

Harper's Weekly, 19 November 1870

## 2010 World Programme on Population and Housing Censuses: Sub-regional Workshop on Census Cartography and Management

UNSD, Bangkok, Thailand  
15 – 19 October 2007

- when it has to be **right**

**Leica**  
Geosystems

# Leica Solutions for Census Management

Shanmugam Ganeshkumar

Enterprise Solutions Manager

- when it has to be **right**



# Agenda

- **Leica's Commitment**
- **Overview of GIS and IT Issues**
- **Where Leica ADE Technology and Solutions Fit In**
- **Example – US Census Bureau**
- **Summary**

# Commitment to Standards

## ISO

- Editor / Project Leader of ISO-19000 specifications (TC211)  
(19128, 19139, 19134, ...)
- Head of Belgium delegation at ISO TC211  
(Vincent Dessard, Ionic Software)
- Liaison officer between ISO TC211 and United Nations  
(UNGIWG)  
(Vincent Dessard, Ionic Software)



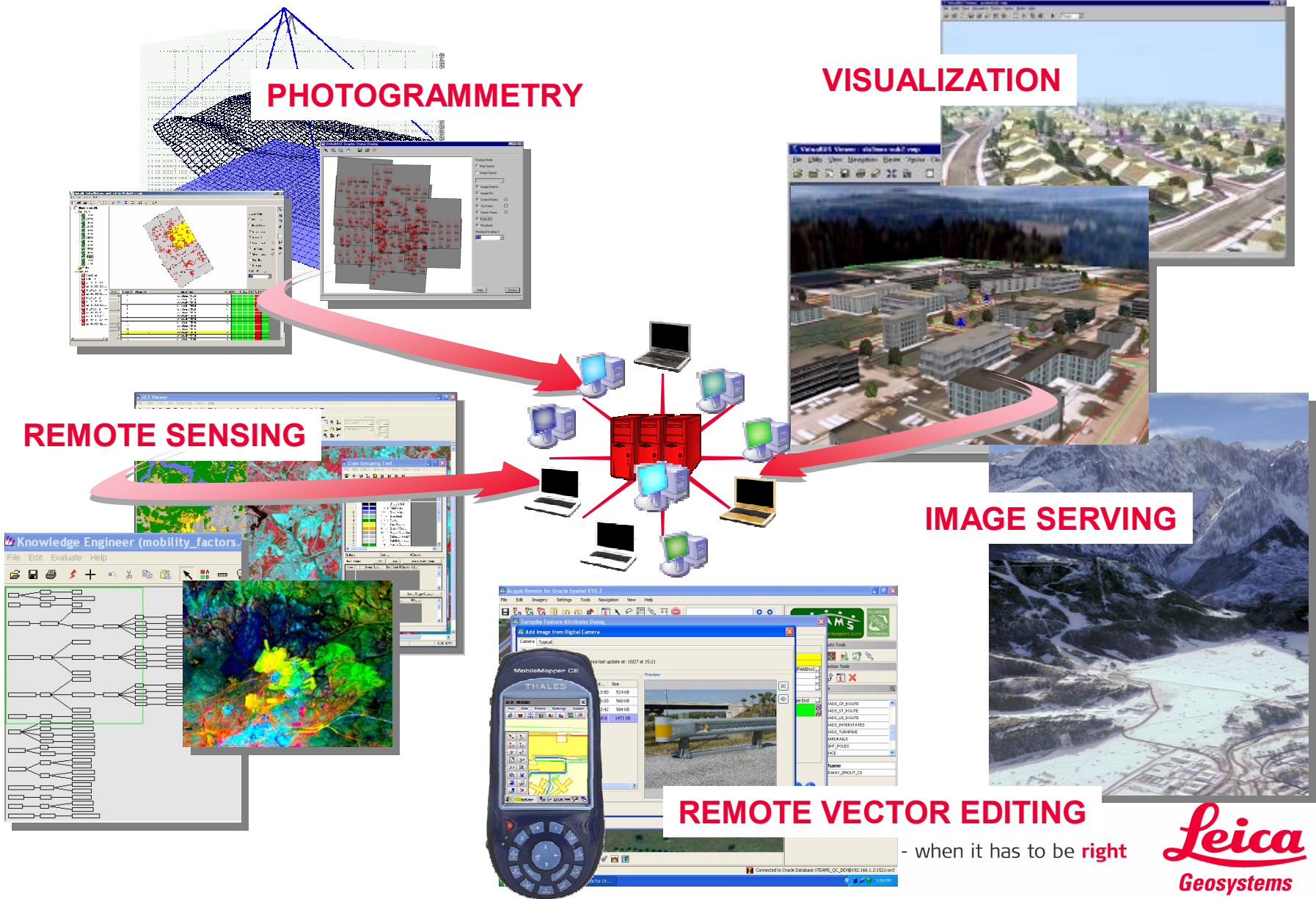
# Commitment to Standards

## Open Geospatial Consortium (OGC)

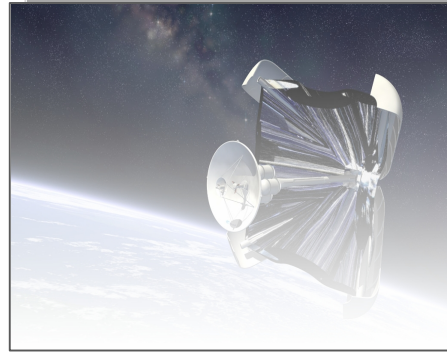
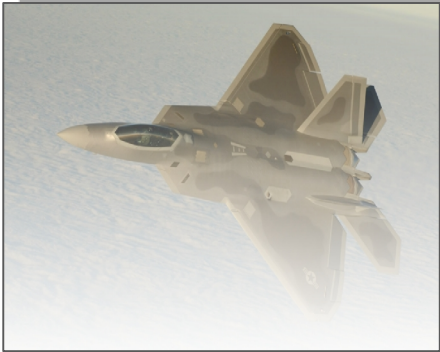
- Technical Member since 1999, **Principal Member** since 2007
- **Co-author of multiple** OGC specifications  
(WMS, WFS, WCS, Catalog, Context, GML, ...)
- **Seat at OGC** Management & Planning Committee since 2002  
(Vincent Dessard, Ionic Software)
- **Co-Chair of the** OGC Forum (ex-SIG) since 2003  
(Vincent Dessard, Ionic Software)
- Member of the OGC **Board Of Directors** since 2005  
(Chris Tucker, Ionic Enterprise)
- Member of the OGC **Board Of Architecture** since 2006  
(Bernard Snyers, Ionic Software)



# Leica's Response to the Enterprise Market



# Market Positioning



## Defense

- Geospatial Intelligence
- Security / Surveillance
- Homeland Security



## Space

- Ground Segment Application
- Earth Observation
- Imagery Libraries



## Government

- Spatial Data Infrastructures
- E-Gov & Geo-Portals
- Disaster management
- Public Safety



## Enterprise

- Geo-enabled Systems
- Location Based Services
- New Mobility
- Geo Business Component



