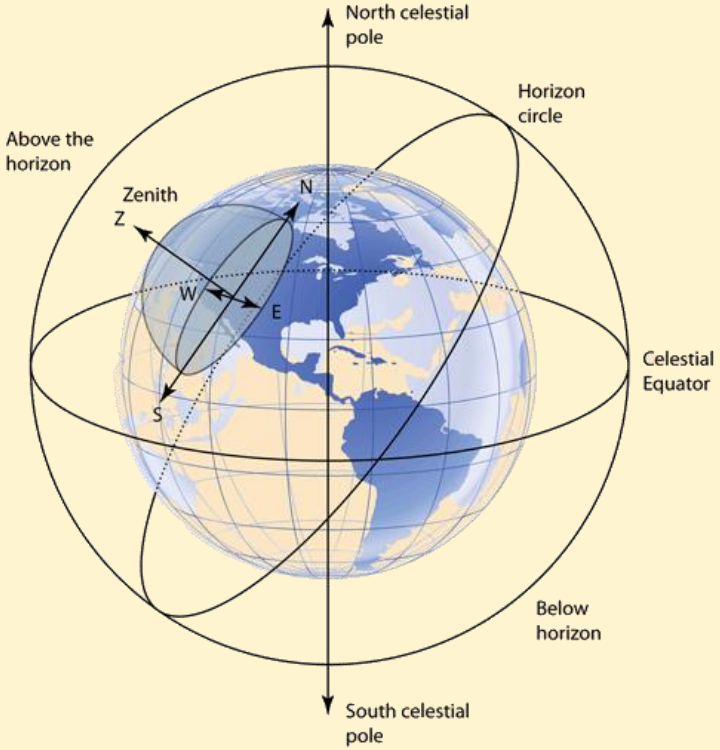
Experts in Geomatics, Surveying, Positioning, Geospatial Data, and Mapping Sciences

Coordinate Reference Systems: Best Practices for Assignment, Manipulation, and Conversion in GIS Systems



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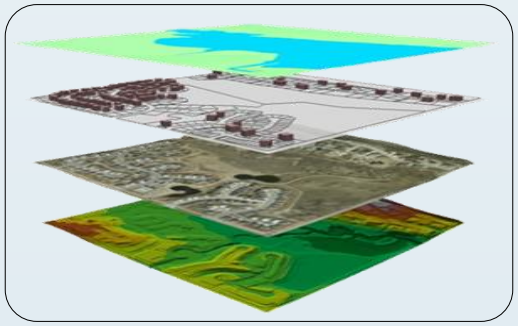
April 13, 2017

Outline

- **Determine GIS Project Coordinate Reference System (CRS) Information**
- **Manipulating and Converting CRS in ArcMap**
- **Distributing Geographic Information**
- **Summary**

Overview



GIS Project Setup

- What is my area of interest?
- How do I determine valid coordinate reference systems for my area of interest?
- What is the preferred coordinate reference system?

CRS in ArcMap

- What happens when I import my data into ArcMap?
- Which transformation do I use?
- Cautionary in ArcMap Projections

Dissemination of Geo-Information

- Web Applications
- Map Products

Potential for geodetic integrity issues at all stages

Agenda

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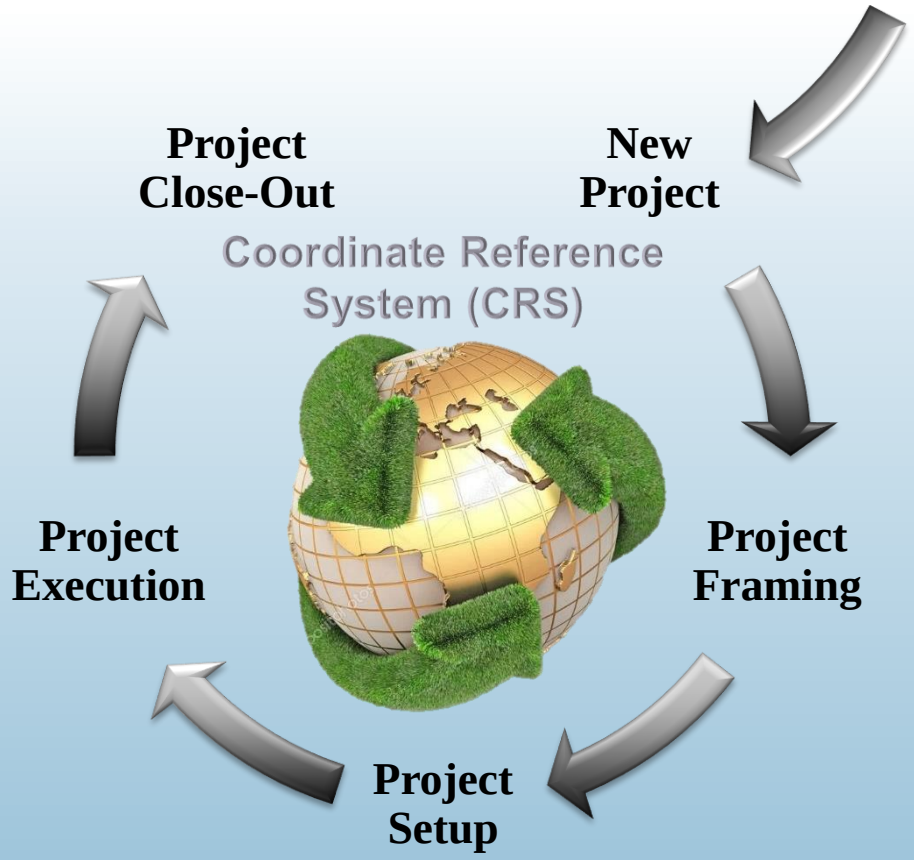
GIS CRS Lifecycle

- **Mandatory Coordinate Reference System (CRS) definition at beginning of the project**
- **Ensure CRS validation for <u>all</u> subsurface applications**
- **Geomatics experts contacted at project start-up**



