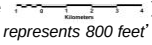
Scale & Projection

Two Key Ideas

- Scale
  - Map distance < ground distance
- Projection
  - Going from round earth to flat map

Scale

- Map scale: relationship between map units and real units
  - Ratio scale: representative fraction (RF) = map:ground distance
  - Graphic scale (e.g., bar scale )
  - Verbal scale (e.g., '*One inch represents 800 feet*')

What is a key advantage of a bar scale?

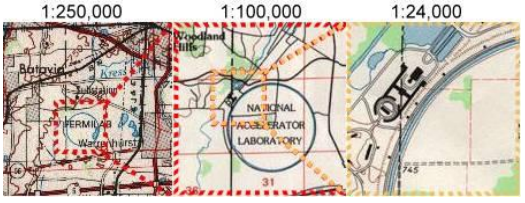
A 3 cm street on a map with an RF of 1:100,000 is how long in reality?

3 cm × 100,000 = 300,000 cm = 3,000 m = 3 km

Scale Matters

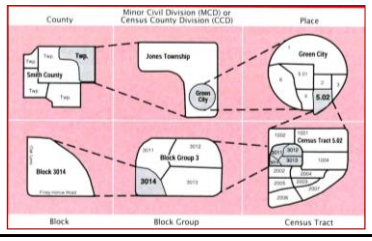
Scale selection

Small	Map scale	Large
Large	Mapped earth area	Small
Less	Information detail	More



Scale and Resolution

- Data have different resolutions for different uses…
  - Census data are collected at the **household**
  - Reported (tabulated/calculated) at **tracts** or lower
  - Mapped at many resolutions



Projection

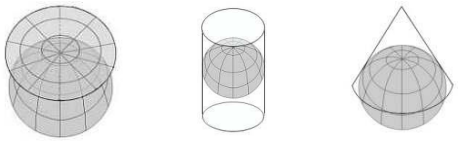
- Globes are realistic = Good
- Globes are hard to use = Bad
  - Not easy to carry
  - Not easy to work on
  - Small scale

Projection

- Projection makes the globe flat

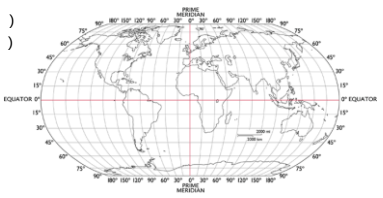
Projection Concepts

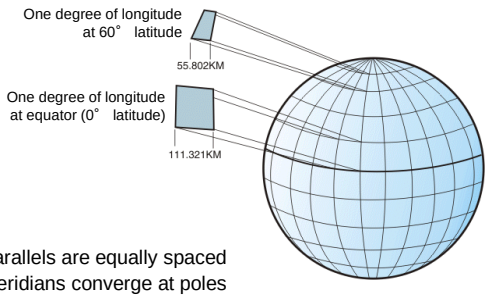
- Coordinate systems
- Projection mechanics
- Projection surfaces
- Projection properties



Coordinate Systems: The Graticule

- Coordinates on 3d globe = the graticule
- Longitude (-180° to +180°)
  - Prime (Greenwich) Meridian (0°)
  - International Date Line (180°)
- Latitude (-90° to +90°)
  - Equator (0°)
  - North Pole (+90°)
  - South Pole (-90°)

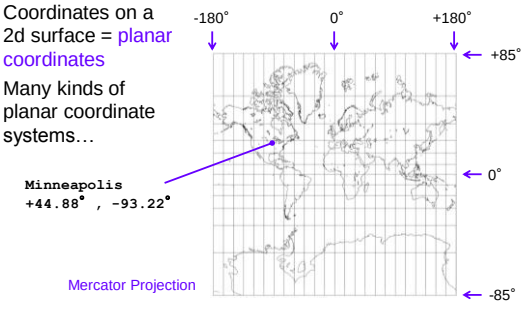


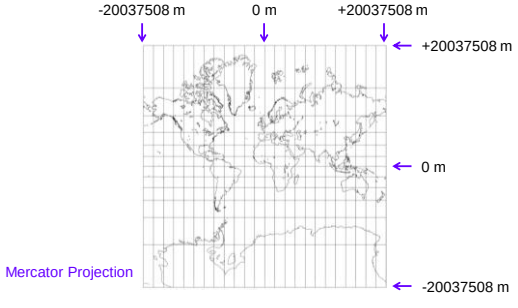


- Parallels are equally spaced
- Meridians converge at poles
- Parallels and meridians cross at right angles

Coordinate Systems: Planar

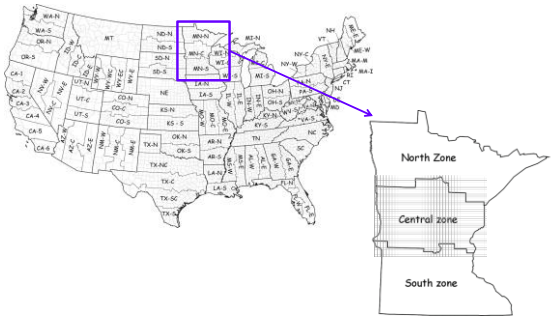
- Coordinates on a 2d surface = planar coordinates
- Many kinds of planar coordinate systems…