Mercedes-Benz



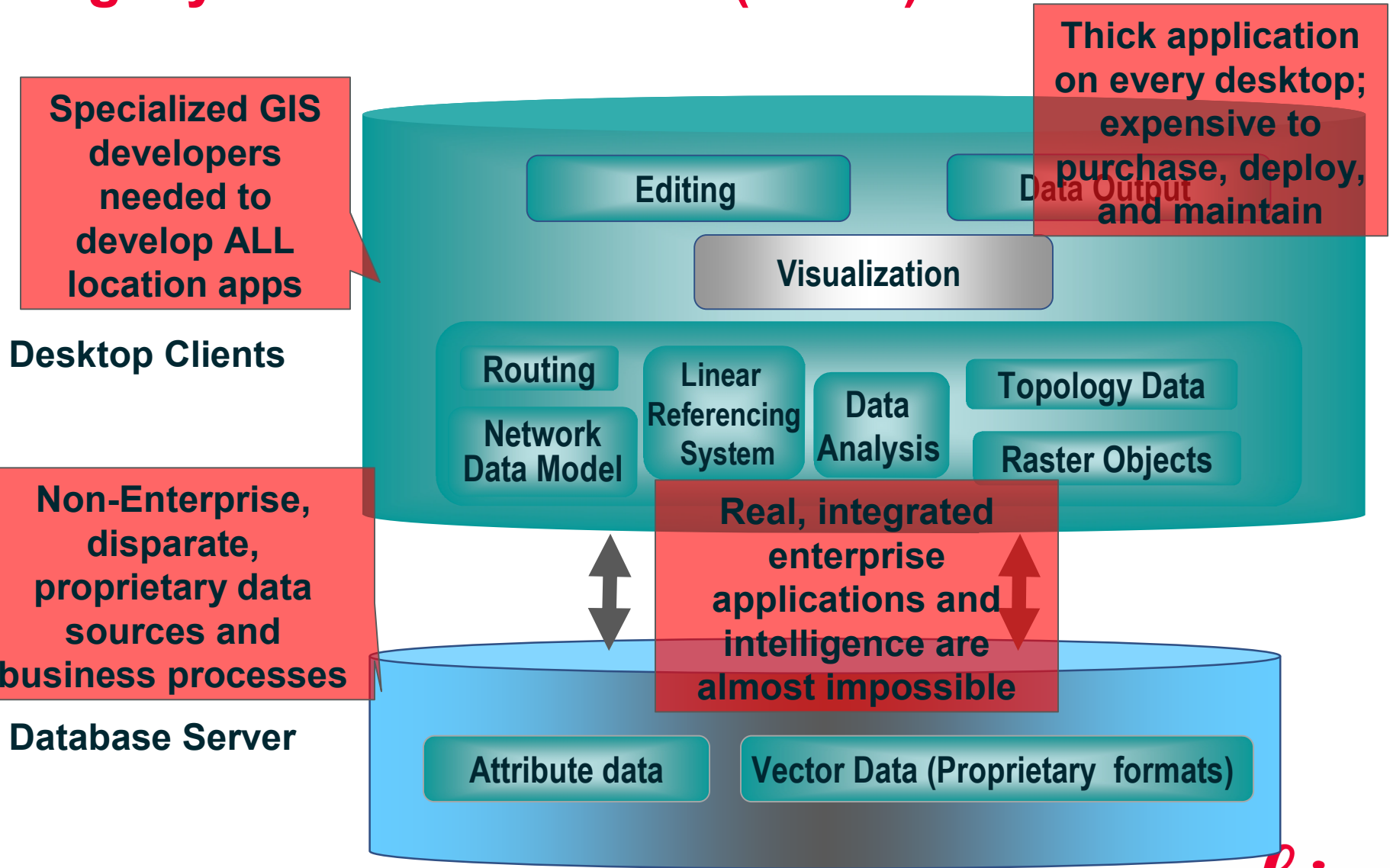
# Leica ADE Enterprise Suite

- when it has to be **right**



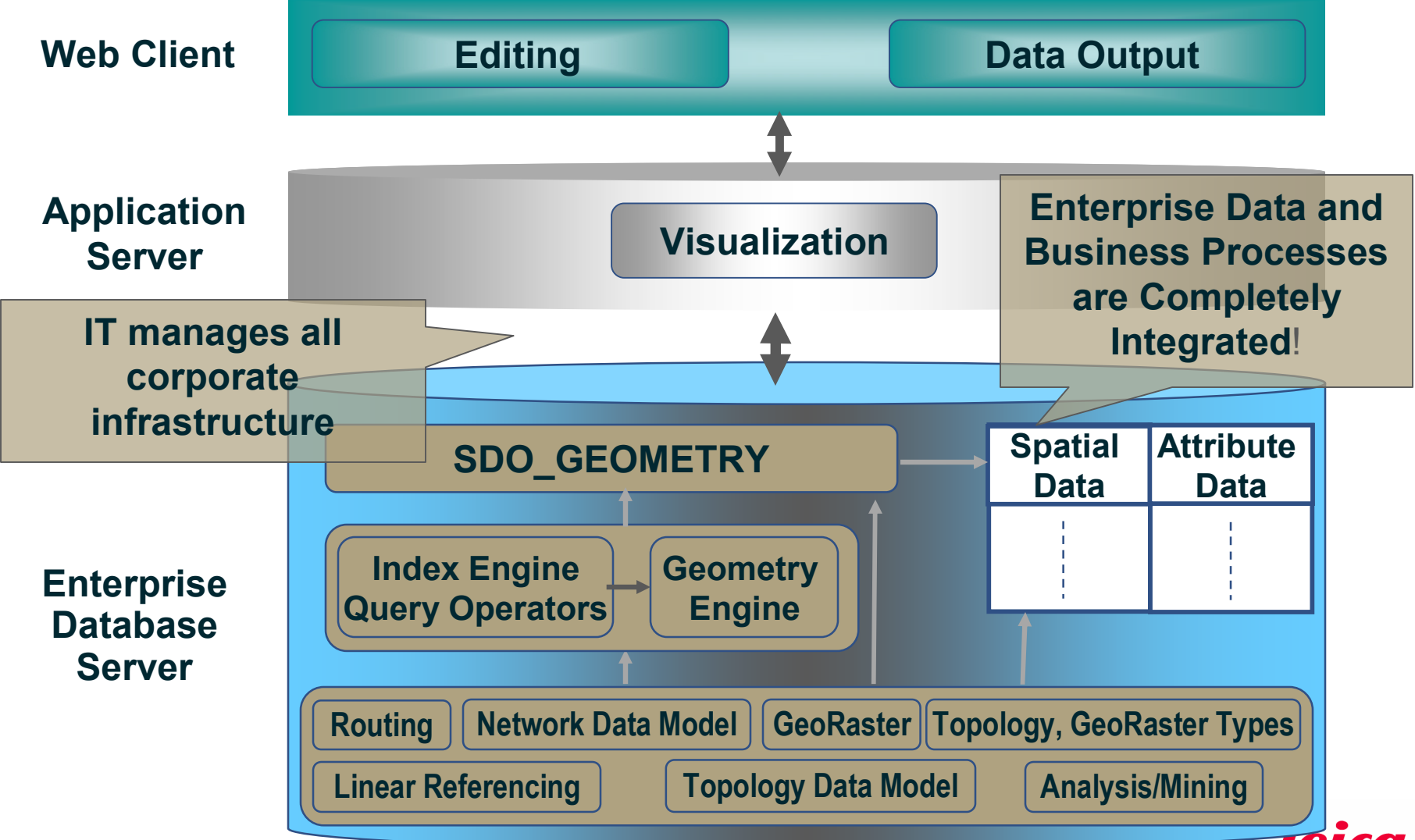


# Legacy GIS Architectures (2 Tier)



- when it has to be right

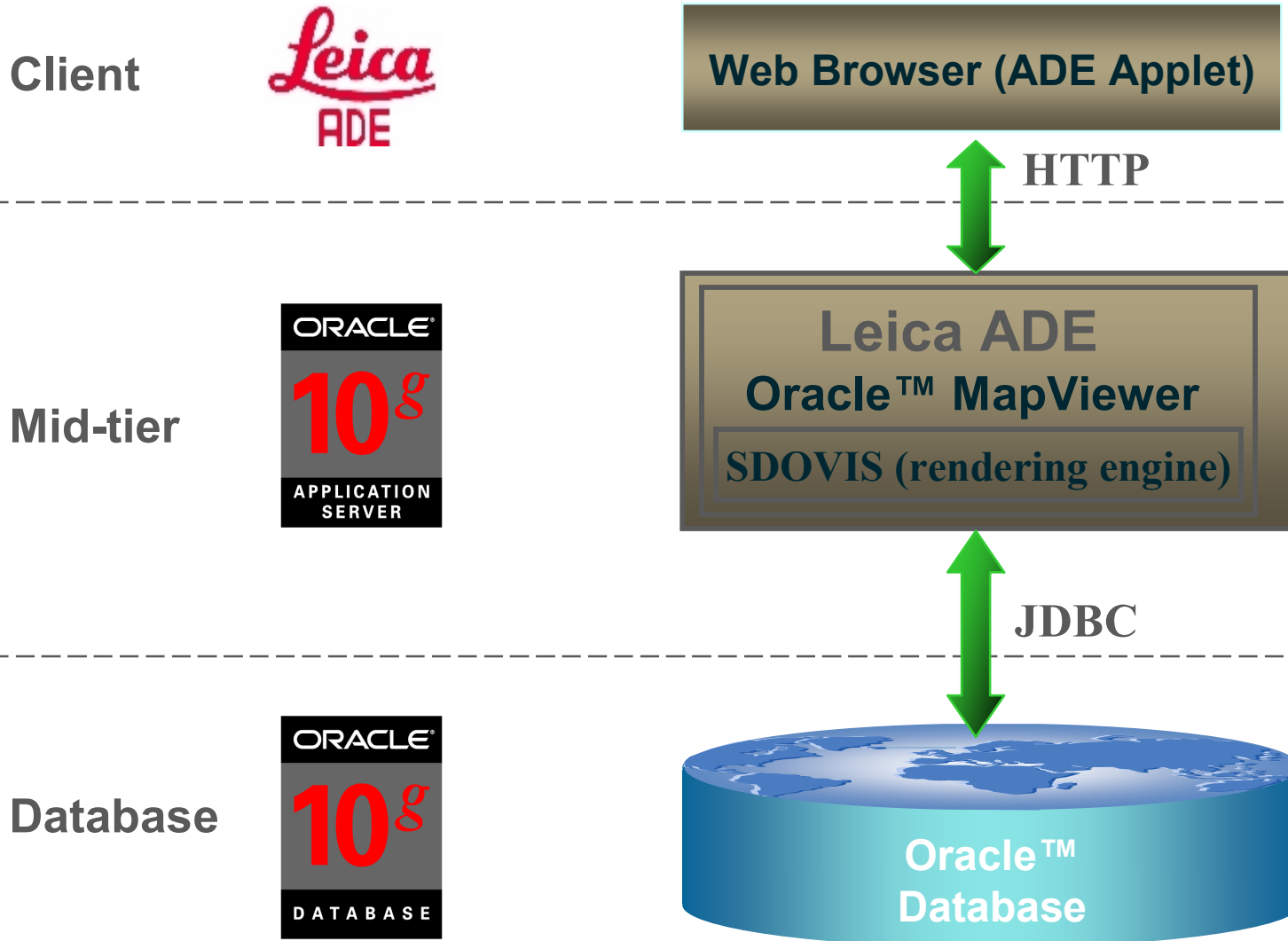
# Leica ADE Enterprise IT Architecture



- when it has to be right

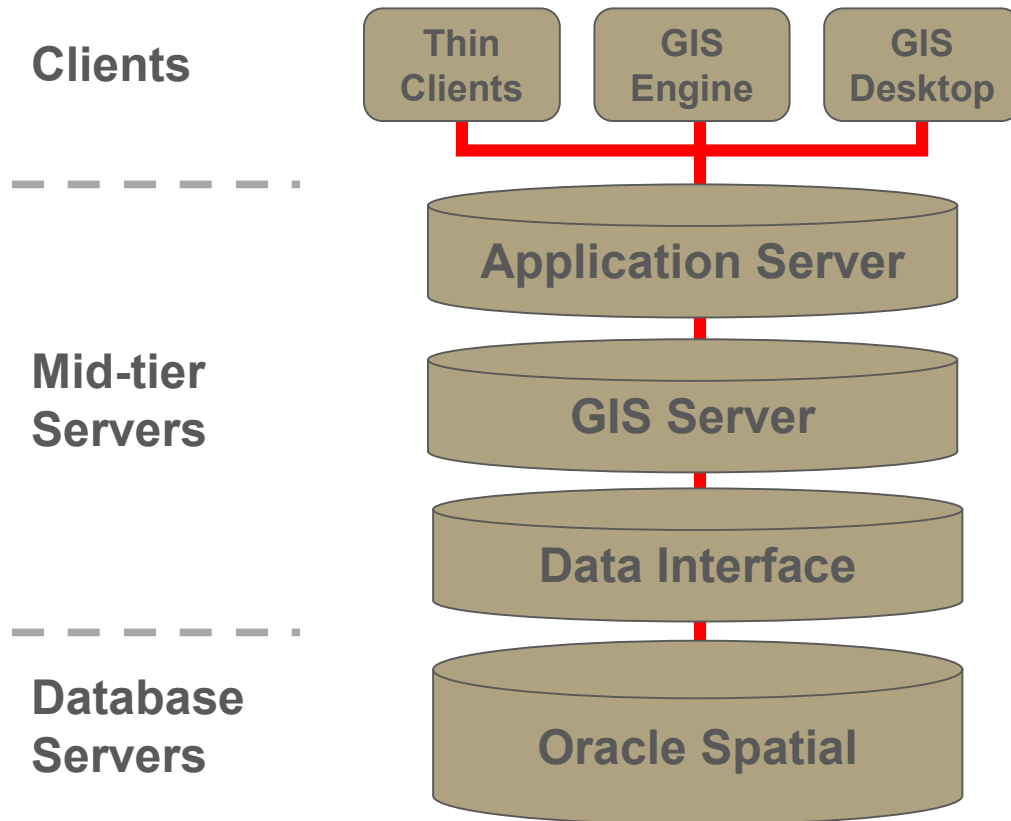


# Leica ADE Architecture



- when it has to be right

# Legacy Architecture vs. Leica ADE Enterprise Architecture



Database (including Spatial) used as a commoditized file system

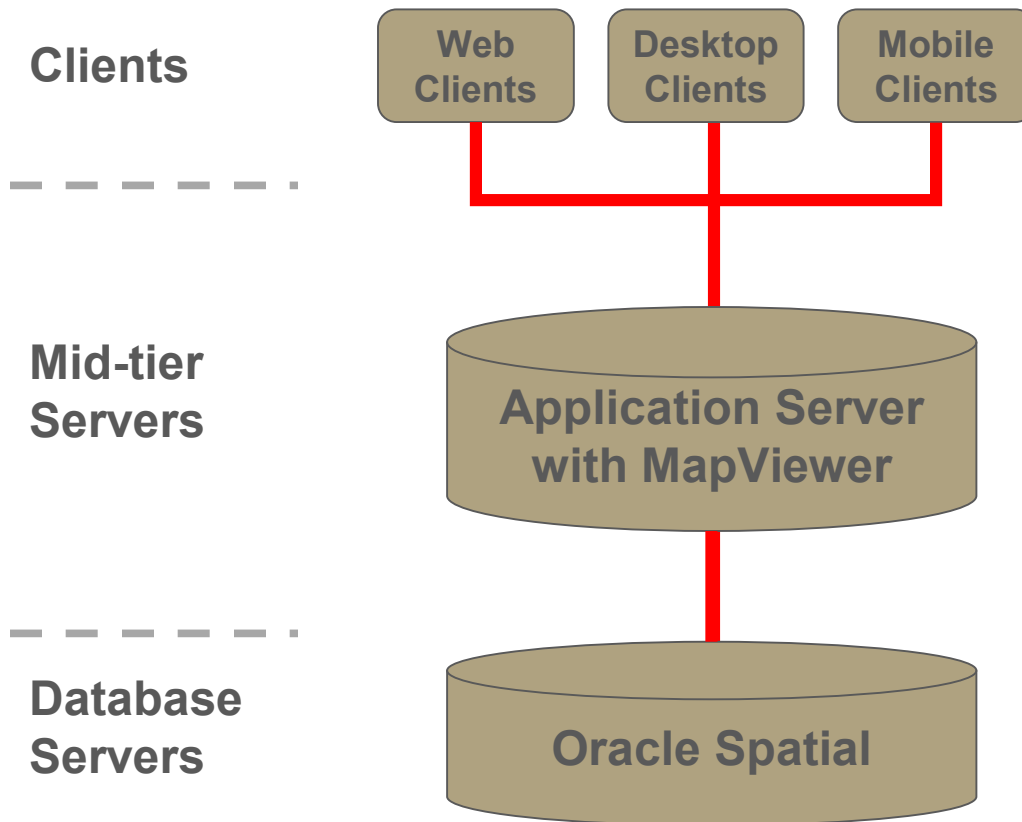
Database design and data analysis beholden to GIS

No easy (or inexpensive) way to create custom applications or usage workflows

Must upkeep licenses for many servers etc.

