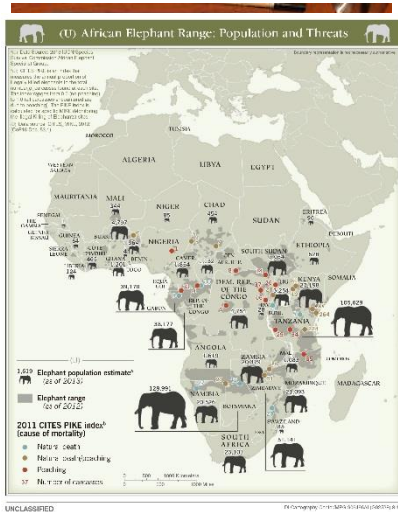


Speaking the Language of Coordinate Systems: From Field to Feature Class

Bill Trask

Fisher Associates

My Background



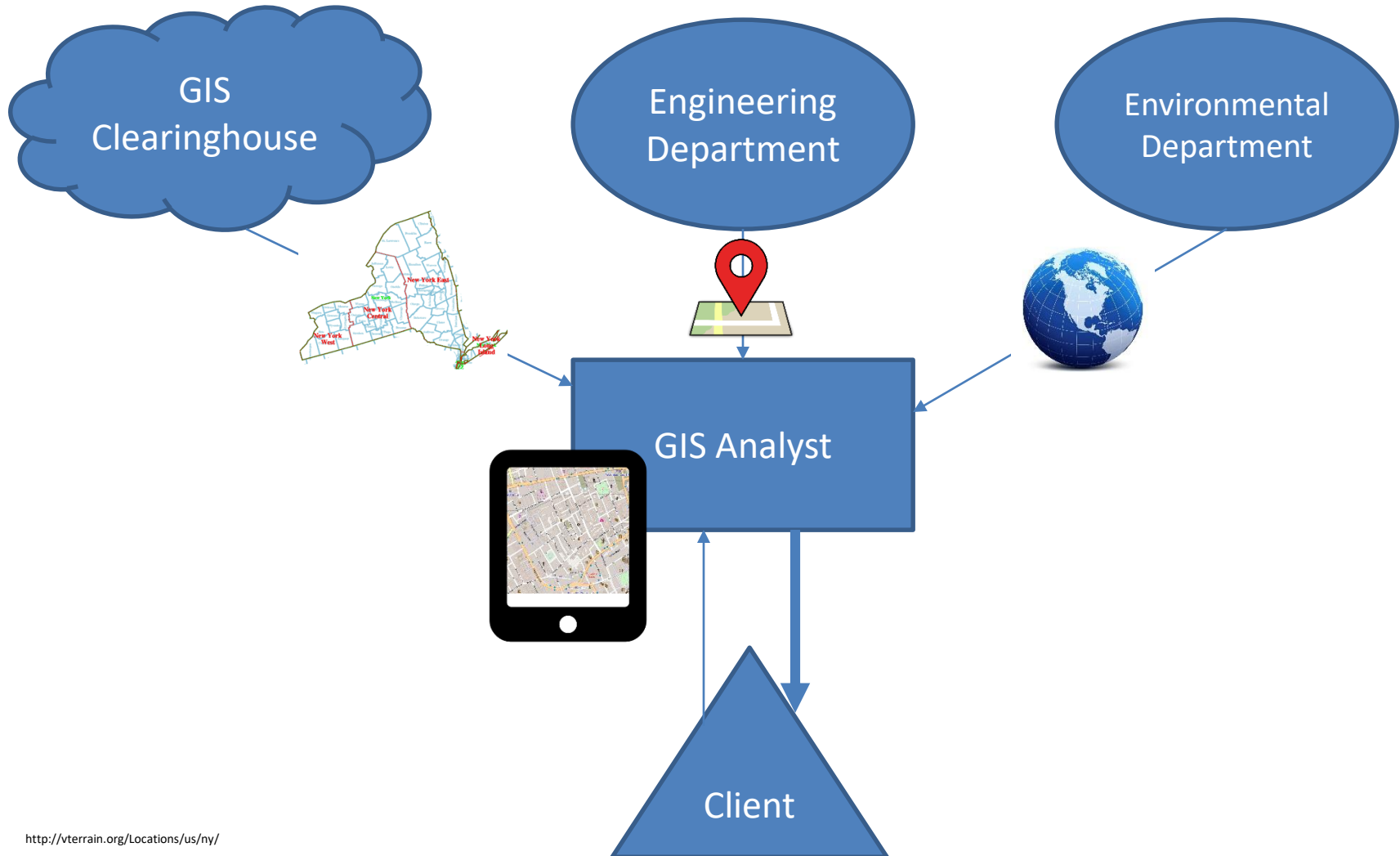
Outline

- GISers as the curators of coordinates
- Defining Spatial Reference Systems
- Using Spatial Reference Systems
- Strange Spatial Reference Systems

Theory

Practice

GISers as the nexus between other departments and coordinate systems



GISers as the nexus between other departments and coordinate systems



Where am I?

What datum and coordinate system are you in?

I don't care...

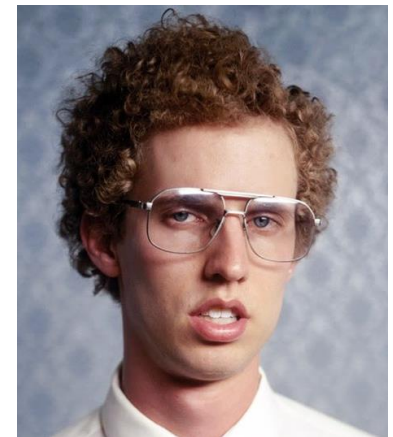
But I need to know that informat...

Whoa...getting too technical for me. **Just answer my question!**

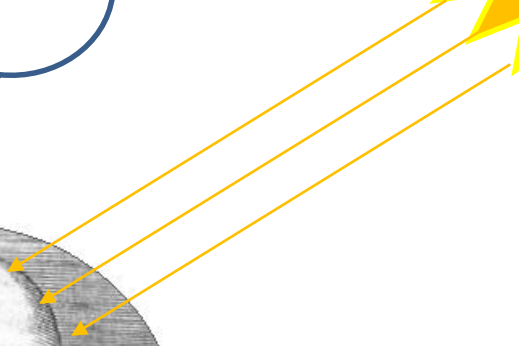
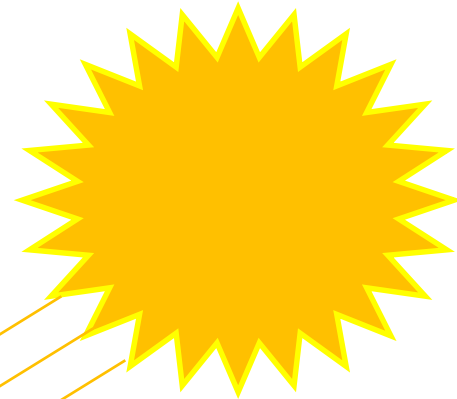
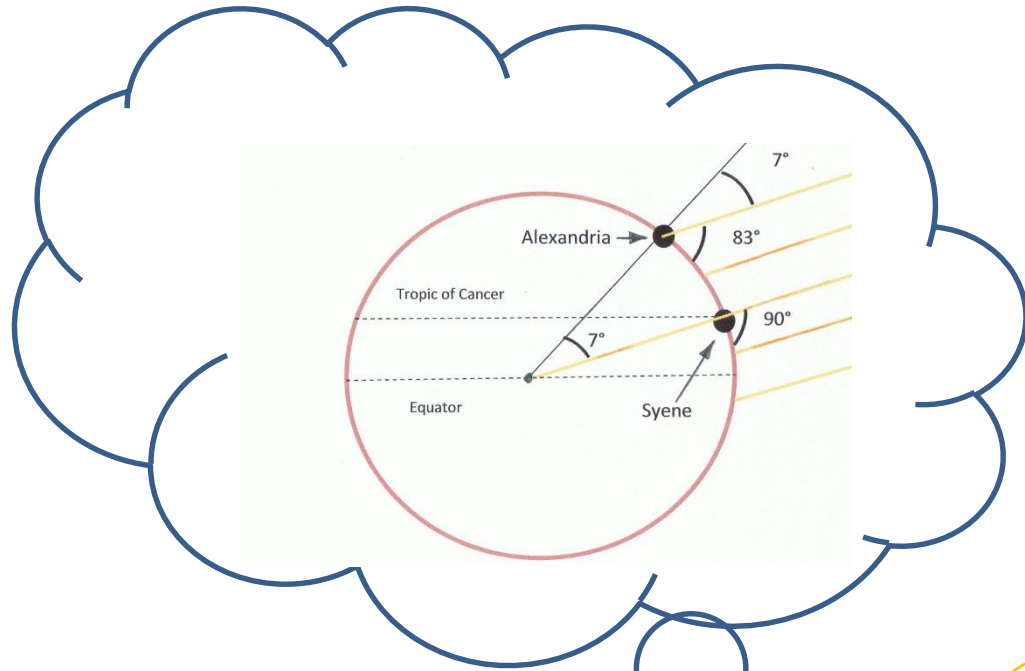
Ummm...3

Great, thanks

You bet



Defining Spatial Reference Systems



Defining Spatial Reference Systems



<http://giphy.com/gifs/globe-12q22p3qYdD5V6>

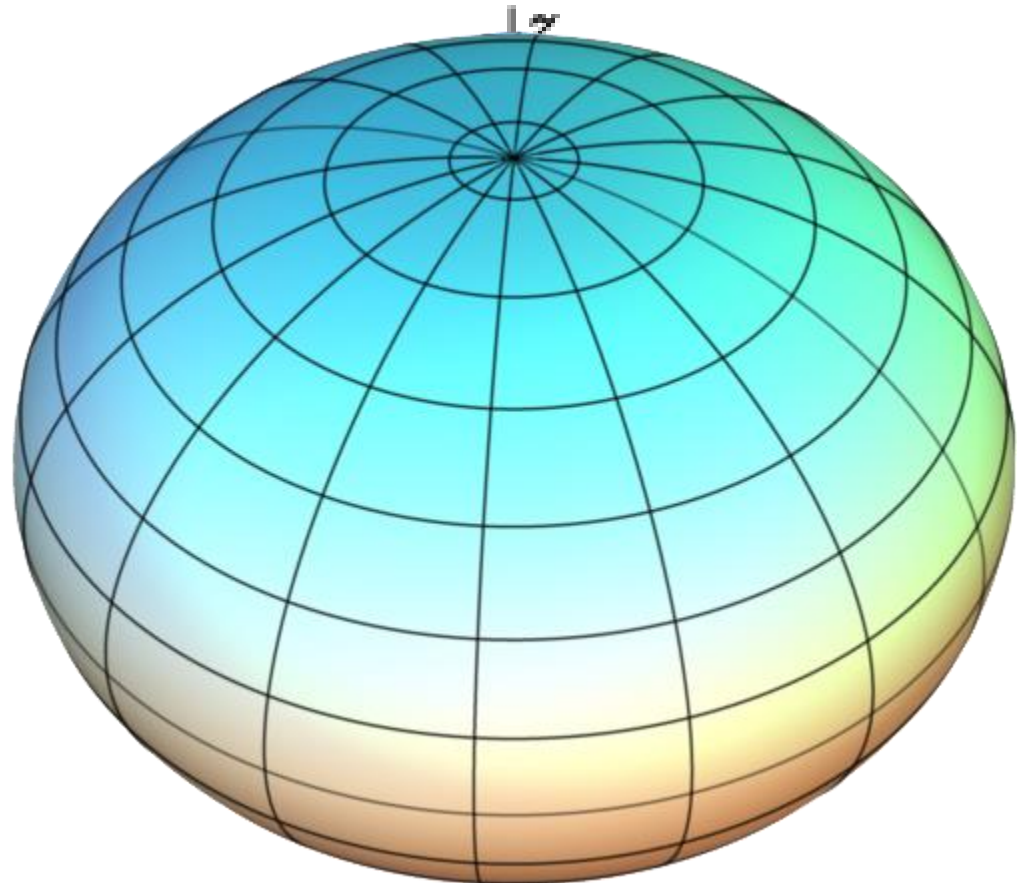
<http://giphy.com/gifs/cat-loop-ball-xkCK3tAhDSUBa>



