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science for a changing world

The National Map

Integrating ESRI geodatabases and Oracle RDBMS in The National Map

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Abstract

Geodatabases can be started from scratch and developed entirely within the ESRI environment. However, others can evolve from an existing Oracle RDBMS with its own applications and data maintenance processes built with Oracle tools. What can be done to optimize the complementary capabilities of both the ESRI GIS and the Oracle relational environments? How can the hierarchical structure of the geodatabase be reconciled with an existing complex relational design without unnecessary duplication of data or processes? How can GIS and text-based applications be merged, leveraging both for optimum user access and data maintenance over the Web? USGS faced these issues when designing the Structures, Boundaries, and Names layers of The National Map and integrating them with the Geographic Names Information System (GNIS). This presentation will discuss the issues, problems, answers, and proposed answers to optimizing the ESRI GIS and Oracle RDBMS paradigms in the same system without constraining either.

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Agenda

- From MIS to GIS
- Example: GNIS and *The National Map*
- Geospatial Data Storage
- Geospatial Data Access
- Web Services
- Integrated Data Maintenance
- Integrated Applications

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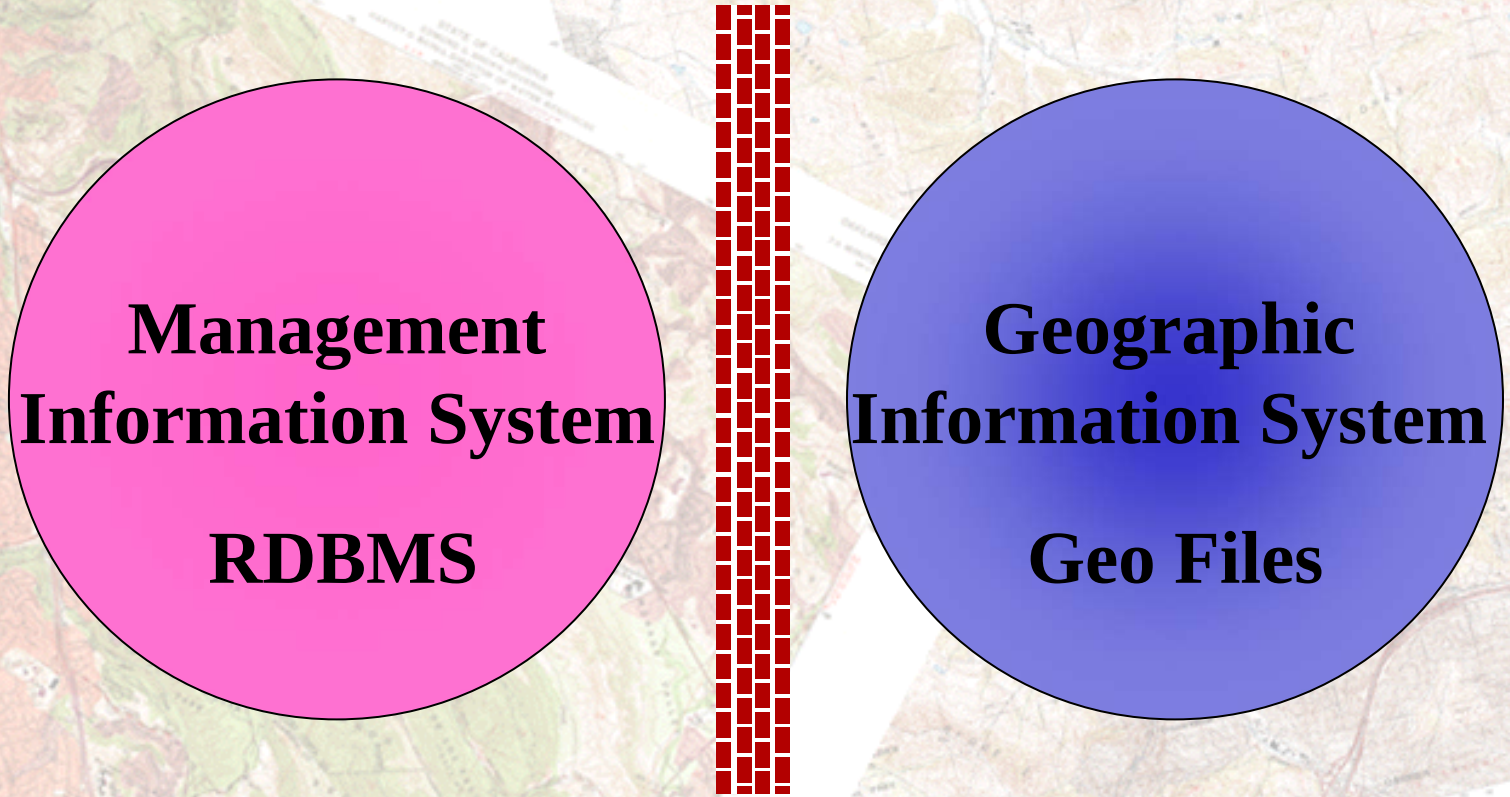
MIS and GIS – Not Long Ago



- Independent paradigms, separate tool sets
- No common data stores, functions, or applications

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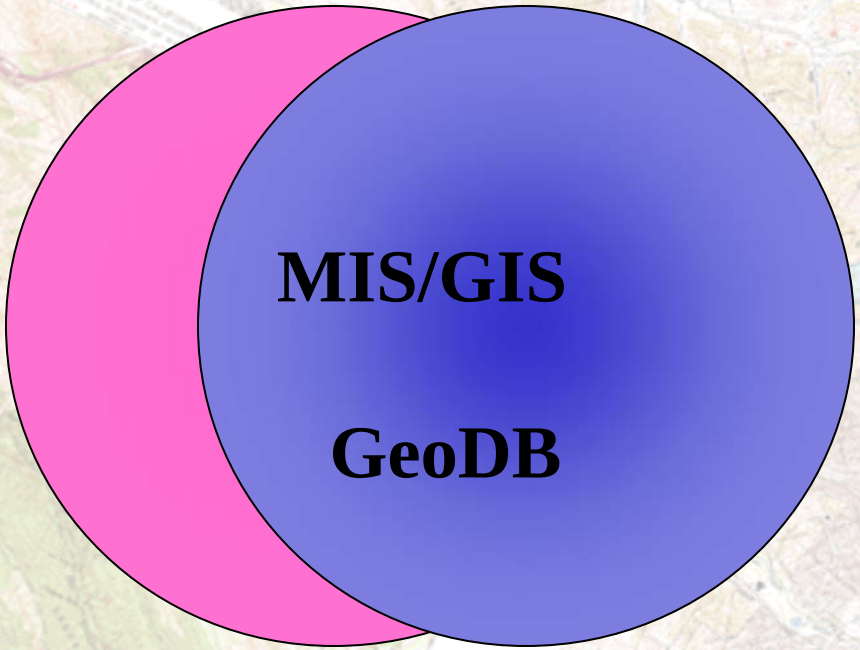
MIS and GIS Now



- Merging paradigms, compatible tool sets
- Common data stores
- Potential for common functions and applications

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Example: GNIS

The Geographic Names Information System

Single authoritative and official electronic source for applying geographic names to Federal maps and other products depicting areas under U.S. jurisdiction

- 1.92 million U.S. features
- 2.29 million feature names
- 13,733 Antarctic features
- 354,406 USGS cell definitions

