

# Did You Know There's No Difference between "Grid" and "Ground"?

(or it all depends on how you define *difference*)

*presented by*  
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New Jersey Society of  
Professional Land Surveyors  
Thursday, February 5, 2009

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## About the seminar presenter

**Joseph V. R. Paiva** is a consultant in the field of geomatics and general business, particularly to international developers, manufacturers and distributors of instrumentation and other geomatics tools. Prior to this he was managing director of Spatial Data Research, Inc., a GIS data collection, compilation and software development company. Immediately prior, he was at Trimble Navigation Ltd. His roles included senior scientist and technical advisor for Land Survey research & development, VP of the Land Survey group and director of business development for the Engineering and Construction Division. Previous to that, Paiva was vice president and a founder of Sokkia Technology, Inc., guiding development of GPS- and software-based products for surveying, mapping, measurement and positioning. He has also held senior technical management positions in The Lietz Co. and Sokkia Co. Ltd. Dr. Paiva was assistant professor of civil engineering at the University of Missouri-Columbia, and a partner in a surveying/civil engineering consulting firm. Dr. Paiva's special areas of interest include interface development and design for software and hardware, errors analysis and survey instrumentation of all types. His key contributions in the development field are: design of software flow for the SDR2 and SDR33 Electronic Field Books and the software interface for the Trimble TTS500 total station. He is a member of several professional societies, has presented numerous papers and writes columns for **P.O.B.** magazine and **The Empire State Surveyor**. In May 2006 he completed an approximately three year stint as a columnist for **Civil Engineering News**. He is a Registered Professional Engineer, Registered Land Surveyor, is an ACSM representative to ABET, serving as a program evaluator and team chair on accreditation visits to surveying programs, and has more than 30 years experience working in civil engineering, surveying and mapping. Dr. Paiva is currently working on book to be published soon on the subject of total stations; it is intended to be a practitioner's guide to help in the understanding, operation, testing and adjustment of these ubiquitous instruments.

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# There's No Difference Between Grid and Ground

New Jersey Society of Professional Land Surveyors

SurvCon 2009 - February 5, 2009

Bally's Park Place Hotel - Atlantic City, New Jersey

Joseph V.R. Paiva, PhD, PS, PE

## The grid headache

- Why do we have it anyway?
- Is it those darn software manufacturers?
- Why can't we have the good old "ground" days?

## Topics

- Surveys of limited scope vs. large extent
- Plane surveys vs. geodetic
- How projection makes large surveys easier
- Why mixing GPS and total station even in small surveys creates a problem
- Calculations
- Strategies for dealing with the grid/ground thing

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## Introduction

- Most small-area surveys can be done assuming the earth is flat (plane surveys)
- For large areas, Earth's curvature *has* to be considered
- This usually involves determining geodetic positions (latitude and longitude) of survey stations

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## State Plane Coordinate System

- SPCS was designed in the early 1930s by the (then) Coast and Geodetic survey to solve the problem of surveys of large extents for the "local" surveyor
- In addition to allowing plane survey concepts to be used, it delivers several additional benefits

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## SPCS benefits

- Simplifies calculations for surveys over large distances
- Provides common datum of reference for all surveys (if tied in)
- Well suited for engineering projects of large extent, i.e. highways, but also photogrammetry, large scale cadastral surveys, etc.

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## SPCs

- When surveys are tied into the SPCS, their locations become (potentially) indestructible
- With GPS, the problem of what coordinates to use once geocentric coordinates of GPS have been transformed in geodetic coordinates makes SPCS a natural choice

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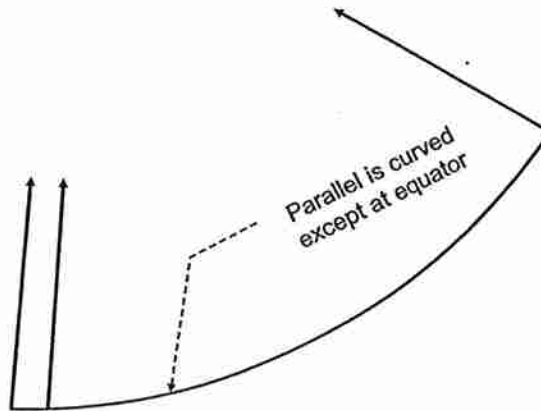
## Projections

- The basic problem with plane surveying is that it assumes the earth is flat
- Some problems...

