Leveraging Oracle Spatial and Graph for Airport GIS

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OVERVIEW

- Los Angeles World Airports (LAWA) is the City of Los Angeles department that owns and operates Los Angeles International (LAX) and Van Nuys (VNY) general aviation airports.
- Sixth busiest airport in the world and third in the United States serving over 74 millions passengers and 2 million tons of cargo in 2016.

CHALLENGES / OPPORTUNITIES

- Create a single repository for CAD/GIS related data (single source of truth)
- Provide engineering data to a wider audience at the airport
- Support applications that have GIS integration points, e.g., CMMS, Lease Management, etc.

SOLUTIONS

- Oracle Database 12c with Spatial and Graph option
- Adoption of a flexible data standard
- .NET Framework C#
- ColdFusion Enterprise 11
- Autodesk Infrastructure Map Server 2016
- ESRI ArcGIS Server 10.4.1

RESULTS

- Establishment of a single source for all geospatial data
- Support for FAA A/C 5300 18b as well as National CAD Standards (no conversion required)
- Multiple platform support (Autodesk & ESRI)
- Provide geospatial data to other LAWA departments
- Over 200 feature classes representing over 2 million geometric features have been uploaded to the database
Overview

• Introduction
• Requirements / Goals
• Data Management & Challenges
• Solution
• Hurdles
• Benefits
• Q/A
Introduction

- **LAX** In 2016, LAX served over 74 million passengers, processed over 2 million tons of air cargo valued at over $90 billion, and handled over 615,000 aircraft operations
  - 680 daily flights to 96 domestic cities
  - 930 weekly nonstop flights to 59 cities in 30 countries on 63 commercial air carriers.
Requirements/Goals

• Create a single repository for CAD/GIS related data (single source of truth)
• Provide engineering data to a wider audience at the airport
• Support applications that have GIS integration points, e.g., CMMS, Lease Management, etc.
• Perform Sophisticated Model Driven Spatial Analysis and Visualization of Results
• Take advantage of the tools and technologies that are built around GIS, e.g. Spatially driven mobile applications
Challenges

• Variety of data
  – Over 200 feature classes
  – Over 2 Million geometric features in the database
    • 1.5 Million floor plan features
    • 500 ~ 700K of SDS/FIE classified features
• Years of effort have been devoted to authoring maps and developing symbology for a “corporate look and feel”
### Challenges

**Layers**

- **Buildings**
  - Structure Foundation Line
  - Building
  - Existing Structure
  - Future Structure
  - Slab Area
  - Boarding Bridges
  - Tenants

- **Boundaries**
  - LAWA Property Line
  - State Area
  - Land Registry
    - LAX LANDBASE
    - LAX TML 0722013
  - Ground Lease - Avioft
  - Ground Lease
  - Acquisition Area
  - Airport Areas

- **Transportation**
  - Airside
    - Airfield Light Point
    - Navigational Aid Point
    - Aircraft Parking Spot
    - Service Road
    - Runway
    - Taxiway
    - Taxi
    - Apron
    - Infield
  - Airfield Surface
  - Airfield Surface Proposed
  - Landside
  - Thomas Brothers

- **Landside**
  - Road Centreligne
  - Railroad Centreligne
  - Surface Marking
  - Bridge Columns
  - Pedestrian Footbridge
  - Road Bridge
  - Median
  - Road Shoulder
  - Driveway
  - Road
  - Tunnel
  - Cargo Vehicle Loading Zone
  - Vehicle Parking Lot
  - Thomas Brothers
    - TB-Freeway
    - TB-Freeway Connectors
    - TB-Railroad
    - Rapid Transit
    - TB-Streets

- **Utilities**
  - Communications System
  - Manhole
  - Twisted Pair Cable
  - Fiberoptic Cable
  - Coaxial Cable
  - Other Cable
  - Antenna Line
  - Ductbank
  - Antenna Area

**Layers**

- **Energy Control Monitoring System**
  - Cable Line
  - Compressed Air System
  - Pipe Line
  - Electrical System
  - Cable
  - Ductbank
  - Fuel System
  - Pipe
  - Tank
  - Communication / Electrical Sites
  - Conduit Centerline
  - Substructure
  - Industrial Waste System
    - Pipe
    - Oil / Water Separator
  - Hot and Chilled Water System
    - Pipe
    - Natural Gas System
    - Pipe
    - Proposed Pipe
    - Pump Station
  - Water System
    - Hydrant
    - Pipe
    - Proposed Pipe
    - Tank
  - Sanitary Sewer System
    - Pipe
    - Oil / Water Separator
  - Storm Drain System
    - Pipe
    - Proposed Pipe
    - Open Drainage
    - Culvert