- when it has to be **right**

# Legacy Architecture vs. Leica ADE Enterprise Architecture



Same database, same database design, same queries

Flexible and scalable architecture

Inexpensive and easy to develop custom applications and workflows (XML, Java, JSP, WMS APIs)

Part of the IT architecture

- Inherently integrated into CRM, ERP and other IT-centric solutions
- Can integrate common geospatial data types such as shape files

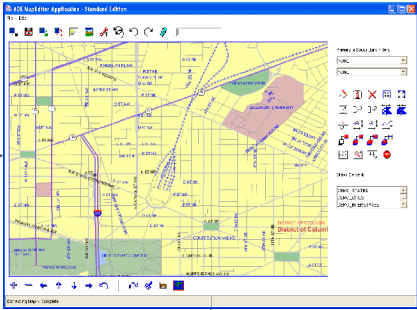
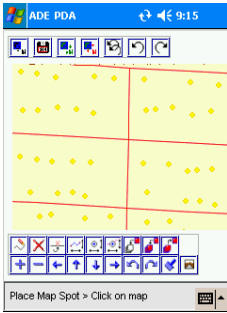
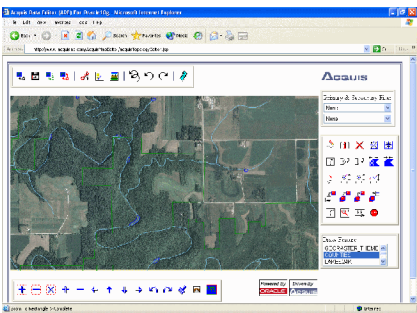
- when it has to be **right**

# Leica ADE Technologies

Leica ADE Enterprise

Leica ADE Mobile

Leica ADE Remote



HTTP

HTTP

HTTP

JDBC

J2EE Application Server

HTTP Web Server

OC4J (Oracle Containers For Java)

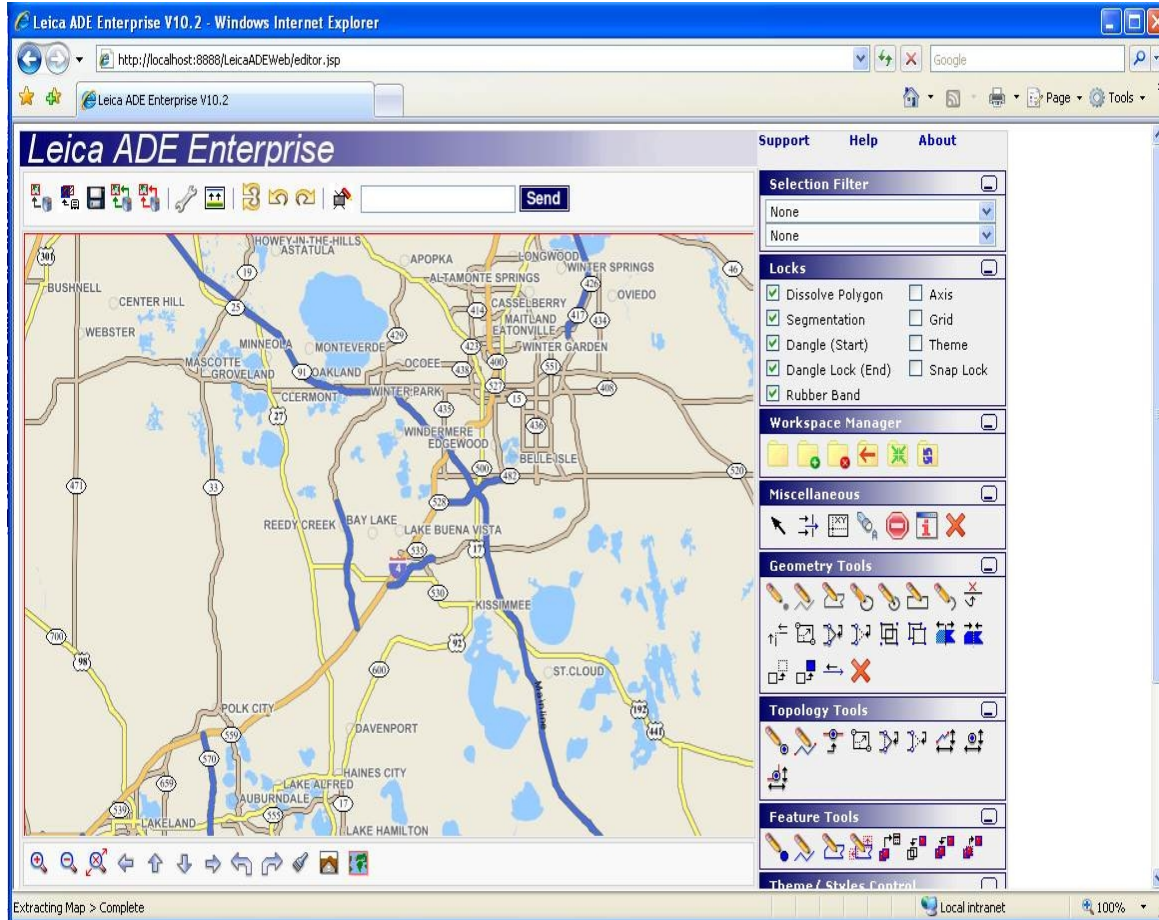


JDBC

- when it has to be right



# Leica ADE Enterprise



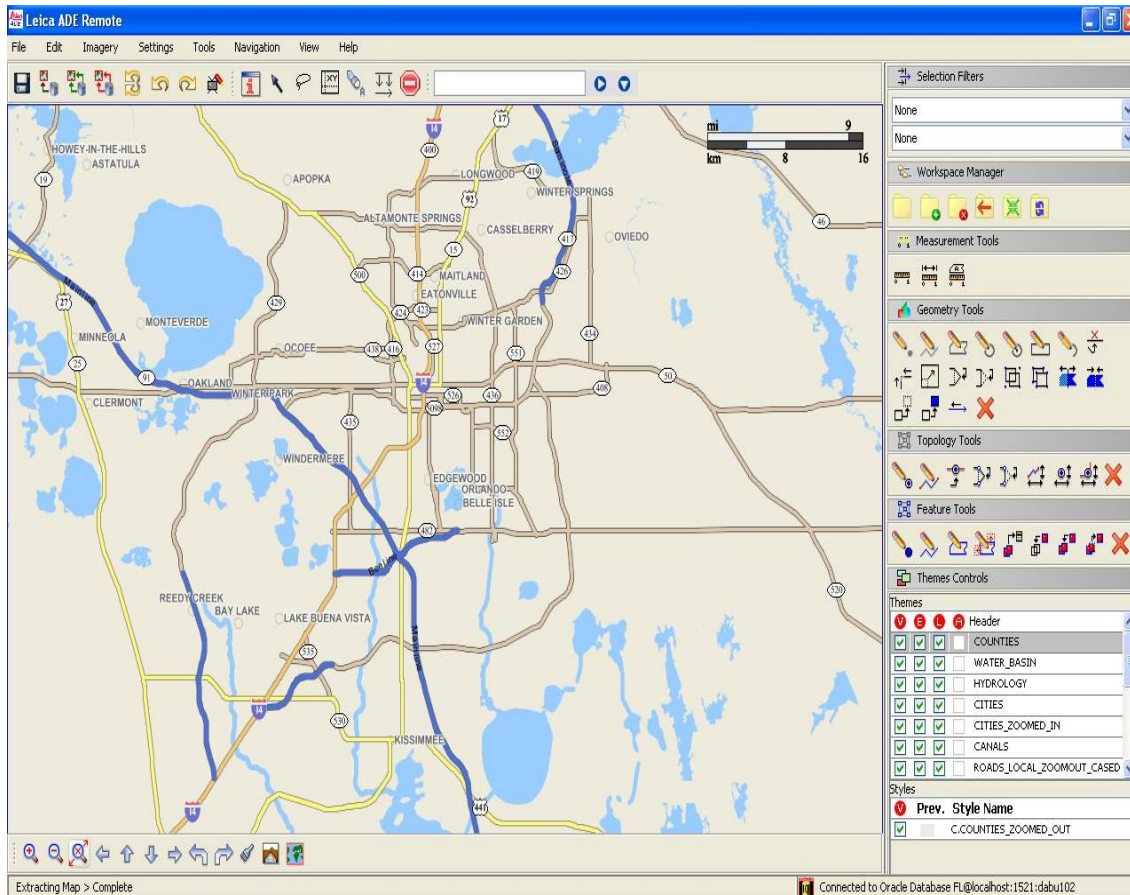
## Develop Once – Deploy Everywhere

- Single code base for all platforms
- Common API
- Manages Oracle Spatial and attribute data in real time via the web
- Utilizes the entire Oracle enterprise architecture
  - Not legacy
  - Not proprietary
- Deploy to ANY J2EE application server on ANY OS platform:
  - Microsoft, Unix, Linux...