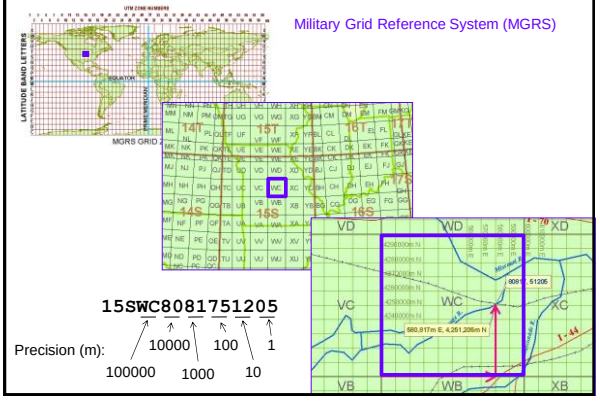


A single projection can be used with many coordinate systems

State Plane Coordinate System (SPCS)

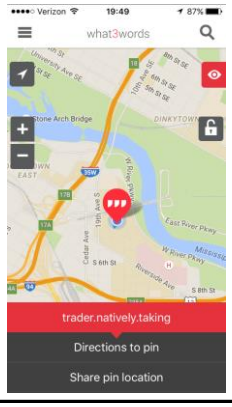


Military Grid Reference System (MGRS)

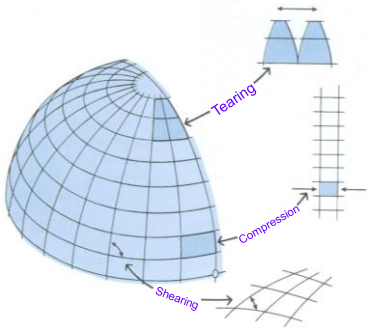


What3Words

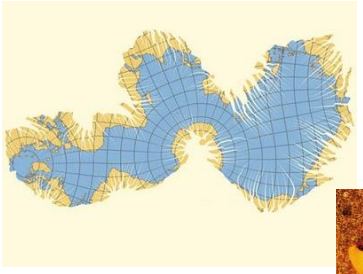
- 3m x 3m squares
- 57 trillion squares cover globe
- Three words identify a square
- Easier to remember than long number sequences



