Oregon Department of Transportation

The Oregon State Plane Coordinate System The end of an era?

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ODOT Surveyors Conference

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Topics Covered

- Review of the Oregon State Plane Coordinate (SPC) System
- Review of the Local Datum Plane Coordinate (LDPC) System
- Identify problems with SPC and LDPC and the need for change.
- Present overview of a Low Distortion Projection (LDP) solution

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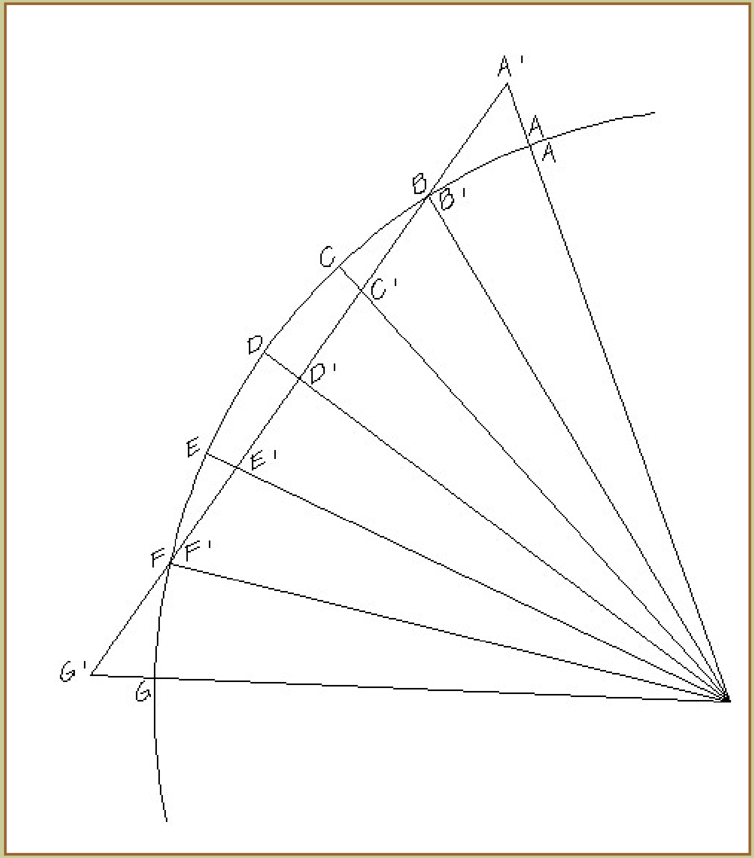
Map Projection

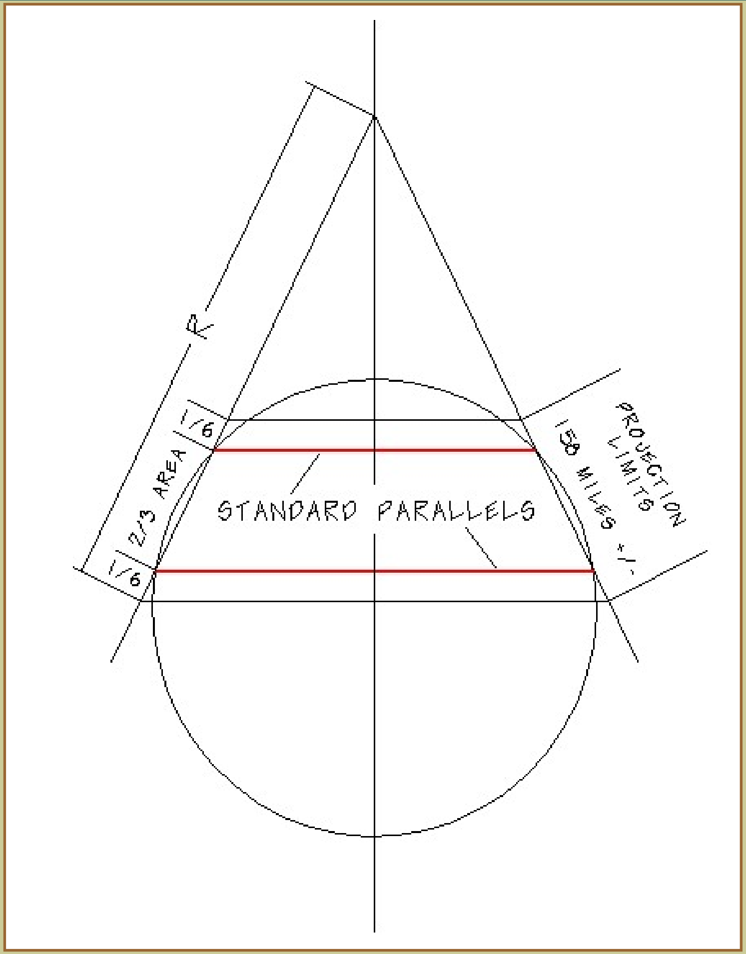
It is impossible to represent a curved surface on a plane without introducing distortion of:

- Angles
- Azimuths
- Distances
- or Areas.

An appropriate map projection must be chosen such that some of the four remain undistorted.



State Plane Coordinate System



Developed by USC&GS in 1933 at the request of an engineer from the North Carolina Highway Department

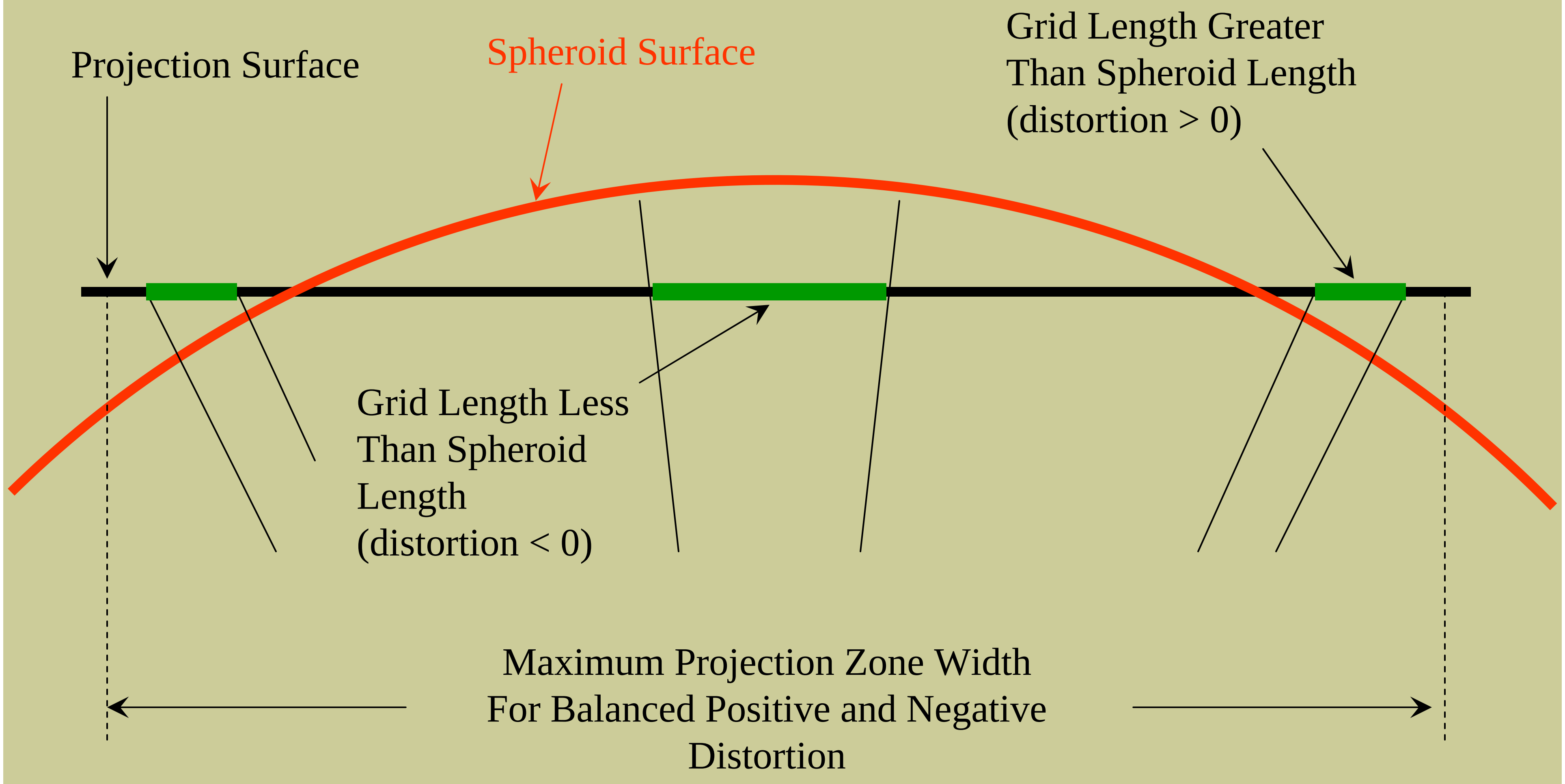
Oregon State Plane Coordinate System

- Developed by USC&GS in 1938
- Given legal status in 1945
- Lambert Conformal Conic Projection
- 2 zones
- 158 mile wide
- Maximum projection distortion 1:10,000
- No consideration for distortion by height

Linear Distortion

- Difference in distance between a pair of grid coordinates when compared to ground coordinates.
