# State Plane Coordinate Systems & GIS

## An overview of SPCS with emphasis on “Grid vs. Ground” coordinates.

New Jersey Geospatial Forum Meeting

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# History of SPCS

- In 1933, The North Carolina Highway Department asked the US Coast & Geodetic Survey to develop a system of mapping equations so that geodetic latitudes & longitudes could be converted to Cartesian X & Y coordinates.
- This made it possible to calculate long highways across the whole state using plane surveying computations.
- Within one year, SPCS were developed for all the states.

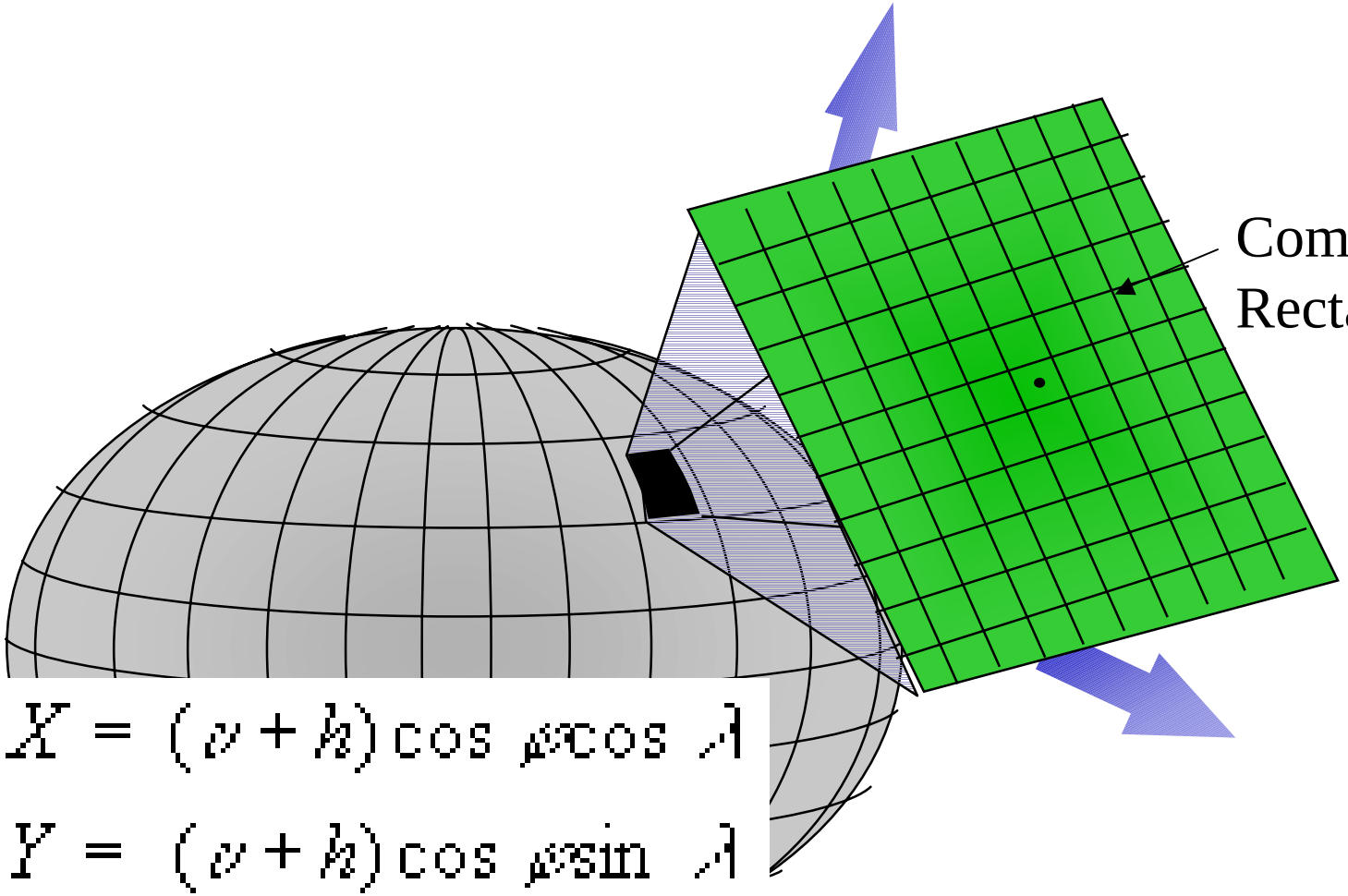
# Basics of SPCS

- SPCS are used to flatten out the curved earth so that plane trigonometry and coordinate geometry can be used to calculate positions rather than calculating on the curved ellipsoidal surface using arc measurements of Latitude and Longitude
- The distortion imposed by the mapping projection was set to be less than the accuracy attainable with normal transit & tape surveying methods.
- Geographic Latitudes & Longitudes can be converted to Plane X (East) and Y (North) Coordinates and visa versa.