Defining Spatial Reference Systems

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = 1,$$

- $c < a$: **oblate** spheroid
- $c > a$: **prolate** spheroid



<https://en.wikipedia.org/wiki/Ellipsoid>

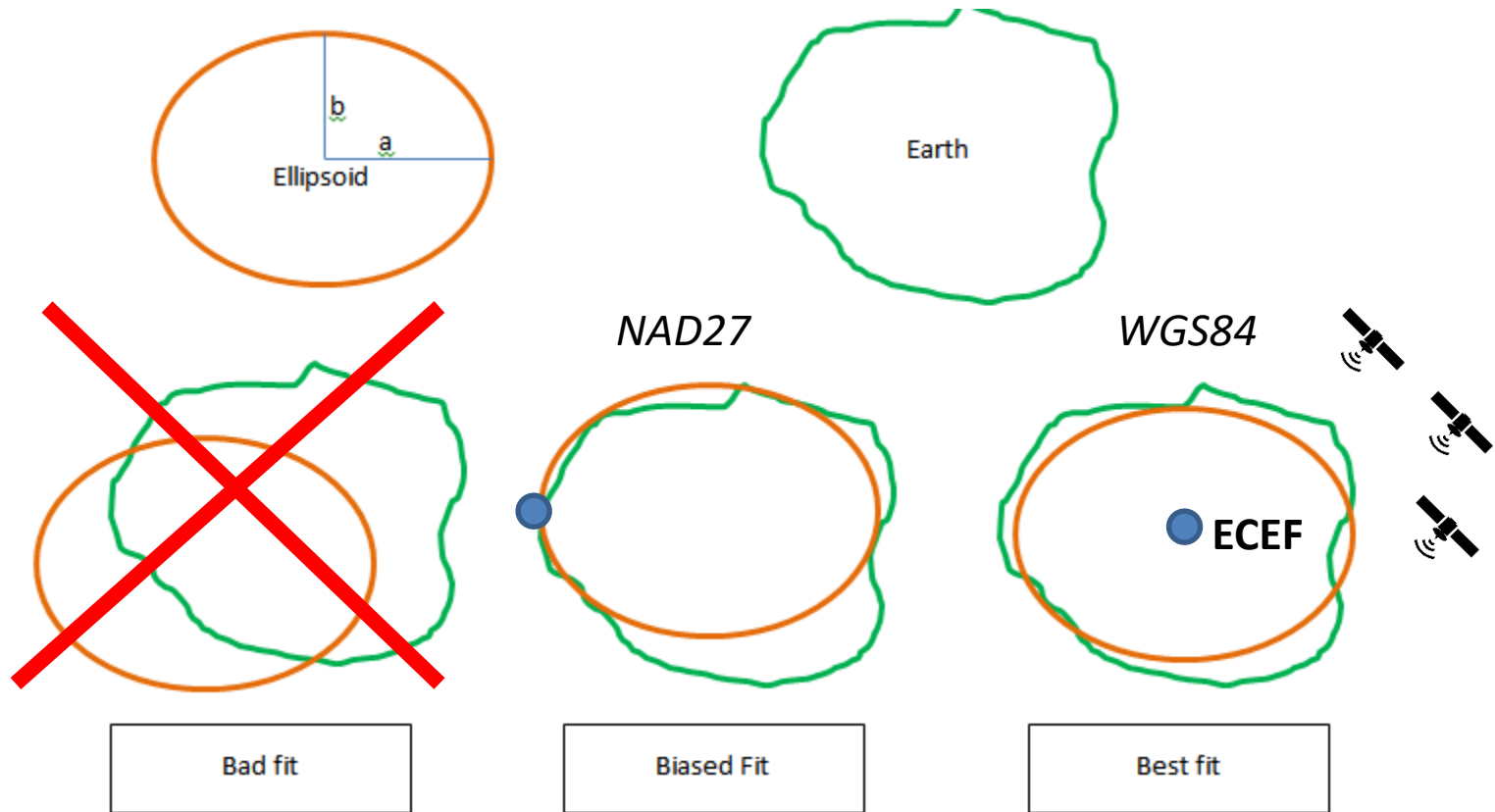
<https://en.wikipedia.org/wiki/Spheroid#/media/File:OblateSpheroid.PNG>

<https://en.wikipedia.org/wiki/Spheroid#/media/File:ProlateSpheroid.png>

Defining Spatial Reference Systems



Defining Spatial Reference Systems



Defining Spatial Reference Systems

6 realizations

WGS84(1987)

G730(1994)

G873(1997)

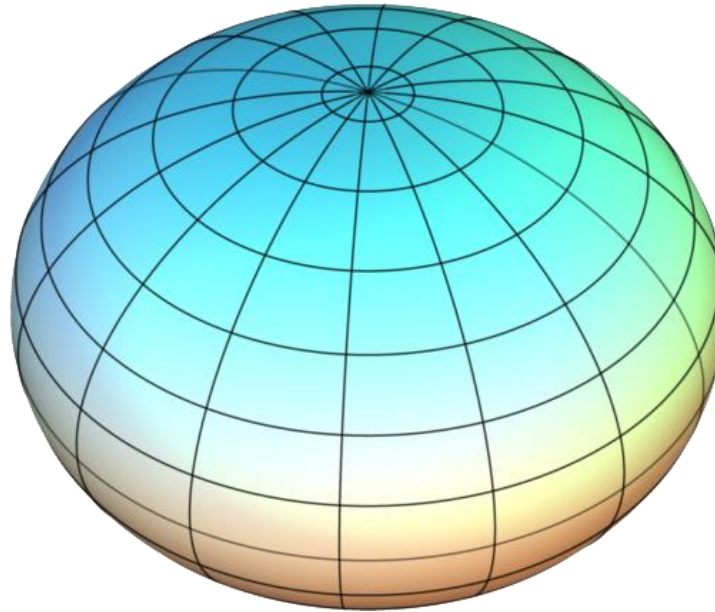
G1150(2001)

G1672(2005)

G1674(2005)

ITRF90

ITRF08



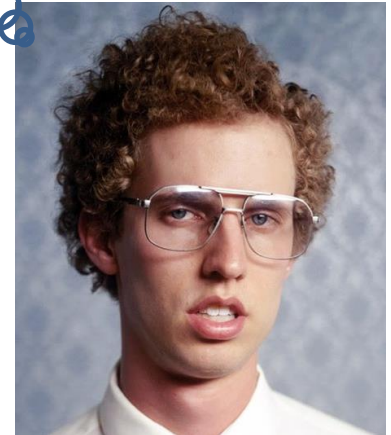
WGS 84

Defining Spatial Reference Systems

So what is a datum?



The point at which we
attach the ellipsoid to
the Earth.



Defining Spatial Reference Systems

From Datums to Coordinate Systems

Data Source

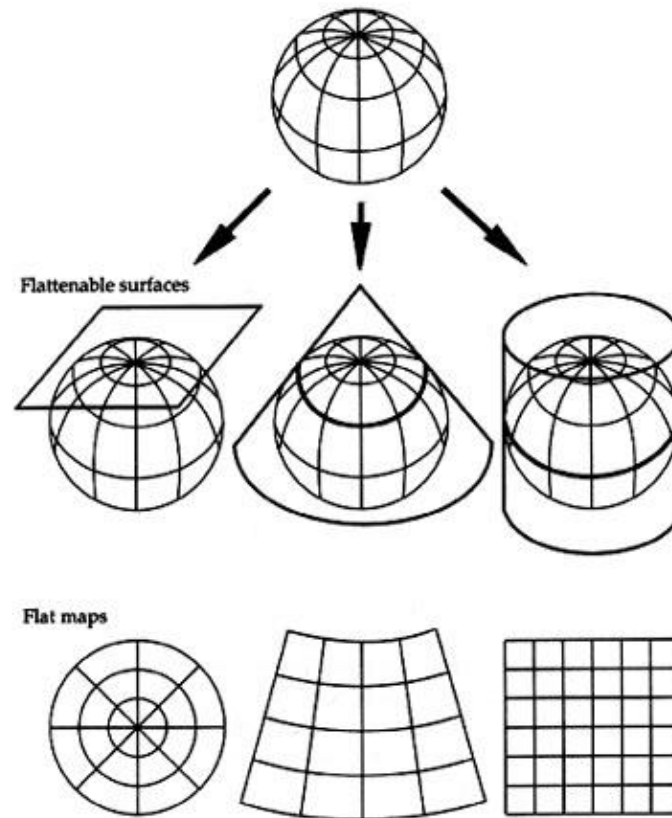
Projected Coordinate System:	NAD_1983_UTM_Zone_17N
Projection:	Transverse_Mercator
False_Easting:	500000.00000000
False_Northing:	0.00000000
Central_Meridian:	-81.00000000
Scale_Factor:	0.99960000
Latitude_Of_Origin:	0.00000000
Linear Unit:	Meter
Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Projected Coordinate System:	NAD_1983_StatePlane_Pennsylvania_North_FIPS_370
Projection:	Lambert_Conformal_Conic
False_Easting:	1968500.00000000
False_Northing:	0.00000000
Central_Meridian:	-77.75000000
Standard_Parallel_1:	40.88333333
Standard_Parallel_2:	41.95000000
Latitude_Of_Origin:	40.16666667
Linear Unit:	Foot_US
Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Defining Spatial Reference Systems