- Can be positive or negative
- Negative - grid length shorter than ground
- Positive - grid length longer than ground

Linear Distortion



Linear Distortion Due to **Earth Curvature**

Zone Width (miles)	Maximum Linear Distortion		
	PPM	Feet/Mile	Ratio
16	+/- 1	+/- 0.005	1:1,000,000
50	+/- 10	+/- 0.05	1:100,000
71	+/- 20	+/- 0.1	1:50,000
112	+/- 50	+/- 0.3	1:20,000
158	+/- 100	+/- 0.5	1:10,000
317	+/- 400	+/- 2.1	1:2,500

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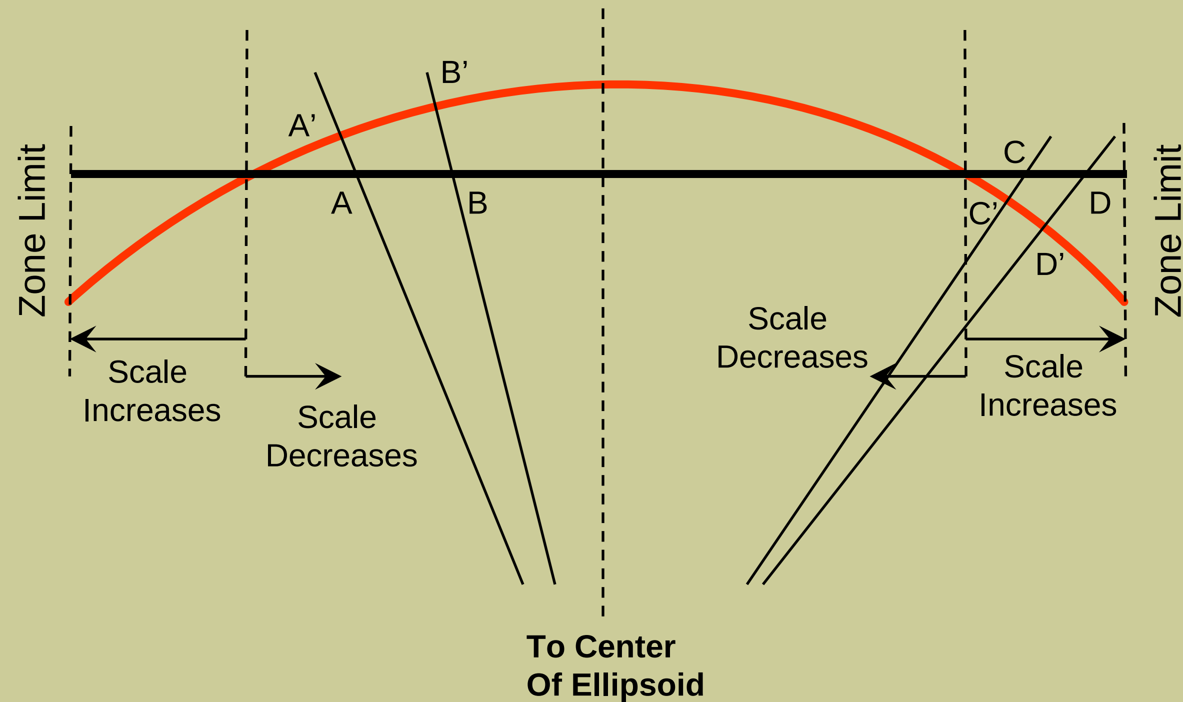
Projection Scale Factor

The Projection Scale factor is the ratio of a distance on the grid projection to the corresponding distance on the ellipsoid caused by earth curvature.