# Basics of SPCS – continued

- Presented without the math & equations
- Focusing only on the lengths
- Grid Factor and Elevation Factor
- Combined Factor
- Angular differences are not considered

# Basics of SPCS – continued



Computations on Rectangular Grid

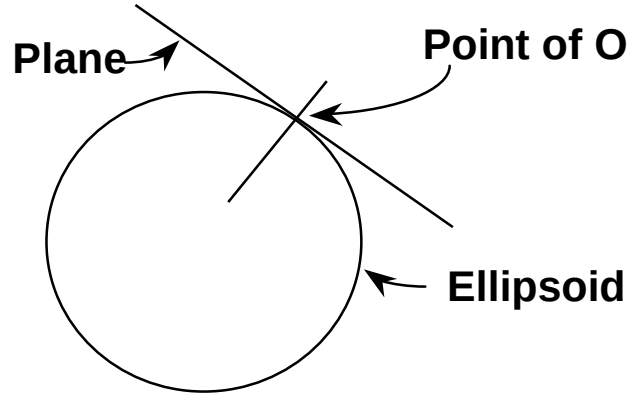
$$X = (v + h)\cos\varphi\cos\lambda$$

$$Y = (v + h)\cos\varphi\sin\lambda$$

$$Z = ((1 - e^2)v + h)\sin\varphi$$

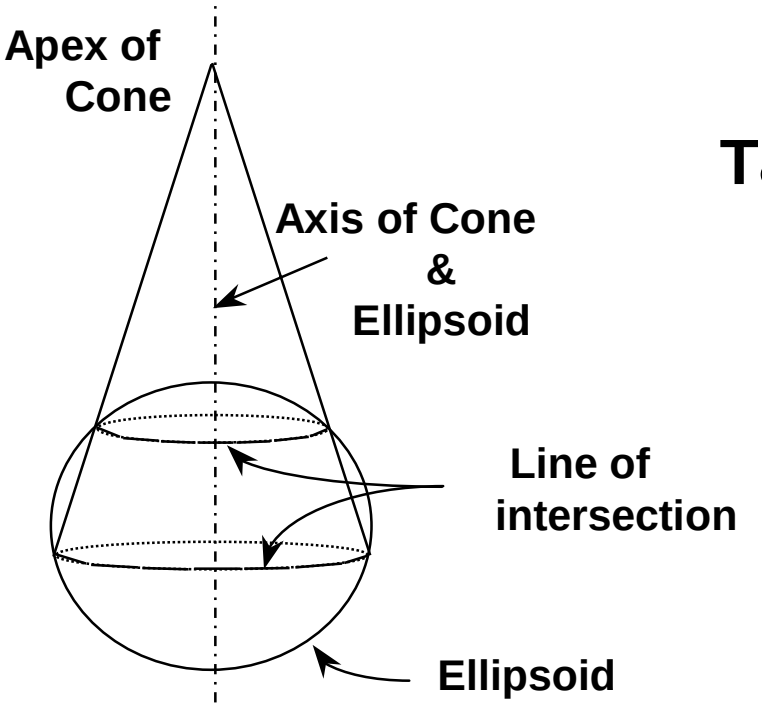
Computations on Ellipsoid

# Basics of SPCS – continued



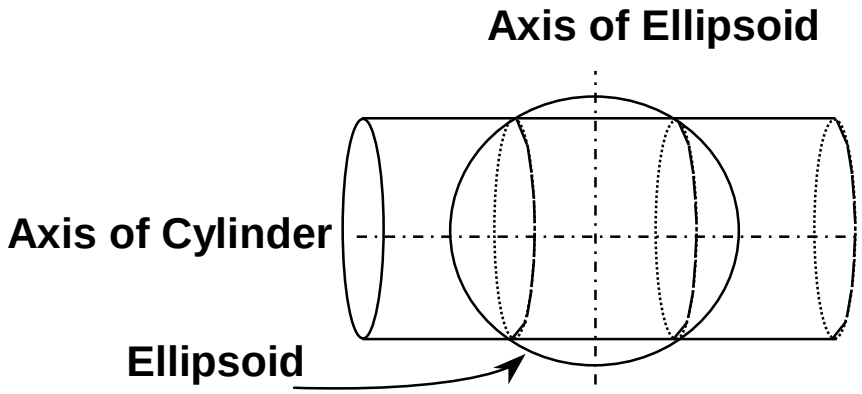

**Tangent Plane**

**Local Plane**




**Intersecting Cone**

**2 Parallel Lambert**

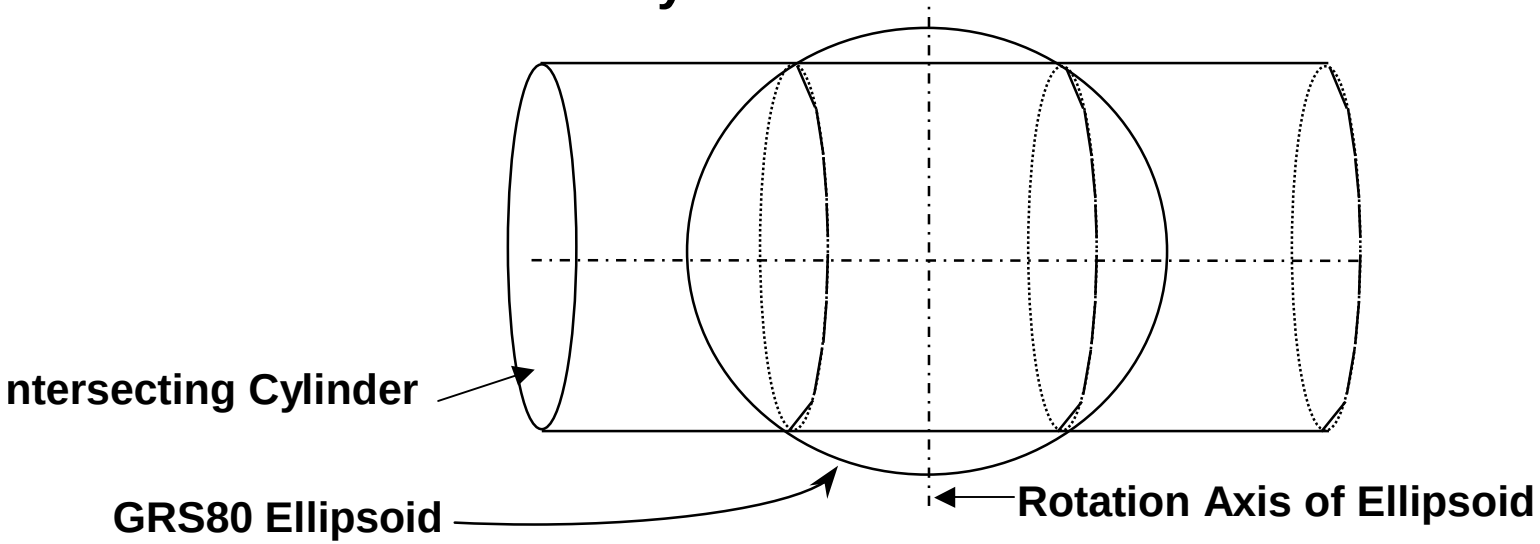