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## Problems

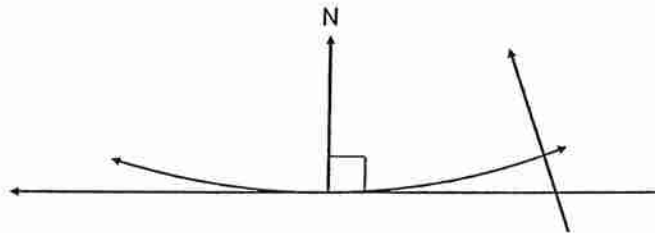
- meridians converge



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## Problems

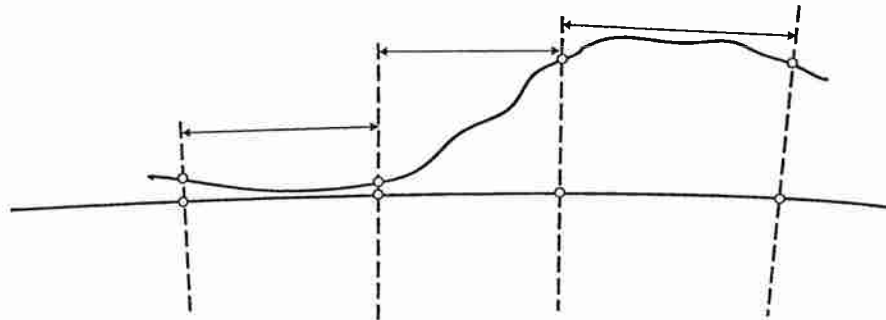
- On the Earth, "straight lines" are not straight except for meridians (or the equator) and the difference gets larger as you extend them



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## Problems

- Changes in elevation cannot be ignored, that is why all geodetic distances are at "sea level"



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## Projections

- To have a plane coordinate system, it is necessary to distort the curved surface of the earth to fit on a plane
- Orange peel analogy
- This process of flattening must be systematic in order to have accuracy
- In surveying this process is called a projection

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## Projections / 2

- Systematic way to portray (curved) surface of the earth on a flat surface
- Distortions inevitable
- Different projections are used because each minimizes distortion in some properties at the expense of others

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## Types of projections

- Different mathematical treatments are given to projections depending on the result desired

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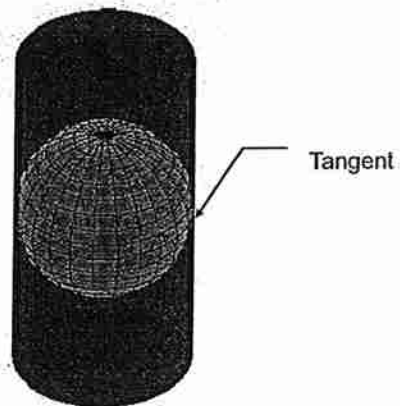
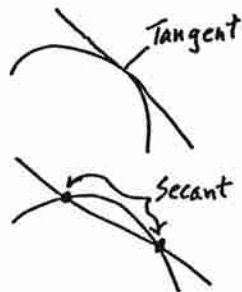
## Developable surface

- A shape that can be made into a plane
  - Cone
  - Cylinder
  - Plane (of course)

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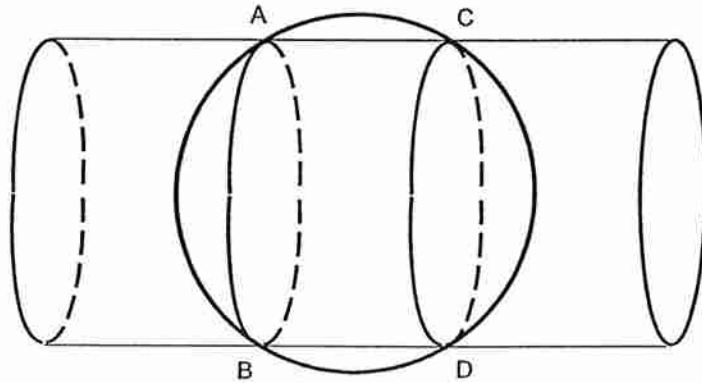
## General classes

- Cylindrical



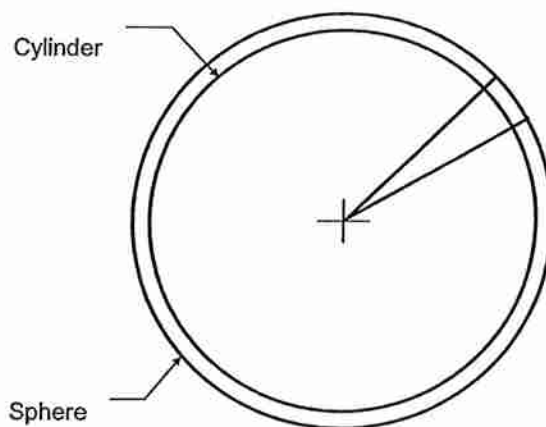
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# Transverse Mercator