- **Grid Distance A-B is smaller than Geodetic Distance A'-B'**
- **Geodetic Distance C'-D' is smaller than Grid Distance C-D**



Angular Distortion

- For Conformal Projections (Oregon) – It is the Mapping Angle (theta)
- The Convergence Angle is the difference between Grid North and Geodetic North
- The Convergence Angle is zero at the Projection Central Meridian
- The Convergence Angle is positive East of the Central Meridian and negative West of the Central Meridian

Convergence Angle

Latitude	Convergence Angle 1 mile from Central Meridian
20°	0° 00’ 19”
30°	0° 00’ 30”
40°	0° 00’ 44”
45°	0° 00’ 53”
50°	0° 01’ 02”

Convergence Angle

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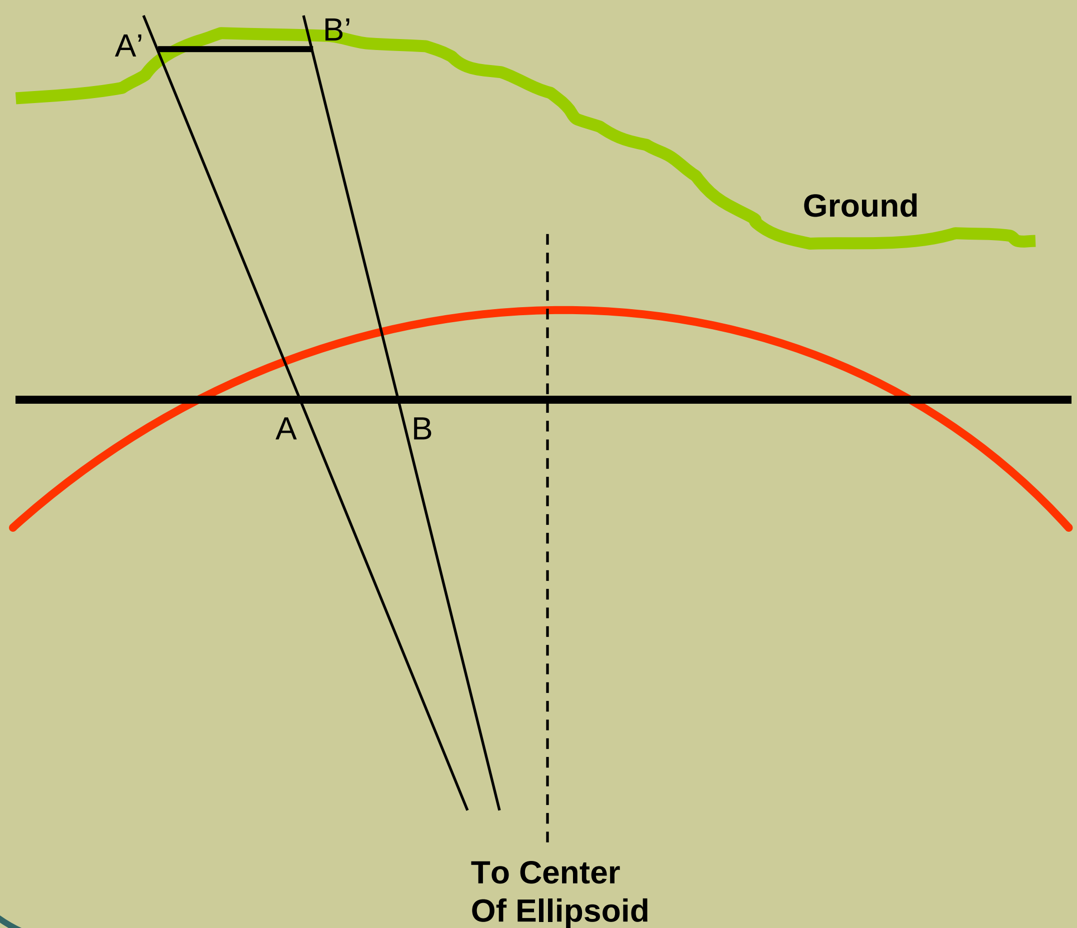
Ellipsoid Height Factor



The Ellipsoid Height Factor is the ratio of a distance on the grid projection to the corresponding distance on the ground plane.