**Intersecting Cylinder**

**Transverse Mercator**

# Basics of SPCS – continued

**New Jersey SPCS - Transverse Mercator**




Datum : North American Datum 1983

Ellipsoid : Geodetic Ref System 1980

Semi Major Axis : 6378137.000m

Flattening 1/f : 298.257

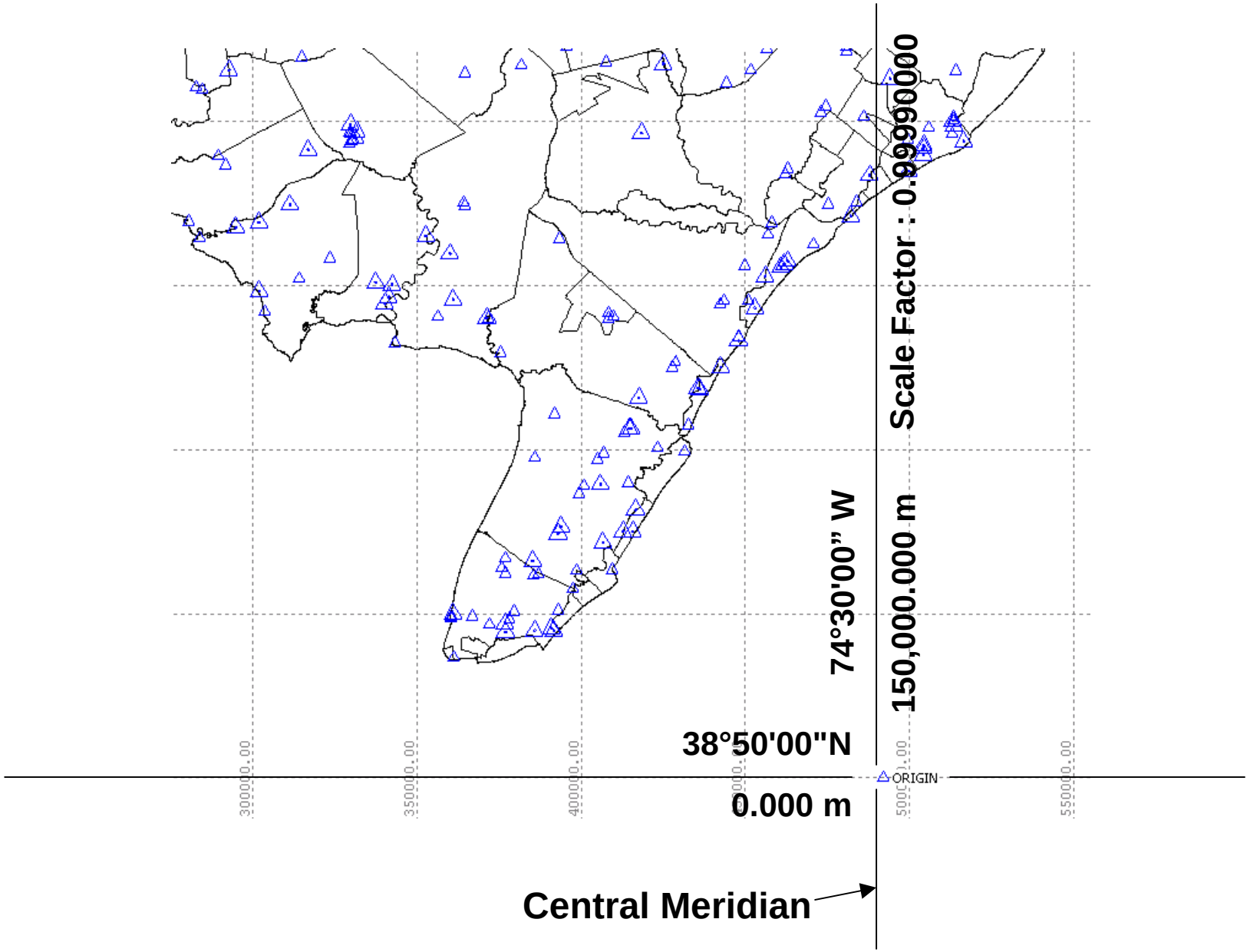
**Mapping Projection Origin -**

Latitude : 38°50'00.00000"N  False Northing : 0.00000m

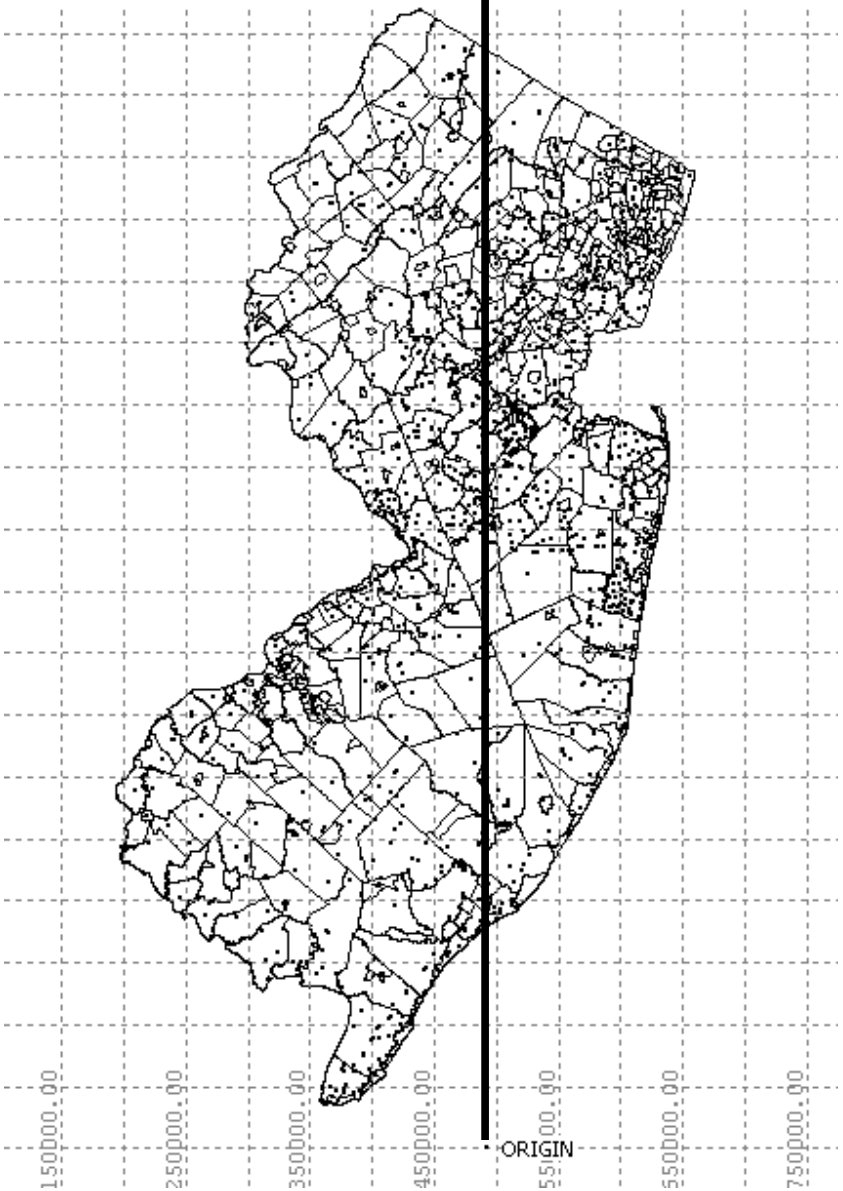
Longitude : 74°30'00.00000"W  False Easting : 150000.00000m

Scale Factor : 0.99990000

# Basics of SPCS – continued



# Basics of SPCS – continued



# Grid vs. Ground

- So? – What is all this talk about Grid and Ground Coordinates?
- Simply stated, lengths on the grid surface are shorter than lengths on the ground surface.
- Does that matter? – Maybe it does and maybe it doesn’t.
- The answer to that depends on the application.

# SPCS Before GPS

- Grid / Ground was not as much of an issue before the widespread and common use of GPS in the late 80s and early 90s.
- The difference between grid and ground was not easily detected using everyday surveying methods and could be ignored for many applications.
- NAD 1927 best fit the North American Continent and the SPCS scale factor was 4 X less distorting (1:40,000 compared to 1:10,000).