- when it has to be **right**

**Leica**  
Geosystems

# Leica ADE Remote



- Rich, secure, flexible spatial and asset management for desktops, laptops and tablet PCs
  - ANY OS Platform!
- Supports enterprise business rules (including topology) *in real-time and disconnected modes*
- Ensures clean data (no data cleansing/reconciliation processes required)
- Data changes made in the field are valid (no post processing of data is required)
- Dramatically reduces data maintenance costs – one update process, lower labor costs, lower application costs (web versus desktop)

- when it has to be **right**



# Leica ADE Mobile



- Real-time and disconnected access to spatial and non-spatial information via handheld, global positioning systems (GPS) and wireless devices.
- Supports enterprise business rules (including topological) in real-time and disconnected modes
- Ensures clean data (no data cleansing required)
- Data changes made in the field will be topologically valid (no post processing of data is required)
- Enables business, spatial data and mobile application to be written to an SD card – simply inserting the SD card into the device and launching the application - a user is not restricted by the limitations of the hardware device

- when it has to be **right**

# Solution Case Studies

- when it has to be **right**



# United States Census Bureau

Enterprise IT and Topology Management Solution

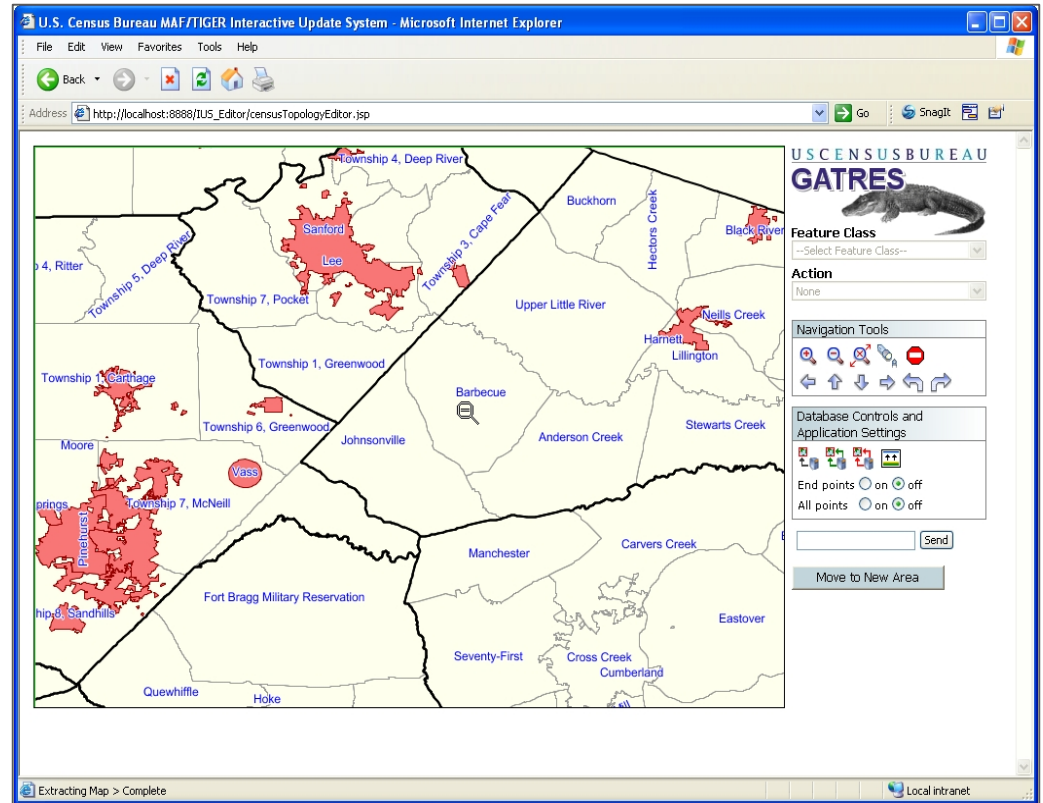
- when it has to be **right**



# Location-enabling the Enterprise with Oracle Spatial and Leica ADE Enterprise - US Census Bureau

## Problem:

- USCB utilizing legacy architecture and solution - MAF/TIGER
- Was state-of-the art when created, but is over 20 years old
- NO web-based capability
- NOT a multi-user environment
- VERY hard to maintain and extend

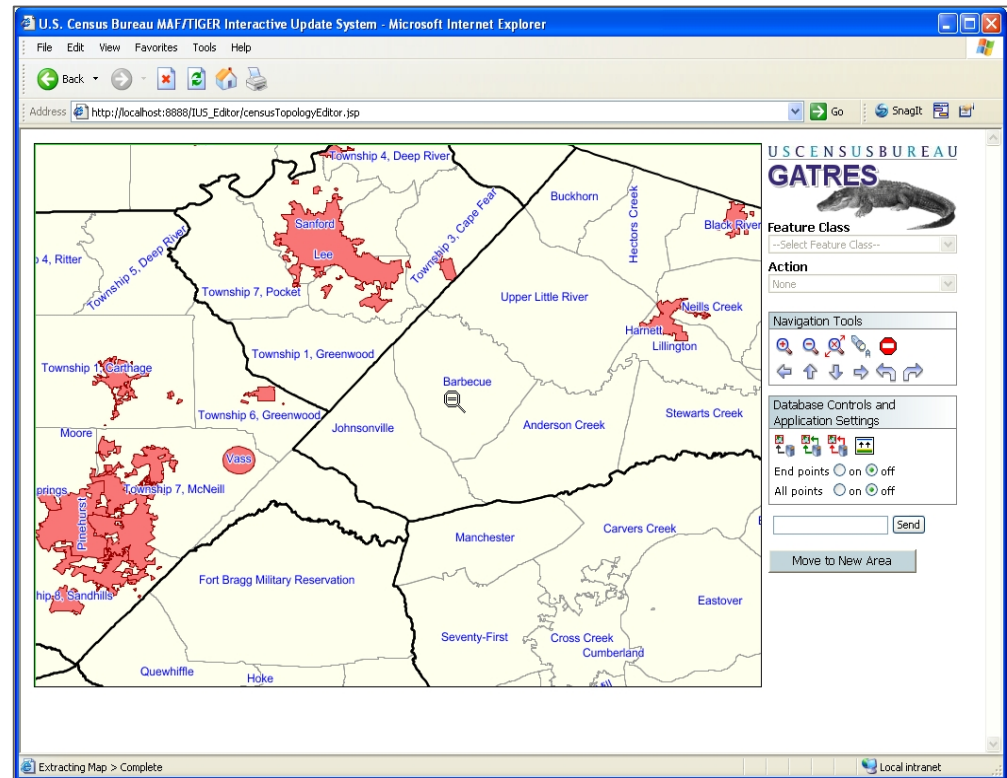


- when it has to be **right**

# Location-enabling the Enterprise with Oracle Spatial and Leica ADE Enterprise - US Census Bureau

## Solution:

- Oracle Spatial and ADE Enterprise enable seamless management of data and core business rules
- Oracle Spatial topology model
- Scalable across the enterprise
- Centrally business rules and validations
- MAF and TIGER data seamlessly integrated into a National data set



- when it has to be **right**

**Leica**  
Geosystems



An Intranet-Based Data Editor for Oracle Spatial  
10g Topology, Built Around Leica ADE Technology

# GATRES U.S. Census Bureau

- when it has to be **right**

**Leica**  
Geosystems

# What is GATRES?

- **GATRES – Geographic Acquis-based Topological Real-time Editing System**
- A web-based data editor for the MAF/TIGER database (Oracle 10g and 10g Spatial Topology)
- Highly customized Leica ADE Enterprise
- Part of a heterogeneous processing environment that includes the Oracle, ESRI, other COTS software and in-house developed software
- Part of the MAF/TIGER Enhancements Program and MAF/TIGER Redesign project

# US Census

**Requirement : Census is incorporated into the Constitution of the United States\***

**Used for:**

- **Congressional apportionment**
- **Electoral college voting**
- **Government program funding**



**\*Article 1, Section 2: "The actual Enumeration shall be made within three Years after the first Meeting of the Congress of the United States, and within every subsequent Term of ten Years, in such manner as they shall by law direct."**

- when it has to be **right**

**Leica**  
Geosystems



# MAF/TIGER

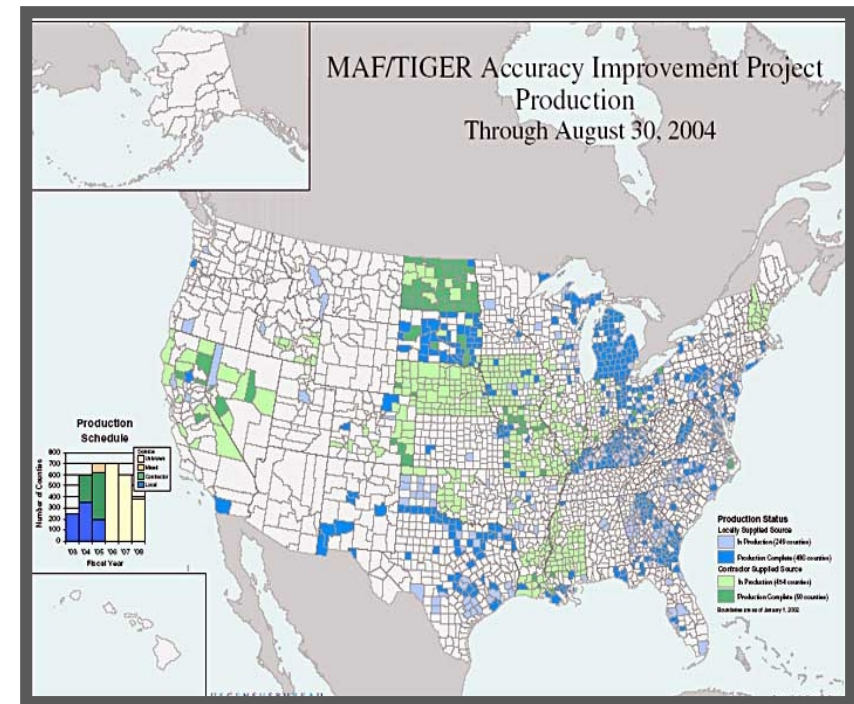
- when it has to be **right**

**Leica**  
Geosystems

# US Census

To help with its constitutionally mandated role, Census developed the MAF/TIGER system

- Master Address File (MAF)
- Topologically Integrated Geographic Encoding and Referencing (TIGER)



- when it has to be **right**

# US Census

## Master Address File (MAF)

- List of all known living quarters in the US, Puerto Rico, and associated islands
  - Address
  - If no address, maintains description of location
- Census Geographic Location
- Source and history information
- Currently has no geospatial component



- when it has to be **right**

**Leica**  
Geosystems

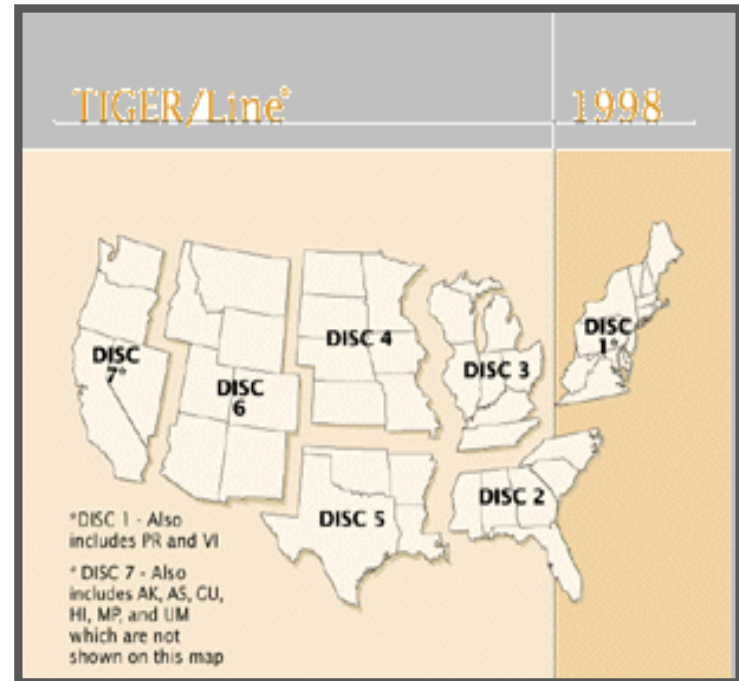
# US Census

## Topologically Integrated Geographic Encoding and Referencing (TIGER)

- Street center-line geographic database system of the entire US, Puerto Rico, and associated island areas
- Based on street features and names

TIGER system also includes many other feature classes with attribute information stored in a topologically consistent format

- Hydrographic information (lakes and streams)