From Datums to Coordinate Systems



Defining Spatial Reference Systems

From Datums to Coordinate Systems

Data Source

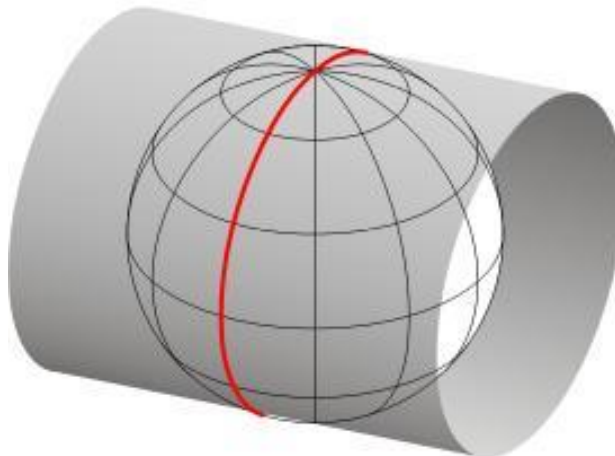
Projected Coordinate System:	NAD_1983_UTM_Zone_17N
Projection:	Transverse_Mercator
False_Easting:	500000.00000000
False_Northing:	0.00000000
Central_Meridian:	-81.00000000
Scale_Factor:	0.99960000
Latitude_Of_Origin:	0.00000000
Linear Unit:	Meter

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree

Data Source

Projected Coordinate System:	NAD_1983_StatePlane_Pennsylvania_North_FIPS_370:
Projection:	Lambert_Conformal_Conic
False_Easting:	1968500.00000000
False_Northing:	0.00000000
Central_Meridian:	-77.75000000
Standard_Parallel_1:	40.88333333
Standard_Parallel_2:	41.95000000
Latitude_Of_Origin:	40.16666667
Linear Unit:	Foot_US

Geographic Coordinate System:	GCS_North_American_1983
Datum:	D_North_American_1983
Prime Meridian:	Greenwich
Angular Unit:	Degree



Secant
two standard parallels

Projection Surfaces



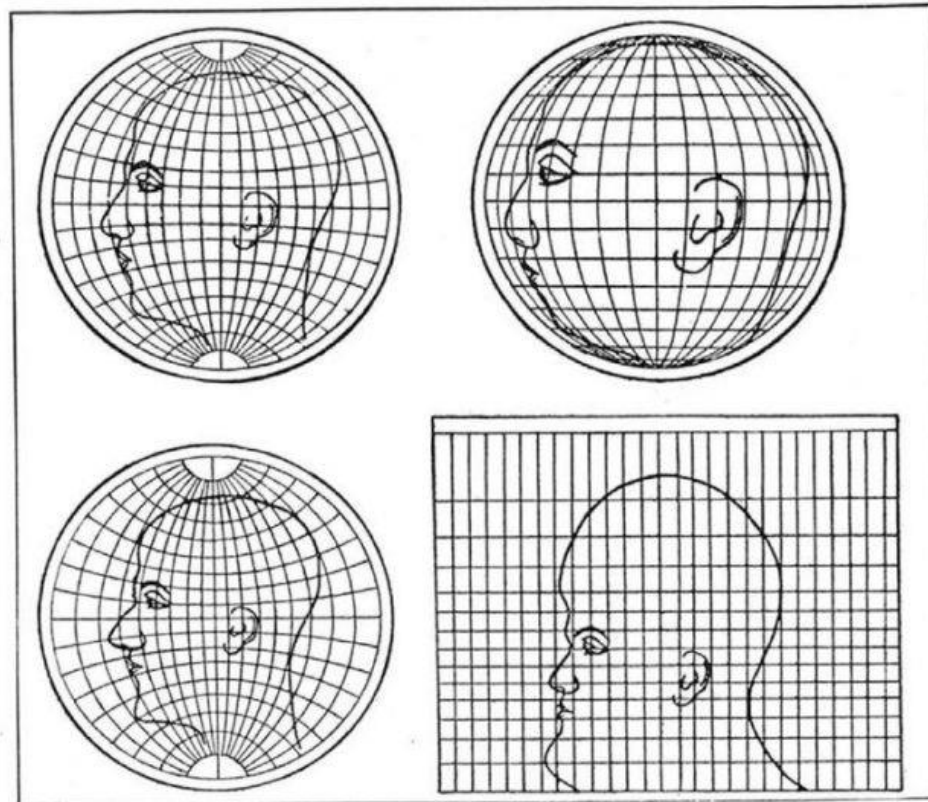
Projection Surfaces



Projection Distortion



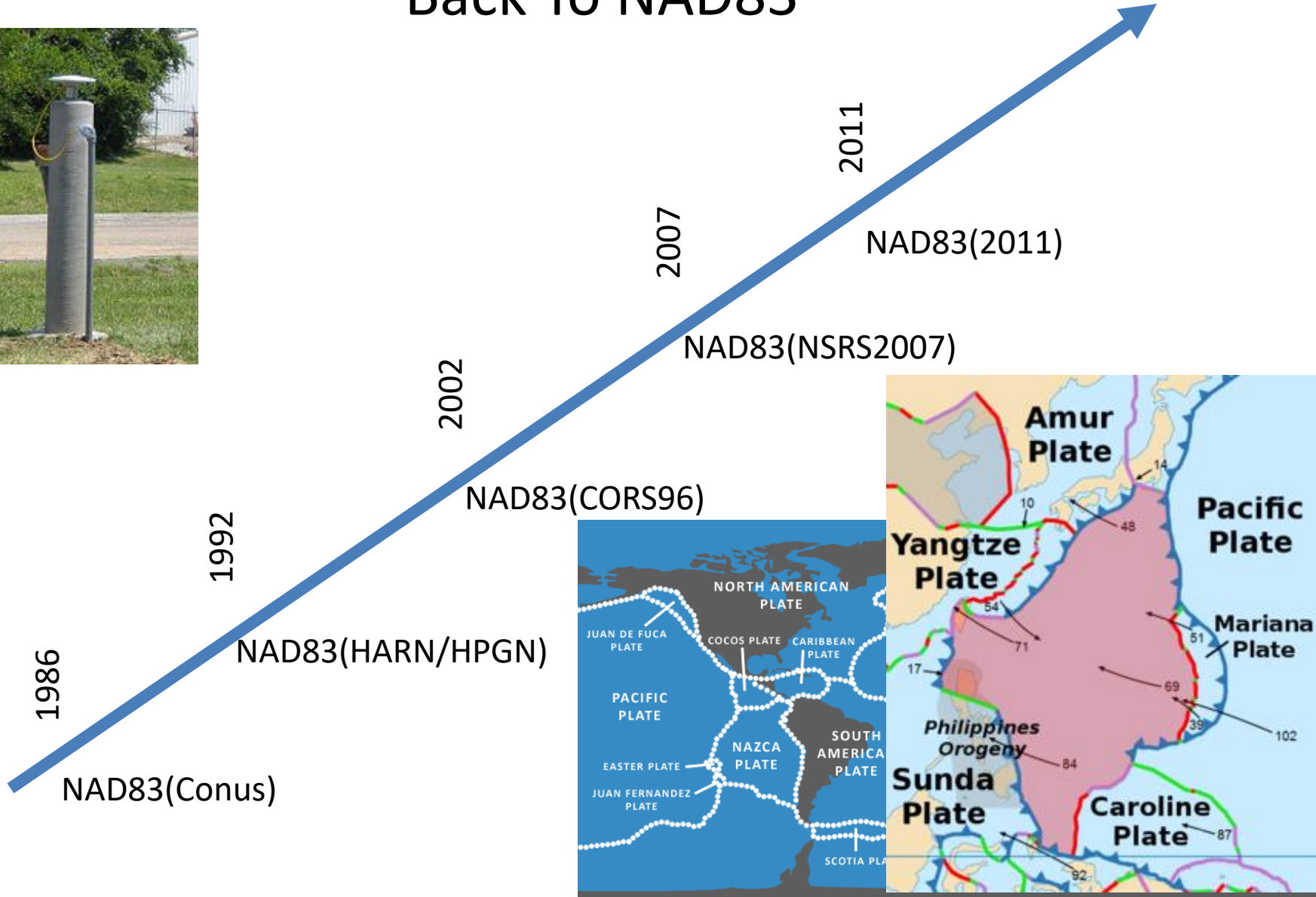
Elements in Map Projection (1921)



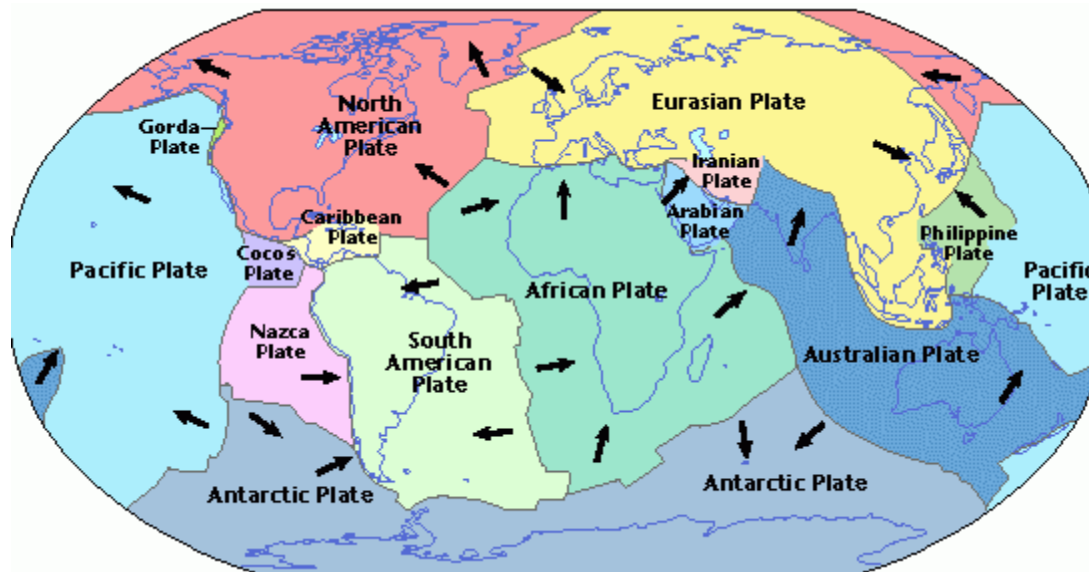
*Upper left: Globular. Upper right: Orthographic. Lower left: Stereographic.
Lower right: Mercator*