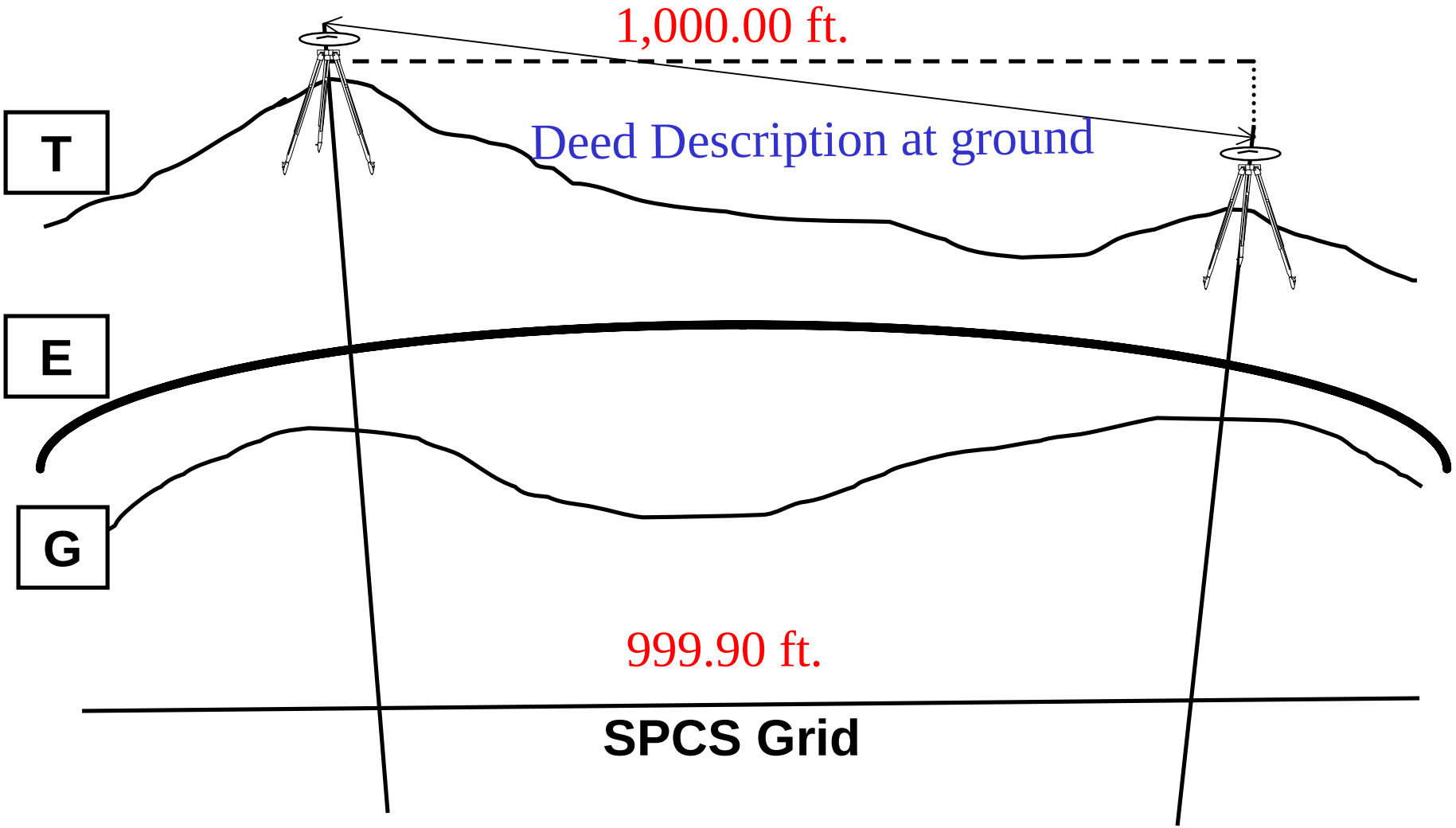
# SPCS & GPS

- Grid vs. Ground becomes an issue for 2 main reasons.
- 1) NAD83 published in 1986, is geocentric as opposed to continental best fit NAD27.
- 2) GPS usage grows – late 80s, early 90s – huge increase in measurement accuracy.
- Increased accuracy enables detection of grid scale factor by more SPCS users.
- EDM vs. GPS

# Grid / Ground Issues

- Grid lengths do not match lengths on ground surface.

# Grid / Ground Issues - Lengths



# Grid / Ground Issues

- Grid lengths do not match lengths on ground surface.

- Area on grid is less than area on ground.

# Grid / Ground Issues - Area

| Area Acres | Approx. Side | Difference Sq Ft | Difference Acres | Class |
|---|---|---|---|---|
| 20 | 933 | 174 | 0.004 | Small Tract |
| 500 | 4667 | 4356 | 0.10 | Medium Tract |
| 2000 | 9334 | 17423 | 0.40 | Large Tract |
| 190000 | 90975 | 1655197 | 38.0 | County |

- Land is described on the ground surface
- Is 0.004 Acres significant?

# Grid / Ground Issues

- Grid lengths do not match lengths on ground surface.
- Area on grid is less than area on ground.

•Education & awareness is needed to know when this matters and how to handle it.

# When does it matter, not matter?

- Survey Control for Construction?
- Existing Conditions Survey for Design?
- Utility Mapping for GIS?
- Wetlands Delineation?
- Monitoring Well Locations?
- GIS Parcel Mapping? (meter, centimeter?)
- Municipal & County Boundaries?

# Grid / Ground Issues

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•Methods to Handle Grid / Ground.

