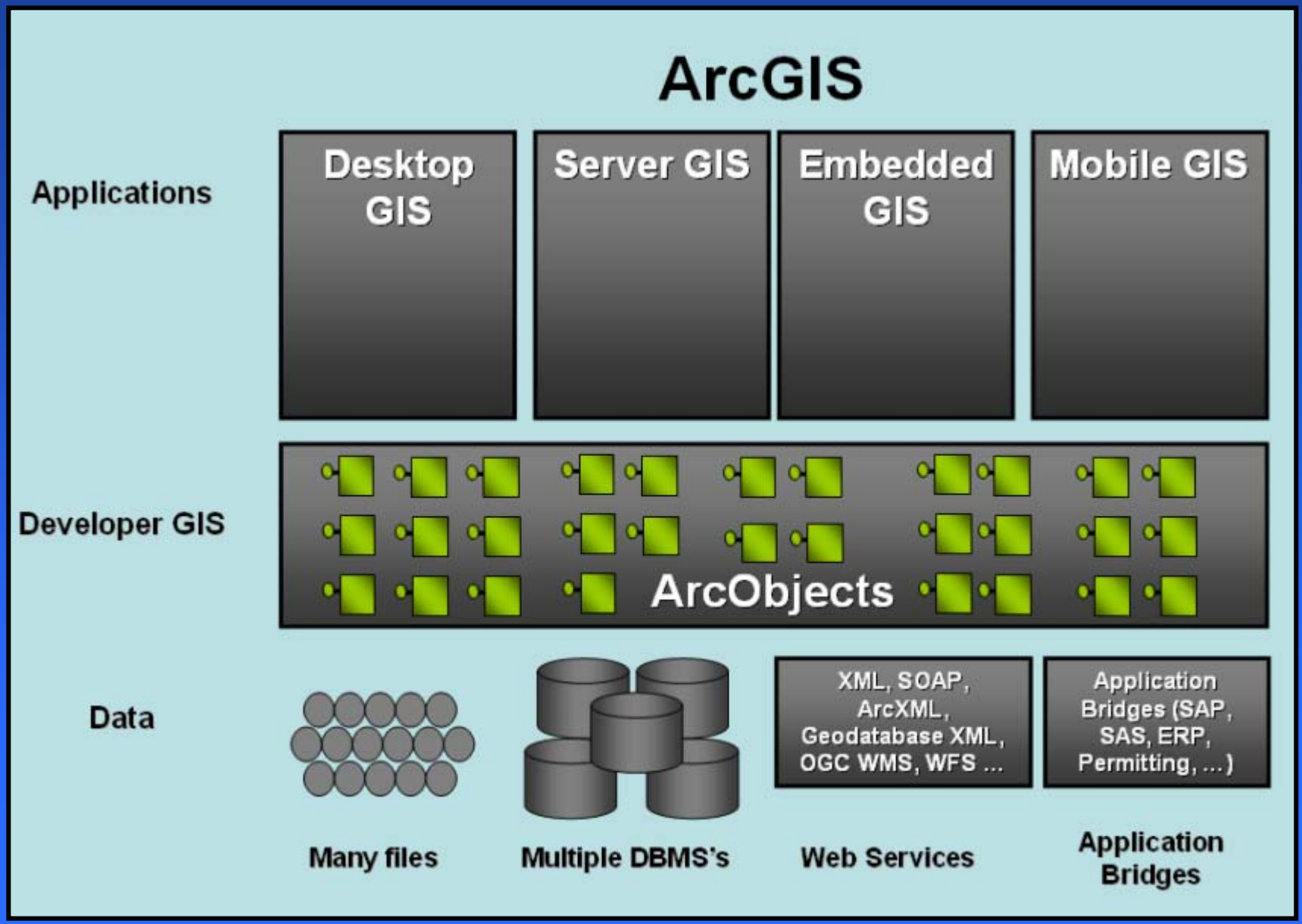
Transactional Data Management

National Map Public Server



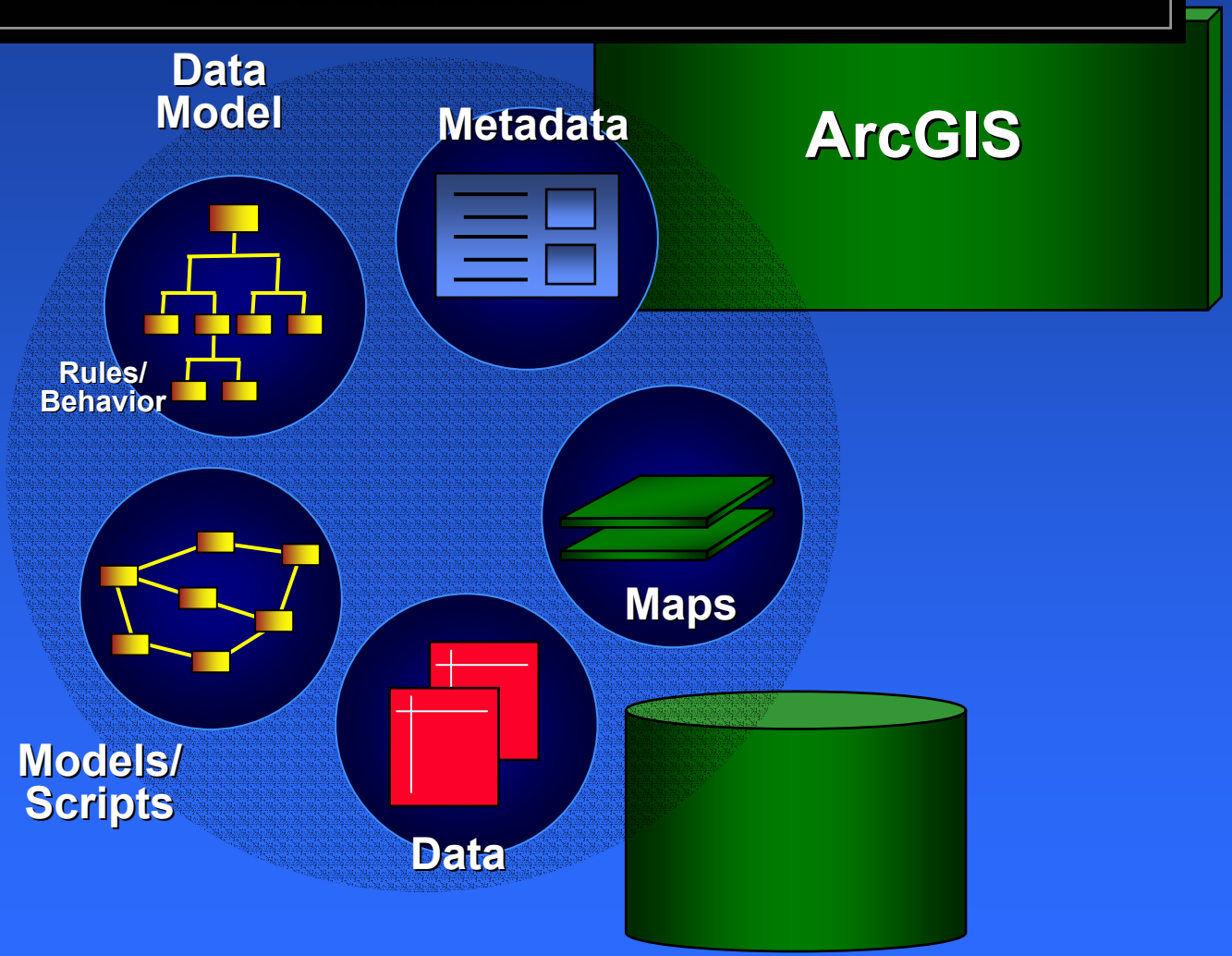
