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Best Practices for Interoperating Spatial Data Between Different Software Platforms for Modeling and Analytics

Presented by

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An Introduction to Bechtel



- Top U.S. construction contractor by Engineering News-Record (ENR) for 15 straight years
- Revenue of \$37.9 billion in 2012
- 52,700 employees world-wide



- **Four Global Business Units (GBUs)**
 - Infrastructure
 - Mining and Metals
 - Nuclear, Security & Environmental
 - Oil, Gas & Chemicals



- **Signature Projects: Hoover Dam, English Channel Tunnel, Hong Kong International Airport, Ivanpah Solar Energy Site, Riyadh Metro Project**



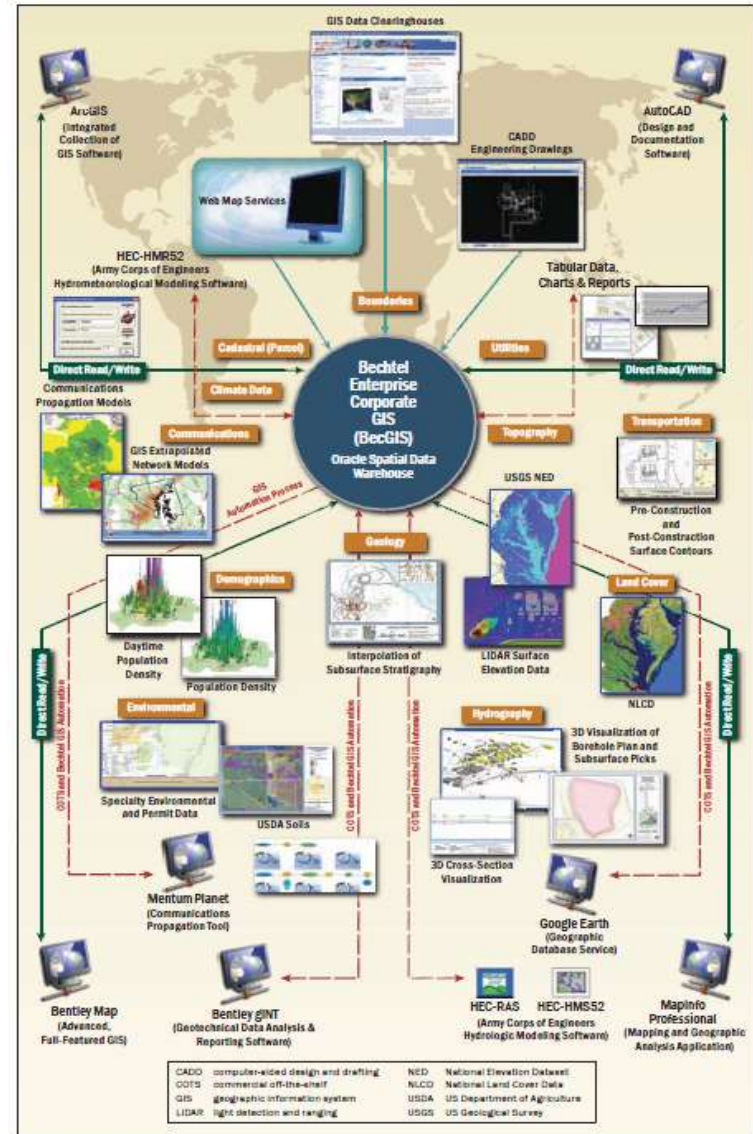
Enterprise Spatial Data Deployment Strategy with Oracle Spatial

- GIS Data Configuration Management Processes and Content Sharing (Retrievability)
- Scalable, Multi-Tiered Data Security (System, Database, Feature)
- Return on Investment (ROI) on GIS Software and Spatial Data
- Prevent Duplicate Efforts on Data Purchase and Preparation between Data Stewards
- GIS User-Specific Experience
- GIS Data Model Standards Facilitate Automation
- Interoperable Data Strategy

Sources:

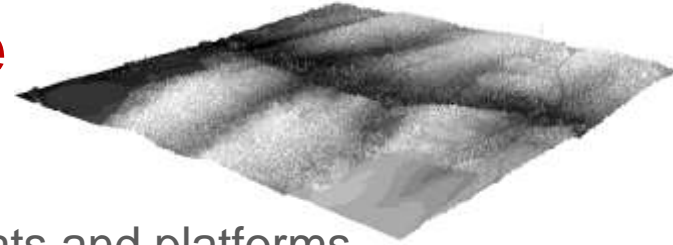
McLane, Tracy and Yongmin Yan. *Enterprise Spatial Data Deployment Strategies in a Global Engineering Environment – The Bechtel Experience*. The 17th International Conference on GeoInformatics 2009. Johnson Center, George Mason University, August 12th-14th, 2009 Fairfax, VA, USA

McLane, Tracy, Yongmin Yan and Robin Benjamins. *Interoperable Deployment Strategies for Enterprise Spatial Data in a Global Engineering Environment*. Bechtel Technology Journal, An Independent Analysis of Current Technology Issues. Volume 2, No.1, December 2009.





The Spatial Data Challenge

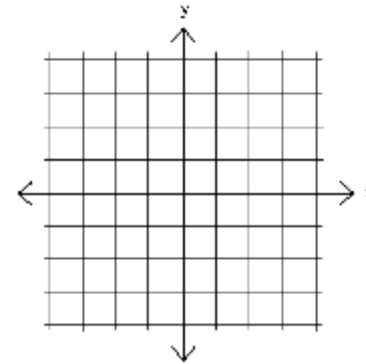


- Interoperating Data between different software formats and platforms can offer a challenge when integrating spatial and tabular data into a Geographic Information System (GIS) or 3D Model
- This presentation will share many of the best practices discovered in handling spatial data on a day to day basis and preparing it for use in a variety of different data formats and software packages
- Issues related to database connections, supported coordinate system references, software configuration, data formats, and workflow processes can all impact the ability to view and analyze spatial data in different software



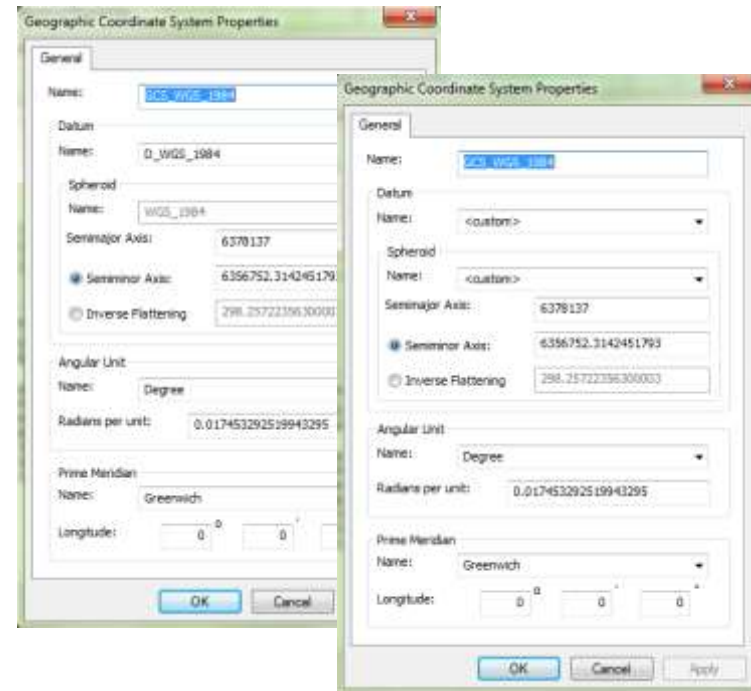


Differences in Coordinate System Reference Naming



- **Example:** Horizontal Datum Naming Between **Global Mapper** and **ArcGIS Desktop**
- There are some slight differences in coordinate system definition translation between the Global Mapper software and ArcGIS Desktop software. The Geographic (latitude/longitude), WGS84 coordinate system comes in with a “**D_WGS84**” definition from Global Mapper, whereas the datum definition in ArcGIS Desktop is “**D_WGS_84**.”
- The “**D_WGS84**” datum from Global Mapper is seen as a “Custom” datum when a spatial layer with that coordinate system definition is used in ArcGIS Desktop and will cause display problems if used to define the coordinate system of other features.

Best Practice: Always check to make sure that the coordinate reference system names and parameters between software match exactly when interoperating data between different software and data formats.