What four commonly used projections do, as shown on a human head

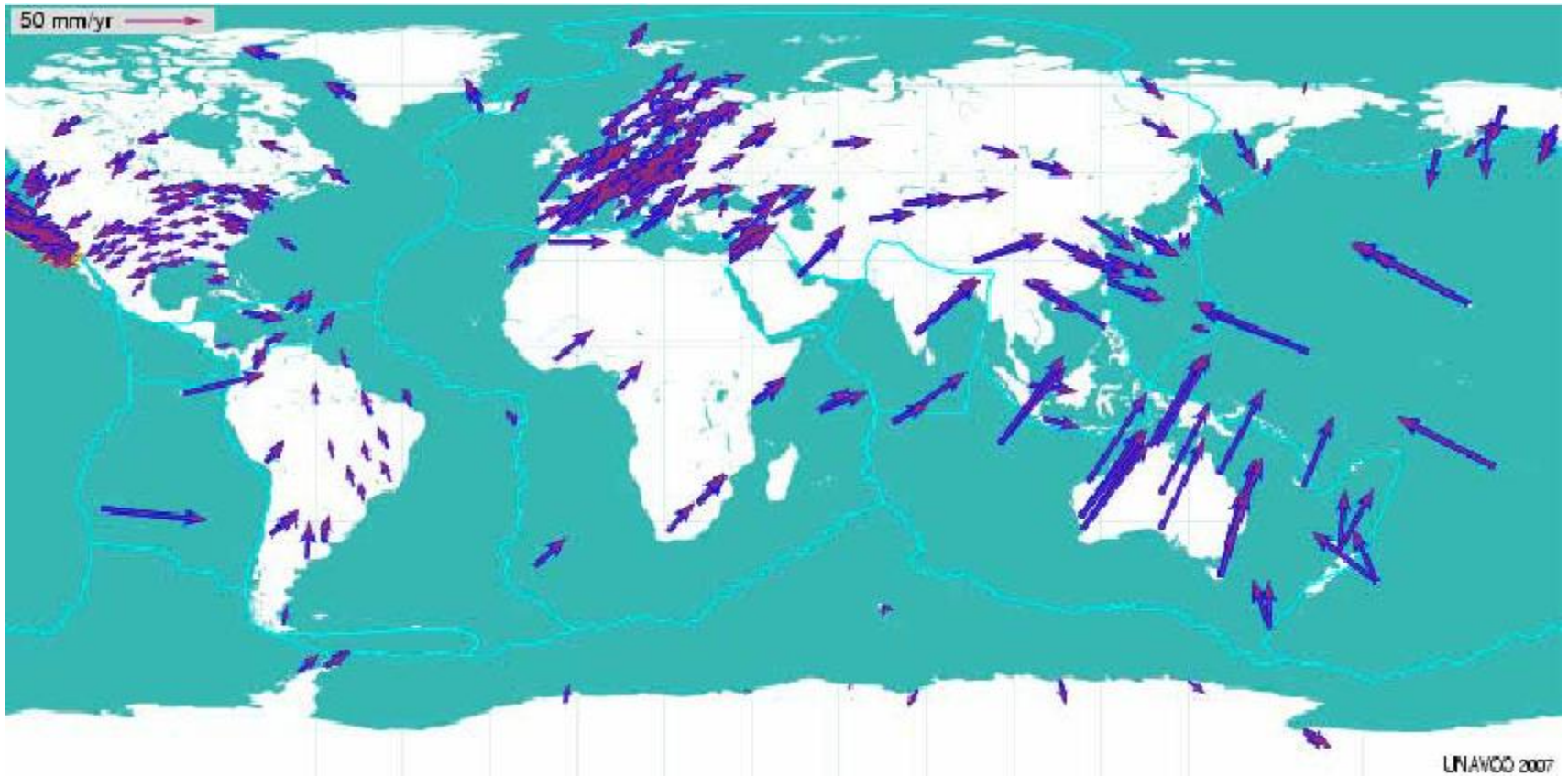
Defining Spatial Reference Systems Back To NAD83



Global vs Local Coordinate Systems



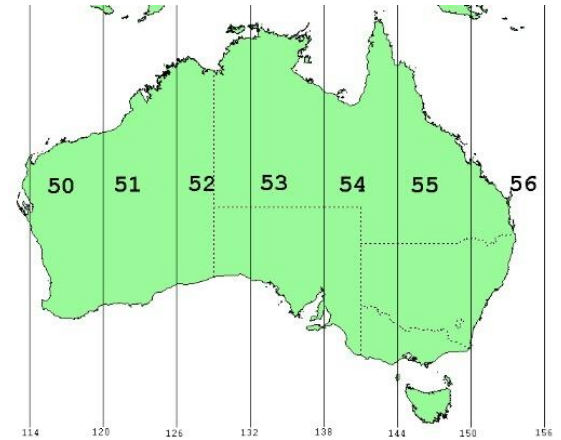
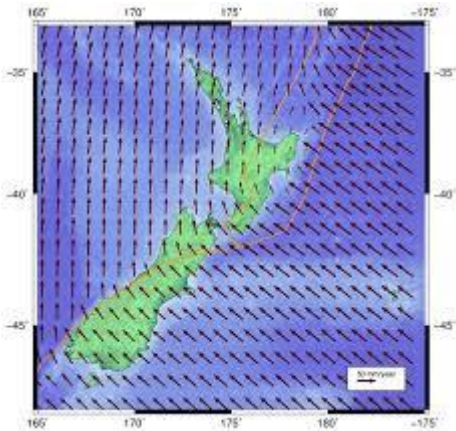
Datum Types