Pilot Implementation

ArcGIS 9.0 System Architecture



ArcGIS Manages the Basic Elements of Geographic Knowledge in the

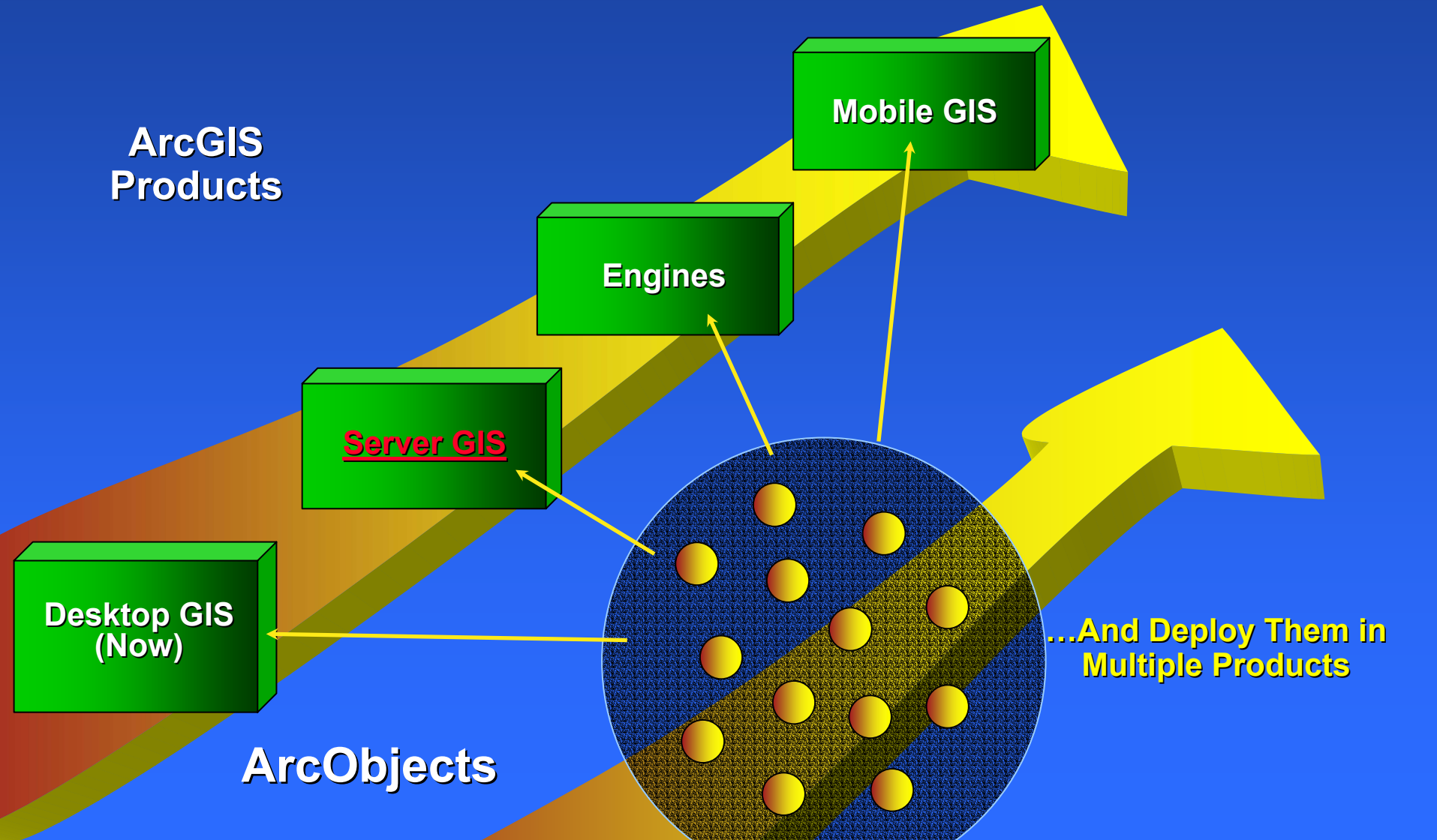
. . . Simple, Open, and Interoperable



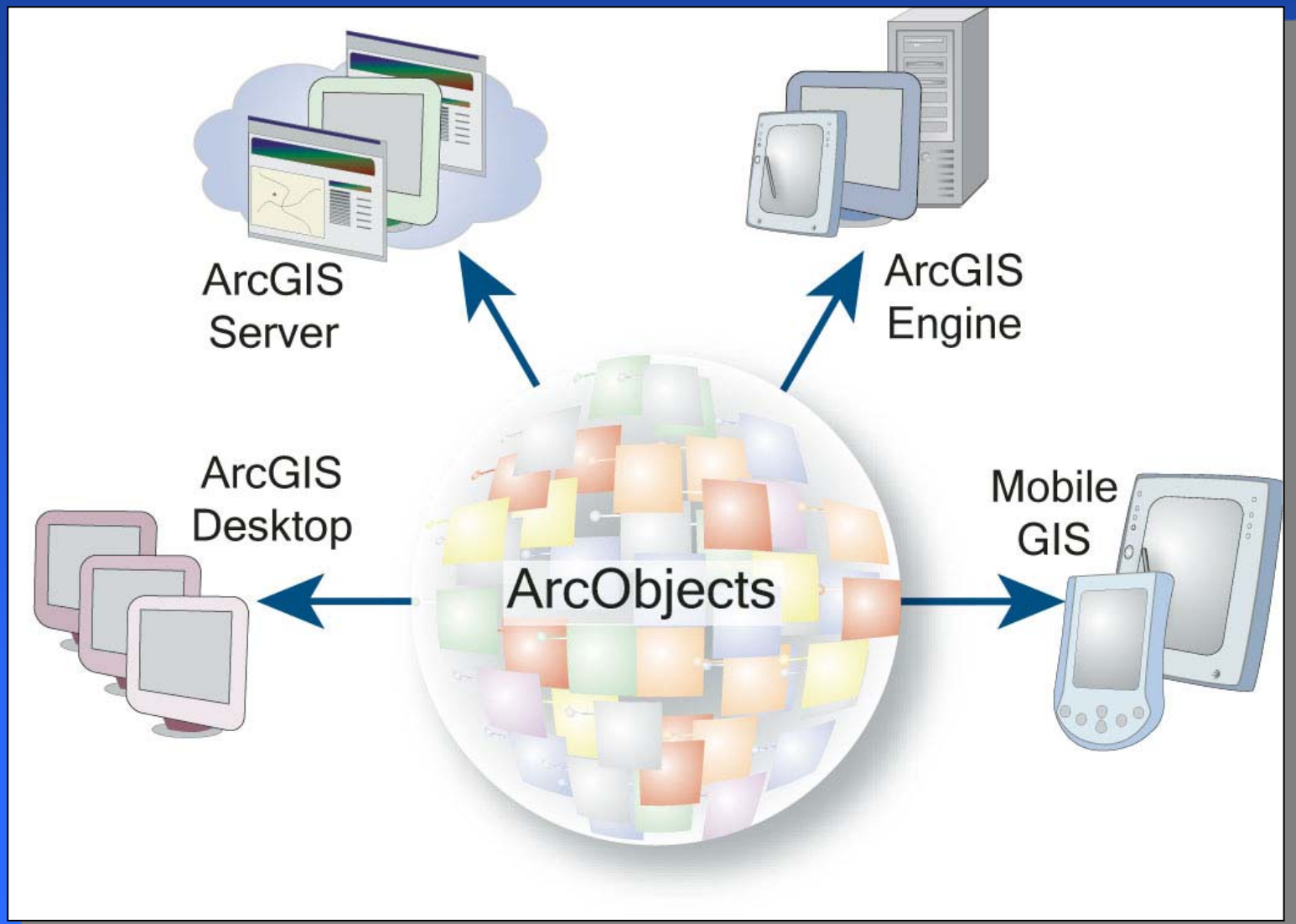
. . . And Makes Them Directly Accessible

ESRI Software Strategy

Develop Generic GIS Components . . .