Differences in Coordinate System Reference ID



- **Example:** Coordinate System Identifier Differences Between **Oracle Spatial** and **ArcGIS Desktop**

World Geodetic System 1984:
SRID: 4326
SRID: 8307

- When bringing in 2D and 3D data into an Oracle Spatial database, the use of different Spatial Reference System Identifier (SRID) values for different coordinate systems may not be recognized by other software
- The example below provides a means of defining Oracle Spatial geographic (latitude/longitude), WGS84 data using an SRID of 8307 into ArcGIS Desktop (which does not recognize 8307, as it is unique to Oracle Spatial). An alias system, SRID 4326 is used to temporarily modify some of the coordinate system parameters to allow the data to be viewed in ArcCatalog

Best Practice: When making decisions to alias coordinate system reference ID information for your spatial datasets, be sure to review the Well Known Text (WKT) to ensure that the parameters match and preserve the level of precision found in your data. Note the slight precision differences in the unit definition for the two SRID values, which did not affect the accuracies of the data used for this example.

SRID: 4326 (WKT from
MDSYS.SDO_CS_SRS)

SRID: 8307 (WKT from
MDSYS.SDO_CS_SRS)

```
GEOGCS [ "WGS 84", DATUM
["World Geodetic System 1984
(EPSG ID 6326)",
SPHEROID ["WGS 84 (EPSG ID
7030)",
6378137.0, 298.257223563]],
PRIMEM [ "Greenwich",
0.000000 ], UNIT ["Decimal
Degree",
0.01745329251994328]]
```

```
GEOGCS [ "Longitude /
Latitude (WGS 84)",
DATUM ["WGS 84",
SPHEROID ["WGS 84",
6378137, 298.257223563]],
PRIMEM [ "Greenwich",
0.000000 ], UNIT ["Decimal
Degree",
0.01745329251994330]]
```





Resolving Differences in Coordinate System Reference ID

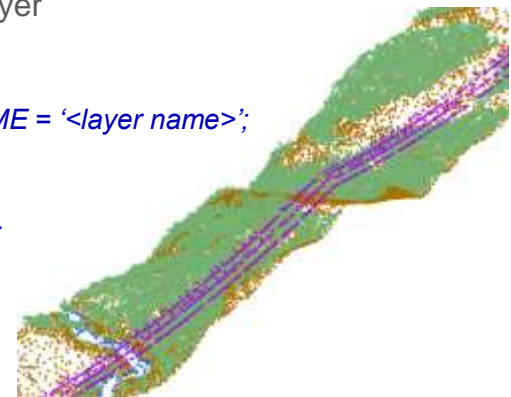
■ **Example:** Coordinate System Identifier Differences Between Oracle Spatial and ArcGIS Desktop

SRID: 4326 ("WGS 84" from the MDSYS.SDO_CS_SRS table)

SRID: 8307 ("WGS 84" from the MDSYS.SDO_CS_SRS table)

- 1) Update Oracle Spatial SRID Value from 8307 to 4326
UPDATE USER_SDO_GEOM_METADATA SET SRID = 4326 WHERE TABLE_NAME = '<layer name>;'
- 2) Retrieve spatial index name in Oracle Spatial:
SELECT INDEX_NAME FROM USER_SDO_INDEX_INFO WHERE TABLE_NAME = '<layer name>;'
- 3) Drop the Spatial Index of the Layer (which also contains the SRID 8307)
DROP INDEX XXXXXX;
- 3) Create layer with a 4326 Coordinate System Reference using ArcCatalog and define
- 4) Insert the SDO_GEOMETRY data from the original Oracle Spatial layer ArcCatalog layer
- 5) Update Geometry Column Reference in Oracle Spatial Metadata
UPDATE USER_SDO_GEOM_METADATA SET COLUMN_NAME = 'SHAPE' WHERE TABLE_NAME = '<layer name>;'
- 6) Recreate Spatial Index
CREATE INDEX <index name> ON <layer name>(shape) INDEXTYPE IS MDSYS.SPATIAL_INDEX;