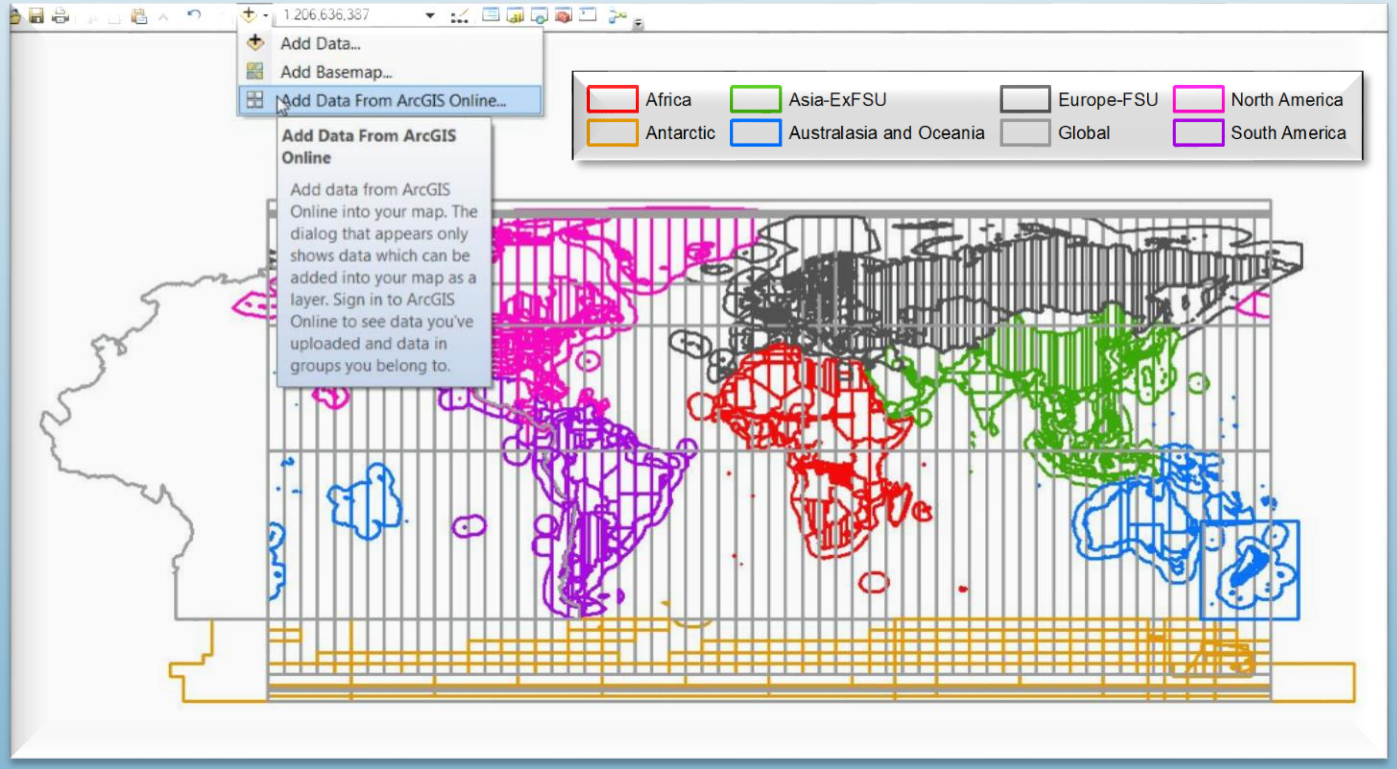
Source: depositphotos (2017)

Users should not make assumptions regarding CRS!

IOGP's EPSG CRS Area Polygons

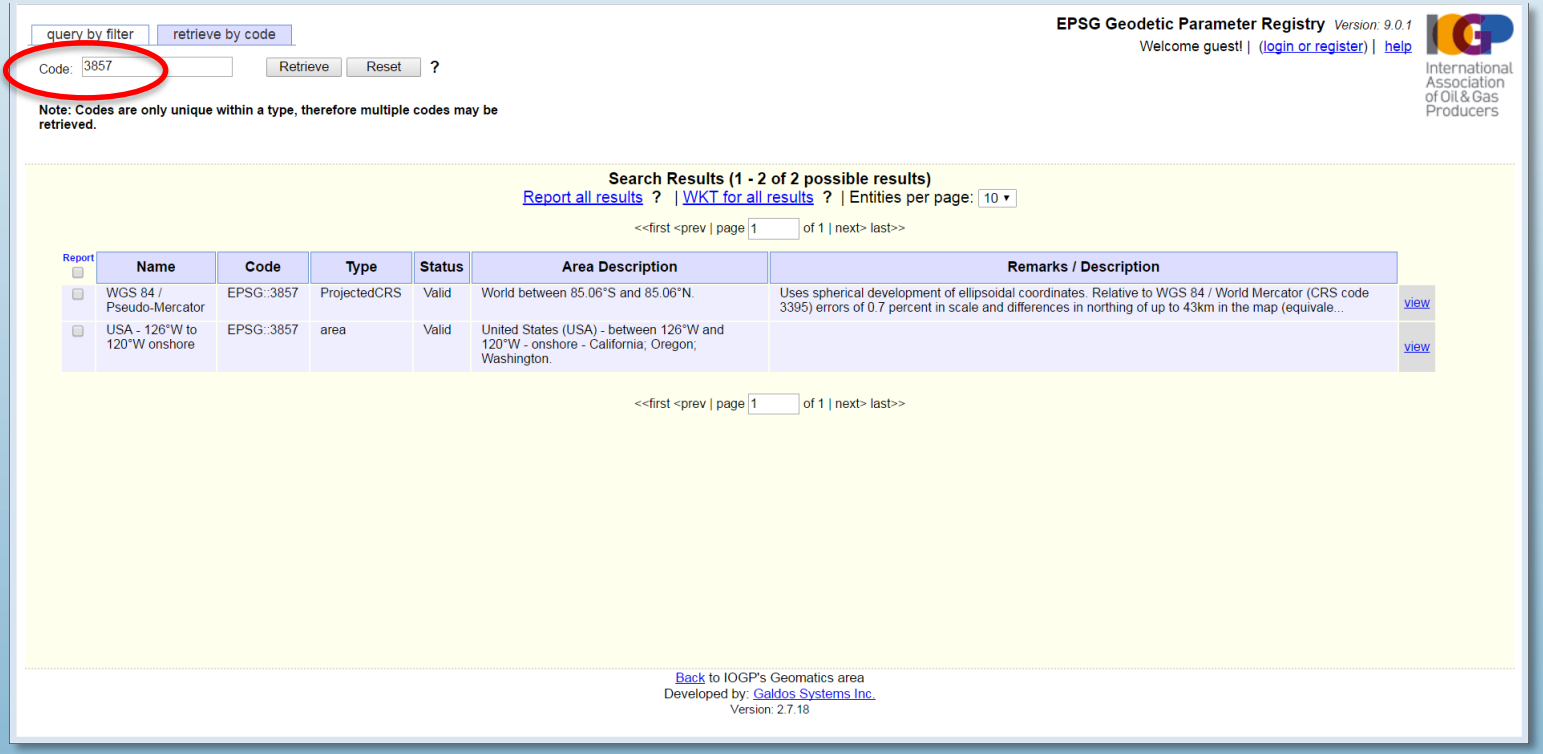
- **Determine coordinate system for Area of Interest**
- **Register at www.epsg.org**
- **Download shapefile and load into ArcMap**
- **Add from ArcGIS Online**

3900+ Validated EPSG CRS polygons available online



EPSG Geodetic Parameter Registry

- **Structured dataset of Coordinate Reference Systems and Coordinate Transformations**
- **Options to "query by filter" or "retrieve by code"**



Source: IOGP www.epsg-registry.org

EPSG Geodetic Parameter Registry (cont.)

query by filter | retrieve by code

Code: 32065 Retrieve Reset ?

Note: Codes are only unique within a type, therefore multiple codes may be retrieved.