Supporting U.S. Board on Geographic Names since 1975

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http://geonames.usgs.gov

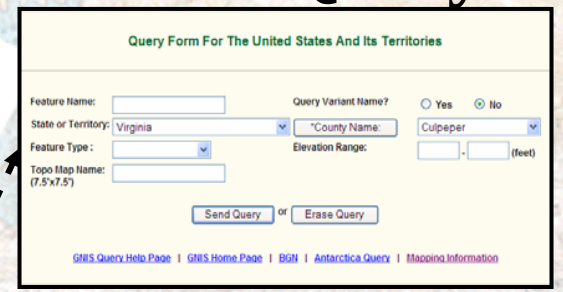
MIS Architecture

Web Server
(Oracle IAS 9i)

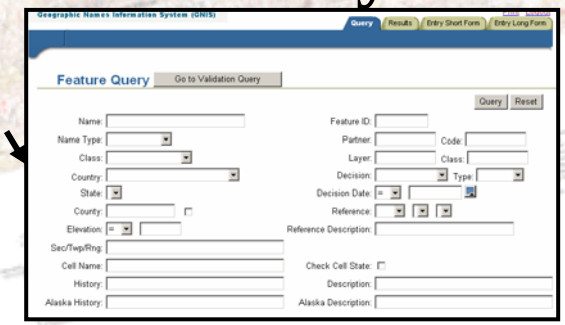
Applications
(Oracle HTMLDB)

RDBMS
(Oracle 10g)

Public Query



Data Entry/Edit



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Feature Record

Feature Name:	Rapidan River
Feature Type:	stream

State	County
Virginia	Culpeper
Virginia	Spotsylvania
Virginia	Orange
Virginia	Madison
Virginia	Greene

Variant Name(s)
Rapid Ann River
Rapid Anne River
Rapidanna River
South River

Latitude / Longitude (nn°nn'nn" / nnn°nn'nn")	USGS 7.5' x 7.5' Map
382204N 0773709W	Salem Church
382206N 0773730W	Chancellorsville
382232N 0773822W	Richardsville
382244N 0775231W	Culpeper East
382230N 0775434W	Unionville
382040N 0780000W	Rapidan
381459N 0781119W	Gordonsville
381500N 0781606W	Rochelle
382007N 0782231W	Stanardsville

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Official Name

Feature Class

Counties containing the feature. (Relational, not spatial data)

Variants – Names other than the official name.

Coordinates – One point per standard UGSS Topographic Map containing the feature. (Relational, not spatial data)

MIS Capabilities

- Feature based
  - Feature ID – Random number unique record identifier
- Complex RDBMS schema
  - ~ 30 tables, 130 columns, 30 keys
  - Multiple domains, tiered relationships
  - Easily expanded without affecting established tables
- Normalized data
- Optimized for relational data management
- Large customer base
- Operational web-based query & data maintenance
- Established contributing data partners

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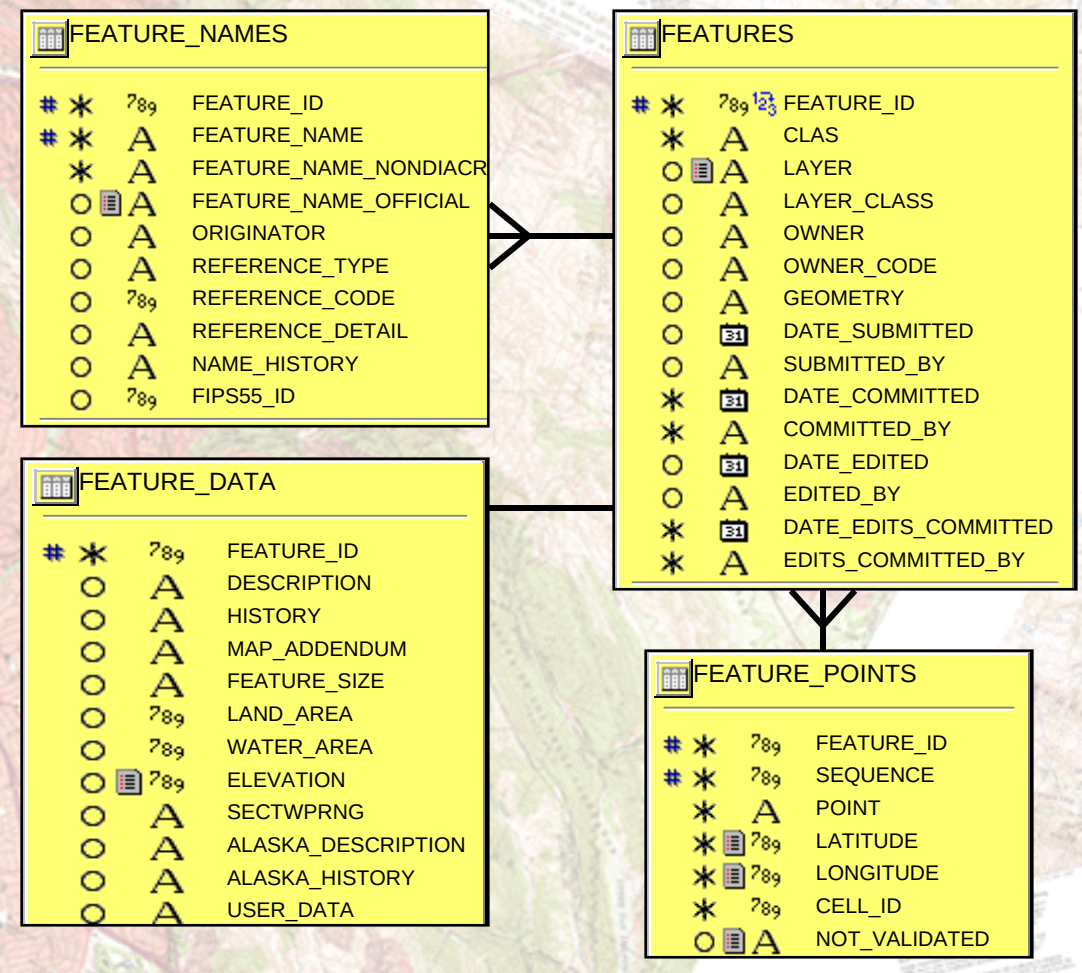
Relational Database (Simplified)



- **Entities = Tables**
- **Attributes = Columns**
- **Relationships:**
  - = Many to 1
  - = 1 to 1
- **Key = Feature ID**
- **Normalized Data**

(A GIS generally is not a fully normalized RDBMS)

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GIS Potential

- Primary Attributes
  - Feature ID
  - Official Feature Name
  - Official Feature Location – Lat/Long in decimal degrees
- Secondary Attributes
  - Feature Class
  - Names other than official
  - Secondary points – one per standard USGS quad
  - Counties/States – relational data, not spatial
  - History, Description, References, Name Decisions, etc.
- Can add geospatial data tables/columns

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New Challenge – *The National Map*