ORACLE
DATABASE





Custom Coordinate Systems and Transformation Methods

- **Example:** Issues Related to Custom Coordinate Systems and Transformation Methods Used on Data
- There are both 3-parameter and 7-parameter transformation methods that may be applicable to data being used for a project site. Differences in accuracy, purpose (survey, cadastral mapping, etc.), methods and even scaling factors can result in differences in a user’s transformation results.
- Document all coordinate system parameter and transformation methods by EPSG numbers, as naming can vary by software package:

Transformation Method Name:	EPSG ID:	Software Program
Egypt_1907_TO_WGS_1984_2 (WKID 108043)	8537	ArcGIS Desktop
Egypt 1907 to WGS 72 (1) & WGS72 to WGS84	8537	Geographic Calculator

*Transformation Description: Egypt 1907 to WGS84 (EPSG 8537)
 Method: Geocentric Translation
 dx= -121.8 m
 dy= +98.1 m
 dz= -10.7 m
 rx= 0 sec
 ry= 0 sec
 rz= +0.554 sec
 ds (scale factor): +0.2263 ppm
 Accuracy: 5 meters*

Best Practice: Make sure to use consistent transformation methods for data over the course of a project and document EPSG numbers for all coordinate system parameters and transformation methods related to all input and output datasets. When switching transformation methods, document procedures for correct handling of the data to prevent unintended horizontal and vertical shifts in the output data.

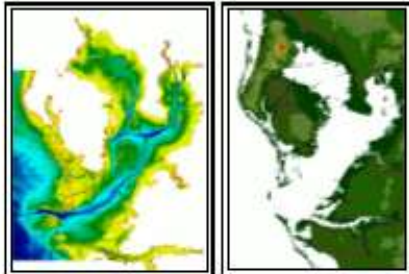
Source: Parameters for the EPSG 8537 Concatenated Transformation Method (source: <https://epsg.io/8537>)





Normalization of Vertical Reference Systems

NOAA Bathymetry USGS Topography

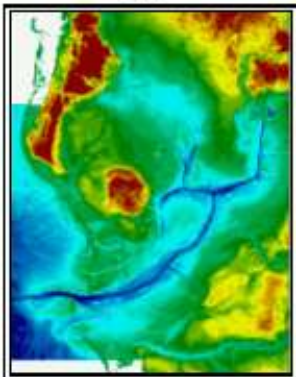


- **Example:** Blending Tidal, Orthometric and Magnetic Reference System Datasets

- When modeling data that blend datasets with tidal datums (such as bathymetric data) and orthometric datums (as with elevation contours on land), it is important to have precise local models for vertically shifting the data to a singular system

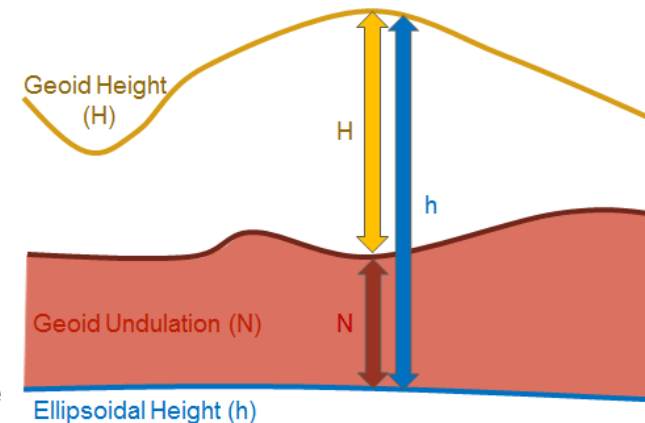
- Tidal stations and use of published vertical models in software like the NOAA VDATUM and Blue Marble Geographic Calculator software, will enable users to perform accurate vertical shift to these type of datasets.

- Local geodetic survey data can be used to refine vertical shift models for performing vertical shifts for a more detailed fit of surface and subsurface model data. The new version of the Blue Marble Geographic Calculator can use your custom shift models to vertical shift your data.



Integrated Bathy/Topo DEM

$$\text{Geoid Undulation (N)} = \text{Geoid Height (H)} - \text{Ellipsoidal Height (h)}$$



Geoid Undulations (N) were calculated at each of the geodetic control benchmark locations.