EPSG Geodetic Parameter Registry *Version: 9.0.1*

Welcome guest! | (login or register) | help

International Association of Oil & Gas Producers

Search Results (1 - 1 of 1 possible results)

Report all results ? | WKT for all results ? | Entities per page: 10

<<first <prev | page 1 of 1 | next> last>>

Report	Name	Code	Type	Status	Area Description	Remarks / Description	
☐	NAD27 / BLM 15N (ftUS)	EPSG::32065	ProjectedCRS	Valid	United States (USA) - between 96°W and 90°W - Arkansas; Illinois; Iowa; Kansas; Louisiana; Michigan; Minnesota; Mississippi; Missouri; Nebraska; Oklahoma; Tennessee; Texas; Wisconsin; Gulf of Mexico o...		view

ProjectedCRS [NAD27 / BLM 15N (ftUS)] metadata

Code: *EPSG::32065*

Name: *NAD27 / BLM 15N (ftUS)*

Aliases

Area of Use [USA - 96°W to 90°W and GoM OCS] metadata

Code: *EPSG::3640*

Name: *USA - 96°W to 90°W and GoM OCS*

Description: United States (USA) - between 96°W and 90°W - Arkansas; Illinois; Iowa; Kansas; Louisiana; Michigan; Minnesota; Mississippi; Missouri; Nebraska; Oklahoma; Tennessee; Texas; Wisconsin; Gulf of Mexico outer continental shelf (GoM OCS) between approximately 96°W and 90°W - protraction areas East Breaks; Alaminos Canyon; Garden Banks; Keathley Canyon; Sigsbee Escarpment; Ewing Bank; Green Canyon; Walker Ridge; Amery Terrace.

Bounding Box Boundary	Value (Decimal Degrees)
South Bound Latitude	25.61
West Bound Longitude	-96.01
North Bound Latitude	49.38
East Bound Longitude	-89.86

Note (Reference CRS): WGS 84 geographical 2D CRS

Polygon (Revision Date): 2013-11-05

Base Geodetic CRS [NAD27] metadata

Conversion [BLM zone 15N (US survey feet)] metadata

Cartesian CS [Cartesian 2D CS. Axes: easting, northing (X,Y). Orientations: east, north. UoM: ftUS.] metadata

NAD27 / BLM 15N (ftUS)[VALID]

Scope: Minerals (including oil) management, exploration and production.

Information Source: OGP

Data Source: OGP

Revision Date: 2010-03-05

Change ID: EPSG::2006.391

Change ID: EPSG::2009.031

GML

WKT

Source: IOGP www.epsg-registry.org

Recommendations for CRS Selection

- **Select an appropriate 2D geographic CRS ("datum") which is in common use and has an accepted and well defined transformation to WGS 84**
- **Use an appropriate map projection with small distortions and minimal error***
- **Consider existing legacy data**
- **Consider export of produced data / maps** (i.e., regulatory reporting requirements)

Objective is to minimize geodetic risk

Obvious choice is not always "the best"

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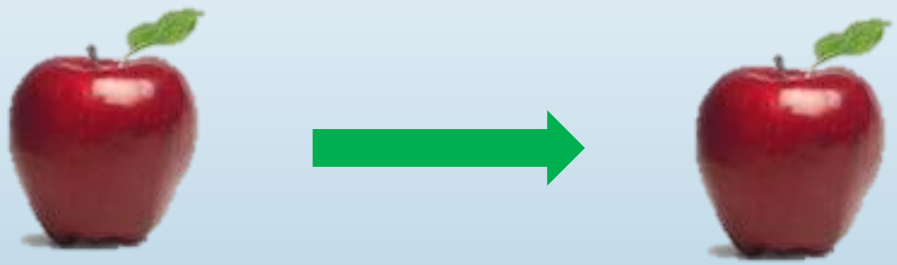
Transformations – When To Use

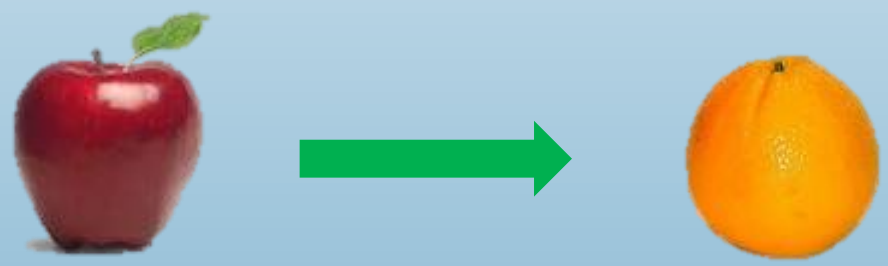
- **A transformation is required when changing coordinates from one CRS to another CRS** (i.e., NAD27 to WGS 84)