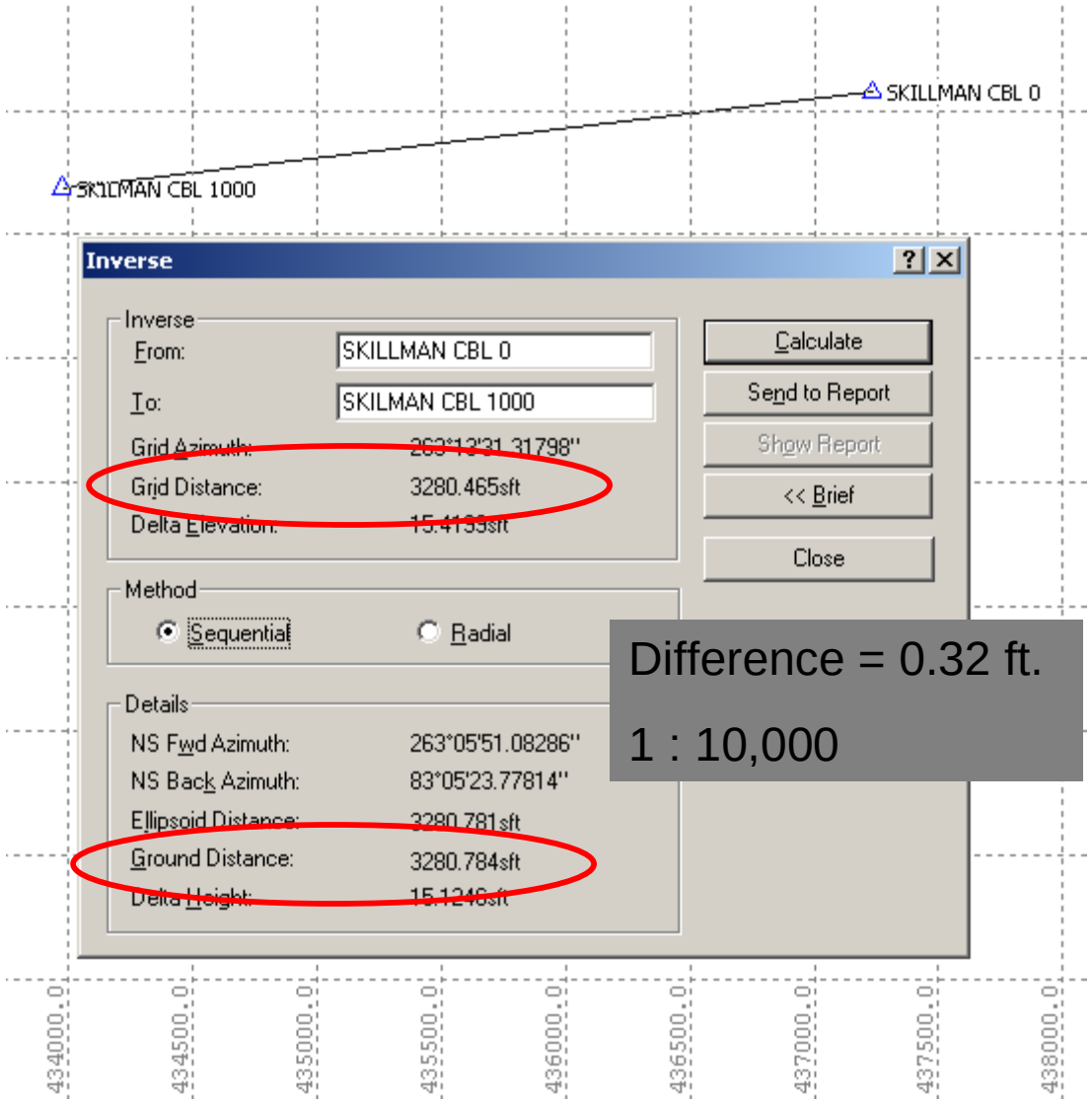
# Methods to Handle Grid / Ground

- Apply scale factor to each length (This can be inconvenient).
- Scale the grid coordinates to ground for each project or parcel. (Popular – Needs metadata)
- Create localized custom map projections referenced to NSRS. (Very useful. LLH to NEE)
- Use software that displays ground lengths & areas using state plane coordinates. (?)
- Request NGS to redefine SPCS to reduce the grid / ground distortion for the whole state from 100 ppm down to 33 ppm (under 2 inches in 1 mile).