**Layers**

- **Environmental**
  - Regulated Tanks
  - Underground Tank Point
  - Above Ground Tank Site
  - Butterfly Preserve Area
  - Buckthorns
  - ESB Preserve Boundary

- **Flora**
  - Flora Species Site
  - Land Vegetation Area

- **Geodetic**
  - Survey Control
  - Control Point

- **Fences Gates and Walls**
  - Fencing Post and Sign
  - Gate
  - Wall
  - Fence
  - Security Perimeter Fence
  - Miscellaneous

- **Land Status**
  - Construction and Other Use
  - Construction Site
  - Batch Plant
  - Concrete Material Yard
  - Dockwater Beach
  - Dockwater Dock
  - Dockwater Beach
  - Land Condition

- **Aerial**
  - Landform
  - Spot Elevation Point
  - Elevation Contour Line
  - Pacific Coast

- **Parks and Recreation**
  - Grid Layers
Database Organization

• Oracle Stored Procedures and Packages for
  – Spatial data classification
  – Security
  – Automatic Spatial View Creation
  – Geodatabase creation
  – Spatial Data cleanup (Geometry)

• Triggers
  – Spatial table
    • Before Insert – Auto populate fields
    • After Insert – Create & link record in the attribute table
    • Before Update Auto populate fields
    • After Update – Maintain data integrity
    • Before Delete – Clean up attribute table records
Data Management - Foundational Blocks

- Geometric Data development and Management
- Tools for Maintaining and Viewing the data
- Enterprise Application Support (CMMS, Lease Management, etc.)
- Geospatial Analysis (Locating facilities, view in 3D)
Data Management - Organization

• Selection of an RDBMS with direct support for standardized geometry support (currently Oracle Database 12c with Spatial and Graph option)
• Adoption of a flexible data standards (SDS / FIE)
  – An existing national data standard
  – Ability to filter out relevant data for the airport
  – Open spatial data standard covering both CAD & GIS platforms
• Adopt flexible data standards to support current and future requirements
  – Support for NCS
  – Support FAA A/C-5300 18b
  – Support for multiple platforms (e.g. Autodesk, ESRI, etc.)
  – Easily customizable
Data Management - SDSFIE Implementation

**ESRI Geodatabase**
- Feature Dataset
  - Feature Class
    - Subtype

**SDS/FIE**
- Entity Sets
- Entity Classes
- Entity Types
- Entities
  - Tables
    - Attributes
      - Domains
  - Relationships
    - Lists
    - Ranges

**Example**
- “Utilities”
- “Water”
- “Line”

**Oracle Repository**
Database Schema

• Two Oracle Schemas
  – Spatial Data
  – Non-Spatial Data
• Single Oracle table for storing Spatial data and common attributes
  – Feature Classification information
  – Username/time stamp
• 1370 attribute tables for feature type specific information (e.g., pipe diameter, material, etc.)
• Over 36,000 attributes in the above attribute tables
MSC & GDB Tools are software modules developed by x-Spatial to support the ESRI platform.
Data Management - Application of standards

SDS / FIE:
Set=Utility
Class=Waste Water System
Type=Line
Entity=Service
LAWA CAD Layer=C-SSWR-SERV

A/C 5300-18b:
Group Name=Utilities
Class Name=Utility Line
FAA CAD Layer= C-SSWR-MAIN-

ESRI Geodatabase:
Dataset=Utilities-Waste Water System
Class=Line
Sub-Type=Service
Web Based Maintenance of the Database Schema

- Using the web interface to maintain the DB schema
- Defining new features using web forms rather than “GIS or CAD centric” tools.
- Easier and more Efficient
- Eliminates the need for ad-hoc programming
Web Based Maintenance of the Database Schema

Note: If you are changing the "Is Active" settings of this Entity, be sure to run the "Update AutoCAD Object Classes" command of the SDS-Administration Panel. Update the Object Classes when you are finished with changes to all Entities (including deleting).
Web Based Maintenance of the Database Schema

• Allows Data Administrators to add any feature type with any set of attributes
• No programming is needed for modifying
  – User interface
  – Oracle tables and fields
• Extremely time efficient for data maintenance.
Why Use CAD to Maintain Data?