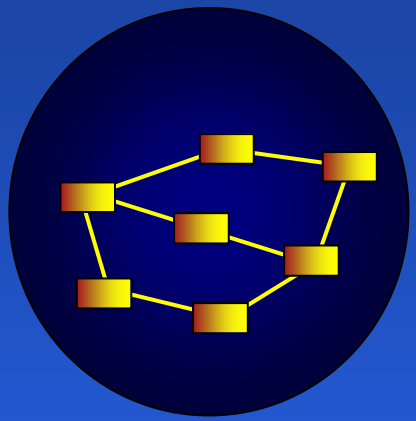


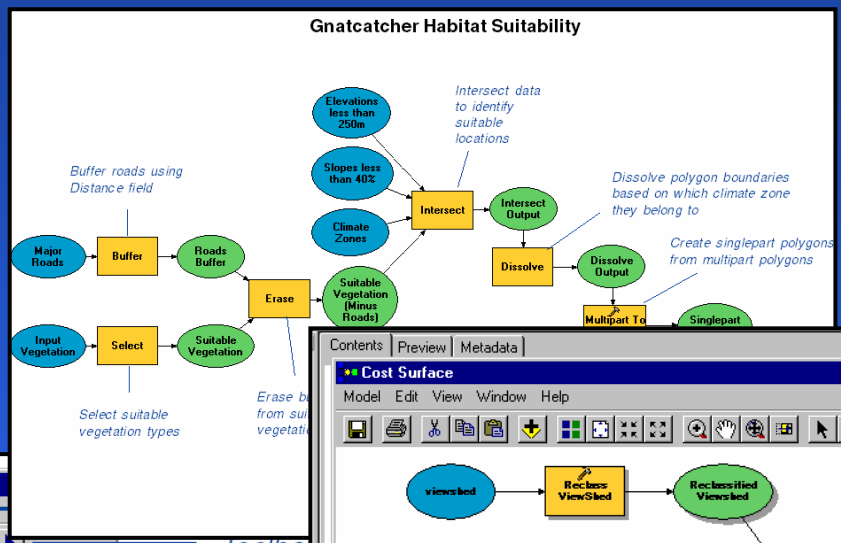
This Allows GIS Functionality to be Deployed Anywhere . . .