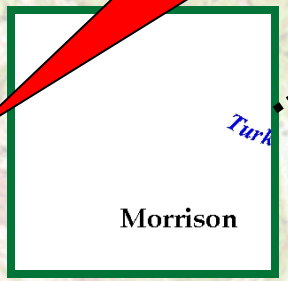
Orthorectified imagery

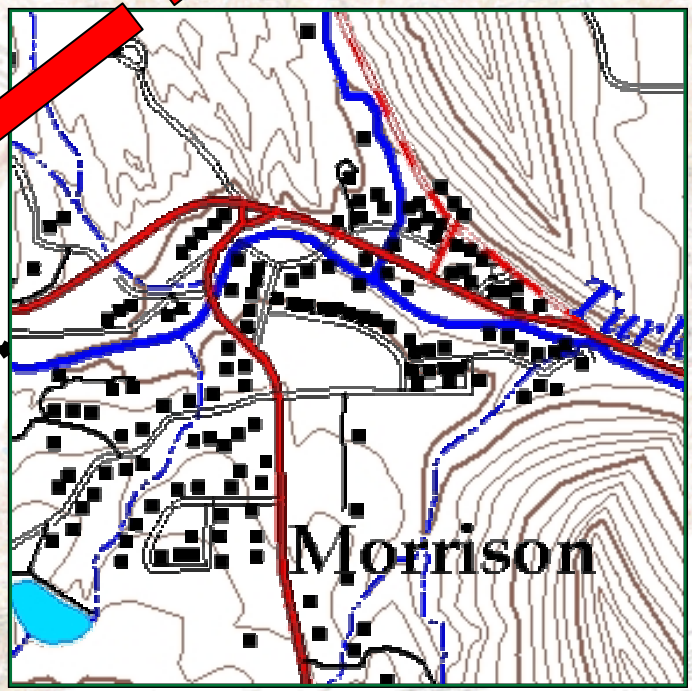
Names a Primary Layer

Elevation

Transportation
Hydrography
Structures
Boundaries

Geographic Names





http://nationalmap.usgs.gov/

Land cover

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How to get from MIS to GIS?

- Database
  - ✓ Store and manage geospatial data in MIS (completed)
  - ✓ Utilize existing relational schema (completed)
  - ✓ Produce spatial layer views of the data (completed)
- Provide web services – ✓map, ✓XML, feature,
- Web Applications
  - ✓ Maintain data – entry and edit (completed)
  - Query/Display/Maintain geospatial data
  - Integrate graphic displays with existing applications
- Goal: Optimize capabilities of both MIS and GIS
- Bottom Up approach

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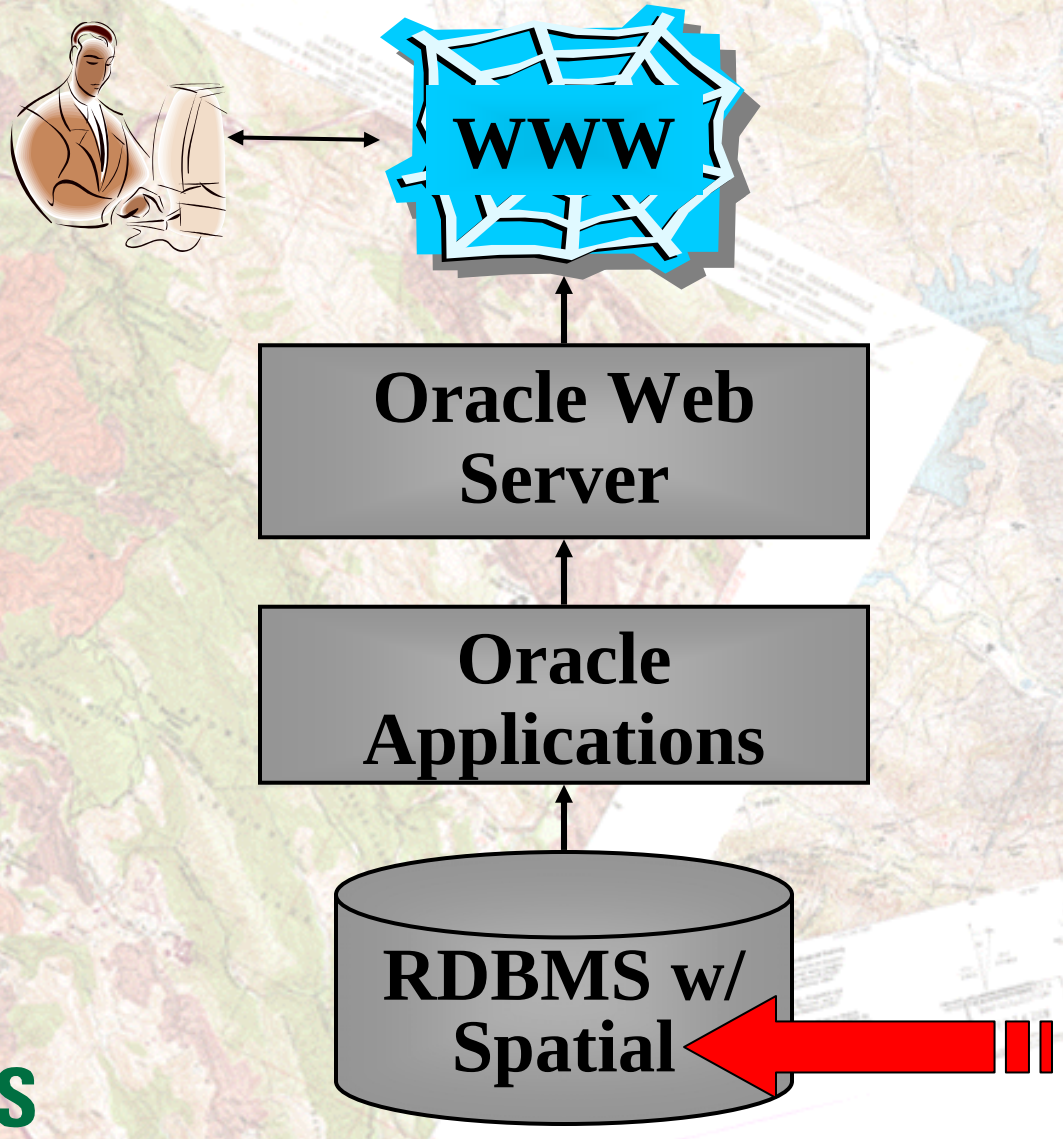
Geospatial Data Storage



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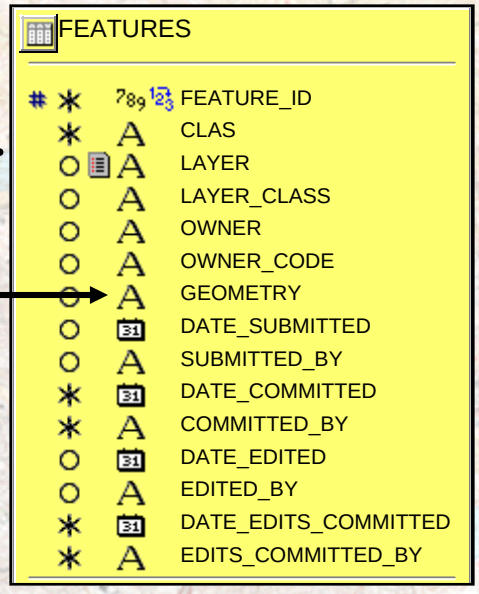
Geospatial Data Storage

The easy part

- Convert lat/long to SDO_GEOM
  - (Or Long Raw, LOB, ST_GEOM, Image. Same design principles apply)
- Just another column
- Not necessary to change schema
  - Although can be done if needed
- Full SQL access and capability
- Multiple geometry columns possible
  - Add geom column for feature polygon boundaries