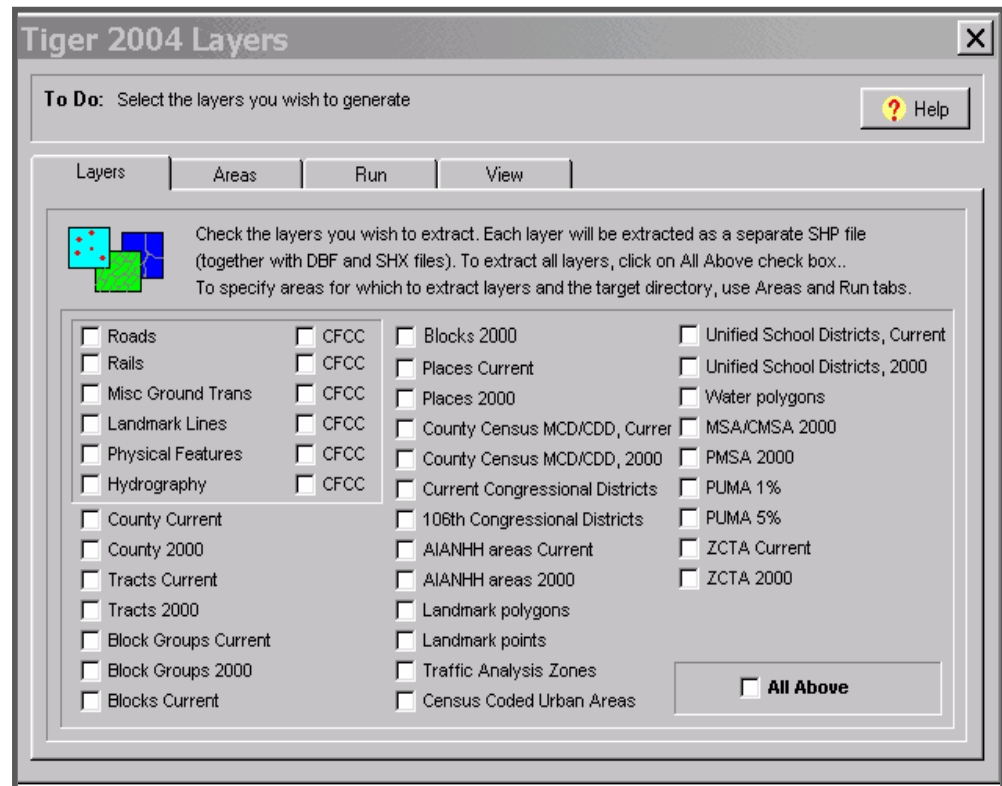


- when it has to be **right**

# US Census: Other TIGER features

- Geopolitical boundaries, names, and codes (states, counties, census tracts, census blocks, etc)
- Housing unit locations (for certain areas)
- Key geographic locations (airports, schools, etc.)
- ZIP Codes and address ranges (for streets with city-style addresses)

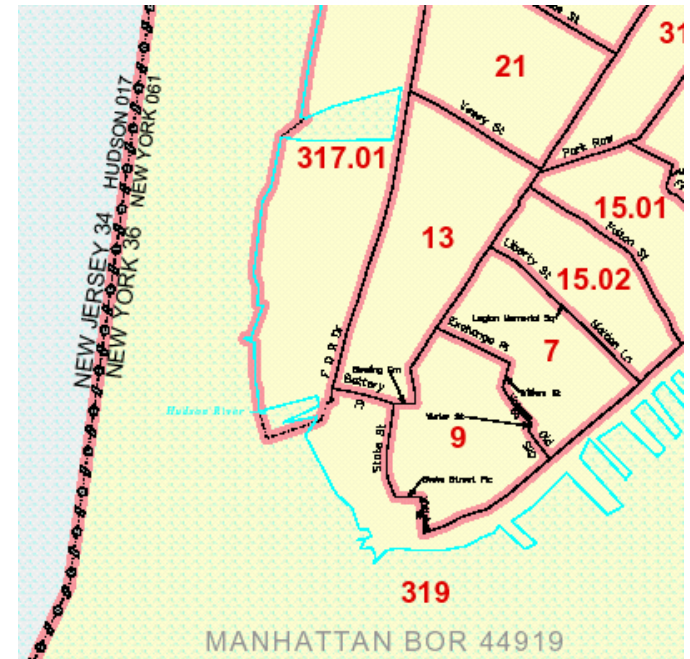
Over forty different feature classes



- when it has to be **right**

# MAF/TIGER – Mission Critical

- MAF/TIGER provides storage, processing, products and services that support agency's statistical programs
  - Geocoding
  - Maps
  - Residential Address Lists
- Continually updated with new address and geographic information
- Wide public use of geographic information

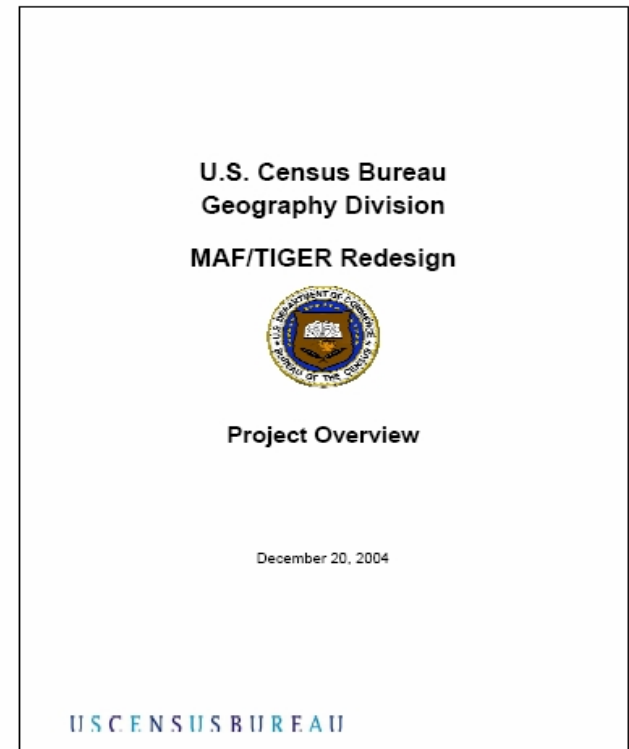


- when it has to be **right**

# MAF/TIGER Redesign

MAF/TIGER was an innovative state-of-the-art system when developed

- Utilized persistent topology
- Automated production of digital mapping products
- Allowed batch processing for automated updates
- Provided for efficient retrieval
  - Included spatial indexing



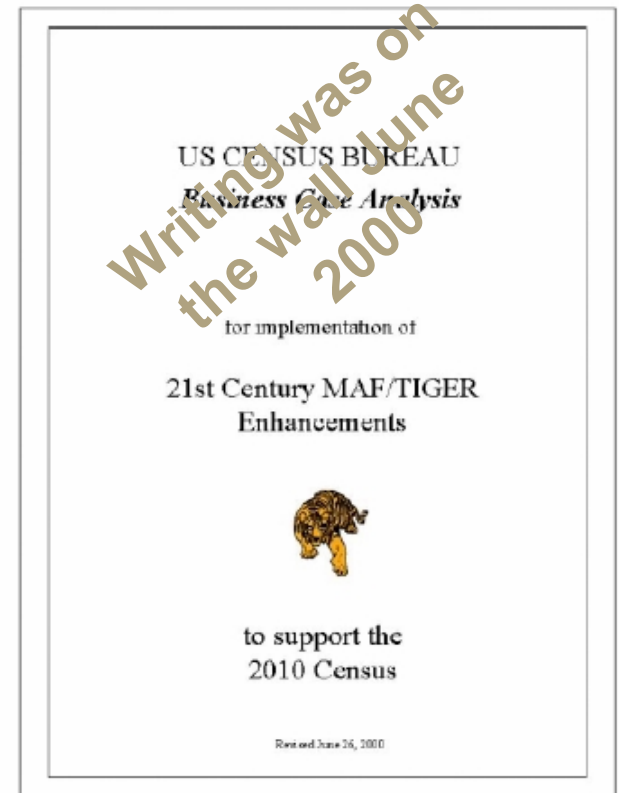
- when it has to be **right**

**Leica**  
Geosystems

# MAF/TIGER Redesign

## MAF/TIGER is now over 20 years old...

- Does not integrate well with current commercial off-the-shelf (COTS) tools
- Pre-existed Web technology
- Cumbersome to change
- Difficult to learn for new developers
- Not integrated into a single national data set
- No multi-user access (one person per county)
- Not accessible via a standard query language
- MAF and TIGER completely separate



- when it has to be **right**



# Foundations of GATRES: Oracle Spatial and Leica ADE

- when it has to be **right**



# MAF/TIGER Redesign

In June 2000 US Census decided it was time to make a fundamental change in the way they manage their business...

Made the following decisions:

- **New system had to be based on a highly functional commercial DBMS**
  - Security, scalability, performance, replication, administration, etc.
- **MAF and TIGER data had to be integrated**
- **Can recruit developers with appropriate skill set**
- **Create and use a seamless national data set**
- **Improved concurrency (read and write)**
- **Open, interoperable environment**
- **Web-based tools, editing, and dissemination**

- when it has to be **right**

## First Decision: Use Oracle Spatial as the Foundation

The Oracle Spatial Topology Data Model met the US Census requirements:



- Oracle's model stores the nodes, edges, and faces that features are composed of (persistent topology)
- Oracle's model includes vertical topology, so multiple feature layers can share the same primitives
- Oracle's model includes topology hierarchies
- Oracle's database infrastructure enables merging of the MAF and TIGER data sets into a single enterprise model
- Oracle provides scalability and performance features such as partitioning and the Application Server

- when it has to be **right**

# Next Decision: Use Leica ADE for Interactive Updates

- **The only web-based product to natively update data in the Oracle Spatial Topology Data Model**
- **Leica ADE Enterprise supports concurrent editing of the same feature**
  - Special capabilities when adding/deleting primitives
- **Easily Customizable**
  - Geography Developers use standard code to support the specific requirements of the Census Bureau Users
- **Highly scaleable platform**
  - Maximizes Oracle's proven data management capabilities both at database and application server
- **Ease of Deployment**
  - No software required other than a web browser



- when it has to be **right**

**Leica**  
Geosystems

# Interactive Updates at US Census

An integral part of the requirements at US Census is the Interactive Update Application

After an evaluation of available products the US Census selected Leica ADE Enterprise as the topology editing tool in the MAF/TIGER Redesign

- Leica ADE Enterprise is the only product designed from the ground up for viewing and editing data in Oracle's Topology Data Model



- when it has to be **right**

**Leica**  
Geosystems

## ***MAF/TIGER INTERACTIVE UPDATE SOFTWARE***

U.S. Census Bureau

“...the government knows of only one product:  
*ADE R2* that meets the Government's functional  
requirements offered by the following source:  
*LEICA INCORPORATED, SILICON VALLEY ...*”