Linear Distortion
Due to **Height Above Ellipsoid**

Height (ft) (above ellipsoid)	Maximum Linear Distortion		
	PPM	Feet/Mile	Ratio
100	4.8	0.03	1:209,000
400	19	0.1	1:52,000
1,000	48	0.3	1:21,000
2,000	96	0.5	1:10,500
4,000	191	1	1:5,200
7,000	335	1.8	1:3,000

Total Linear Distortion

- Combination of distortion due to earth curvature and height above ellipsoid
- Often, the distortion due to the height above the ellipsoid is greater than due to curvature

Problems with SPC

- Does not represent ground distances
- Does not minimize distortion over large areas
- Does not reduce Convergence Angle
- Does not support modern surveying accuracy requirements

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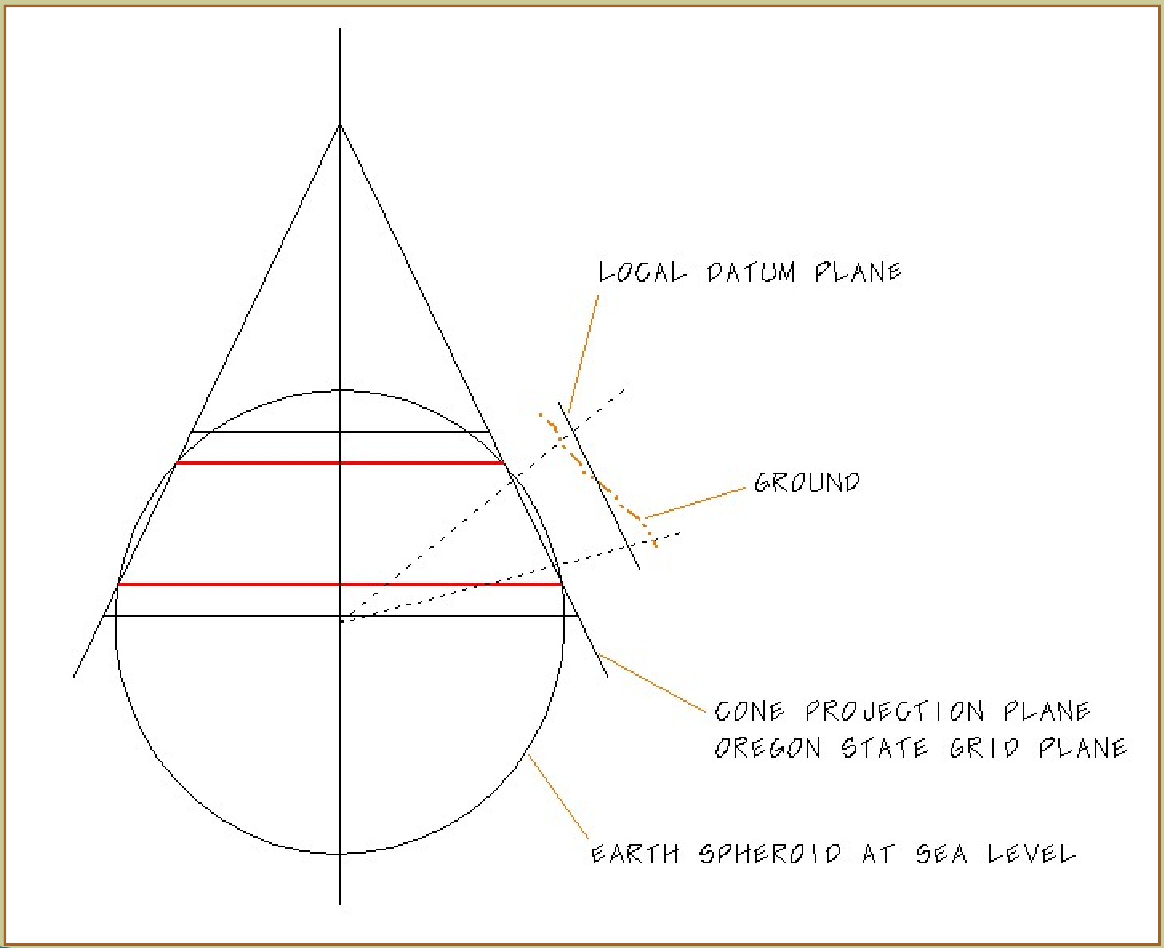
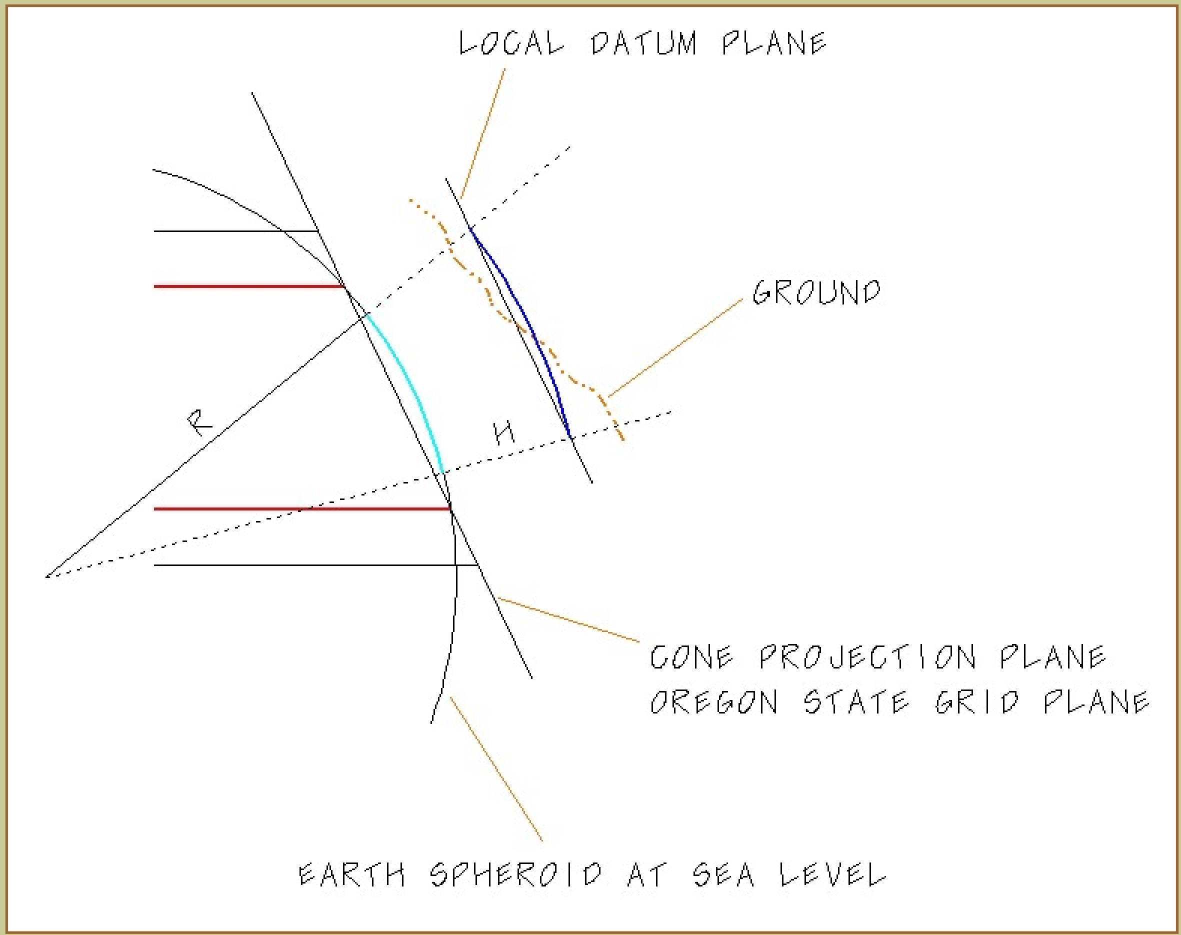
Local Datum Plane Coordinates