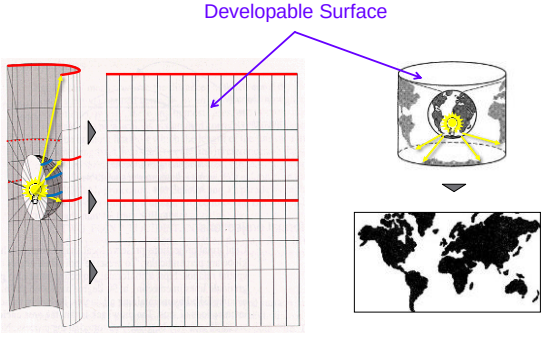
Projection Mechanics



Projection Mechanics

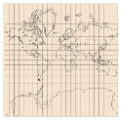


Mechanics: Perspective Approach



Mechanics: Algorithmic Approach

Mercator



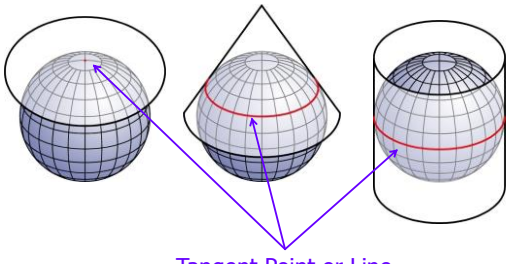
$$x' = Rs\,(\lambda - \lambda_0)$$

$$y' = Rs \log\left(\tan\left[\frac{\pi}{4} + \frac{\phi}{2}\right]\right)$$

Mollweide

Developable Surface Types

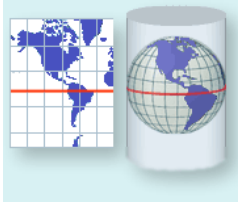
Plane Cone Cylinder



Tangent Point or Line

Distortion varies with surface type and intersection of surface with globe

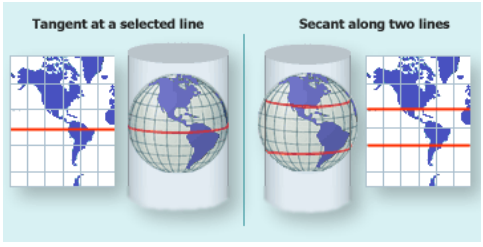
Tangent to Sphere at Line



Tangent to Sphere at Point

Standard Line or
Standard Parallel

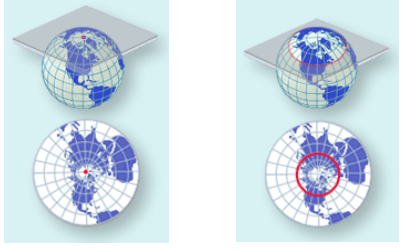
Standard Lines or
Standard Parallels

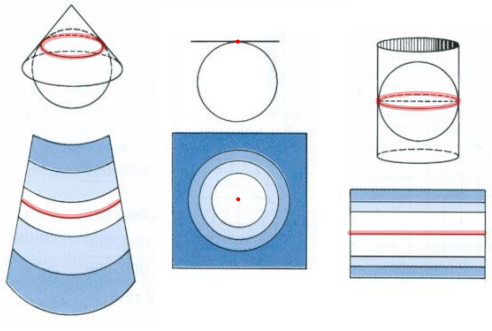


Distortion is minimal at the standard line

Standard Point

Standard Line or
Standard Parallel





Distortion varies with surface type and tangency

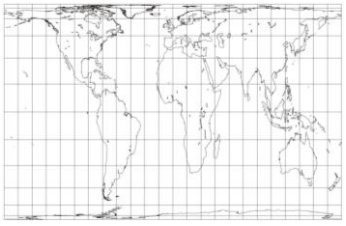
Projection Properties

Property	Map Called	Use	Interesting Fact
Shape / Angle	Conformal Orthomorphic	Navigation Topographic	Meridians and parallels intersect at right angles
Area	Equal-area Equivalent	Thematic	Can be true for whole map
Distance	Equidistant	Atlas	Distance is true along lines of 'true scale'

Property	Map Called	Use	Interesting Fact
Shape / Angle	Conformal Orthomorphic	Navigation Topographic	Meridians and parallels intersect at right angles

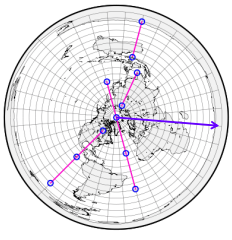
Mercator Projection

Property	Map Called	Use	Interesting Fact
Area	Equal-area Equivalent	Thematic	Can be true for whole map

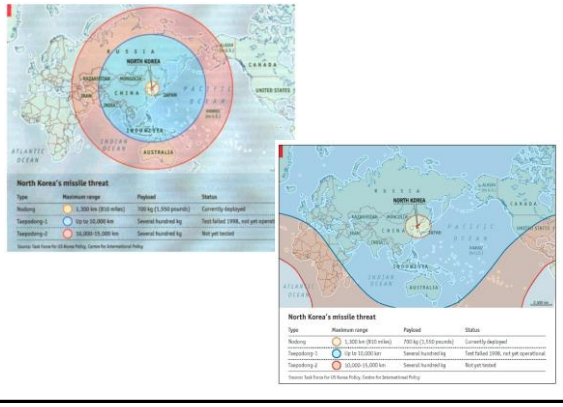


Gall-Peters Projection

Property	Map Called	Use	Interesting Fact
Distance	Equidistant	Atlas	Distance is true along lines of 'true scale'

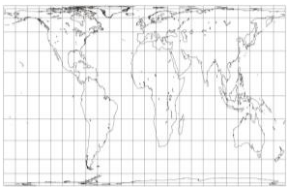


Azimuthal Equidistant Projection



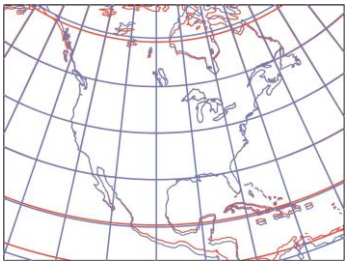
Some projections are very different

Mercator Projection
Cylindrical & Conformal



Gall-Peters Projection
Cylindrical & Equal Area

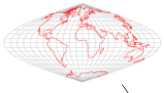
Some projections are quite close



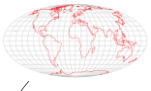
Lambert Conformal Conic vs. Albers Equal Area Conic

Composite projections combine different projections

Goode's Homolosine joins Sinusoidal and Mollweide projections
along north and south parallels 40° 44'11.8"



Sinusoidal represented between
north and south parallels 40° 44'11.8"

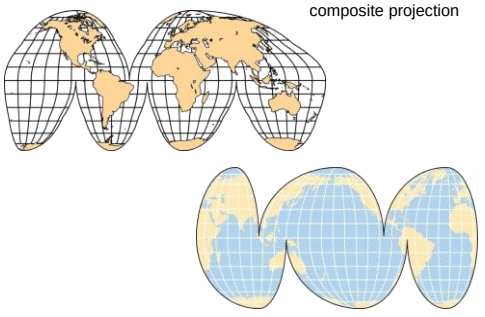


Mollweide represented outside of
north and south parallels 40° 44'11.8"

Goode homolosine composite projection

Interrupted projections cut the surfaces into lobes

Interrupted Goode homolosine composite projection



Conclusion

- Map elements: scale, projection, symbolization
- Scale
  - Scale measures
  - Scale matters
- Projections
  - Projection mechanics
  - Coordinate systems
  - Projection surfaces
  - Projection properties