Datum Types

Dynamic

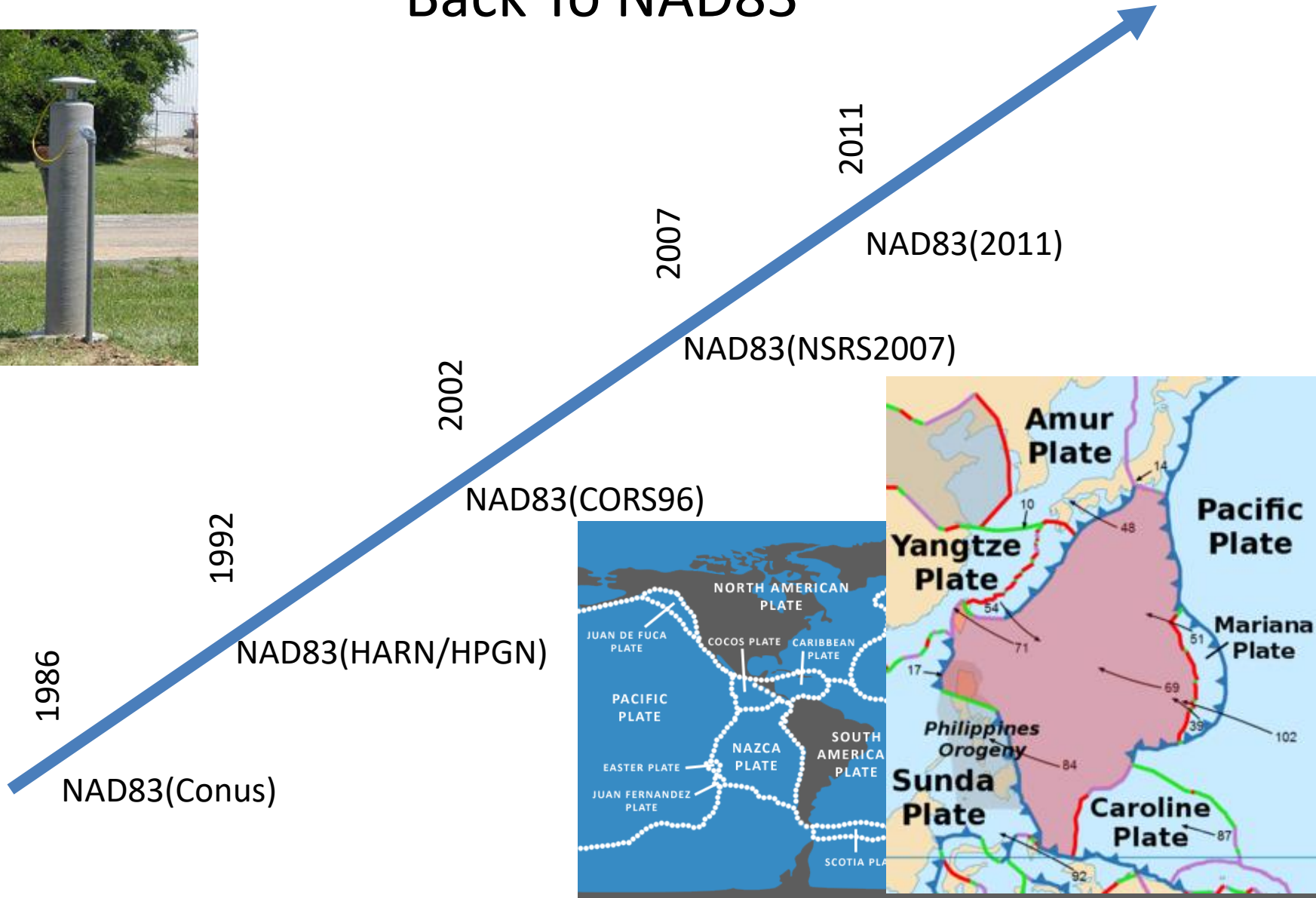
Static



NZGD2000

GDA94

Defining Spatial Reference Systems Back To NAD83



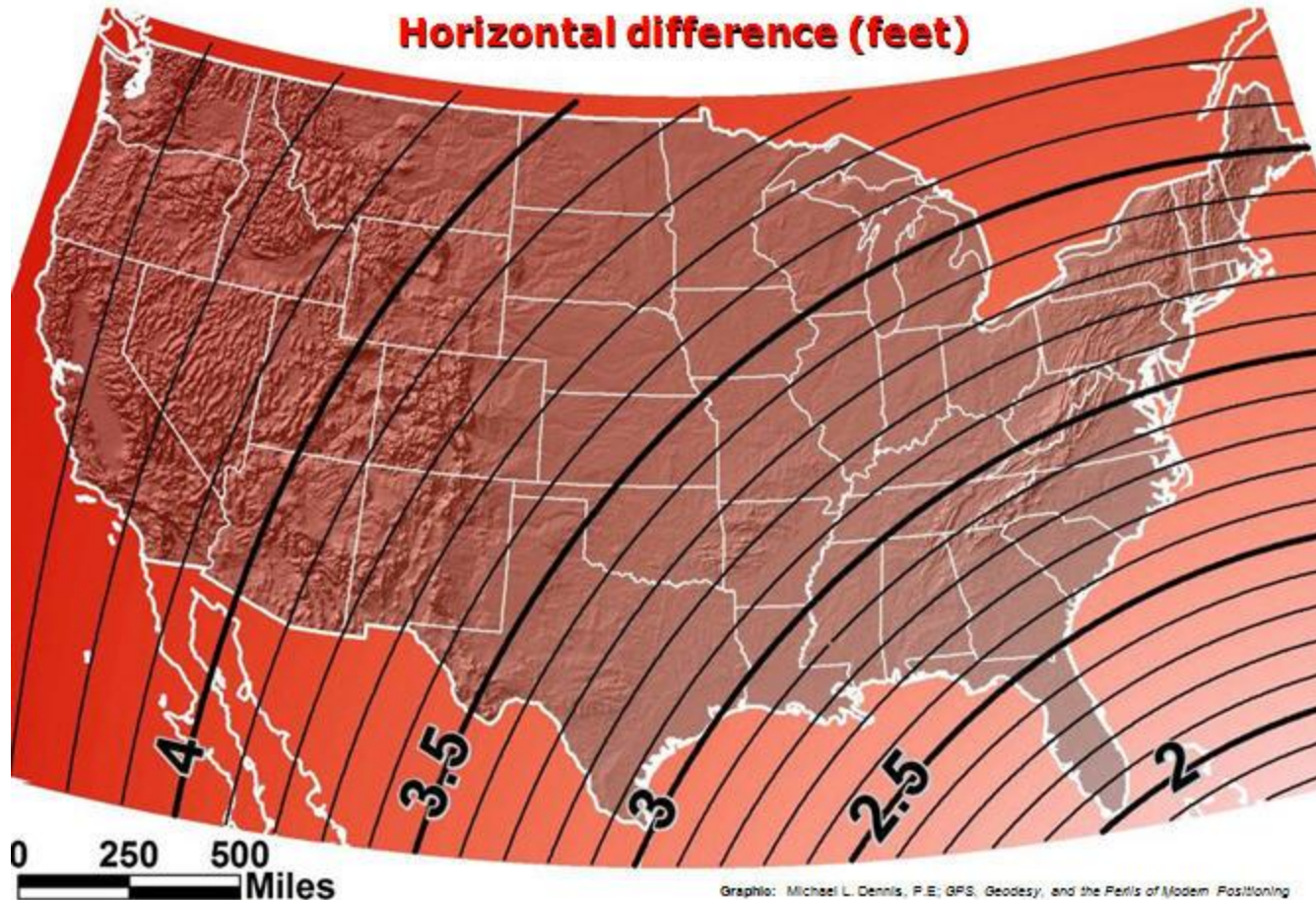
Using Spatial Reference Systems

NAD83

****ALWAYS ASK WHICH NAD83 VERSION YOU'RE RECEIVING****

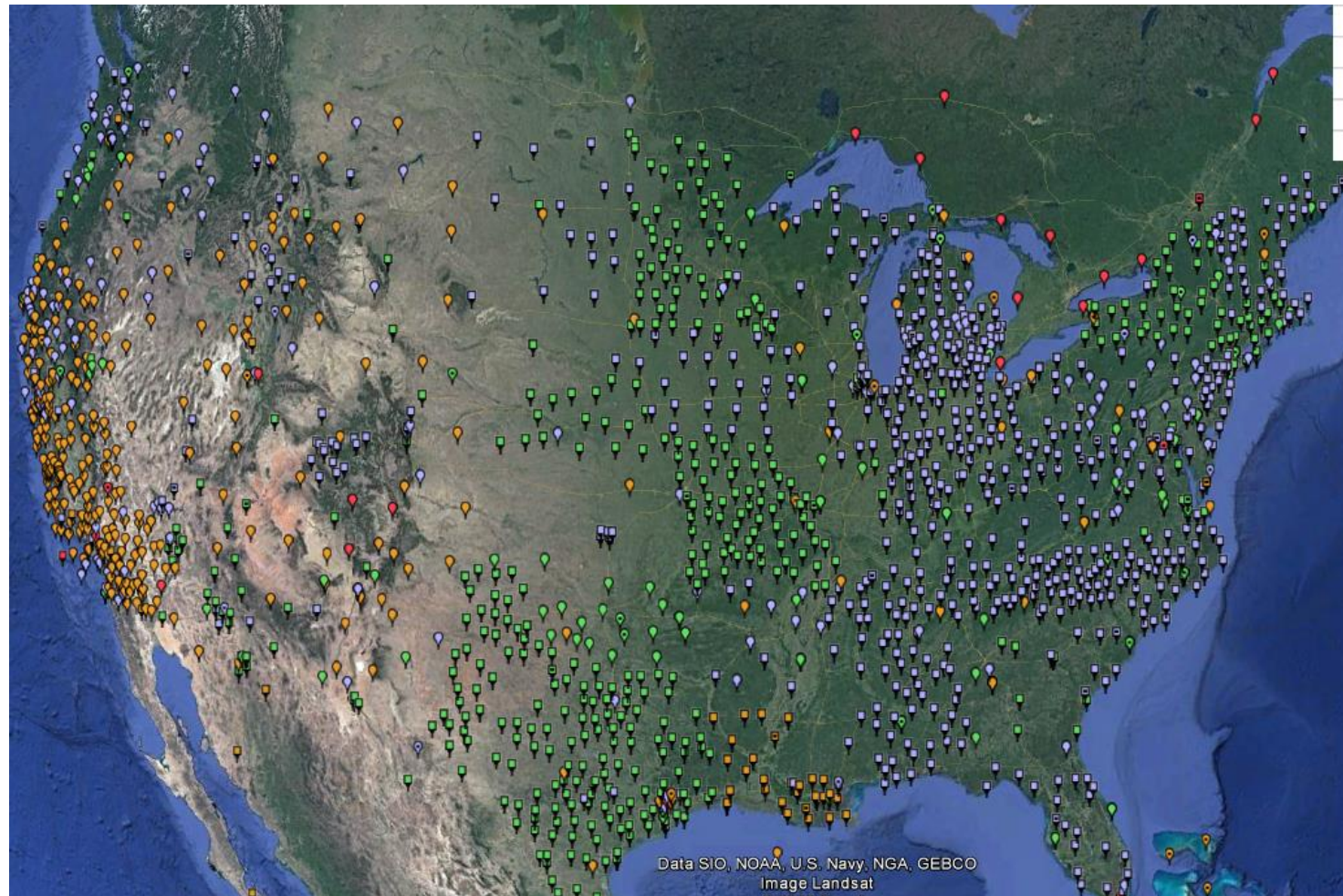
Difference between NAD 83 and WGS 84 (G1150) at 2002.0

Horizontal difference (feet)



Using Spatial Reference Systems

CORS Stations



Using Spatial Reference Systems

NYSNET

****SET UNITS TO COLLECT IN NAD83 (2011)****

[IT'S FREE](#)

RTN: Real Time Network



Transportation

NYSNet CORS/RTN
@nysnet
NYS Spatial Reference Network (NYSNet) Continuously Operating GPS Reference Stations (CORS) Real Time Network (RTN)
Albany, NY
cors.dot.ny.gov
Joined October 2015

TWEETS 123 FOLLOWERS 108 LIKES 1

Following

Tweets Tweets & replies Media

NYSNet CORS/RTN @nysnet · Nov 9
NYST, Saratoga tracking satellites again, since 1545 EST 11/8/16. Providing RINEX and RT data.

NYSNet CORS/RTN @nysnet · Nov 8
NYST, Saratoga stopped tracking satellites since 1015 EST 11/8/16. Not logging RINEX or providing data to RTN. Working to resolve.

NYSNet CORS/RTN @nysnet · Oct 19
Another brief RTN outage today at 1130AM EDT as we continue testing a function of our software. Should last under 10 minutes.

NYSNet CORS/RTN @nysnet · Oct 14
Brief RTN outages possible again this morning as we troubleshoot software.

NYSNet CORS/RTN @nysnet · Oct 12
Brief RTN outage at noon today as we need to reboot a couple of our servers. Should last under 10 minutes.

NYSNet CORS/RTN @nysnet · Oct 12
RTN operating normal this morning. Any further interruptions, if

Who to follow: Refresh · View all

- NWS Bismarck** @NWSBL... Follow
- Dr. Tamitha Skov** @Tamitha... Follow
- NWS Boulder** @NWSBo... Follow

Find friends

Trends · Change

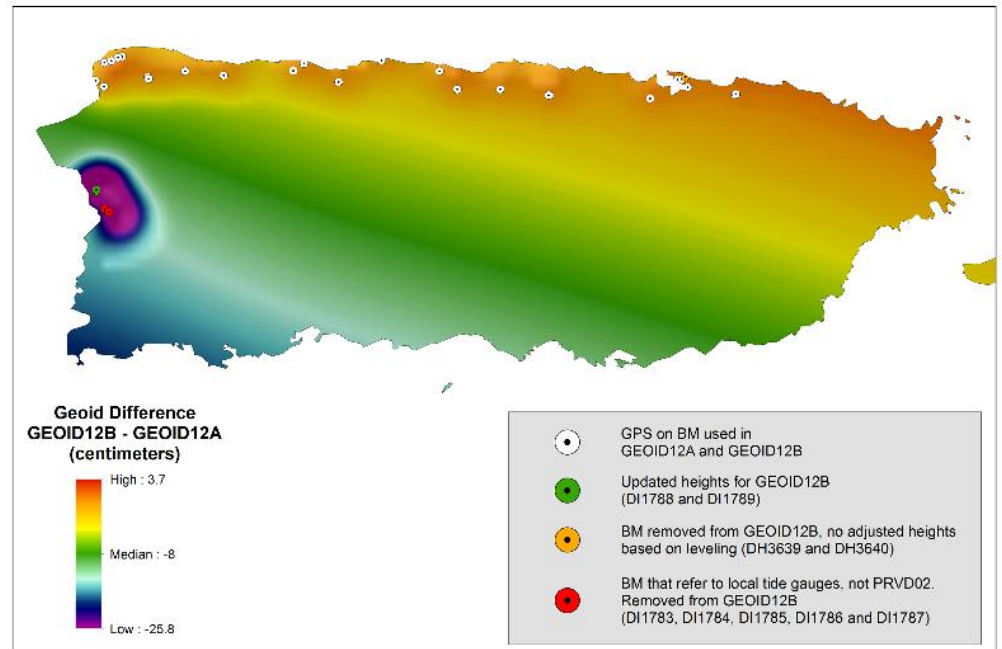
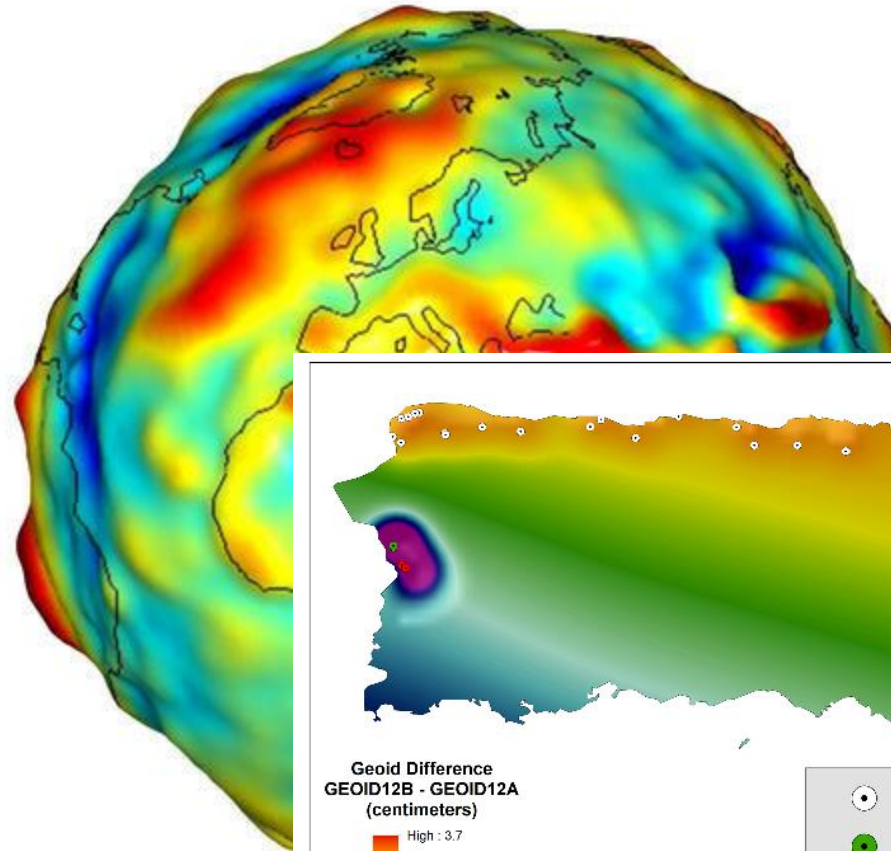
- #ThursdayThoughts** 95.7K Tweets
- Bill Ackman**
- #UFC205** McGregor & Alvarez nearly come to blows in UFC 205 presser
- #VeteransDay** @NYSDEC is Tweeting about this
- Warren Buffett** 1,826 Tweets
- Dream Kardashian** Rob Kardashian and Blac Chyna name their daughter Dream
- #CES2017**
- New Balance**