Source CRS:
NAD27

Target CRS:
NAD27

No Transformation Required



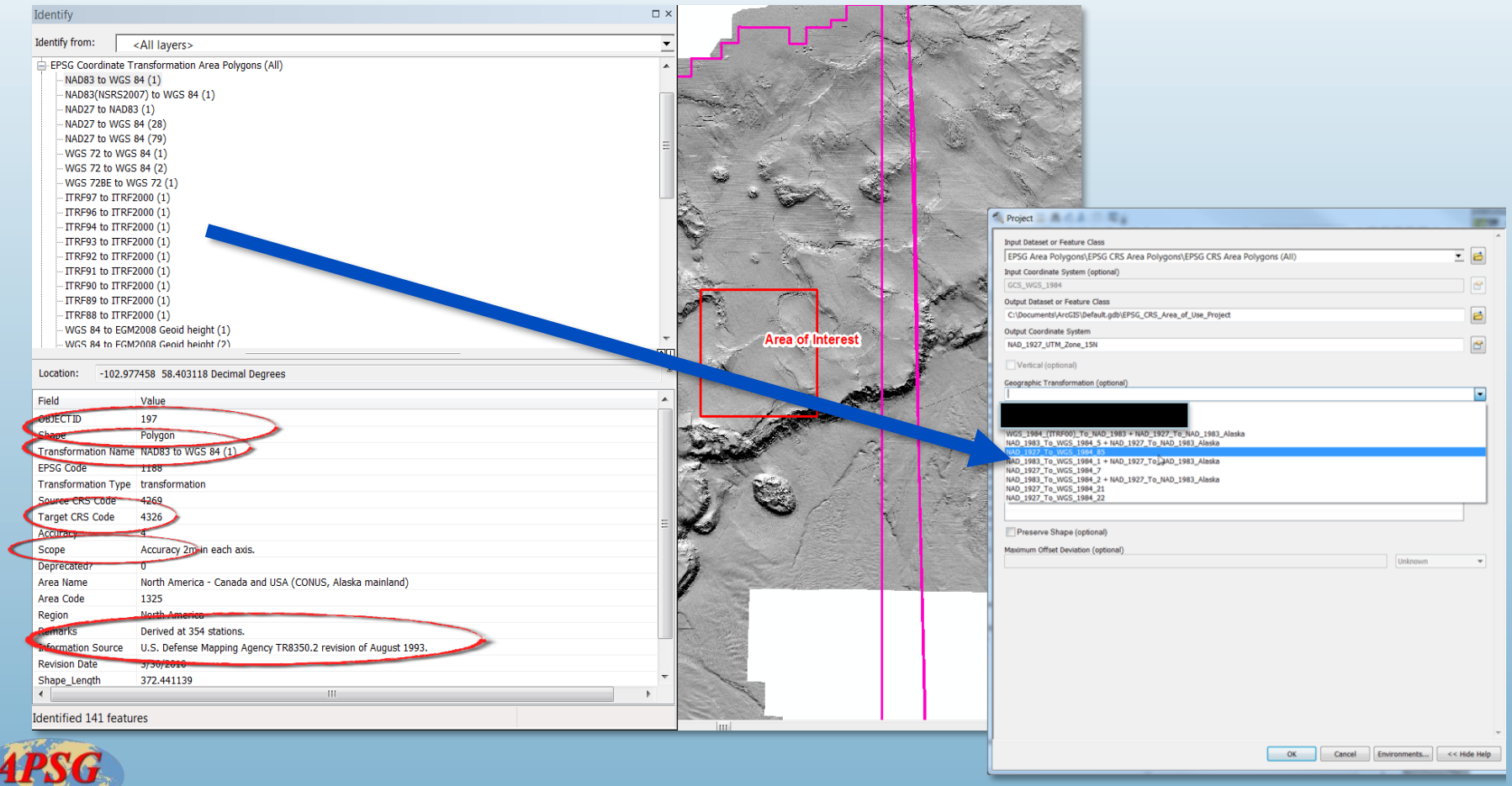
Source CRS:
NAD27

Target CRS:
WGS 84

Transformation Required

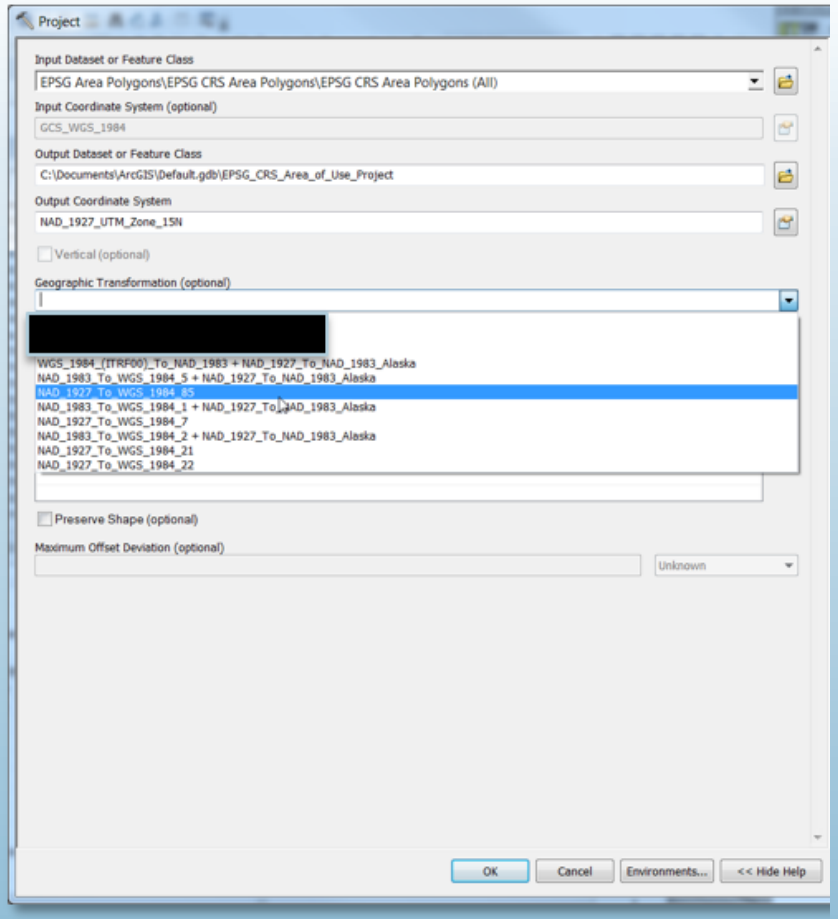
IOGP's EPSG Coordinate Transformation Area Polygons

- **Useful transformation information**
- **Depend on Transformation Method and Area of Use**



Transformations in ArcMap - Tidbits

- **Transformations are bi-directional**
- **If no transformation is used, a default transformation is used.** ***The default is the first chosen in the list and may not be applicable for the area and or suitable for applications that require precise locational accuracy***
- **If you have custom transformations they will be assigned as the default transformation**

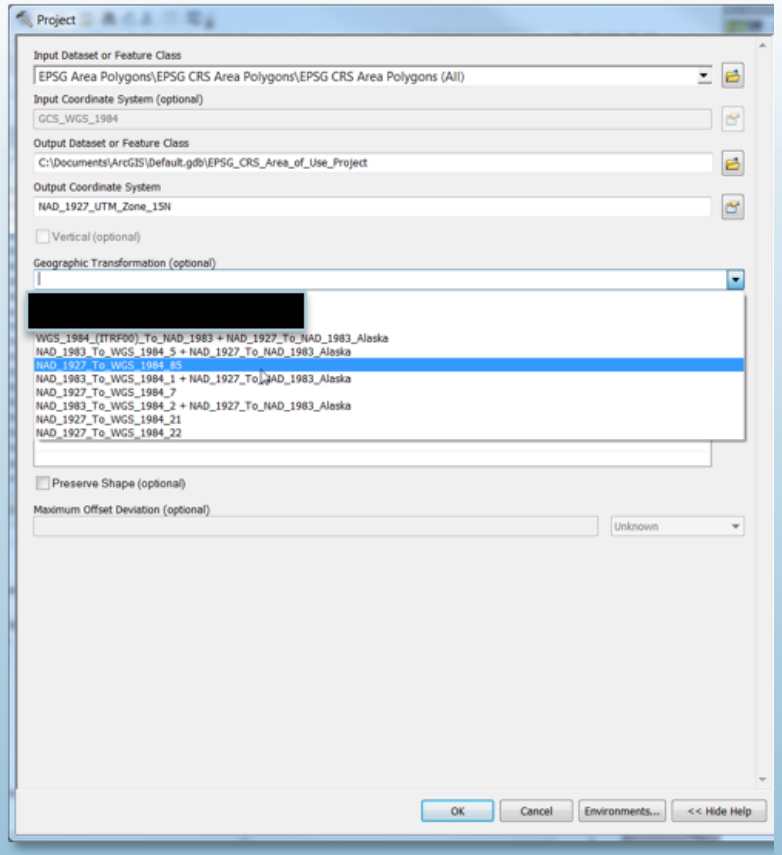


Transformations in ArcMap – Tidbits

- **Preserve Shape – Adds vertices to the output for more accurate.**

- **Vertical – Unchecked = Z values are ignored; Checked = Project tool transforms X, Y, and Z values of geometric coordinates** *****Must have Z Values, requires ArcGIS Coordinate System Data installation package, not compatible with the Preserve Shape parameter***