Source:

McLane, Tracy. *Development of a Vertical Adjustment Model for Modeling a Local Geoid Using Blue Marble Tools*. Blue Marble User Conference 2015. October 6, 2015, Hilton Garden Inn, Arlington, VA, USA



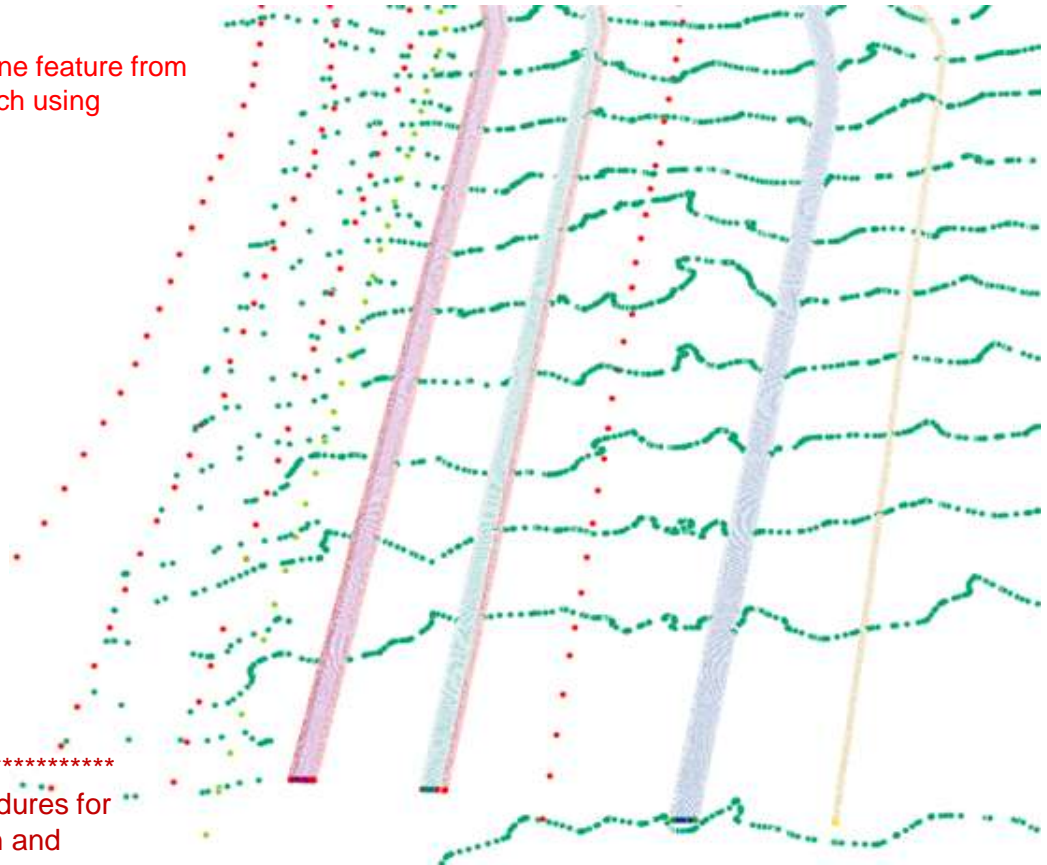
Modeling 3D Geometries from Survey Data

It is often beneficial to use field data to model other more detailed geometry features using a sample of field survey point data and the Oracle Spatial SDO_GEOMETRY function. When blending different datasets for 3D modeling and visualization, it is important to ensure elevations are referenced to the same vertical datum references and that similar geodetic controls were used.

The example below creates a linear 3-dimensional pipeline feature from feature-coded survey point data, which can be run in batch using PL/SQL:

```
INSERT INTO PIPELINE_LINE
(OBJECTID,FEAT_NAME,
FEAT_CODE,SHAPE)
VALUES
(2,'Bechtel Survey Location','906',
SDO_GEOMETRY(3002, 32719, null,
SDO_ELEM_INFO_ARRAY(1,2,1),
SDO_ORDINATE_ARRAY (
452962.39,7334378.237,1516.462,
452989.24,7334357.069,1517.341,
453015.778,7334336.737,1517.861,
453042.731,7334315.67,1518.677,
453070.143,7334294.362,1519.574,
453096.341,7334273.967,1520.216,
453122.154,7334254.268,1520.905,
453147.967,7334234.478,1521.392,
453174.639,7334214.097,1521.569,
453201.704,7334192.756,1522.8,
453228.9,7334172.249,1523.623,
453255.021,7334151.973,1524.126)));
```

Best Practice: Develop procedures for conducting field data collection and standards for the coordinate system parameters and transformations needed for the data.