01/16/11/08 16:28:00 (Site: 52/55)

Using Spatial Reference Systems

Geoids

Geoid96
Geoid99
Geoid93
Geoid96
Geoid99
Geoid03
Geoid06
Geoid09
Geoid12
Geoid12a
Geoid12b



Using Spatial Reference Systems

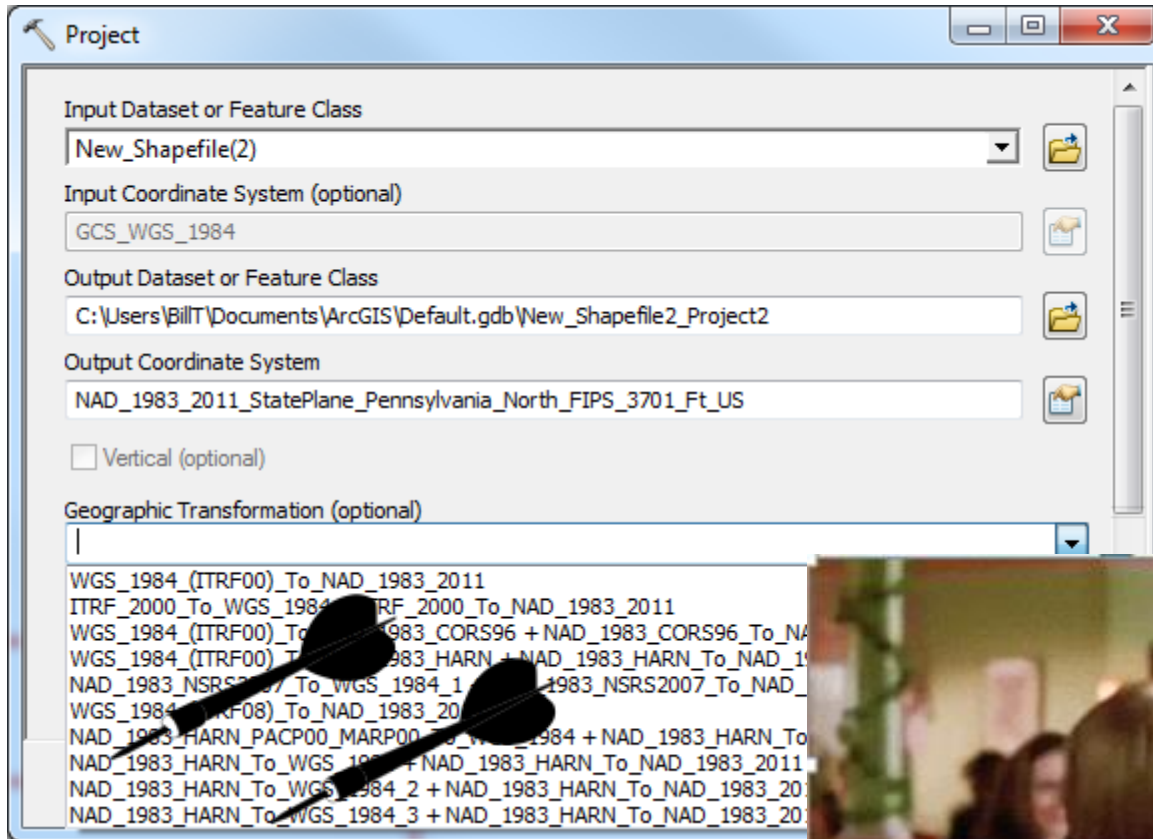
What is your Accuracy?



Miles to Base Station	Unit	Network RTK Accuracy	in Feet	in Inches
10	GEO 7x	Horizontal (external GNSS)	0.06	0.71
	GEO 7x	Vertical (external GNSS)	0.08	0.91
	GEO 7x	Horizontal (internal GNSS)	0.11	1.30
	GEO 7x	Vertical (internal GNSS)	0.16	1.89
	Trimble R1	Vertical (internal GNSS)	0.27	3.27

Using Spatial Reference Systems

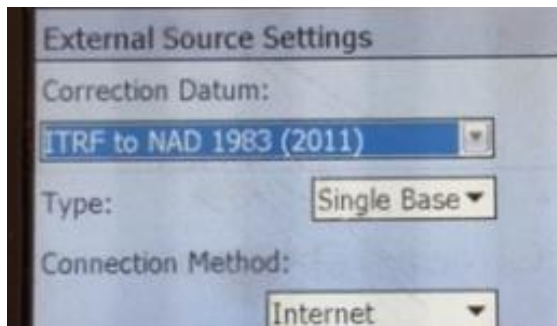
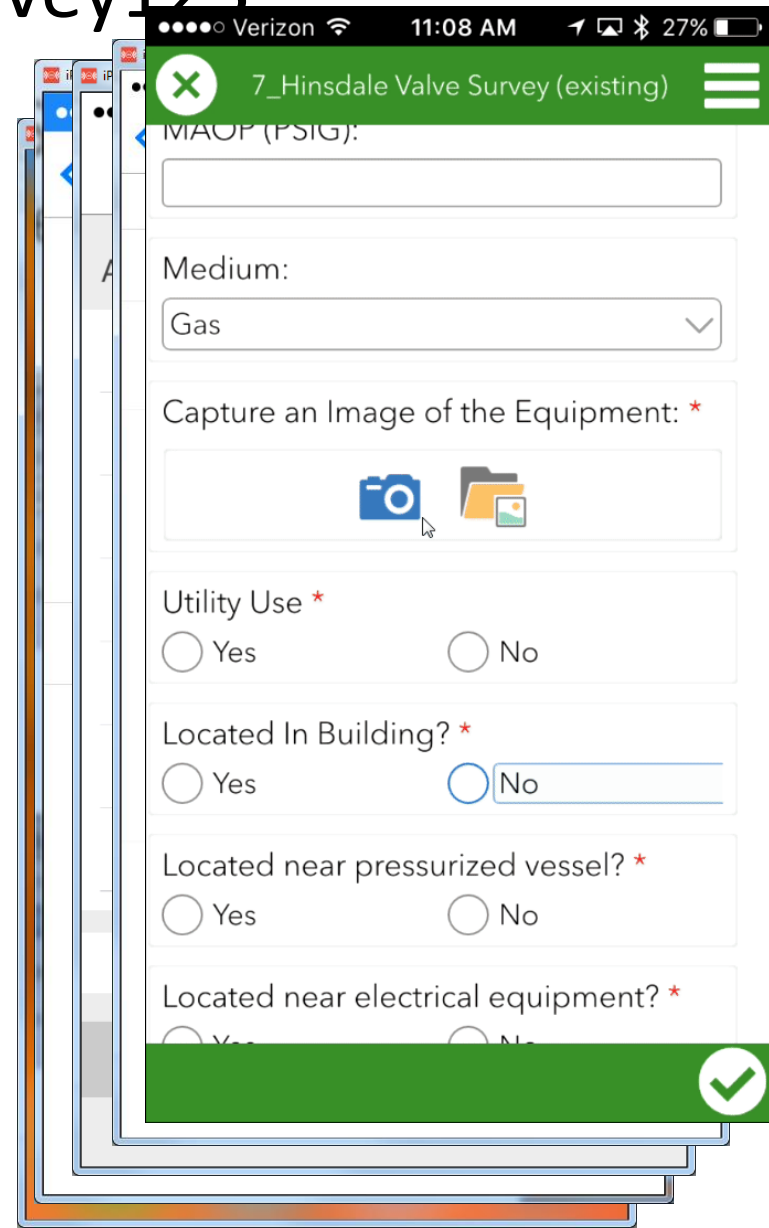
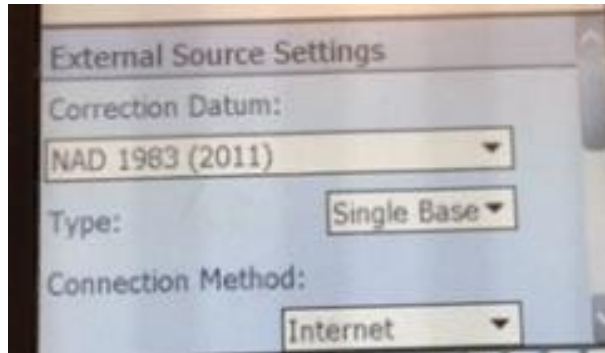
A Word on Transformations



NAD_1983_To_WGS_1984_5

Using Spatial Reference Systems

Terra Sync and Survey123



Using Spatial Reference Systems

Why Web Mercator?

Because Google...

The image is a screenshot of a web browser displaying Google Maps for Buffalo, NY. The browser's address bar shows the URL: `https://www.google.com/maps/place/Buffalo,+NY/@43.6417931,-127.9749301,3z/data=`. The map shows Buffalo, NY, with a search bar containing "Buffalo, NY" and a "SAVE" button. A "Quick facts" section is visible, providing information about Buffalo's location, history, and landmarks. A "Hotels" section is also present, showing a 3-star average and a price of \$133. Overlaid on the map is a large, stylized "IOGP" logo. In the foreground, a "Data Frame Properties" dialog box is open, showing the "Coordinate System" tab. The dialog box has a search bar and a "Transformations..." button. The Esri logo is also overlaid on the dialog box. The browser's taskbar at the bottom shows several open files, including "2D_affine_transfor...png", "epsg_EPSG home.html", "esri.jpg", "IOGP.png", "373-23.pdf", and "373-21.pdf".