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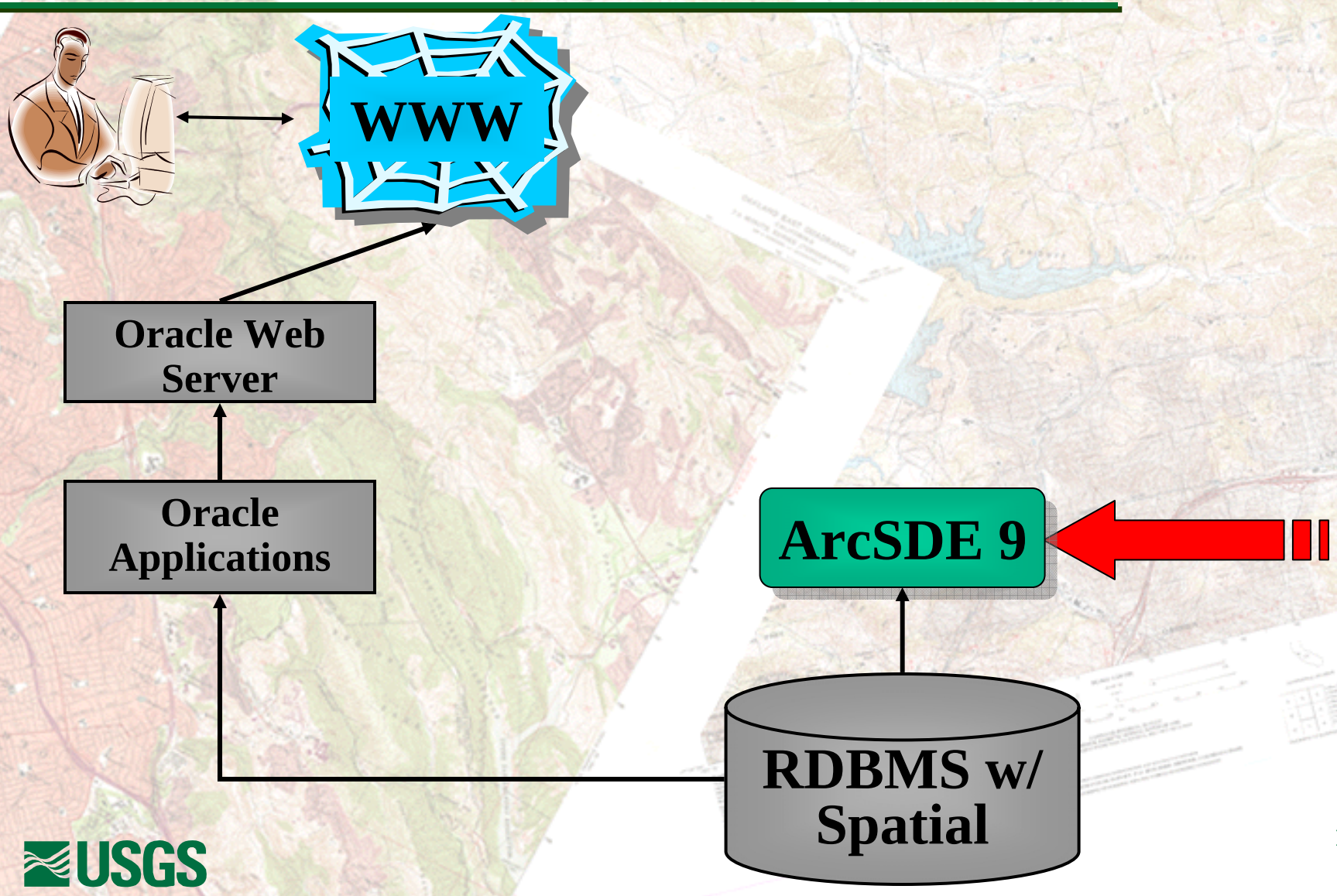
Geospatial Data Access



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Geospatial Data Access

- Gateway for storing, managing, using spatial data
- Mixed vendor environment – Oracle and ESRI
- Learning curve for non-ESRI technical personnel
- ESRI/Oracle interactions good but still evolving.
  - Some rough spots.
- Training required
- Additional DBA effort and resources
- More resources – processors, storage, etc.

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Problem: Tables are Not Layers

Theme Based & Denormalized

Class 1 Layer	Class 2 Layer	Class 3 Layer	Class 4 Layer
Feature ID Name Class Geometry Description (etc.)	Feature ID Name Class Geometry Description (etc.)	Feature ID Name Class Geometry Description (etc.)	Feature ID Name Class Geometry Description (etc.)

How to get from to ?

Names Table	Feature Table	Data Table
Feature ID Name(s) References	Feature ID Class Geometry	Feature ID History Description (etc.)

Relational & Normalized

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Answer: Separate Layer Tables

- Format and create data layer tables – one per layer
  - As GeoDatabase would if created from top down
  - Any combination of attributes – just views on the data
- Primary attributes the same across layer tables
- The same primary key – Feature ID
  - i.e., Feature based system
- Layer Table Data duplicates Base Table data
  - All or specified attributes
- Register the layer tables in ArcSDE

(You ask: How do we maintain duplicate data?
Stand by for application topic.)

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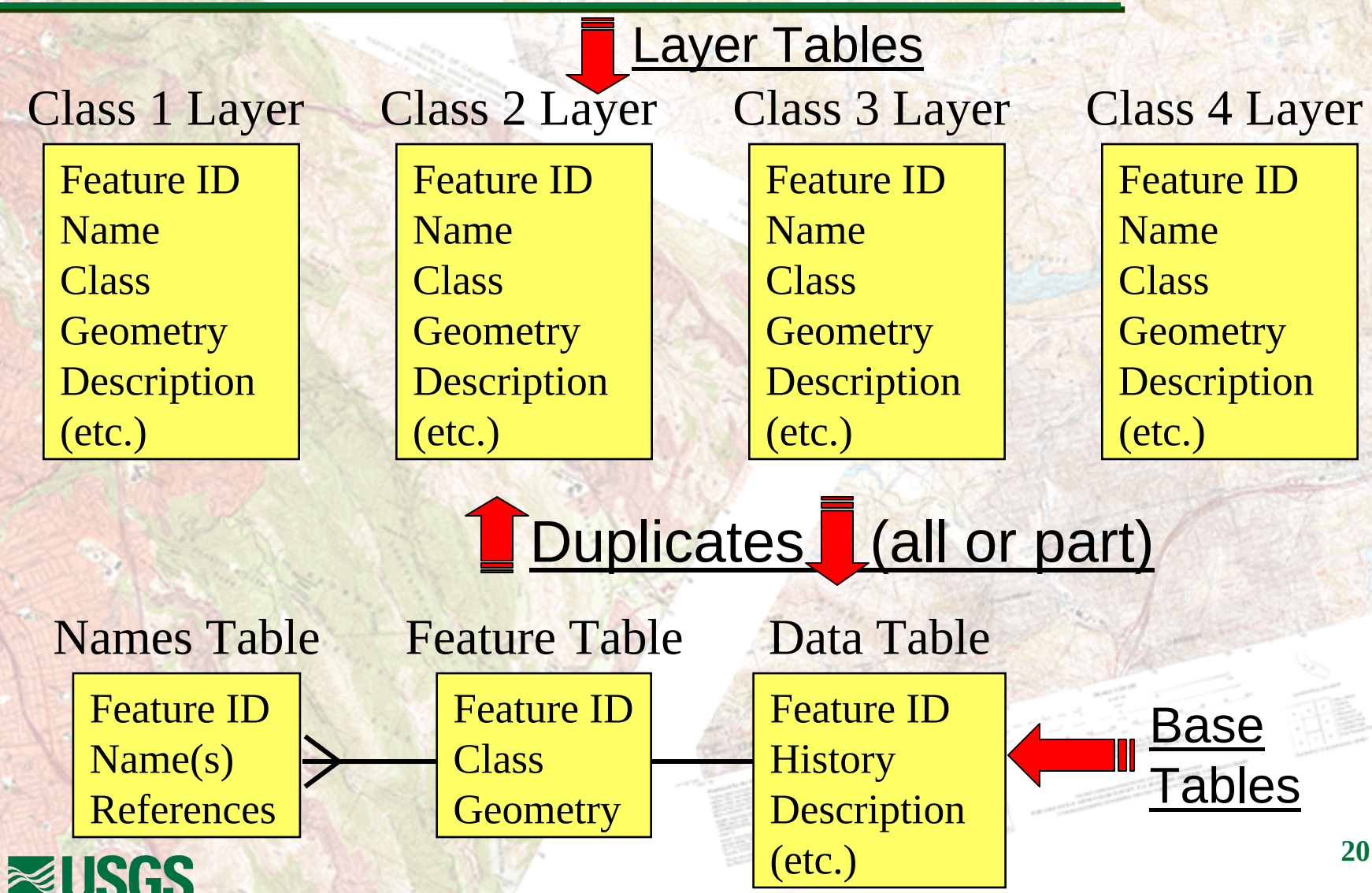
Layer Tables and Base Tables