- **Maximum Offset Deviation - determines the extent of deviation from its exact projected location, default is 100x the XY tolerance of the spatial reference output**

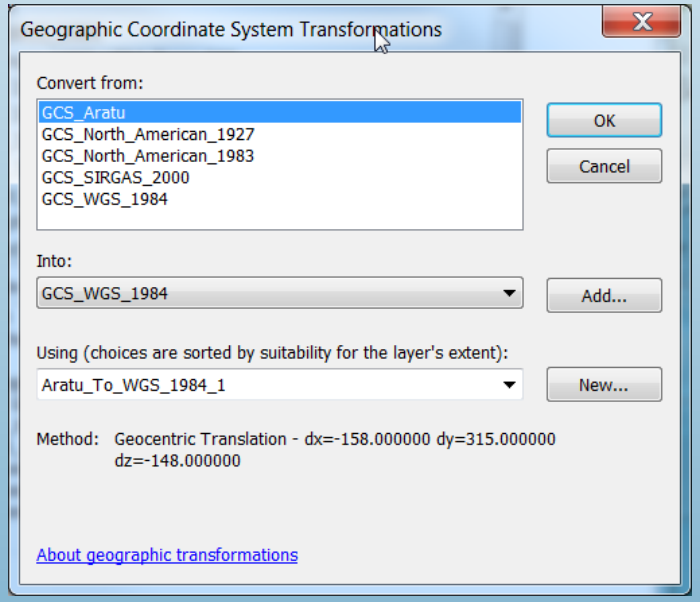


Project on the Fly

- **ArcMap has the ability to transform and project "on the fly"**

- **Can display data in one CRS as if it were in another, without altering the actual data**

Multiple transformations can be used in the data frame, but only 1 per CRS

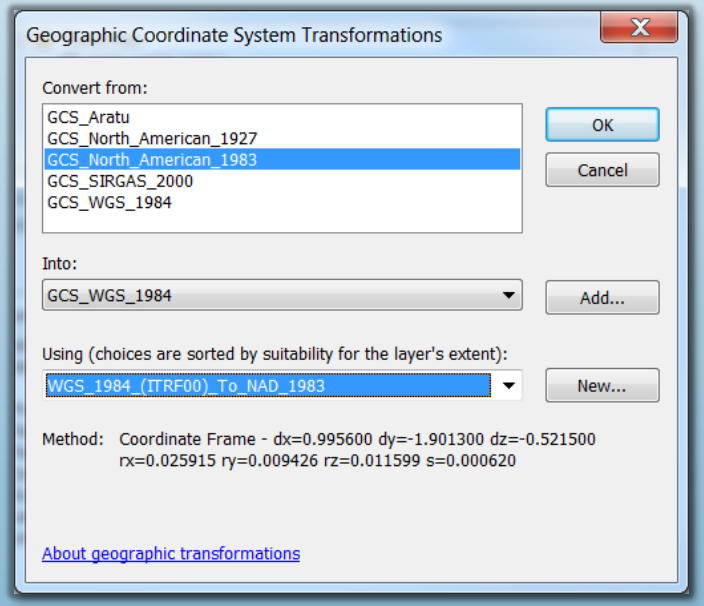


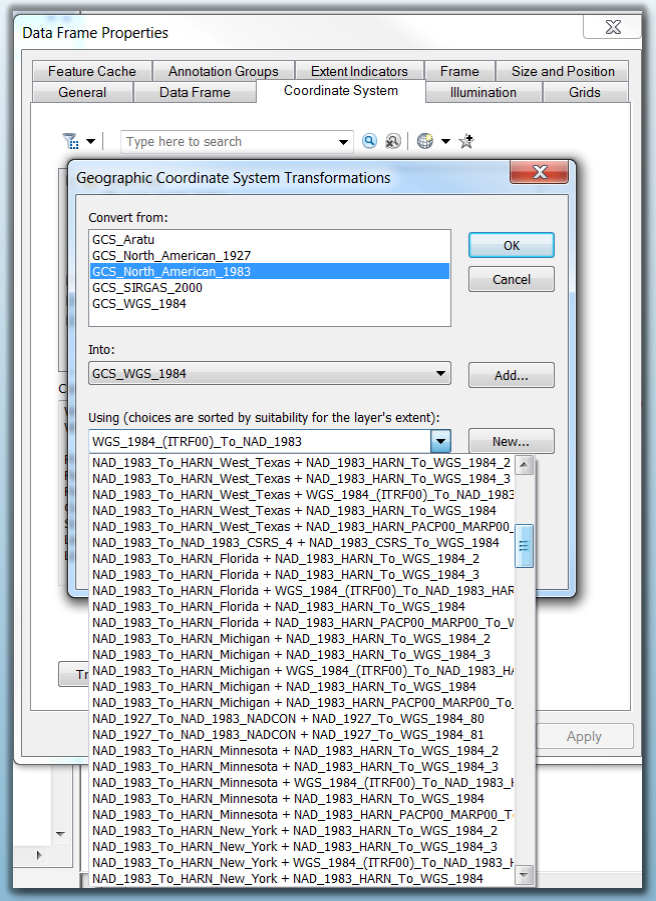
Project on the Fly

NOTE:

- **ArcMap data frames only support one transformation for each geographic coordinate system of the layer to the data frame geographic coordinate system.**

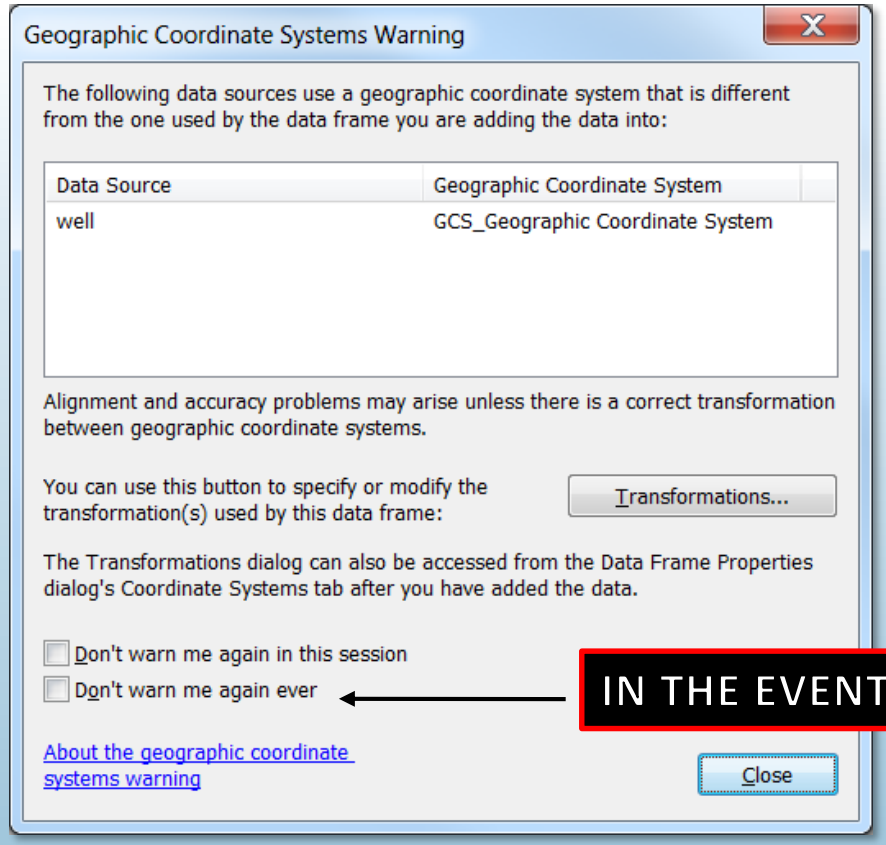
- **Multiple transformations are used in the event that no Transformation exists.**





http://downloads2.esri.com/support/TechArticles/geographic_transformations_1040.pdf