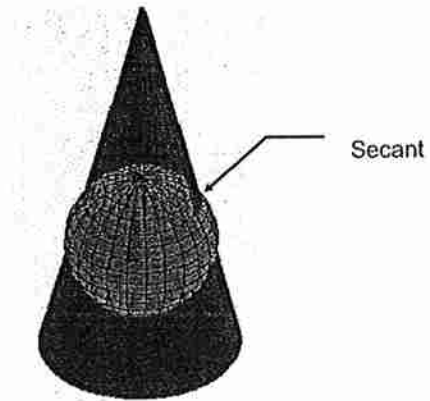
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# TM edge view



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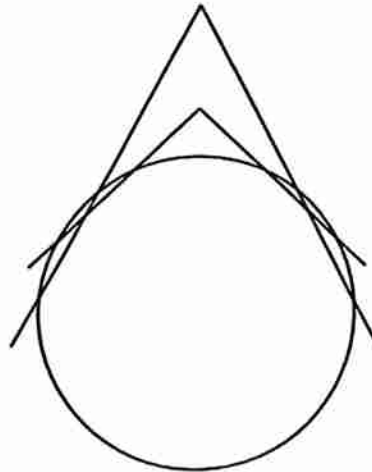
■ Conic



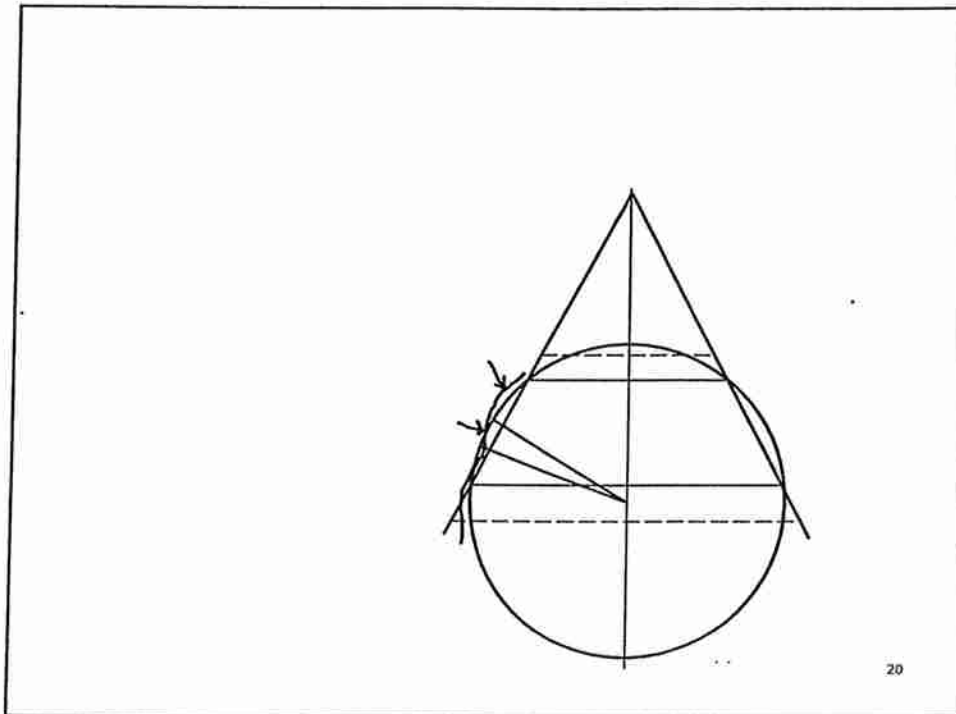
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## Lambert conformal

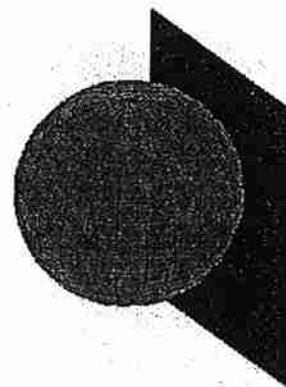
- Varying central apex angle of cone changes section of ellipsoid that is intersected