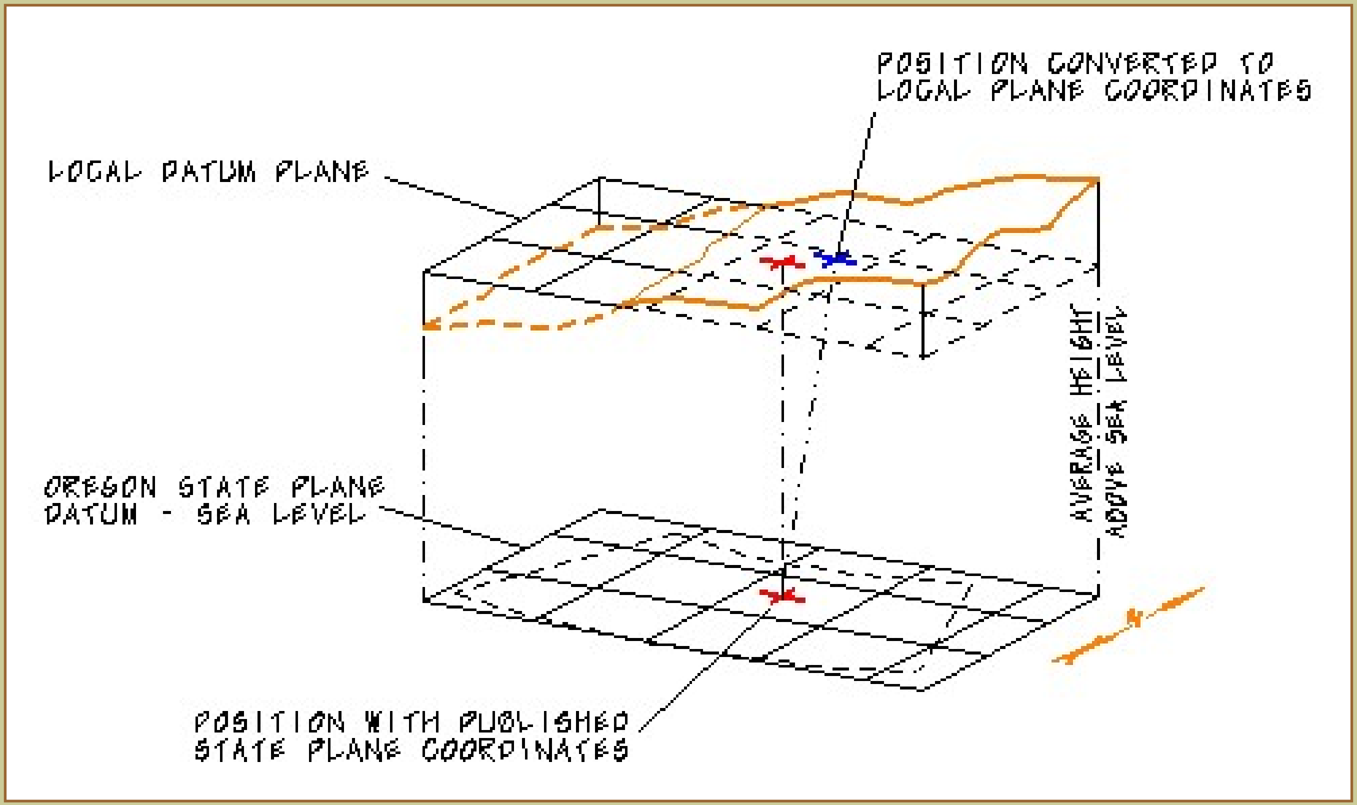


Developed by ODOT shortly after the implementation of the State Plane System

Local Datum Plane Coordinates



Local Datum Plane Coordinates



Local Datum Plane Coordinates

- Creates a plane close to the project elevation that is parallel to the State Plane grid
- Scaled by a Combined Scale factor