Project on the Fly



IN THE EVENT THAT YOU CHECK THIS BOX

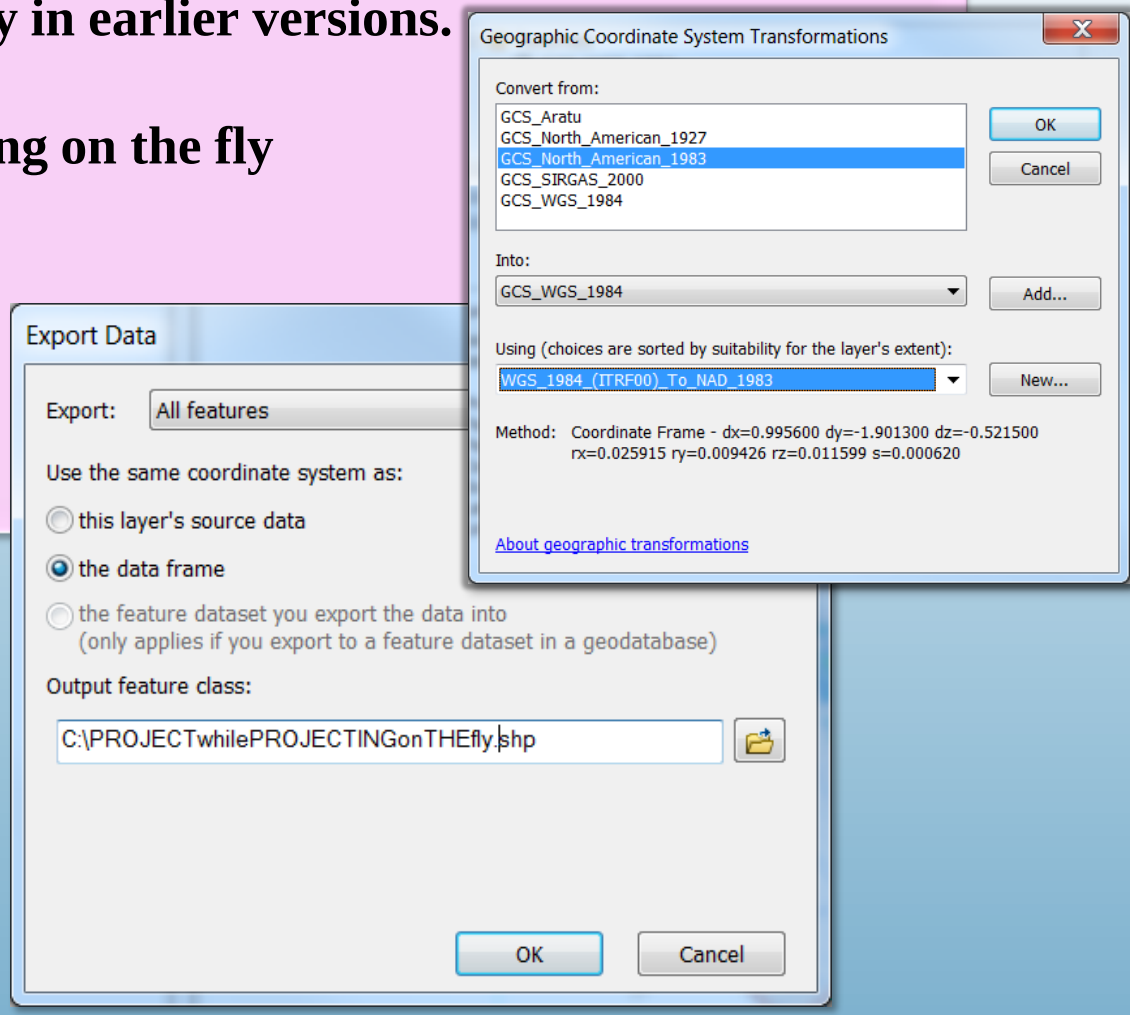
RUN THE ADVANCED ARCMAP SETTINGS UTILITY
<install path>:\Program Files\ArcGIS\Desktop10.4\Utilities

PROJECTING WHILE PROJECTING ON THE FLY

- BUG NO. 000096495
- The Project Raster Tool won't project a custom transformation in ArcGIS 10.4, but is successfully in earlier versions.

- You can project while projecting on the fly

1. Set Transformation
2. Export Data
3. Choose the Data Frame



BE AWARE WHILE PROJECTING ON THE FLY

Project on the Fly - EDITING

Although it is possible to edit data that is in a different coordinate system from the data frame, when high levels of accuracy are critical, it is better to project the data to a common coordinate system before editing.

If you attempt to edit on the fly you will be prompted with 2 options:

BE AWARE OF EDITING WHILE PROJECTING ON THE FLY

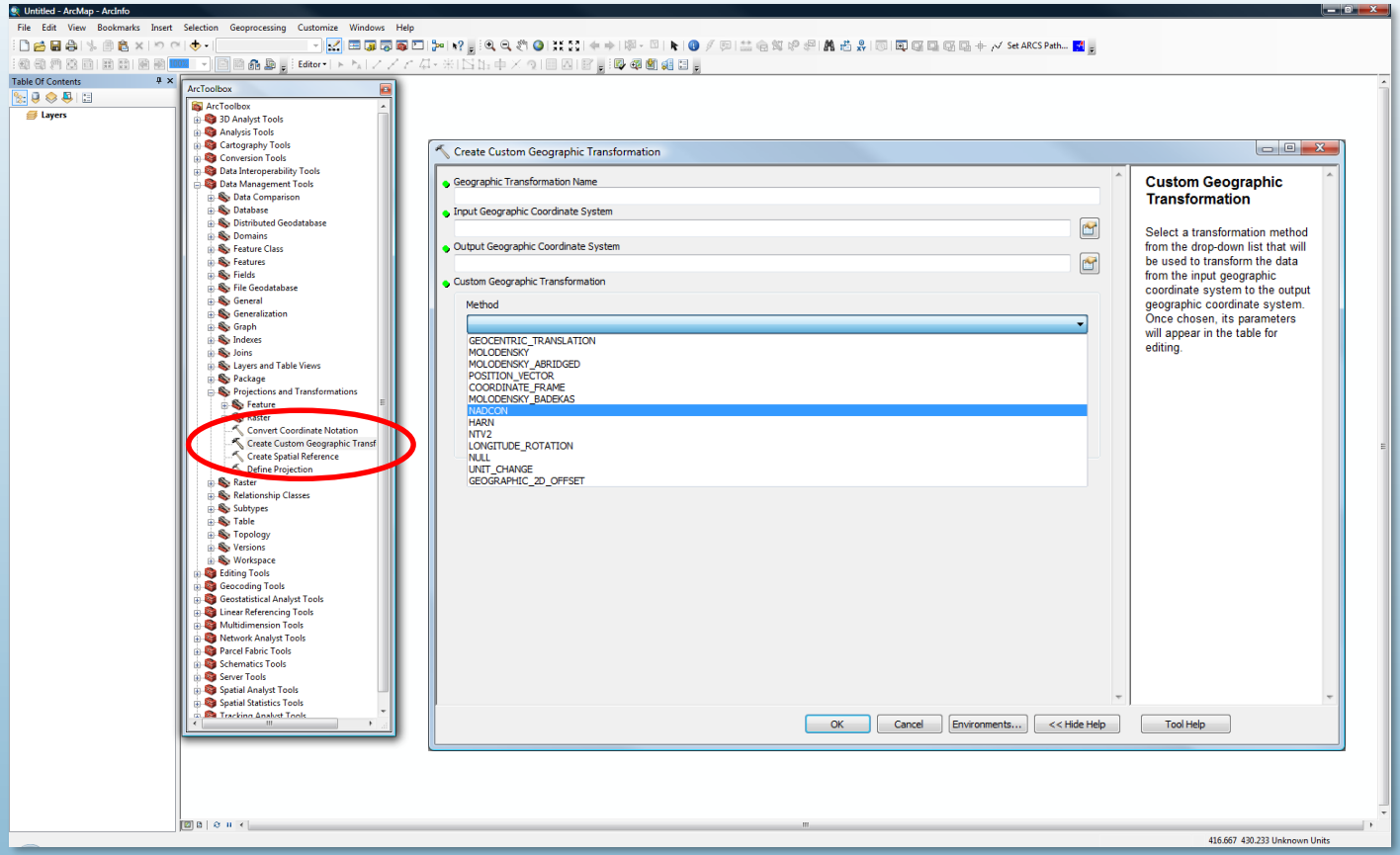
- Continue with your edit session and start editing features in projected space.
- Choose not to continue editing if you want to change the coordinate system used by the data frame to match the native coordinate system of the layer or layers you want to edit.

Your edits will be projected "according to the on the fly transformation" and pushed back to it's native projection. Be aware of:

- Editing beyond the edge of the coordinate system
- Changing the shapes of features, snapping to the edge or boundary of features, or extending and trimming features
- Transformations in the MXD only hold 1 per datum.
- Differences in tolerances

Custom Transformations

- **Users have the ability to create custom transformations**



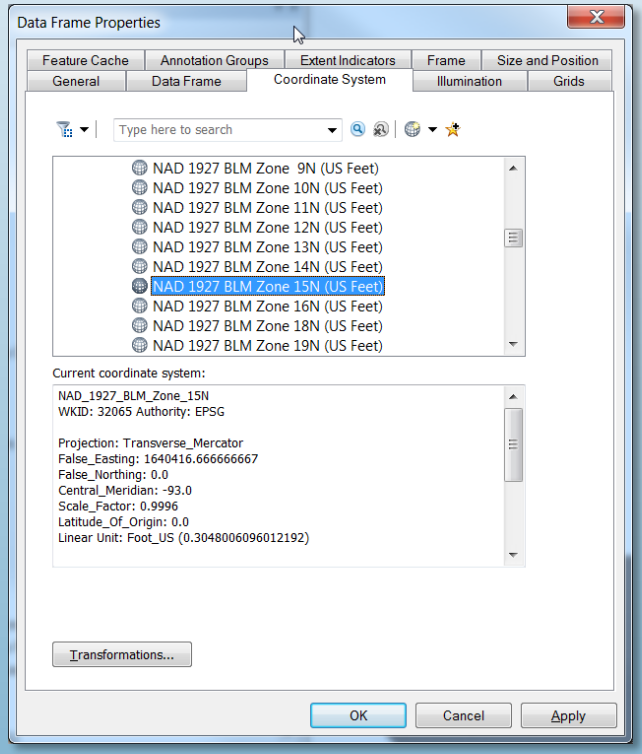
Consult your local geodetic expert!

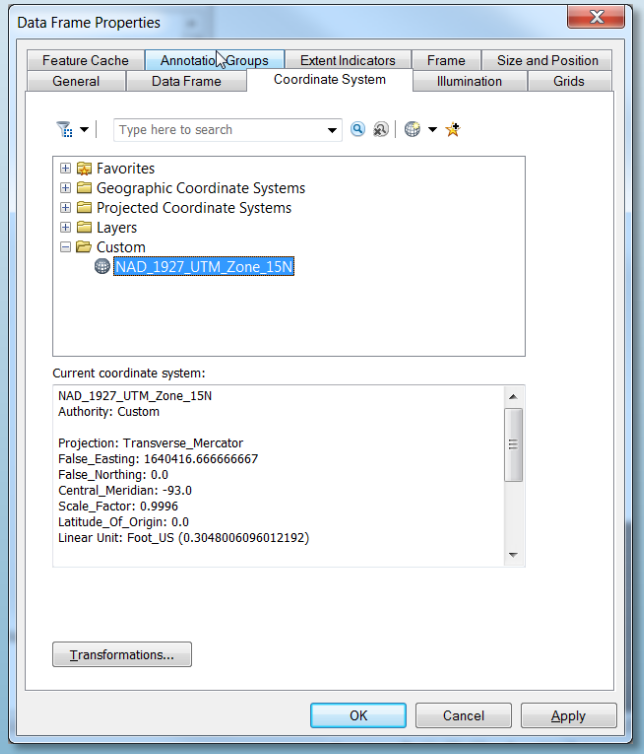
Custom Transformations

- **Careful when transforming in web applications!**
- **Developers with little or no spatial/GIS knowledge fail to understand datums, coordinate systems, projections**
- **Web applications use the projection "Web Mercator, EPSG 3857"- this projection should be used for visualization purposes.**
- **Solutions depends on the application, you can edit the projection parameters, create custom vector basemaps, or reproject a basemap.**

Difference between UTM and BLM

- **UTM are not defined as Feet**
- **The Bureau of Land Management (BLM) developed five unique North American Datum 1927 (NAD 27)-based Outer Continental Shelf (OCS) cadastres when the offshore program was administered by that Agency.**





https://www.boem.gov/uploadedFiles/BOEM/Oil_and_Gas_Energy_Program/Mapping_and_Data/OPDhist.pdf

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Web Maps

- Popular medium for displaying spatial information online
- Uses an internet browser
- Uses Web Mercator projection unless a basemap is defined or projected

Questions:

1) Do you know what coordinate reference system is being used by the application?

2) Do you know the coordinate reference system of your input dataset?

3) Do you know what transformation is being used between the application and the input datum?