Using Spatial Reference Systems: Hacking the Zoom Levels in Collector

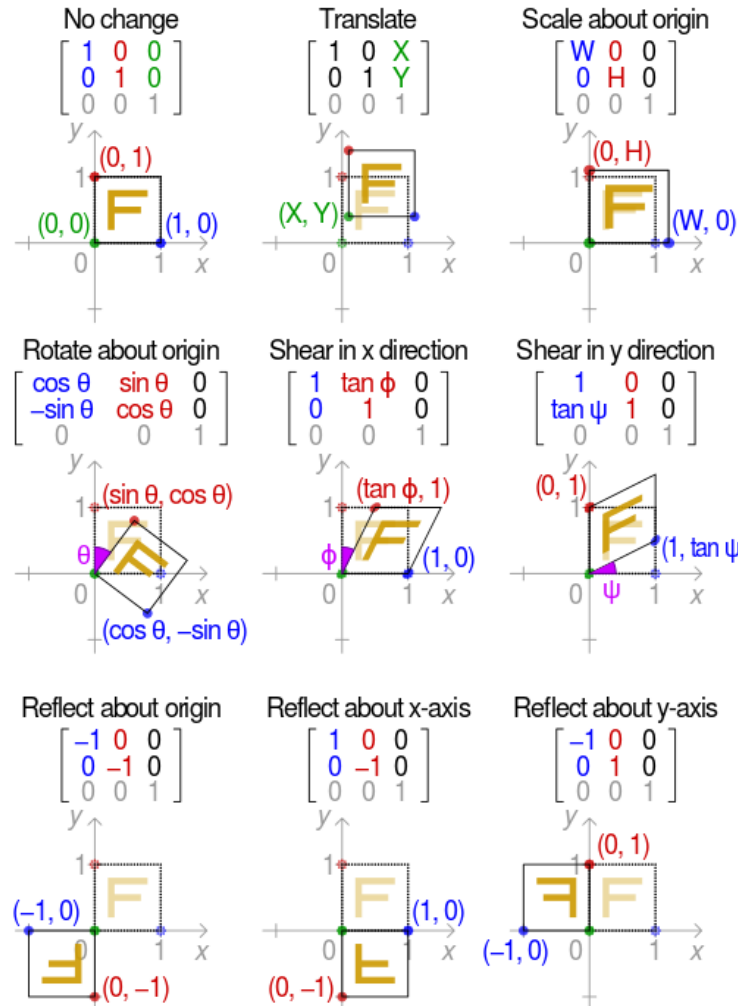
The image shows a Notepad++ window titled "Tile Package" with the file "conf.xml" open. The XML content defines a TileCacheInfo for a projected coordinate system (WGS_1984 Web Mercator Auxiliary Sphere) and a series of LODInfo elements for zoom levels 9 through 25. Each LODInfo element specifies a LevelID, a Scale, and a Resolution. The scales decrease as the LevelID increases, and the resolutions also decrease.

```
<?xml version="1.0" encoding="utf-8" ?><CacheInfo xsi:type="typens:CacheInfo" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xm="http://www.w3.org/2001/XMLSchema" xmlns:typens="http://www.esri.com/schemas/ArcGIS/10.1"><TileCacheInfo xsi:type="typens:TileCacheInfo"><SpatialReference xsi:type="typens:ProjectedCoordinateSystem"><WKT>PROJCS["WGS_1984 Web Mercator Auxiliary Sphere",GEOGCS["GCS_WGS_1984",DATUM["D_WGS_1984",SPHEROID["Spheroid",6378137.0,298.257223563]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.0174532925199433]],PROJECTION["Mercator_Auxiliary_Sphere"],PARAMETER["False_Easting",0.0],PARAMETER["False_Northing",0.0],PARAMETER["Central_Meridian",0.0],PARAMETER["Standard_Parallel_1",0.0],PARAMETER["Auxiliary_Sphere_Type",0.0],UNIT["Meter",1.0],AUTHORITY["EPSG",3857]]</WKT><XOrigin>-20037700</XOrigin><YOrigin>-30241100</YOrigin><XScale>148923141.92838538</XScale><ZOrigin>-100000</ZOrigin><ZScale>10000</ZScale><MOrigin>-100000</MOrigin><MScale>10000</MScale><XYTolerance>0.001</XYTolerance><ZTolerance>0.001</ZTolerance><MTolerance>0.001</MTolerance><HighPrecision>true</HighPrecision><WKID>102100</WKID><LatestWKID>3857</LatestWKID><SpatialReference><TileOrigin xsi:type="typens:PointN"><X>-20037508.342787001</X><Y>20037508.342787001</Y></TileOrigin><TileCols>256</TileCols><TileRows>256</TileRows><DPI><PreciseDPI>96</PreciseDPI><LODInfos xsi:type="typens:ArrayOfLODInfo"><LODInfo xsi:type="typens:LODInfo"><LevelID>0</LevelID><Scale>591657527.591555</Scale><Resolution>156543.03392799999</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>1</LevelID><Scale>295828763.79577702</Scale><Resolution>78271.516963999893</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>2</LevelID><Scale>147914381.59788851</Scale><Resolution>39135.78411314055802</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>3</LevelID><Scale>73957190.79894425</Scale><Resolution>19567.874056570411</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>4</LevelID><Scale>36978595.39947212</Scale><Resolution>9783.919285999998</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>5</LevelID><Scale>18489297.69973606</Scale><Resolution>4891.909257071268299</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>6</LevelID><Scale>9244648.84986803</Scale><Resolution>2445.9546285356341496</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>7</LevelID><Scale>4622324.42493401</Scale><Resolution>1222.7773142679493699</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>8</LevelID><Scale>2311162.21246700</Scale><Resolution>611.38865713397468</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>9</LevelID><Scale>1155581.108577</Scale><Resolution>305.74811314055802</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>10</LevelID><Scale>577790.55428899999</Scale><Resolution>152.874056570411</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>11</LevelID><Scale>288895.279195</Scale><Resolution>76.437028285073197</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>12</LevelID><Scale>144447.638572</Scale><Resolution>38.2185141428285073197</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>13</LevelID><Scale>72223.819285999998</Scale><Resolution>19.109257071268299</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>14</LevelID><Scale>36111.909642999999</Scale><Resolution>9.5546285356341496</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>15</LevelID><Scale>18055.954822</Scale><Resolution>4.7773142679493699</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>16</LevelID><Scale>9027.9774109999998</Scale><Resolution>2.38865713397468</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>17</LevelID><Scale>4513.988704999998</Scale><Resolution>1.1943285668550501</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>18</LevelID><Scale>2256.994353</Scale><Resolution>0.59716428355981699</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>19</LevelID><Scale>1128.4971760000001</Scale><Resolution>0.29858214164761698</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>20</LevelID><Scale>564.24858800000005</Scale><Resolution>0.14929107082380849</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>21</LevelID><Scale>282.124294000000025</Scale><Resolution>0.074645535411904245</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>22</LevelID><Scale>141.0621470000000125</Scale><Resolution>0.0373227677059521225</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>23</LevelID><Scale>70.5310735</Scale><Resolution>0.0186613838529761</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>24</LevelID><Scale>35.26553675</Scale><Resolution>0.009330691926488</Resolution></LODInfo><LODInfo xsi:type="typens:LODInfo"><LevelID>25</LevelID><Scale>17.632768375</Scale><Resolution>0.004665345963244</Resolution></LODInfo></ArrayOfLODInfo></TileCacheInfo></CacheInfo></?xml>
```

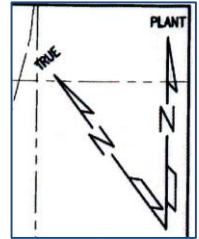
At the bottom of the window, the status bar shows "length: 5,601 lines: 14 Ln: 14 Col: 380 Sel: 0|0 Windows (CR LF) UTF-8 INS". The word "House" is visible in the background of the window.

Using Spatial Reference Systems

Coordinate System Transformations



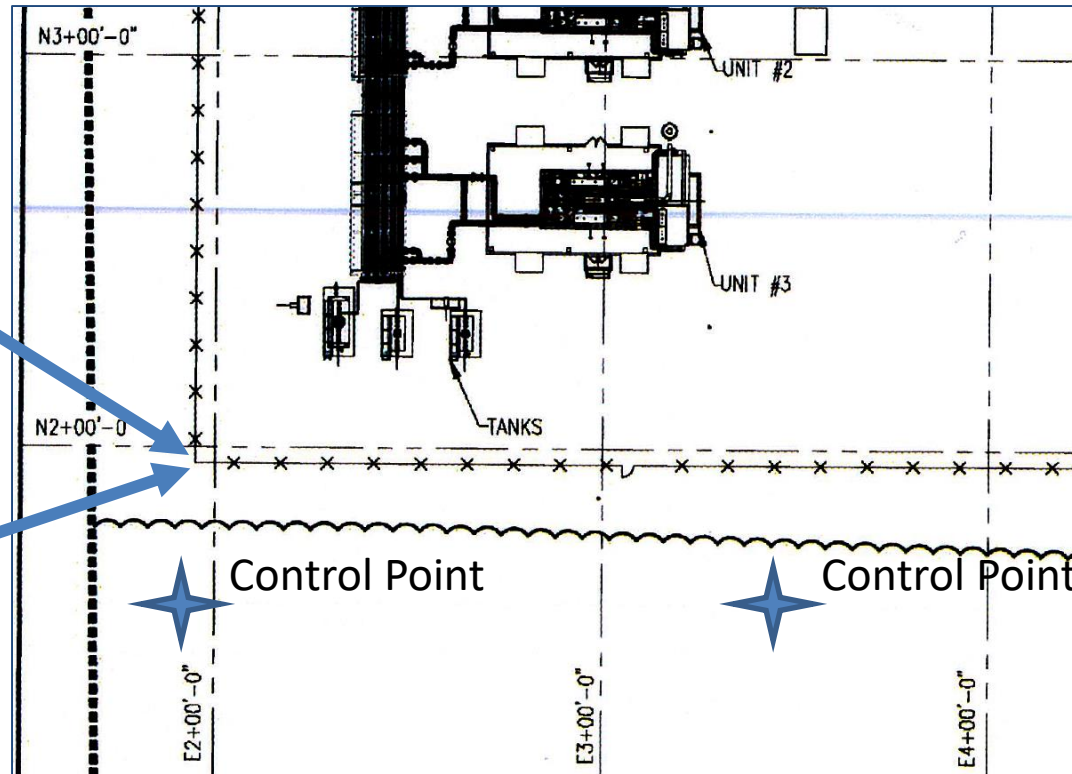
Strange Coordinate Systems: Construction Coordinates