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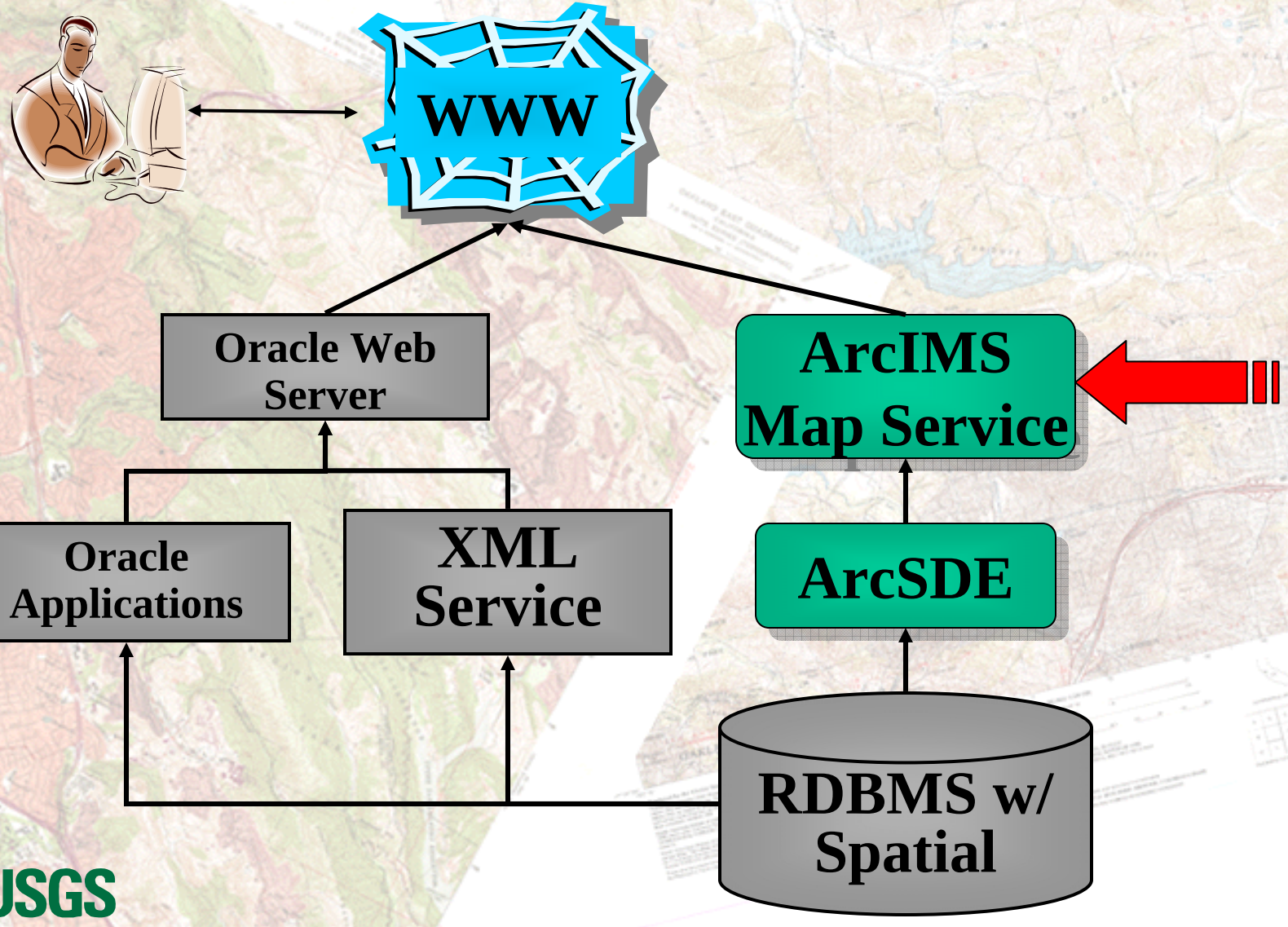
Web Services