- when it has to be **right**

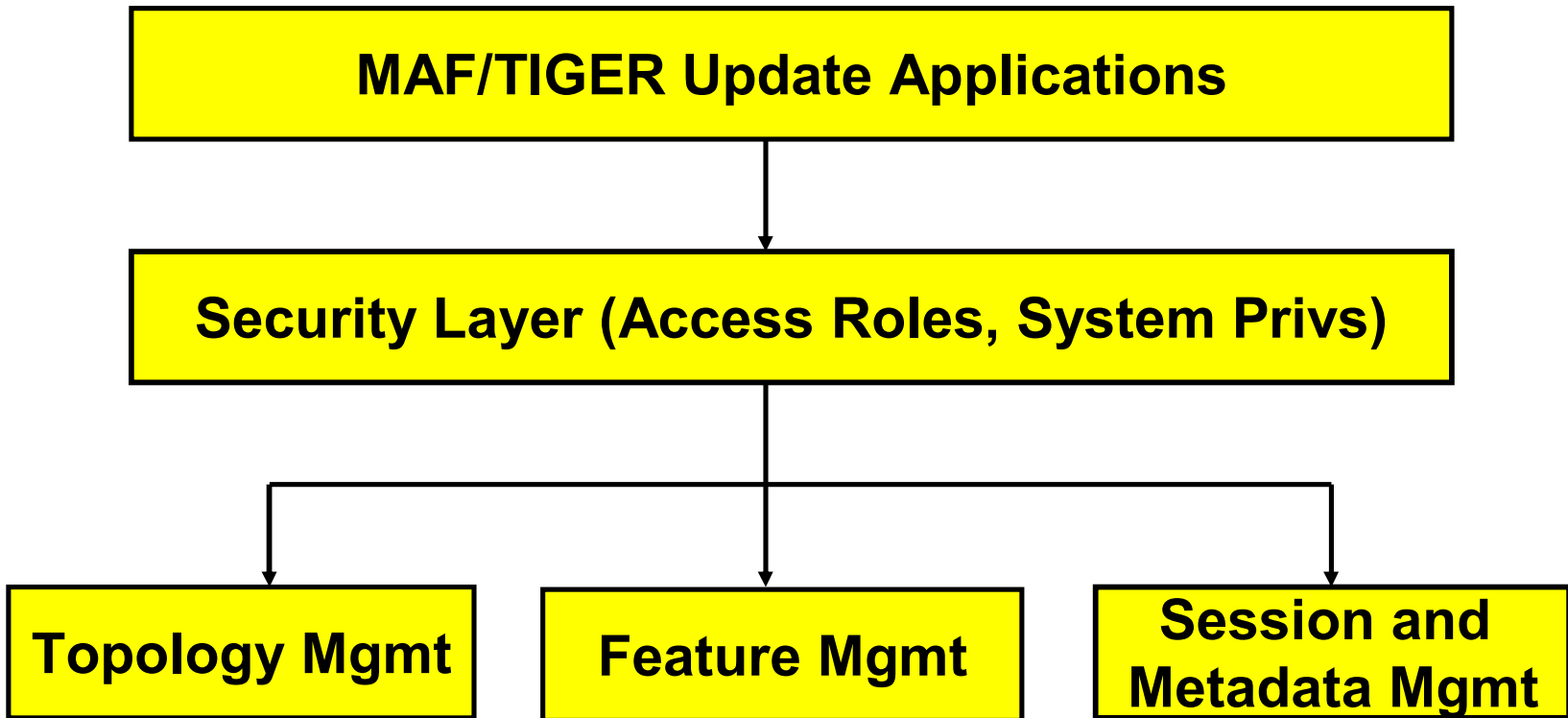
***Leica***  
Geosystems

# Additional Benefits of Leica ADE

- **Automated topology loading**
  - Directly import shape files into topology model processing, all topology rules followed
- **Full disconnected topology editing capability**
  - All topology capabilities are available in Leica ADE Enterprise, Leica ADE Desktop, and Leica ADE Mobile
- **Highly customizable with open APIs**
  - All Acquis functionality is highly customizable with open, published APIs
- **Develop Once - Deploy Anywhere**
  - Identical code base for ADE Enterprise, ADE Desktop and ADE Mobile means that functionality customized for any application can run in all

- when it has to be **right**

## Update System Design (simplified)





# Topology Management (simplified)

## Topology Management (Manages primitive attributes and tracking)

- Gets update permission
- Checks to ensure update allowed in the context of all census topology business rules
  - Legal values
  - Rules repository
- Checks how change effects features
- Understand relationships to other primitives
- Assigns ID
- Use Oracle's topology update routines

# Feature Management (simplified)

## Feature Management Spatial and non-spatial features

- **Feature standardization**
  - Addresses
  - Feature names
- **Geocoding/address matching**
- **Census business rules ensure feature update valid**
  - Legal values
  - Business Rules repository
- **Update metadata**
- **Understand/manage relationships to primitives**

# Session and Metadata Management

## Session and Metadata Management

- **Manages operational history**
  - Adds
  - Deletes
  - Updates
- **Manages Global Metadata**
  - Data: How collected, when was updated, by whom
- **Provides session metadata**
  - Business rules for update
    - Don't override GPS collected data with hand digitized data

- when it has to be **right**

## Database Design

Other interesting facets of the database design:

Includes feature to master address file (MAF) relationship table

- Gives a spatial component to the MAF data

There are over 40 tables related to the different geographic entities

- One of the reasons vertical topology is so important

Each feature appears 5x to keep some historical information on-line and available

- 2000 census
- 2000 census corrected
- etc.

- when it has to be **right**

# User Interface and Business Rules

- when it has to be **right**



# Navigation Module

- Clicking “Outline” retrieves a map of the geographic area

Users select a geography type and location using form controls on the navigation screen.

The screenshot displays a web browser window titled "Navigation to Acquis - Microsoft Internet Explorer". The address bar shows "http://localhost:8888/IUS\_Editor/!s?action=isgeog". The page header includes "USCENSUSBUREAU" and "MAF/TIGER Interactive Update System" with a tiger logo. The main content area features a form with the following fields: "Geography Type" (Incorporated Place), "ST/PL FIPS Code" (empty), "Vintage" (90 - Current), "State" (37 - North Carolina), "Place" (22920 - Fayetteville), "Data Source" (USER\_2), and "Map Name" (ELEMFEAT\_VIEW\_MAP). Below the form are three buttons: "Outline", "Plot", and "Change Area". The "Outline" button is highlighted with a black arrow pointing to a map of Fayetteville, North Carolina, which is highlighted in yellow. The map includes a compass rose with "NORTH", "SOUTH", "WEST", and "EAST" labels. To the right of the map is a control panel with "ZOOM IN" (+), "ZOOM OUT" (-), "Window" (checked), and "Recenter" (unchecked) options.

- when it has to be **right**

# Navigation Module

Navigation to Acquis - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites

Address [http://localhost:8888/IUS\\_Editor/is?action=isgeog](http://localhost:8888/IUS_Editor/is?action=isgeog) Go

USCENSUS BUREAU  
MAF/TIGER  
Interactive Update  
System

Geography Type: Incorporated Place ST/PL FIPS Code: Vintage: 90 - Current

State: 37 - North Carolina Place: 22920 - Fayetteville

Data Source: USER\_2 Map Name: ELEMFEAT\_VIEW\_MAP

Outline Plot Change Area

WEST NORTH SOUTH EAST

Fayetteville

ZOOM IN ZOOM OUT

Window Recenter

**Users click two points to delineate an area of interest, then click "Plot" to launch the customized ADE.**

- when it has to be **right**

# Main User Interface

U.S. Census Bureau MAF/TIGER Interactive Update System - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites Refresh Print W

Address http://localhost:8888/IUS\_Editor/censusTopologyEditor.jsp Go

U.S. CENSUS BUREAU  
MAF/TIGER  
Interactive Update  
System

Feature Class  
--Select Feature Class--

Action  
None  
Start Stop

Navigation Tools

Database Controls

Application Settings  
Send Keyin

Move to New Area

Extracting Map > Complete Local intranet

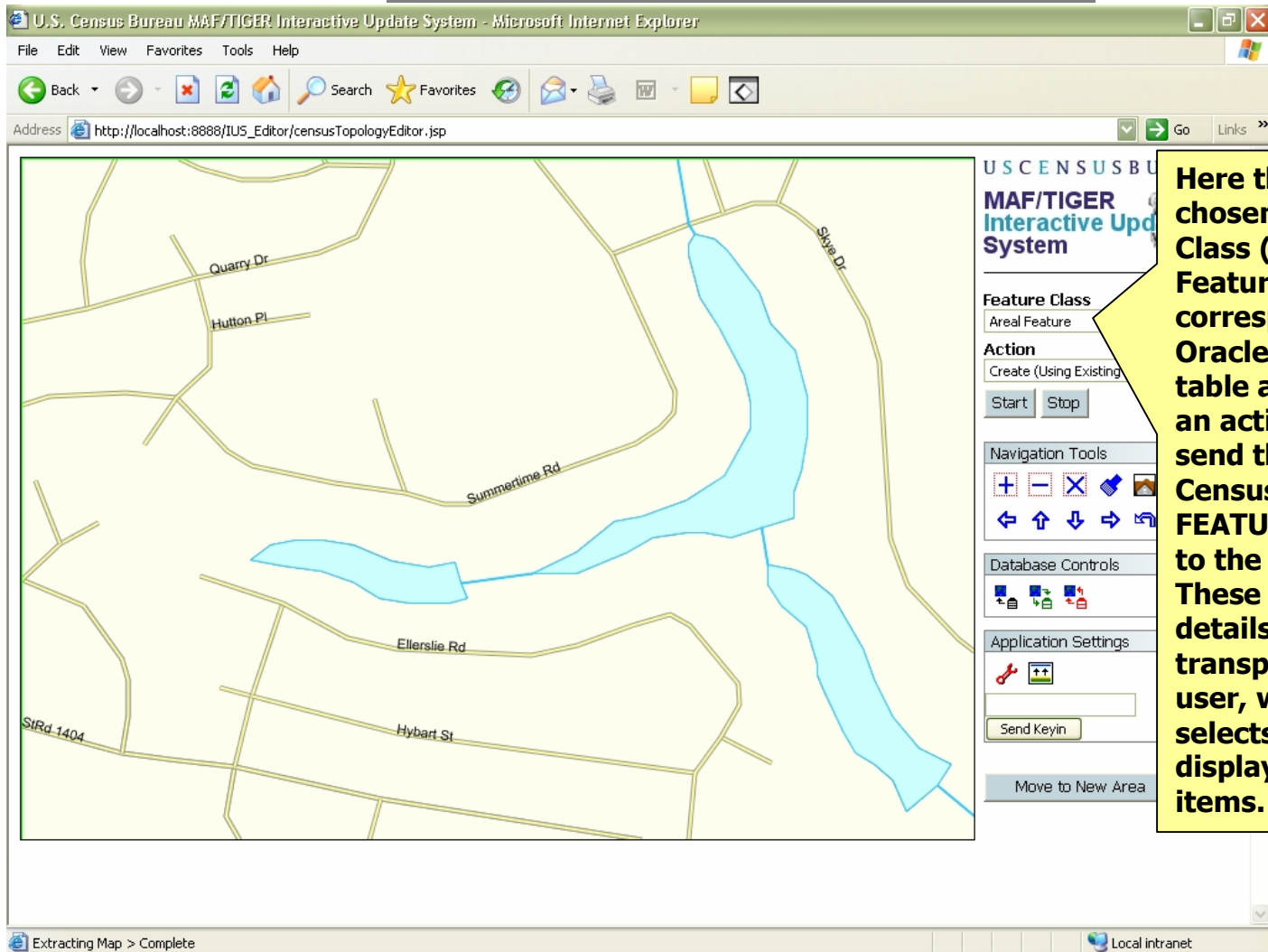
The Feature Class and Action drop-down menus set the active theme and apply the command for each action. Labels and values for these controls are managed through map metadata stored in Oracle's predefined format.

Out-of-the-box ADE buttons were filtered to a core set of navigation, database, and application controls.