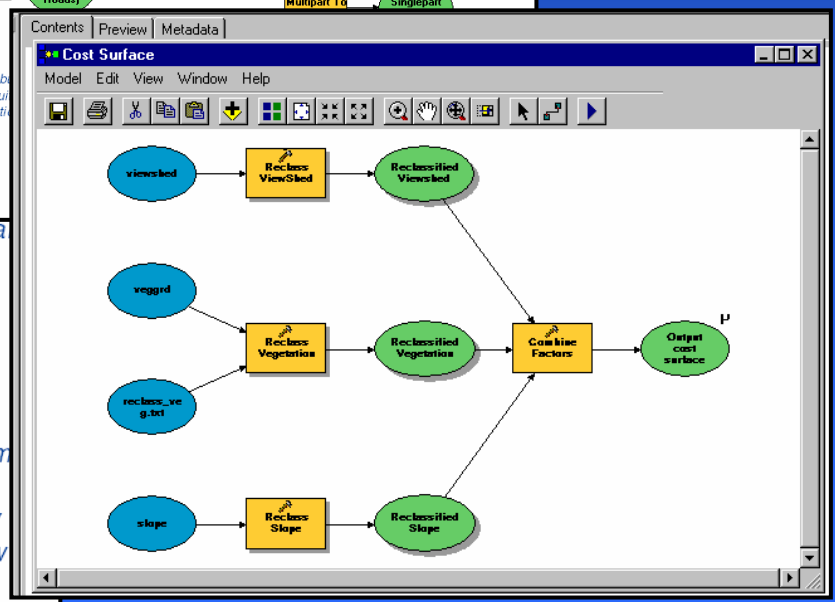


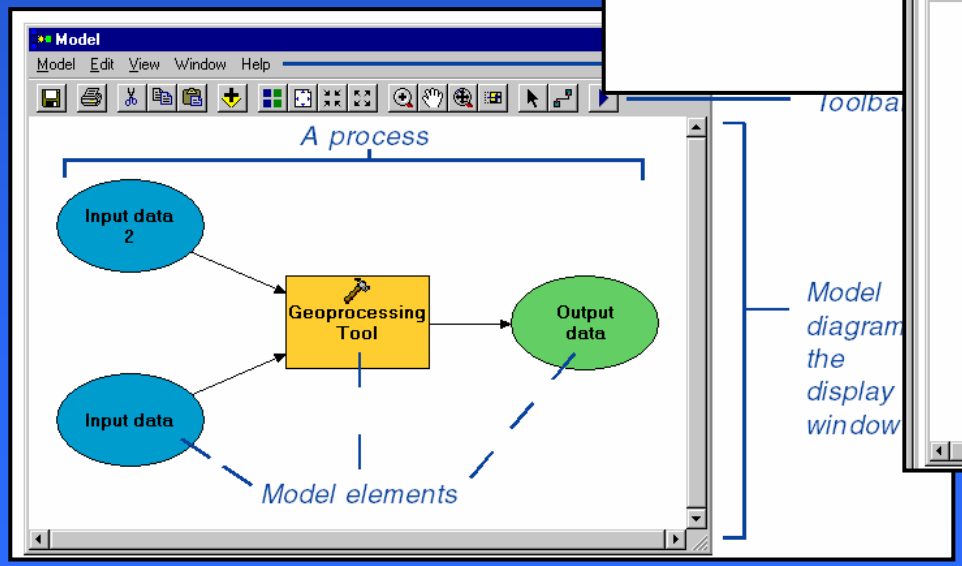
Geodatabase Encapsulates Models

– Best Practices and Applications





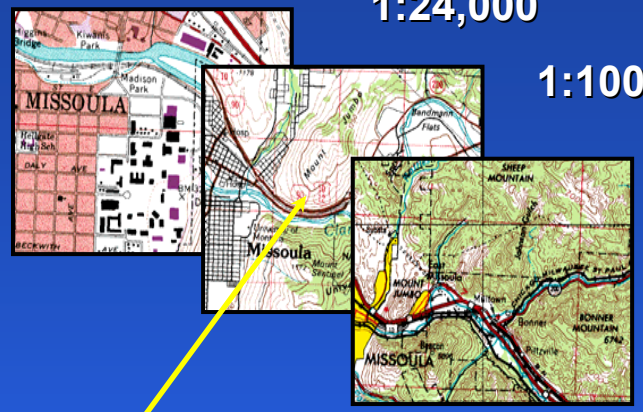




. . . Sharing Geographic Knowledge

Geodatabases Will Manage Maps

Database Cartography

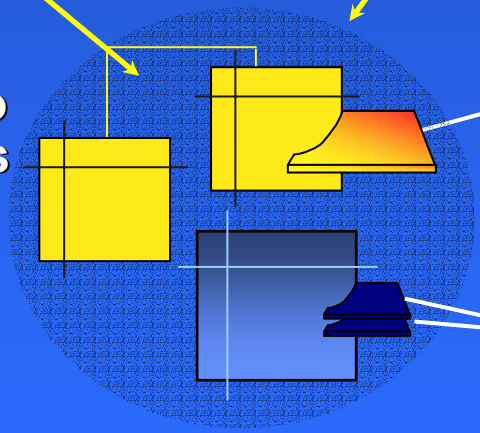


1:24,000

1:100,000

1:250,000

Extended Cartographic Editing Tools



Carto Rules

Carto Layers

GIS Layers

Solves the Problems of

- Map Series
- Generalization
- Multi Representation

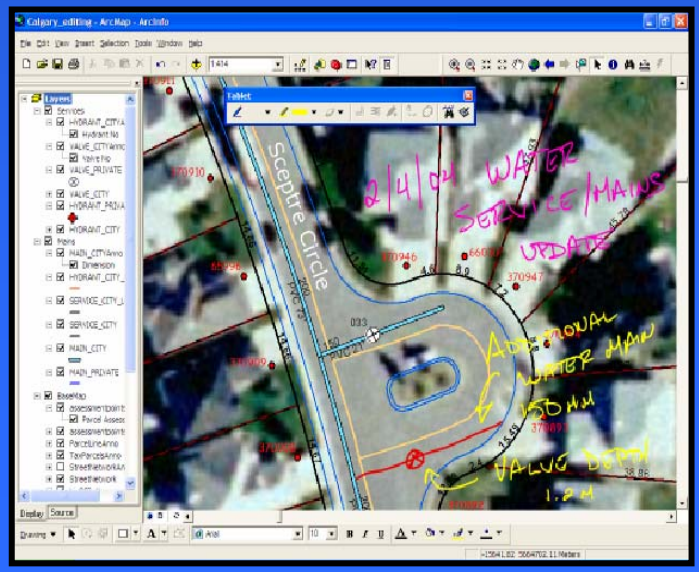
A New Approach for Production Cartography