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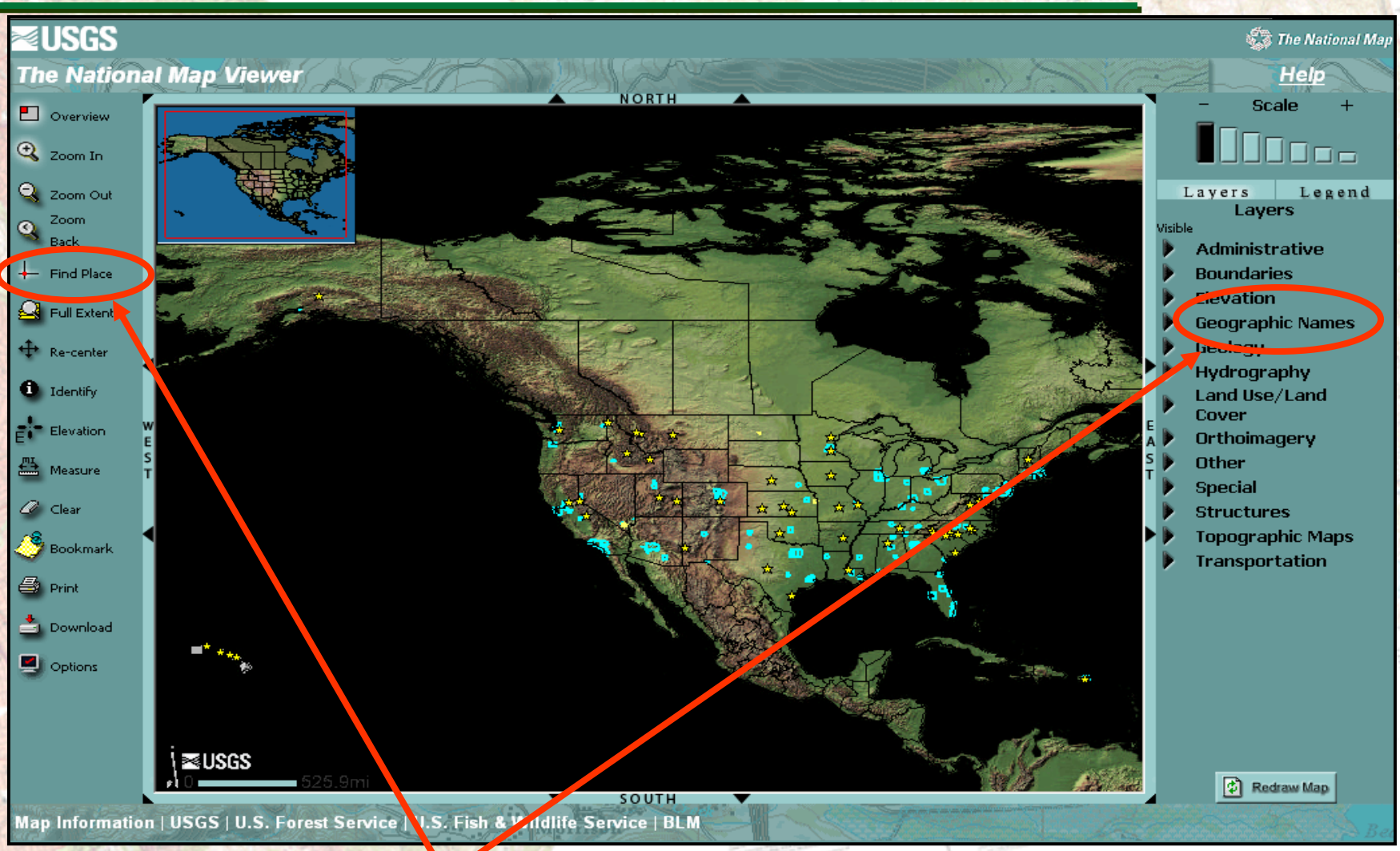
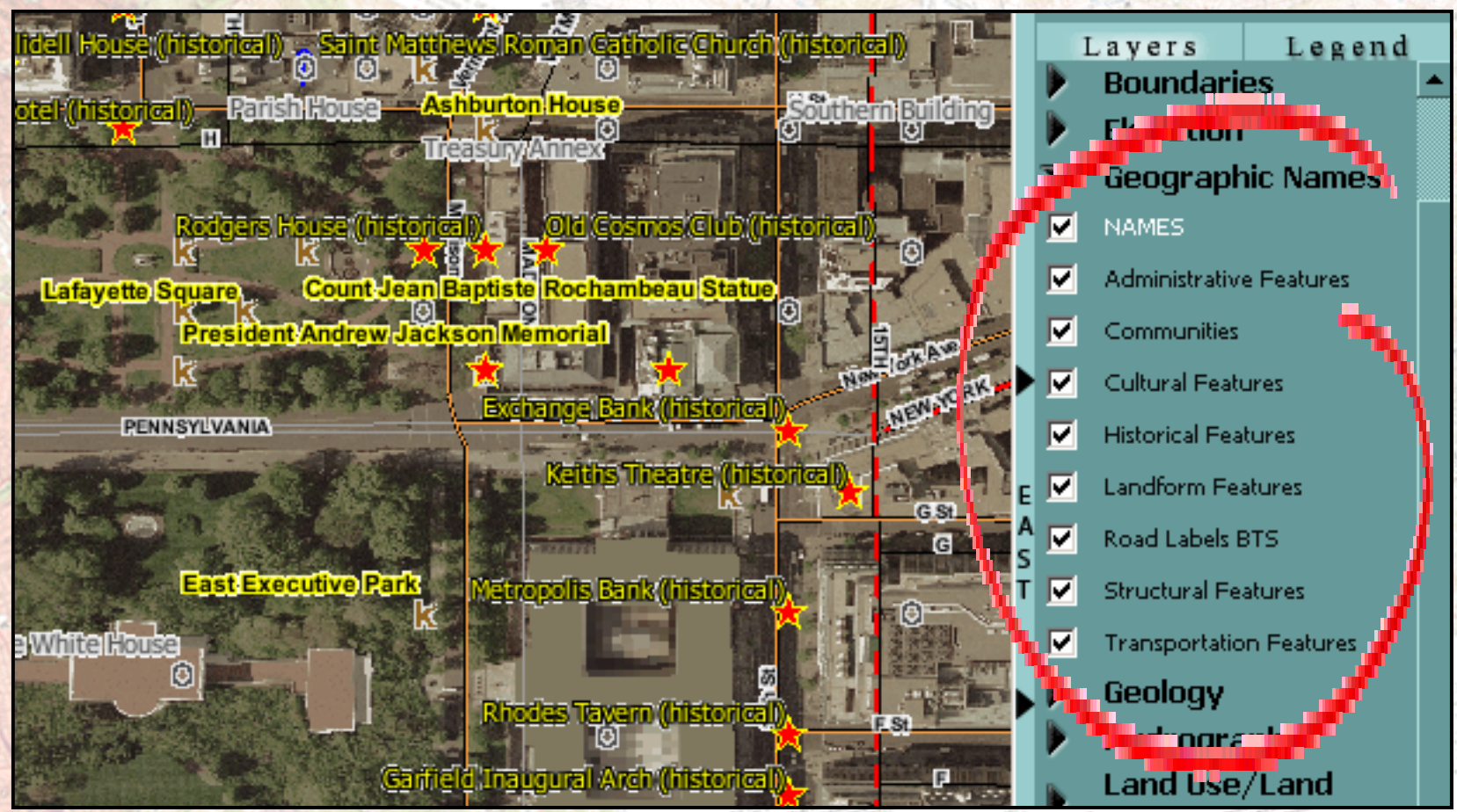
Names in *The National Map* Viewer