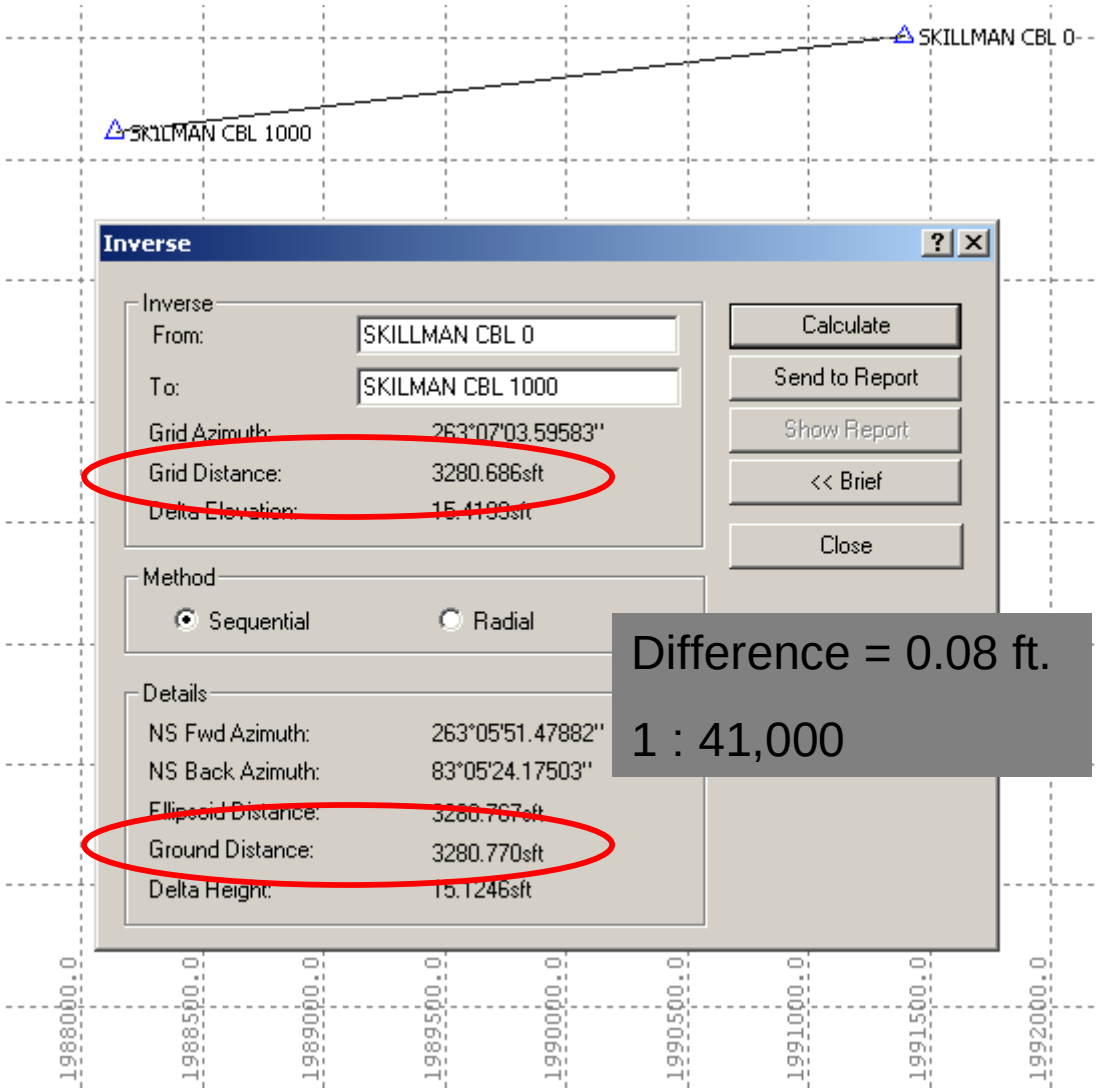
# SPCS Redefined

| 1 PART IN | SCALE | PPM | ZONE WIDTH MILES | USED FOR |
|---|---|---|---|---|
| 1,000,000 | 0.9999990000 | 1.0 | 16 | CITY OR TOWN |
| 100,000 | 0.9999900000 | 10.0 | 50 | HIGHWAY PROJECT |
| 40,000 | 0.9999750000 | 25.0 | 79 | NAD27 |
| ***30,000*** | ***0.9999666667*** | ***33.3*** | ***91*** | ***Redefined by NGS?*** |
| 10,000 | 0.9999000000 | 100.0 | 158 | NAD83 |