- when it has to be right



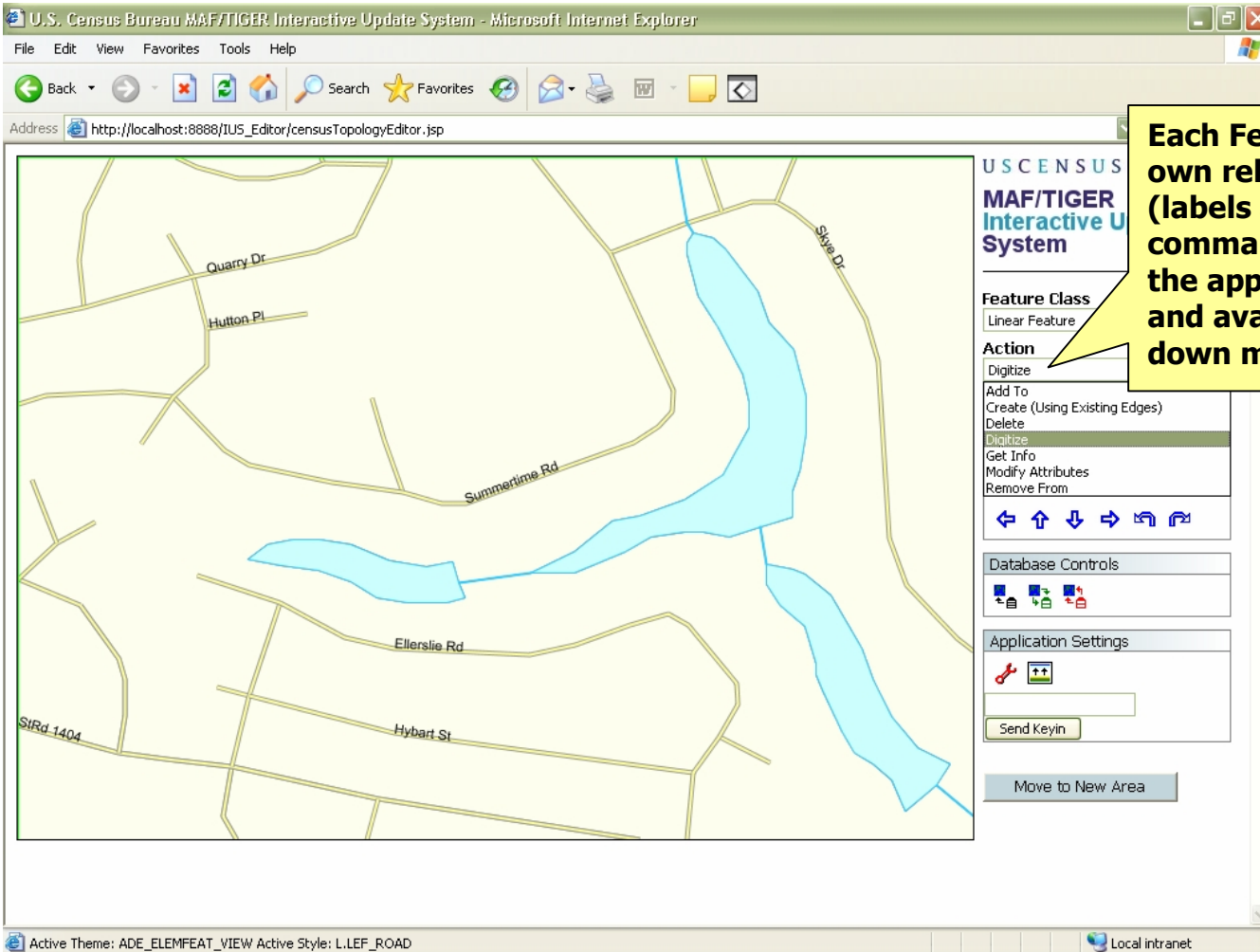
# Main User Interface



Here the user has chosen a Feature Class ("Areal Feature") corresponding to the Oracle ELEMFEAT table and selected an action that will send the custom Census MT ADD FEATURE command to the application. These operational details are transparent to the user, who simply selects from the displayed menu items.

- when it has to be right

# Main User Interface



**Each Feature Class has its own relevant set of Actions (labels and keyin commands) supplied by the application database and available in the drop-down menu.**

- when it has to be **right**

# Digitize Line Operation

The Digitize operation is listened for by a custom listener, which enables vertex and end point snapping indicators before passing control to the command methods. The snapping indicators are automatically turned off when the digitize operation is complete.

The screenshot displays the U.S. Census Bureau MAF/TIGER Interactive Update System in a Microsoft Internet Explorer browser window. The main interface shows a map with a network of roads and a large cyan-colored polygon being digitized. The roads are labeled with names such as Quarry Dr, Hutton Pl, Summertime Rd, Ellerslie Rd, Hybart St, and S1Rd 1404. The digitized area is outlined with small blue square markers. On the right side, there is a control panel with the following sections:

- Feature Class:** Linear Feature (dropdown menu)
- Action:** Digitize (dropdown menu)
- Buttons:** Start, Stop
- Navigation Tools:** Includes icons for zoom in, zoom out, pan, and other navigation functions.
- Database Controls:** Includes icons for database operations.
- Application Settings:** Includes a Send Keyin button.
- Move to New Area:** A button at the bottom of the control panel.

At the bottom of the browser window, a status bar reads: "Draw Feature > Left Click to Place Next Point, Right Click to Finish, Shift+Left Click to remove last point". The browser title bar shows "U.S. Census Bureau MAF/TIGER Interactive Update System - Microsoft Internet Explorer".

- when it has to be **right**

# Digitize Line Operation

U.S. Census Bureau MAF/TIGER Interactive Update System - Microsoft Internet Explorer

Address: [http://localhost:8888/IUS\\_Editor/censusTopologyEditor.jsp](http://localhost:8888/IUS_Editor/censusTopologyEditor.jsp)

Column	Value
Base Status	
FEATURENAME	
FULLFN	
Harvested Local Feature Indicator	<input type="checkbox"/>
Military Installation Type	
FIPS 55 Class	
5-digit ZIP Code	
Legal/Statistical Area Description	
Census unit flag.	
Functional Status	
MAF TIGER, Feature Class Code	S1200
Order of chain.	
Route Type	

U.S. CENSUS BUREAU  
MAF/TIGER  
Interactive Update  
System

Feature Class  
Linear Feature

Action  
Digitize

Start Stop

Navigation Tools

Database Controls

Application Settings

Send Keyin

Move to New Area

Local intranet

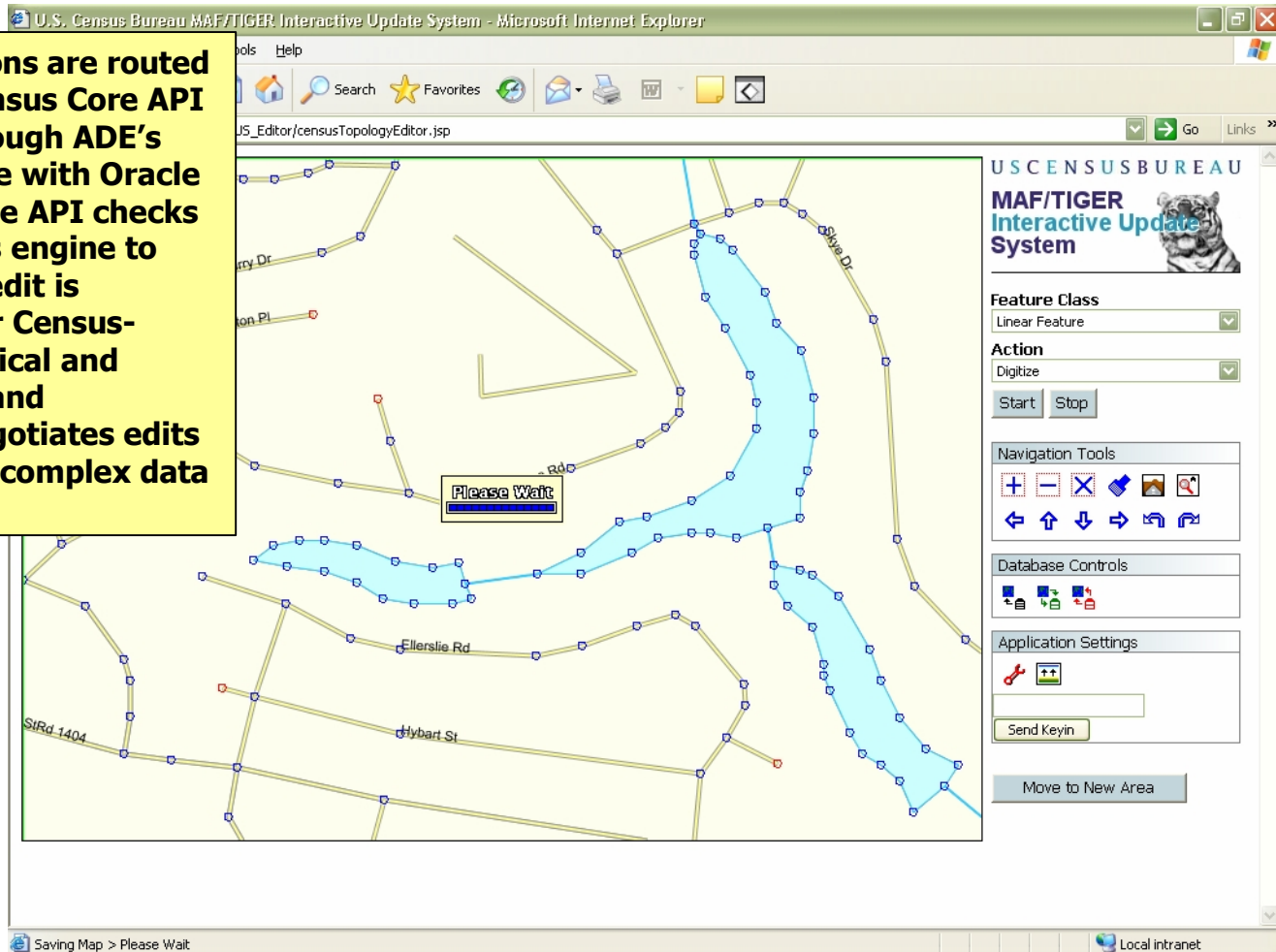
This same model – using the `OperationControllerListener` to listen for specific operation types and displaying attribute dialogs before sending the operation to the server – is repeated for most other editing operations.

A `CensusOperationControllerListener` listens for digitize operations and opens two custom `Swing JDialog` windows before such operations are applied on the application server. These dialogs ask the user to supply a classification code for the new feature and appropriate attribute values. Various attribute fields are constrained by database-supplied legal values, which are presented in the form of drop-down menus. Required values are highlighted for the user.

- when it has to be right

# Editing and Core API

Editing operations are routed through the Census Core API rather than through ADE's default interface with Oracle Spatial. The Core API checks a business rules engine to make sure the edit is allowable under Census-specific topological and attribute rules and successfully negotiates edits to the Bureau's complex data model.



- when it has to be **right**

**Leica**  
Geosystems

# Editing and Core API

This slide shows the Add to Geographic Area operation. This is a custom operation that displays Census-specific dialogs, such as this one requiring the user to specify a geographic area feature sub-class. The selected sub-class, "Incorporated Place (INCPLACE)," will be highlighted after the user clicks "OK."

The screenshot displays the U.S. Census Bureau MAF/TIGER Interactive Update System interface. The main window shows a map with various geographic features and labels such as "Benton Point S/D", "Sunnydale Ct", "SIP-1382", and "SIP-1383". A "Feature List" dialog box is open, showing a list of "Feature Sub Class" options: BAG, BLKGRP, COUSUB, INCPLACE (highlighted), TRIBALCT, and Vintage. The "Vintage" field is set to "90 - Current". The dialog box has "OK" and "Cancel" buttons. The interface also includes a navigation toolbar, database controls, and application settings. The status bar at the bottom indicates "Active Theme: COUSUB Active Style: C.COUSUB" and "Local Intranet".