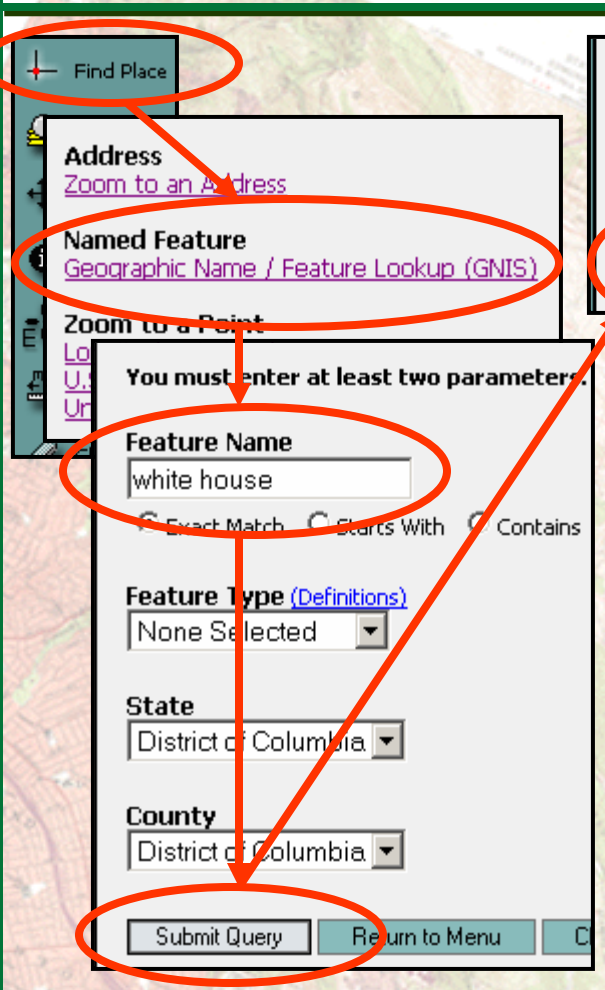
USGS **Names/GNIS**

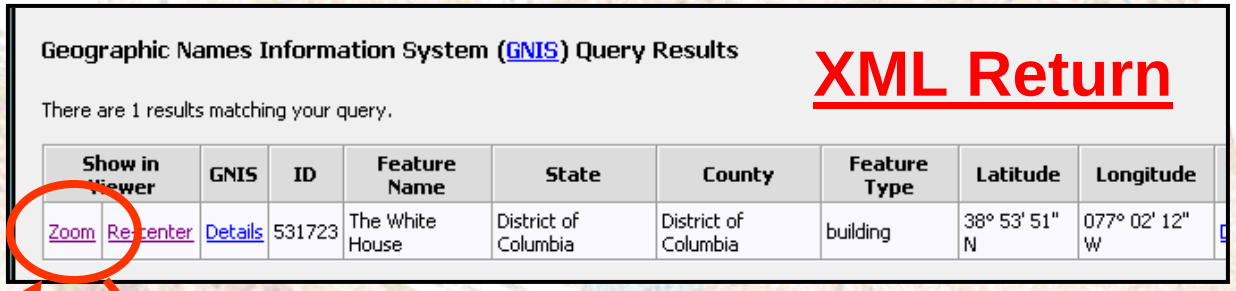
http://nationalmap.usgs.gov

Names Layers from Map Service

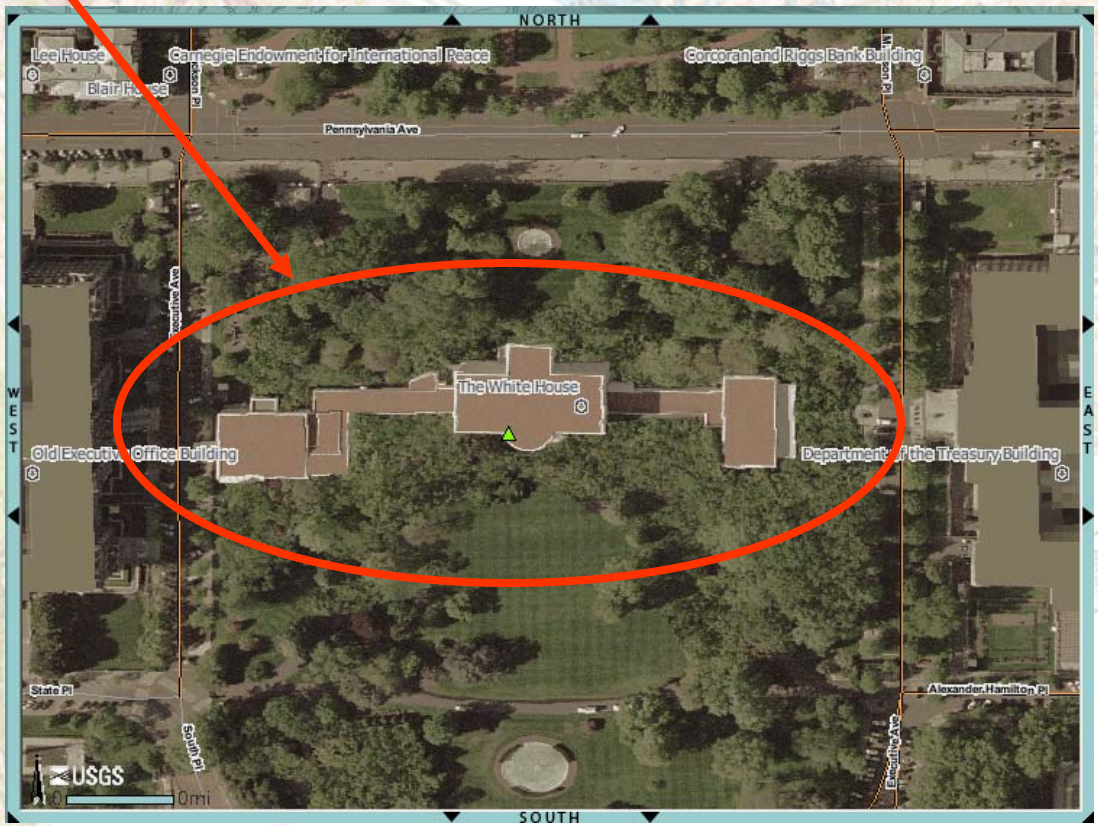


Find Place from XML Service





XML Return



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Sample XML query: Airports in a box

URL: http://geonames.usgs.gov/pls/geodev/testplxml?x1=-109&y1=37&x2=-102&y2=40&f_type='AIRPORT'

```
<!--
SELECT
A.FEATURE_ID,A.FEATURE_NAME,A.CLAS,A.STATE_NUMERIC,A.COUNTY_NUMERIC,C.LATI
TUDE,C.LONGITUDE
  from feature_view_epa a, features b, feature_points c
 where a.clas ='AIRPORT' and a.feature_id = c.feature_id and a.feature_id
= b.feature_id and a.feature_id in (select feature_id from features where
mdsys.sdo_relate ( POINT, mdsys.sdo_geometry (2003, null, null,
mdsys.sdo_elem_info_array (1,1003,3), mdsys.sdo_ordinate_array (-109,37,-
102,40)), 'mask=ANYINTERACT querytype=WINDOW LAYER_GTYPE=POINT') ='TRUE')
-->
- <USGSLIST>
  - <USGS>
      <A.FEATURE_ID>204323</A.FEATURE_ID>
      <A.FEATURE_NAME>Mesa Verde Heliport</A.FEATURE_NAME>
      <A.CLAS>AIRPORT</A.CLAS>
      <A.STATE_NUMERIC>8</A.STATE_NUMERIC>
      <A.COUNTY_NUMERIC>83</A.COUNTY_NUMERIC>
      <C.LATITUDE>37.24972</C.LATITUDE>
      <C.LONGITUDE>-108.50056</C.LONGITUDE>
    </USGS>
```

ETC.

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Data Maintenance – Two Avenues

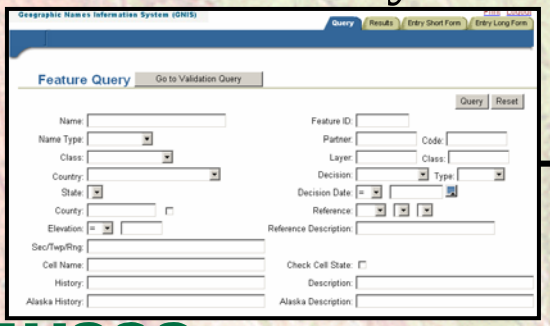
Arc Tools/Applications

Insert/Update/
Delete

Layer Tables

Feature ID	ID	ID	ID
Name			
Class			
Geometry	y	y	y
Description	ion	ion	ion
(etc.)			

Web Data Entry/Edit



Insert/Update/
Delete

Feature ID
Class
Lat/Long

ID
Name(s)
References

Base
Tables

ID

Description
(etc.)