• AutoCAD is the primary tool for data development at the airport
  – All construction / engineering / survey data is delivered in BIM / CAD format
  – AutoCAD provides a simpler & more streamlined tools for data development and maintenance
  – Communication with outside AE firms
• Data maintenance tools are currently CAD based
• CAD data requirements from other airport groups
Geo-locating a floor plan, prior to uploading the drawing to Oracle Database, the location code is customizable and is created during the drawing setup process.
The CAD Modules capability allows viewing lease & spatial attribute data (queried from the dB) of a space in AutoCAD Map.
The object classification tool, allows for creation of objects per CAD & GIS specification, while the second “converts” drawing elements submitted by outside consultants to your standards.
GDMS’ CAD Module allows viewing attribute data for a feature inside AutoCAD Map.
The result of querying pavement data (grey polygons) from the database
As-Built Plans
GIS Data
Hurdles

- Geometry data issues
  - Incompatible Geometry types (e.g. AutoCAD Polyline with an arc segment is not supported in GIS)
  - Geodatabase feature classes are limited to a single geometry type (i.e. Point or line or polygon)
Data clean up

• Transferring spatial data to ESRI Geodatabase requires geometry data cleanup.

• The following Geometry data cleanup are performed using Oracle SDO_XXX utilities (packages)
  – Fix vertices order – sdo_geom.validate_geometry
  – Polygon overlapping itself (bowtie) – sdo_geom.sdo_union
  – Convert arcs to strokes, ie densify – SDO_GEOM.SDO_ARC_DENSIFY
Solution

- Development of tools for cleaning data
  - CAD geometry are not as clean as they need to be for GIS use
- Development of tools for creation of geodatabase
  - Ability to publish any SDS / FIE feature types into its corresponding Geodatabase feature class
  - Leveraged the SDS/FIE open standard to bridge data between CAD & GIS
  - Automated process for creation of a geometric network
Solution

- Development of tools for:
  - Creation of Map Services based on existing corporate thematic & symbology
Benefits

– The automated creation of feature class definitions has greatly streamlined the geodatabase creation
– Changes to feature class definition (attributes, domains, sub-types) are automatically transferred to Geodatabase
  • No need to use ArcCatalog
– Maintain synchronicity between CAD & GIS platforms
– Leverage the best tools for solving real-time problems
Example .. ArcMap
Example .. AutoCAD
Example .. Web App
Example .. ArcGIS Map Services
Q/A

• For more information please contact;

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ESRI Geodatabase Support

ArcGIS

Map Services

CMS

AIMS

MSC

ESRI

Production GeoDB
Oracle or MS-SQL

GDIFF

CFC

GDBCopy

ESRI

Staging GeoDB
Oracle or MS-SQL

GDB

MSAdmin

FDO

Production Oracle dB

Oracle or MS-SQL
### LAX Passenger Volumes
**January 2016 - November 2016**

- **JAN 2015 TO NOV 2015**
  - Domestic: 49,560,427
  - International: 19,000,912

- **JAN 2016 TO NOV 2016**
  - Domestic: 53,205,679
  - International: 20,841,587

### LAX Air Cargo
**Year to Date Comparison 2015 v 2016**

- **JAN 2015 TO NOV 2015**
  - Mail: 81,156
  - Freight: 1,875,607

- **JAN 2016 TO NOV 2016**
  - Mail: 85,477
  - Freight: 1,919,892
Solution- Web Based Maintenance of the Database Schema
The GDMS interface. The left panel provides the tools for accessing data, administrative tasks, and report. The Panel on the right provides the map interaction tools including markup, quick view, etc. The bottom panel displays all resulting tabular data.
Screen shot of LAX facility showing the “signage” map.
Screen shot of LAX facility showing an overlay of an AutoCAD drawing
Example ..Web App.
Example . ArcMap
In this example (left) an electrical panel was selected on the map, the tool tip shows the hyperlinked documents.

The schematic diagram on the right is the result of selecting one of the hyperlinked documents, GDMS loads the drawing, and zooms to the hyperlinked region of the drawing.