Mobile GIS

Tear-off, take GIS to the field

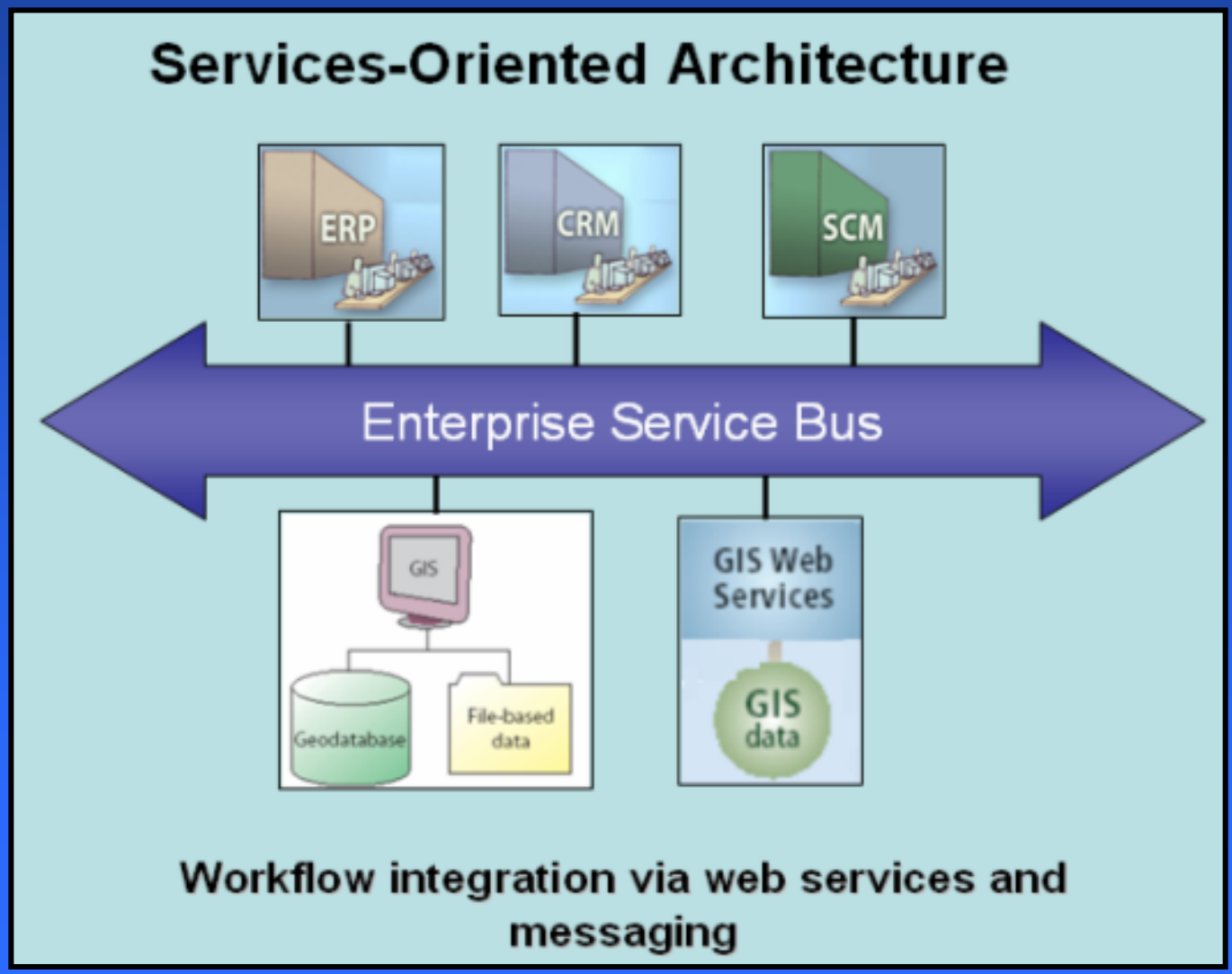
- Focused field applications on Mobile Windows CE and Pocket PC

- More advanced field computing. Ink. Complete GIS logic



Spatially enabling the DOI Enterprise

Starts with modeling (defining) business processes / workflows



52 Up To Date GIS Services

- Imagery
- Weather
- Geocoding
- Streets
- Mapping
- Routing
- Demographics
- Much More

…An Affordable Way to Rapidly Build Server Based Applications