BEWARE OF THE PARAMETERS AND DATA OPERATIONS PERFORMED BY ON AN APP BY APP BASIS

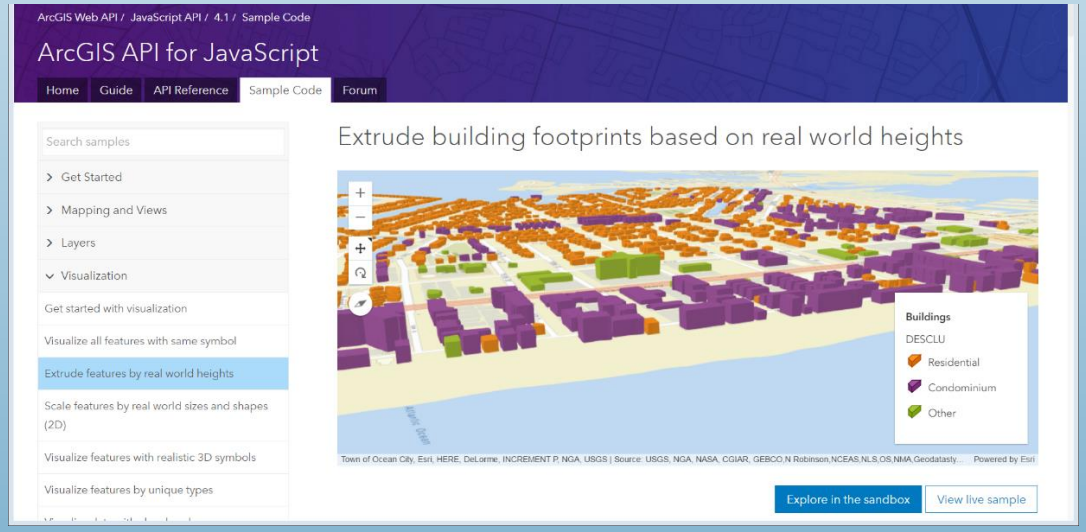
Web Maps

Create a vector tile layers (Vector Basemap)

- Application developed with JavaScript

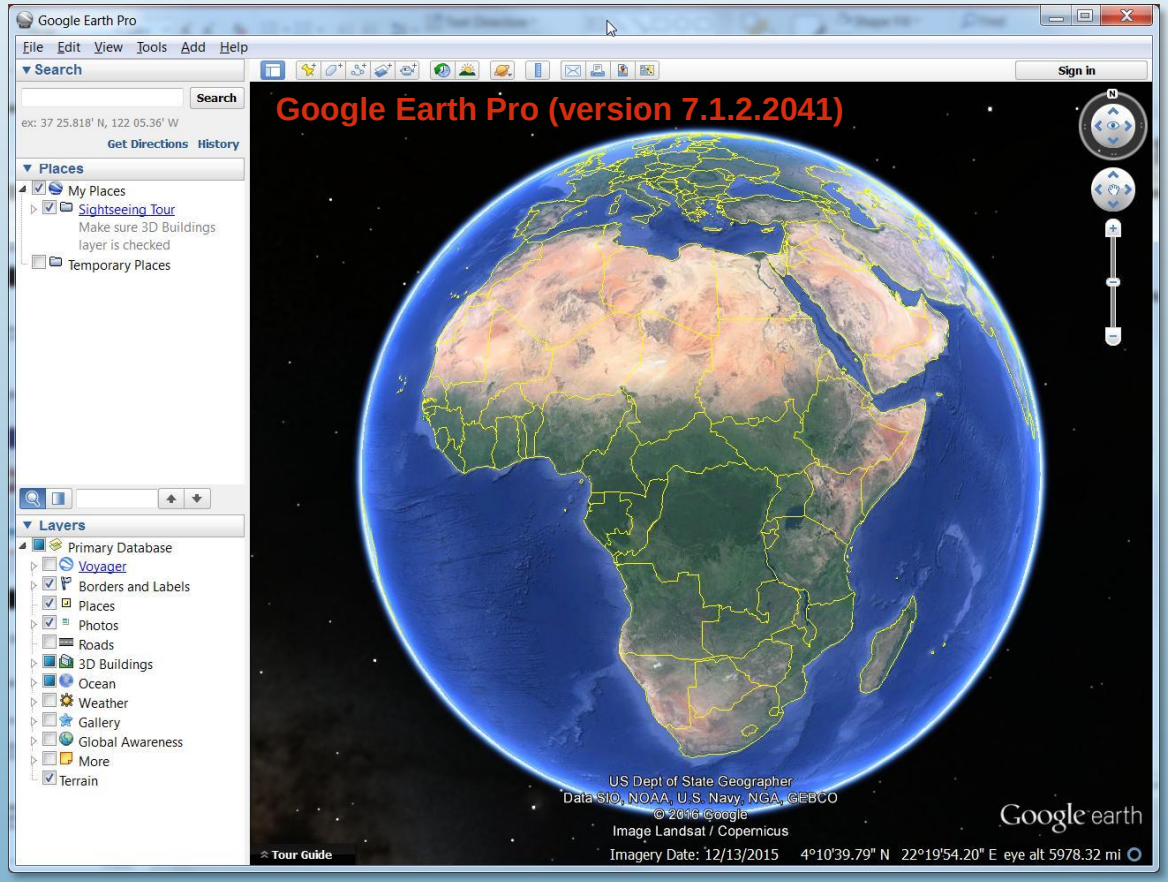
Other APIs are discouraged because they may not natively support the editing of ArcGIS Server feature services; you would have to do a fair amount of programming in order to edit the services.

- ArcGIS Viewer for Silverlight
- ArcGIS Viewer for Flex
- ArcGIS API for Flex & ArcGIS API for Silverlight have been retired
- ArcGIS API for JavaScript



Additional Applications

- **ArcGIS Explorer, ArcScene, ArcGIS Pro, ArcGIS Earth, Google Earth, Unity, IHS Kingdom, Global Mapper**
- **All input and display of GIS data**



It is up to the application distributor to research and choose the correct application suitable for your project and application use.

Coordinate systems and transformation methods will vary.

Map Products

- **All maps should have the coordinate reference system as the minimum; Name and EPSG code**
- **EPSG code is standard for oil and gas industry**
- **Example**
  - **EPSG Name: NAD27 / BLM 15N (ft US)**
  - **EPSG Code: 32065**
- **Look up codes in EPSG Geodetic Parameter Registry**
  - **http://www.epsg-registry.org/**

Summary – Do's and Don't

- **DON'T make assumptions regarding coordinate reference systems**
- **DON'T assume the software sorts out your geodetic problems**
- **DON'T assume the software predicts the correct CRS**

- **DO make use of IOGP EPSG polygons and EPSG geodetic parameter registry**
- **DO seek advice from geodetic experts when in doubt**

Summary

- **Determine GIS project coordinate reference system information by using ESPG's registry and area of use polygons**

- **Manipulating and converting CRS in ArcMap by transformation methods**

- **Address coordinate systems in web applications and map products before distribution**

Questions?

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