- when it has to be right

# Geographic Area Editing

**A customized select operation displays the to-be-edited geographic area in green and allows the user to click neighboring faces (displayed in red) to add to the geographic area.**

U.S. Census Bureau  
MAF/TIGER Interactive Update System

Feature Class: Geographic Area  
Action: Add To

Start Stop

Navigation Tools

Database Controls

Application Settings

Send Keyin

Move to New Area

Left-click -> Highlight/de-highlight a faces. Submit button (or right-click) -> Add faces to the geographic entity.

- when it has to be right

# Attribute Info Dialogs

Second-level attributes that exist in related tables (related to the main feature table through a foreign key) are displayed in separate information dialog boxes. These dialogs are accessible by clicking "Road," "Rail," or "Hydro" in the main feature's information dialog (see below left). Here we see road details that are related to the selected Census feature.

The screenshot shows the U.S. Census Bureau MAF/TIGER Interactive Update System interface. Two dialog boxes are open over a map. The 'Census Feature' dialog on the left displays a table of attributes for a selected feature. The 'Road Attribute Listing' dialog on the right displays a table of road-related attributes for a specific edge ID (1100454). The 'Road' button in the 'Census Feature' dialog is highlighted, and a yellow callout points to it with the text 'Feature selected here.' The interface includes navigation tools, database controls, and application settings on the right side.

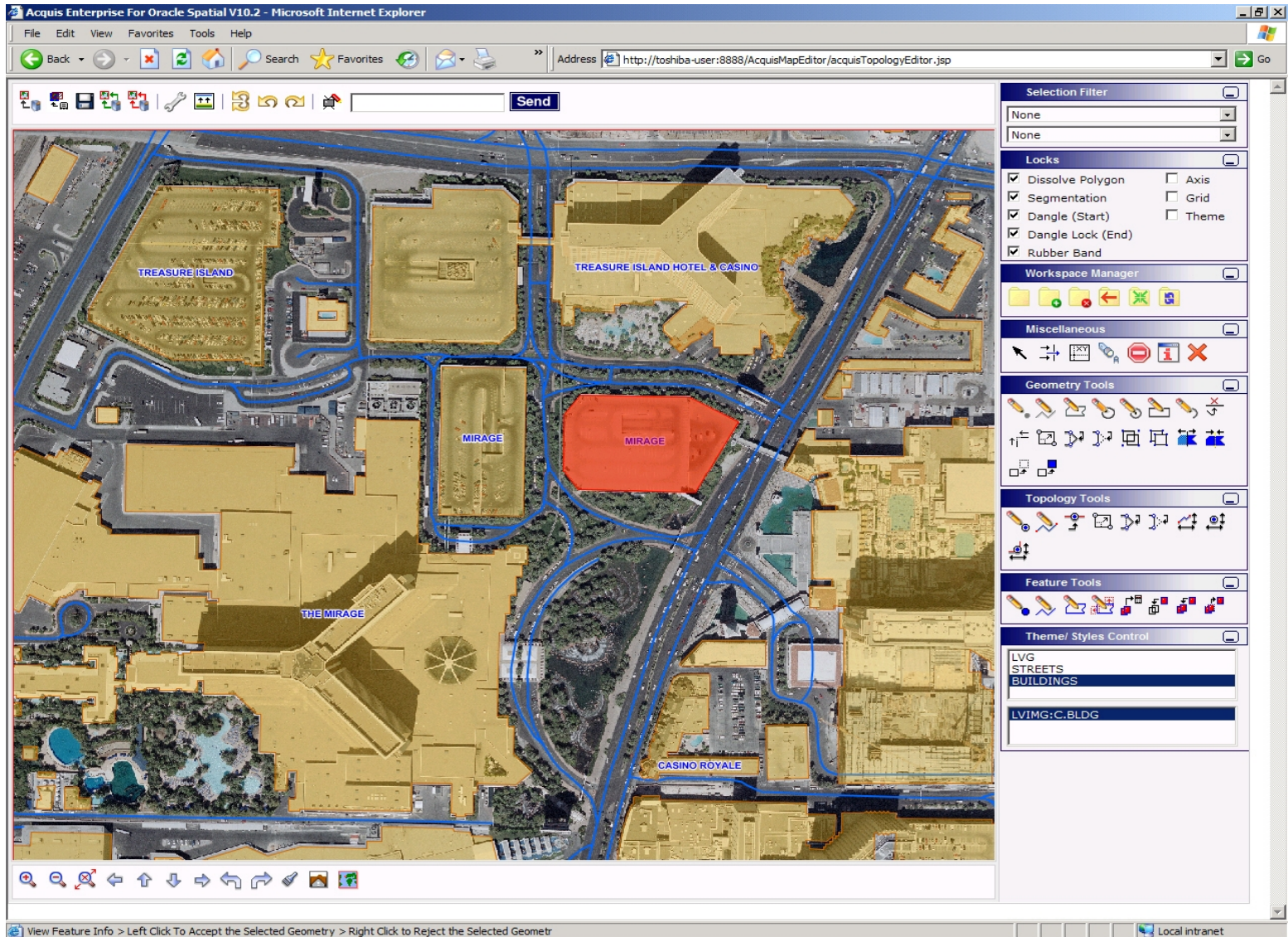
Column	Value
Block Boundary Suggestion Project Flag	0
Census Block Boundary Selection Flag	1
Geographic Corridor/Offset Short Edg...	N
Offset Left Width	
Offset Right Width	
Permanent Edge ID	71971697
Provisional Flag	N
Shape Fidelity Flag	Y
Object ID	82016997141
Extension Type	N
From Stack Level	0
Indicates whether this edge is related...	N
Indicates which type of linear feature...	Y
Indicates which type of linear feature...	N
Left Offset Flag	N
Legacy CFCC	A41
MAF TIGER Feature Class Code	T1100
Primitive related to water feature.	N
Right Offset Flag	N
Row ID referencing the oracle EDGE\$...	1100454
Special Passage Flag	
To Stack Level	0

Column	Value
Divided Road Flag	<input type="checkbox"/>
Embedded Rail Flag	N - Not embedded Rail
Median Traversable by Em...	M - No Median
Median Width	-1
Number of Lanes	
Road Access	A - Access unlimited
Road Maintenance Jurisdiction	
Road Surface Type	P - Paved
Road Width	
Speed Limit	
Toll Road	<input type="checkbox"/>
Traffic Flow	B - Two way traffic

This is the main information dialog for the selected Census feature. In addition to displaying the main attributes of the feature table, a customized ADE information dialog provides a means to access a second level of attributes that reside in related tables.

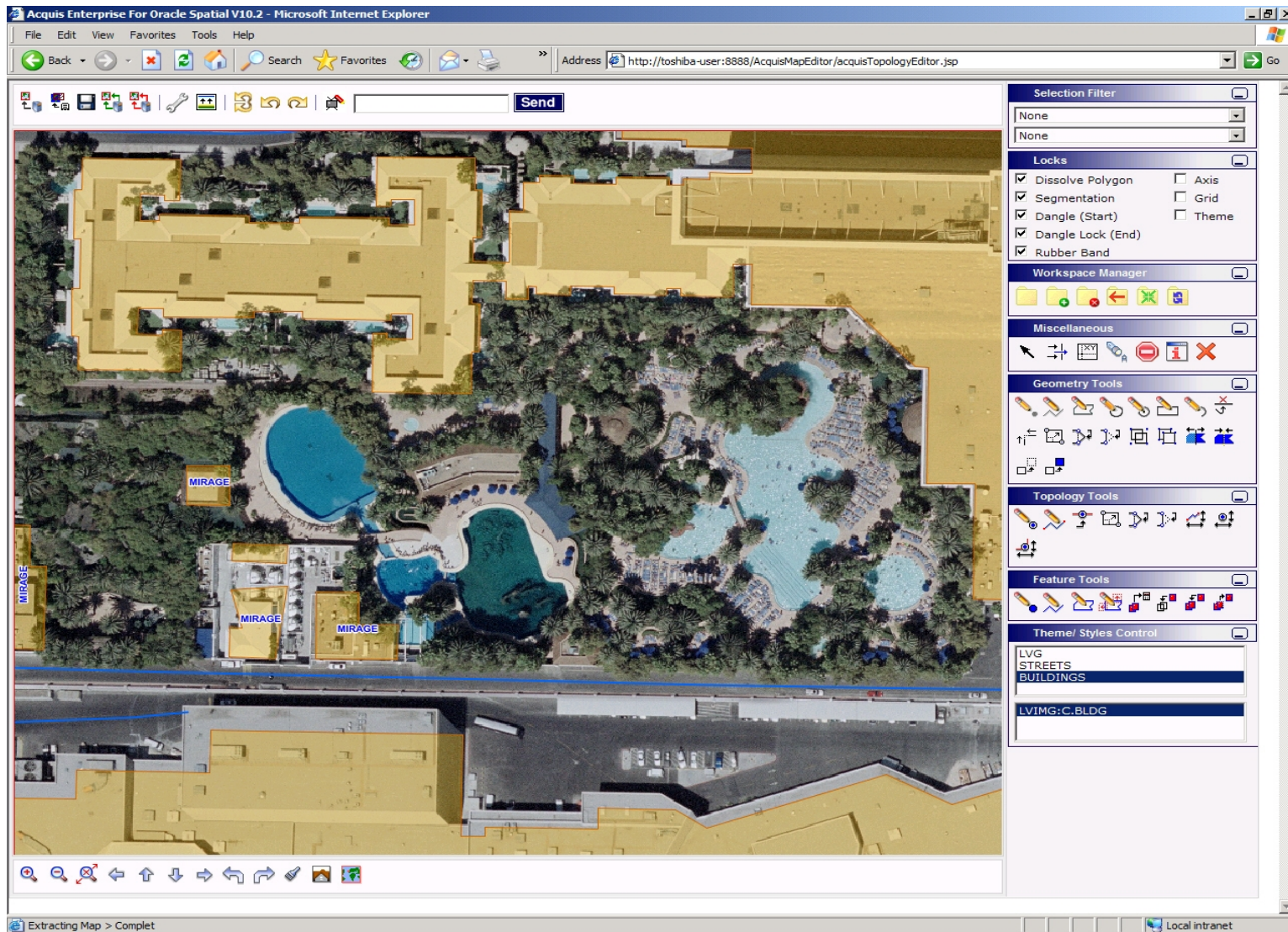


# Vector /Georaster Display



- when it has to be **right**

# High Resolution Georaster Display



- when it has to be **right**

**Leica**  
Geosystems

# Offline Demo

Remote Polygon Editing

- when it has to be **right**

# Future Plans...

- when it has to be **right**

**Leica**  
Geosystems

# Leica ADE Future Projects

- Orthophoto backgrounds through in-house or external imagery web service
- Scanned paper map backgrounds for heads up digitizing and editing
- Workflow integration with “Northbound” (Harris Corp.) TIGER editing process

# Summary

Geospatial data is simply data in an enterprise IT infrastructure

Integrate geospatial data into business applications to turn geospatial data into geospatial information

Using Location-enabled enterprise IT architectures and effective tools has a TREMENDOUS effect on IT efficiency and budget

Leica can help

- Enterprise Products and Services
- Based on Oracle's Enterprise Technologies and Application Platform
  - Oracle Spatial Development Partner
  - Oracle Certified Partner
  - Oracle Approved Education Center for Spatial Courses



- when it has to be right



QUESTIONS  
ANSWERS

- when it has to be **right**

*Leica*  
Geosystems