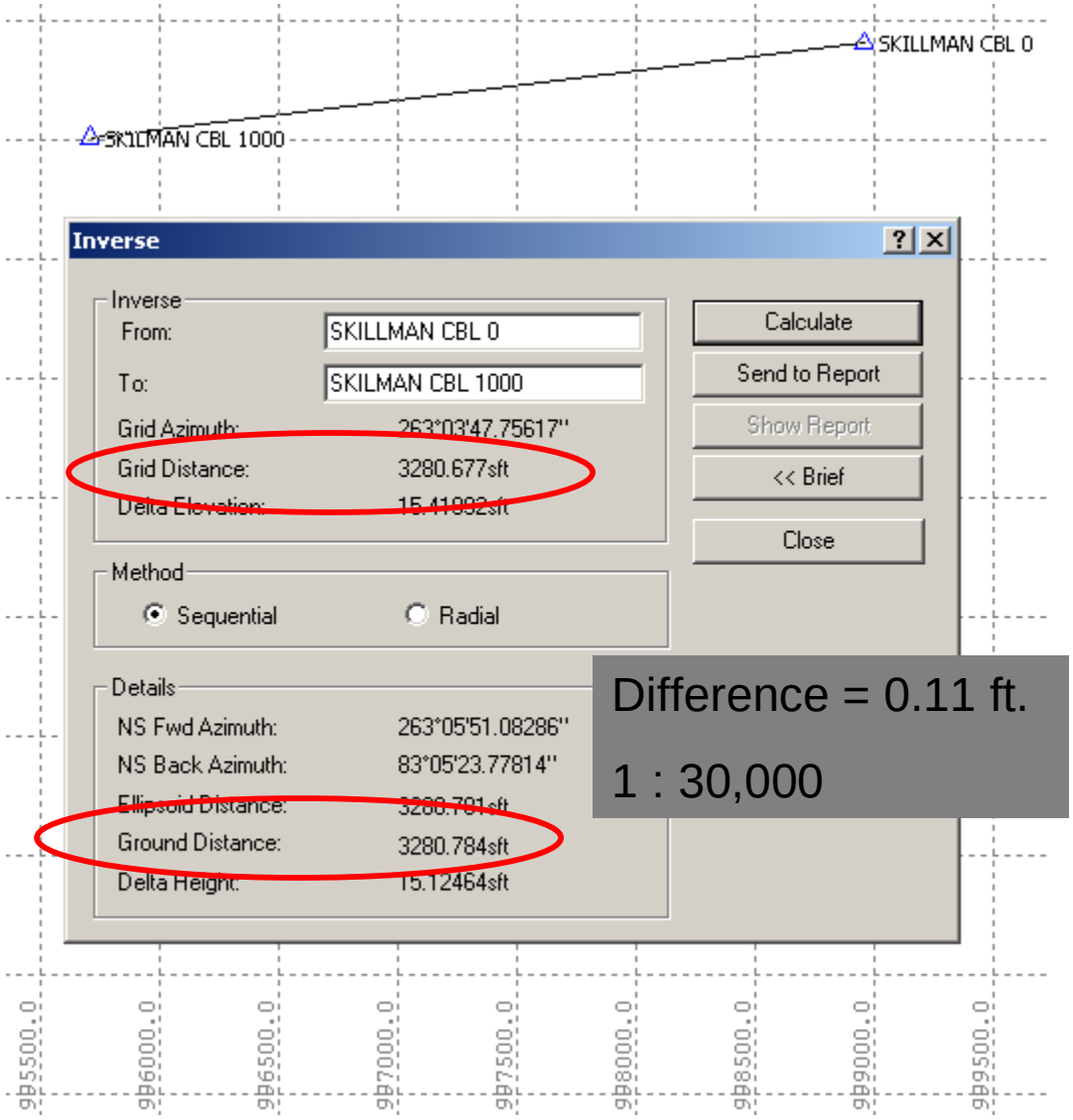
# Example – NAD83



# Example – NAD27



# Example – Redefined SPCS



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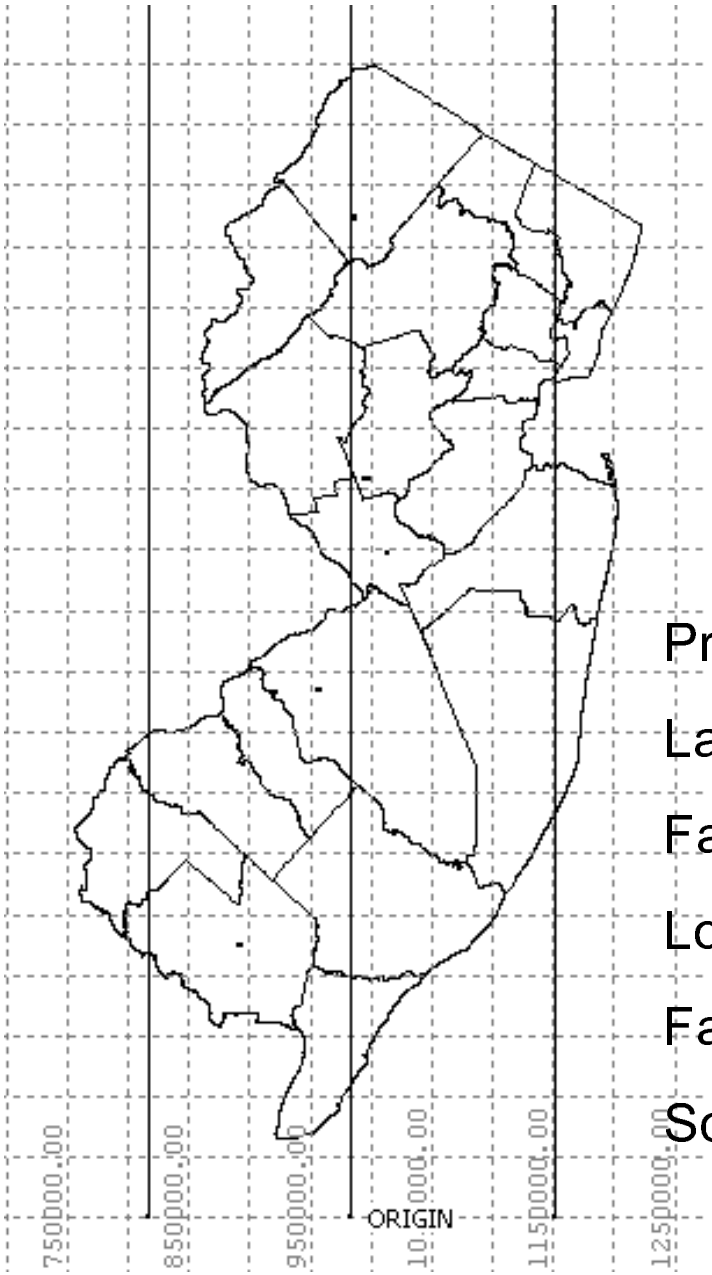


Projection Origin

Latitude : 38°45'00.00000"N

False Northing : 0.00000m

Longitude : 74°45'00.00000"W

False Easting : 300000.00000m

Scale Factor : 0.99996800

# Grid / Ground Issues

- Grid lengths do not match lengths on ground surface.
- Area on grid is less than area on ground.
- Education & awareness is needed to know when this matters and how to handle it.
- Methods to Handle Grid / Ground.

•Metadata – SPCS or some variation?

# Metadata – SPCS or some variation?

- Datum
- Localized? – Where and how?
- Relationship to NSRS?
- Accuracy? – Meter? Centimeter?

Questions?