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- Planar
- This type of projection is created when surveyor sets up arbitrary coordinate system for a survey



- Plus...miscellaneous

## Next step

- Once developable surface parameters are picked, plane is created
- Because a developable surface is used, while there are distortions in converting coordinates on the earth to the developable surface, there is no further distortion of shape or size when it is unrolled or "developed"

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## Most common surfaces in SPCS

- Lambert conformal (conic)
- Transverse Mercator (cylinder)
- Also...skewed (or oblique) Mercator

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## State Plane Coordinate Systems (83)

- System for specifying geodetic stations using plane rectangular coordinates
- Over 120 zones for U.S.
- Long N-S states use Transverse Mercator
- Long E-W states use Lambert
- If square, use either

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## SPCS (83)

- Alaska, Florida and New York use both types of projections
- In addition Alaska has an oblique projection for the southeastern part of the state

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## SPC83 vs. SPC27

- Coordinate values changed (N and E)
- Meters
- Types of projections changed for some states
- Zones different in some
- Numbers of zones per state changed in some

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## Feet!

- U.S. Survey foot =  $[m] \times 3937/1200$
- International foot =  $[m] / 0.3048$
- 2 PPM!
- [0.01 ft in a mile]
- [but with a coord value of 500,000 m, difference is 1 m!]

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## NOAA/NGS document

- NOAA Manual NOS NGS 5  
*State Plane Coordinate System of 1983*
- <http://www.ngs.noaa.gov/>

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## Distortions

- Scale is exact where cone or cylinder intersects ellipsoid surface
- Scale is less than one between lines of true scale (i.e. length on ellipsoid is greater than length on plane)
- Scale is more than one outside lines of true scale (i.e. length on ellipsoid is smaller than length on plane)

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## Zone size

- Where the zone intersects the Earth, and whether it is tangent or secant controls the distortions
- By strategic placement, distortions are minimized, scale differences can be kept to 1:10,000 or less
- Done by keeping zone size to <158 mi and keeping zone width such that two-thirds of the zone is between lines of true scale (secant lines)

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## More on zone size

- Zones are designed to overlap each other considerably
- Thus a survey done near a zone boundary can be done in either zone

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## Transverse Mercator projection

- Also conformal
- Scale varies east to west but not north to south
- Scale is true at the secant line
- All geodetic meridians are curved, converging at the pole

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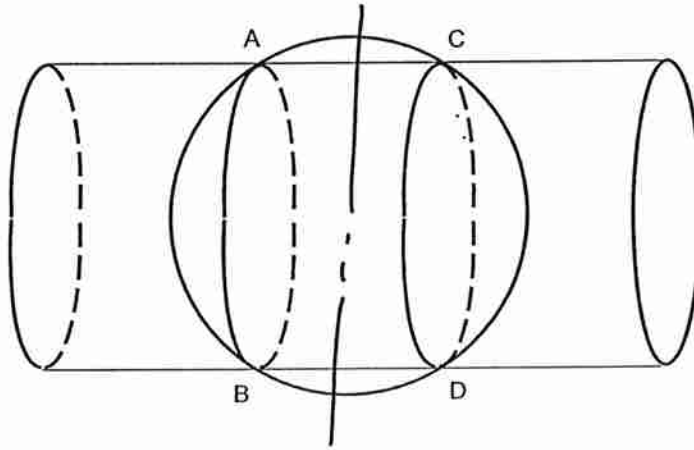
## Transverse Mercator projection / 2

- All parallels (of latitude) are curved
- CM is assigned to a meridian line
- All lines on the plane parallel to the CM are grid north
- East-west lines on the plane are perpendicular to the CM



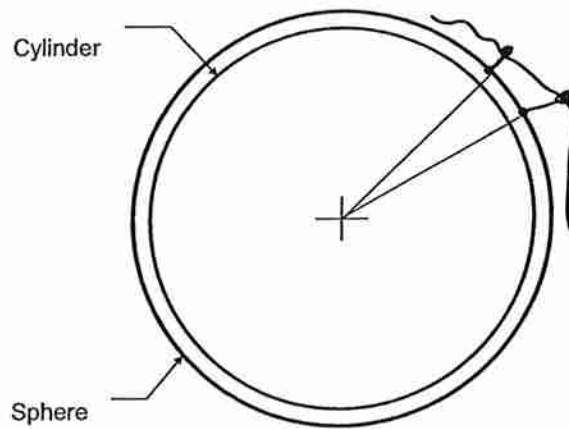
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# Transverse Mercator



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# TM edge view



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