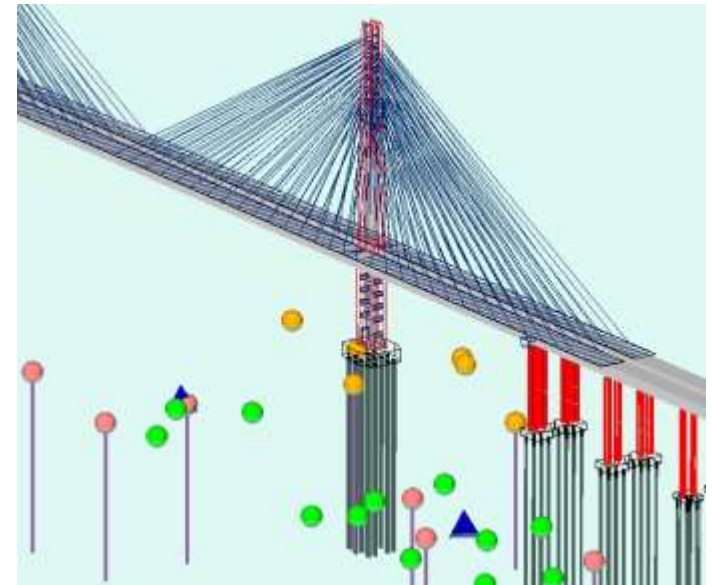
Source:
McLane, Tracy. Innovative Approaches to Modeling GPS/GNSS Construction Data with Oracle Spatial and Graph. Oracle BIWA and Spatial Summit 2015. January 27, 2015, Oracle Headquarters, Redwood Shores, CA, USA





Spatial Attribution and Visualization: Symbolization

- The attribute columns of spatial data are often incorporated into 2D and 3D visualization of the data. How these attributes are used between different software packages may mean differences in preparing the data for visualization.
 - Attributes can be used for symbolization or applying “styles” to geometries (example: number of lanes can be used to apply a single versus multiple lane 3D style to roads)
 - Base and top heights can be used for rendering (when combining elevations from one dataset to another, such as filtered “full earth” LiDAR values, ensure like horizontal accuracies and like vertical system references)
 - Different methods are available for surface Draping imagery on surface model features that will impact visualization results and the closer the publication dates of the image and surface model datasets will yield the best results





Spatial Attribution and Visualization: 3D Rendering

- The 2D and 3D data are rendered for visualization between software differs as well. Most software can use basic 3-dimensional geometry types (point, line, polygon). However, for more complex elements, multiple software packages may be needed to successfully convert data formats for final use in a 3D visualization software (not all software will yield the same output results for various data formats...document best practices and optimal processing speeds)
- When incorporating data into a 3D model for visualization, the model center point should be reference in real-world or a documented custom coordinate system so that datasets can easily be integrated (example: bringing Revit into an InfraWorks 3D visualization project)

- » Aligning Coordinate System References Between Datasets in a 3D Model
- » How and where spatial geometry is stored (3D geometry or attributes)
- » Does rendering require extrusion, exaggeration to normalize vertical units
- » Is data format supported by 3D modeling Software or does it require some type of conversion/preparation for use



Level 4 - Bechtel Public



Best Practice: Ensure elevations to be used for rendering have the same vertical reference, vertical accuracies and units (or apply an exaggerating to resolve unit variation between datasets.



Final Recommendations

- Know the coordinate system parameters of your input data...good metadata should provide this, so don't be afraid to ask for it!
- Know what coordinate systems, datums and geoids are applicable to your study area and data
- Know how the different software you are using use the coordinate system information to perform analysis or render the data
- Have other spatial data in the study area ready to validate your results against
- If a coordinate system transformation is required, have clear parameter requirements for your output datasets
- Know your software tools to perform not only the data transformation, but those that can convert data to needed formats
- Not all software tools will necessarily provide you with the same output