Construction Grid Coordinates

N 1664571.88 US Survey Feet
E 556708.76 US Survey Feet

N 1+96' - 0"
E 1+96' - 0"

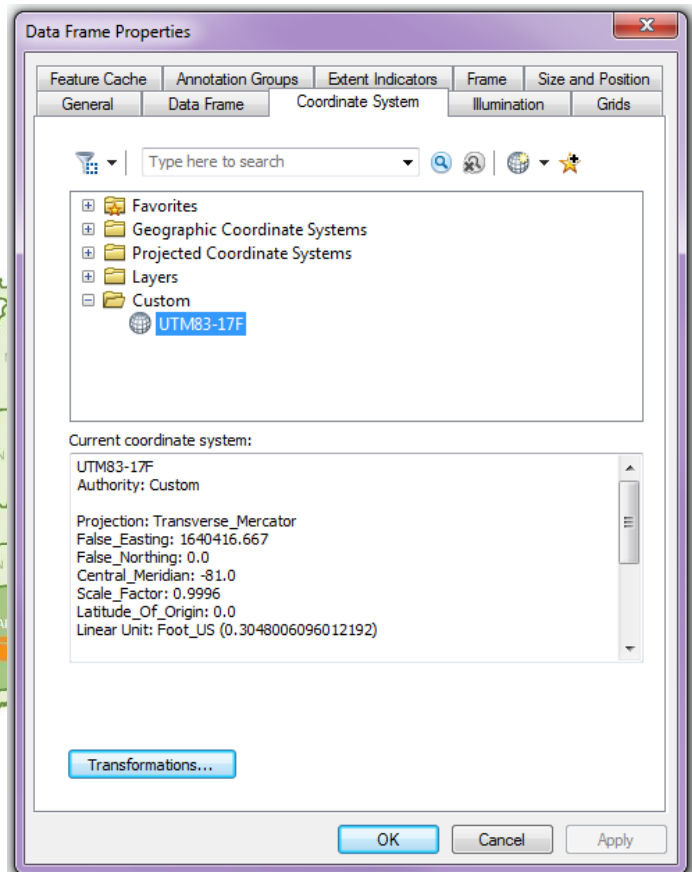
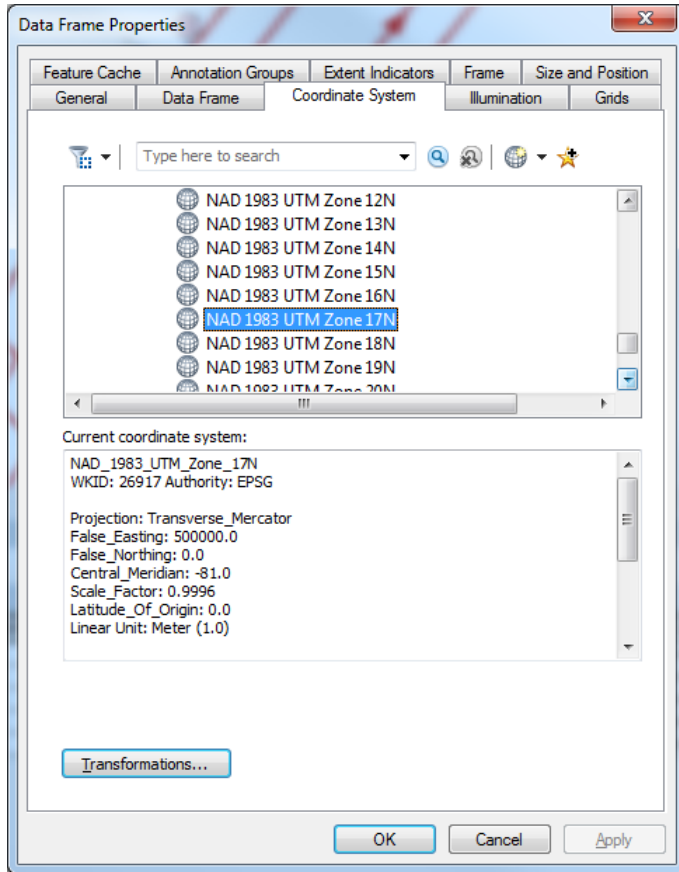


E0+00'-0"

NAD83(2011) → Construction Grid Coordinates → NAD83(2011)

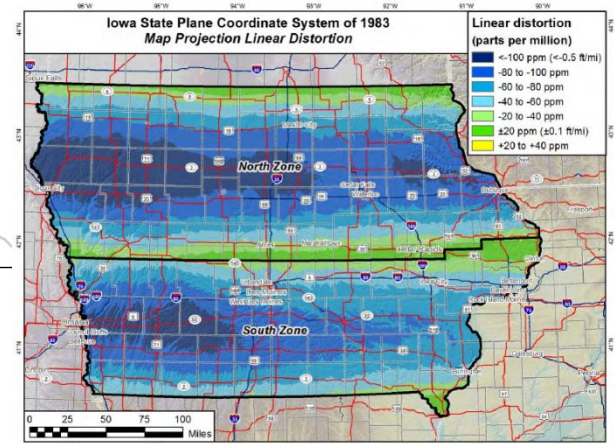
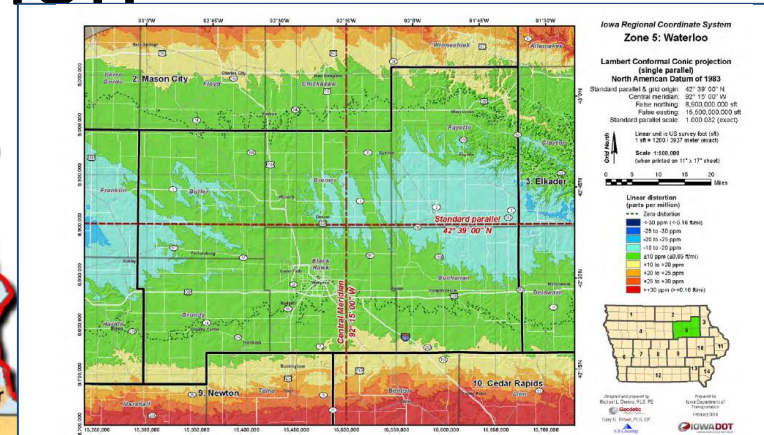
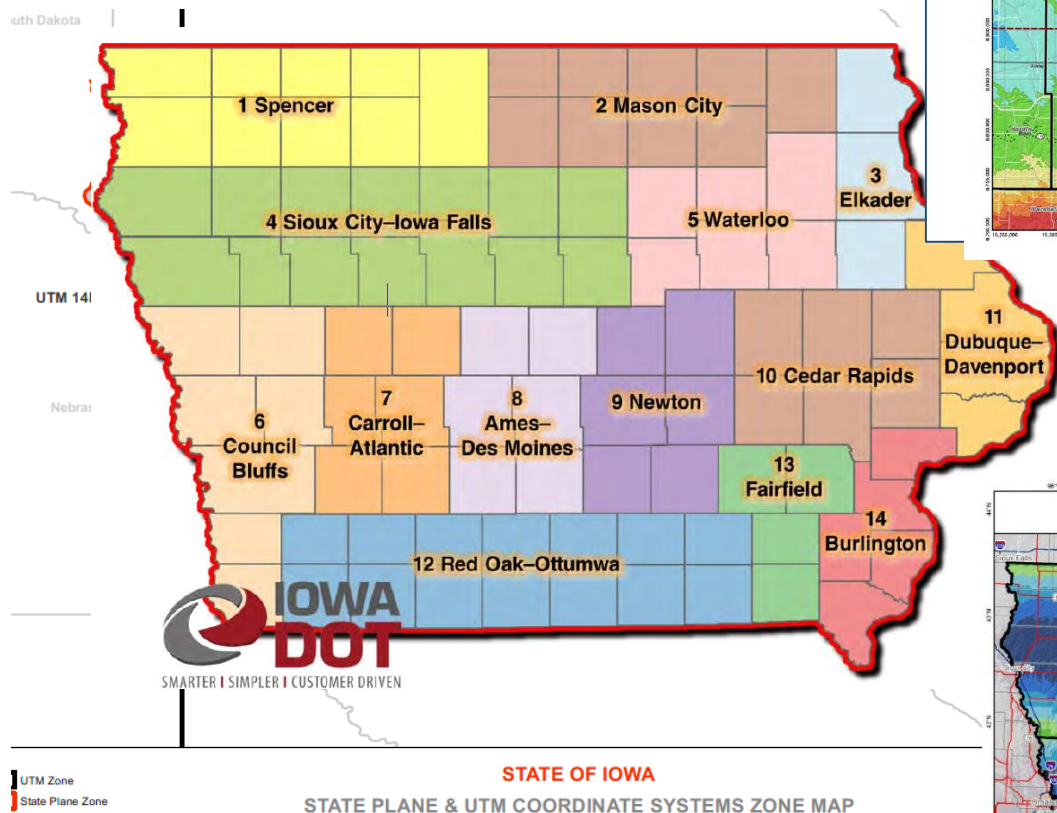
● N0+00'-0"

Strange Coordinate Systems: UTM-17F???



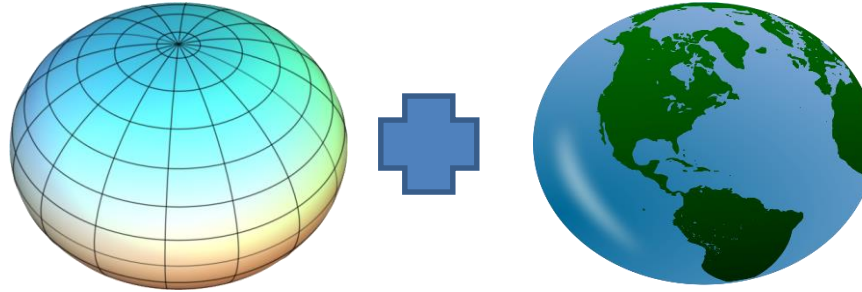
Strange Coordinate Systems: SPCS Rebellion

The Iowa Regional Coordinate System (IaRCS)



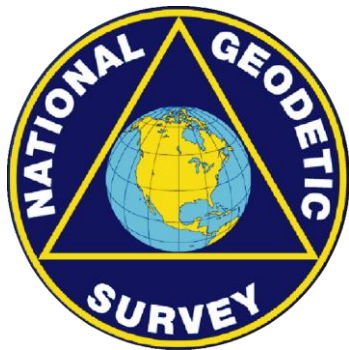
Take Away Points

Datum =



Old NAD83 tracked the center of Earth's mass, new NAD83 tracks North America's crust.

Sources for education...educate yourself, ask questions from trusted sources/vendors. The coordinate buck stops with us!



Closing Thoughts