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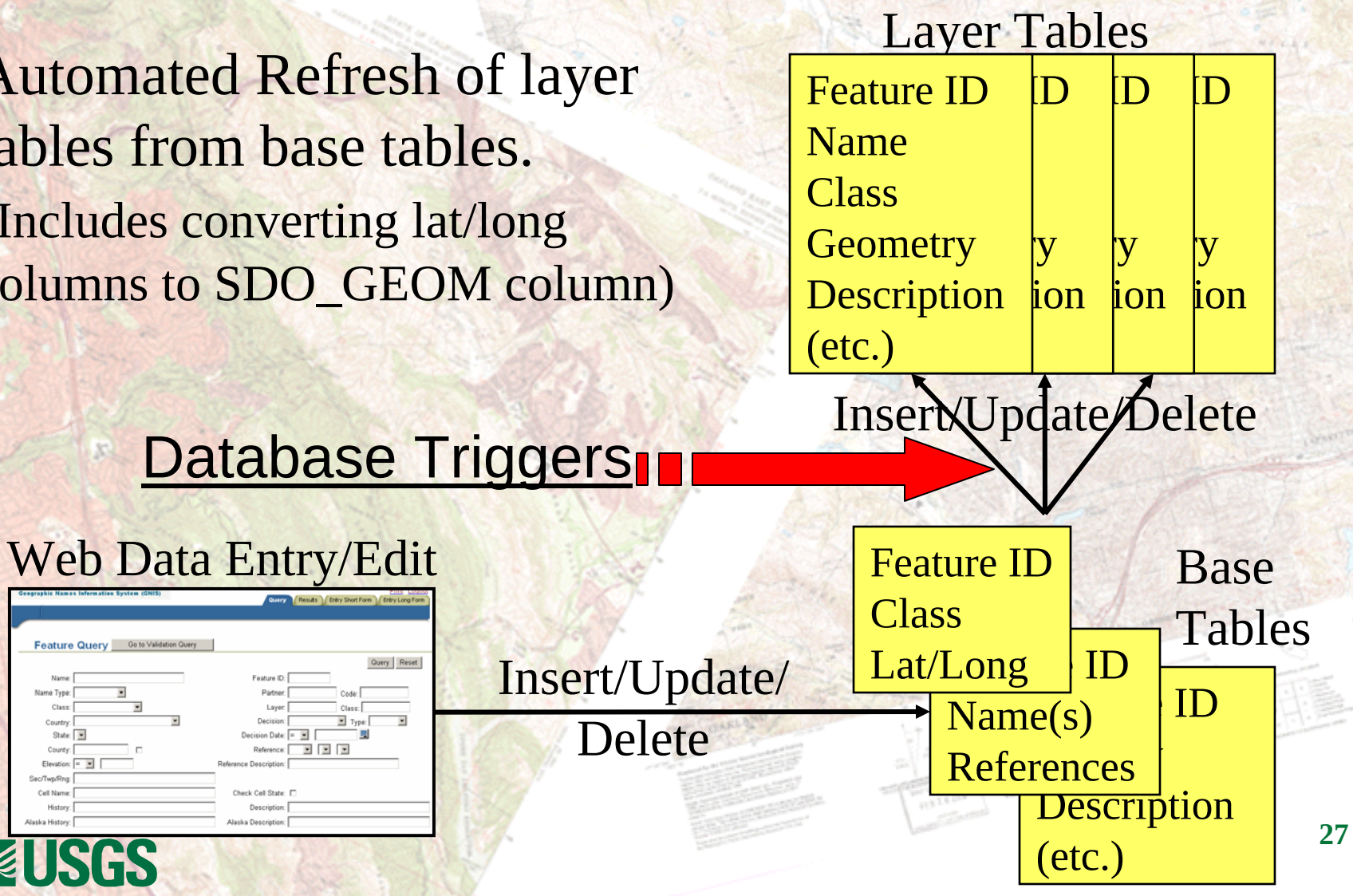
Data Maintenance Step 1 (Completed)

Automated Refresh of layer tables from base tables.

(Includes converting lat/long columns to SDO_GEOM column)



Data Maintenance Step 1

- Advantages – Better for text/number attributes
  - Data normalized (not duplicated across tables)
  - Better management of data, relationships, domains
  - Manage business rules & data validation in the DB
  - Reduces load on middle tier and applications
  - Thin client web maintenance application
- Does not
  - Load or maintain complex spatial attributes
  - Allow geospatial data analysis
  - Leverage other GIS tools & capabilities

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Data Maintenance Step 2

Set up Arc Tools to load/maintain spatial attributes

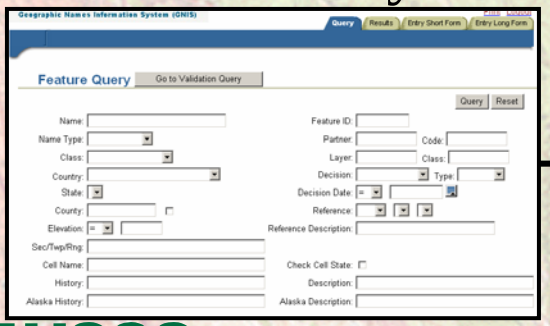
Insert/Update/ Delete

Layer Tables

Feature ID	ID	ID	ID
Name			
Class			
Geometry	y	y	y
Description	ion	ion	ion
(etc.)			

Insert/Update/Delete

Web Data Entry/Edit



Insert/Update/ Delete

Base Tables

Feature ID
Class
Lat/Long

ID
Name(s)
References

ID
Description
(etc.)

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Data Maintenance Issues

- Integrated MIS/GIS Strategy
- New Record Entry – Assign Feature ID
  - In MIS Application, GIS Application or both?
- Record Maintenance
  - Text/number attributes in MIS application/base tables?
    - Triggered to Layer Tables
  - Or, some maintained in GIS along with spatials?
- Guard against duplication or conflict
  - Version control, check in/check out.
- Integrate MIS/GIS applications?

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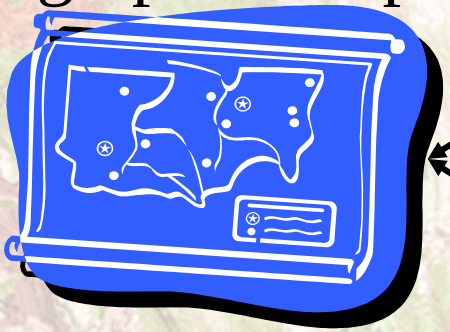
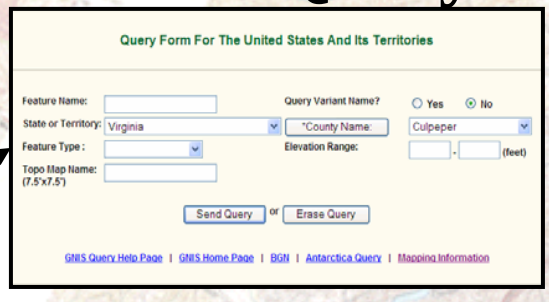
Integrated Applications

Next Goal: Seamless applications with graphic and tabular display and parameter passing.

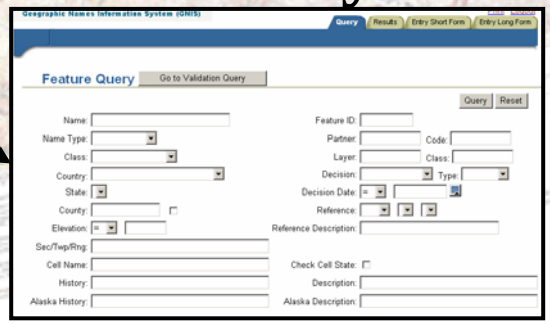
Geographic Display



Public Query



Data Entry/Edit



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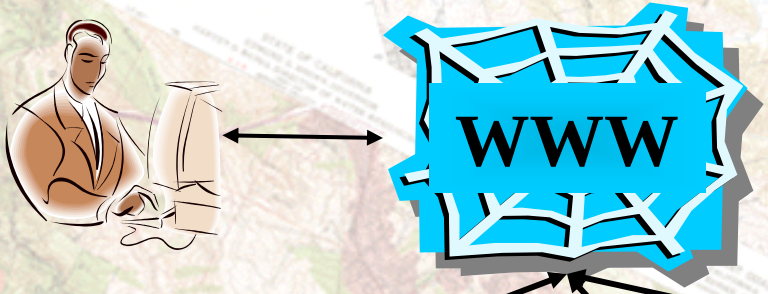
Target Architecture



WWW

Oracle Web Server

XML/Feature Service

Oracle Applications

Arc Tools/ Applications

ArcIMS Map Service

ArcSDE

RDBMS w/ Spatial

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