Problems with LDPC

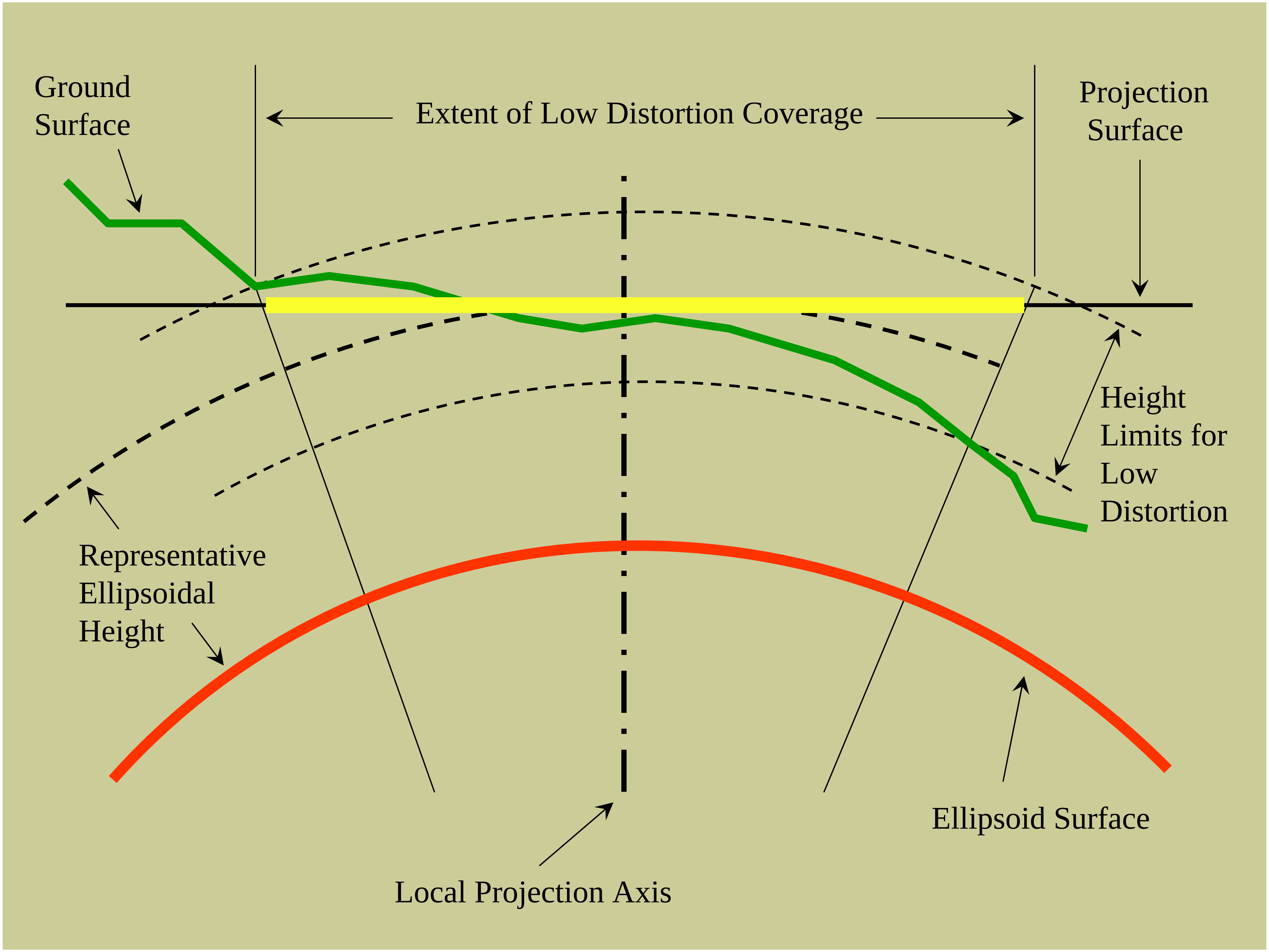
- Small low distortion area
- LDP Coordinates look similar to State Plane
- Not truly Geo-Referenced
- Each project on the LDPC System is on its own local coordinate system, loosely tied to the State Plane system.

Why Change?

- Eliminate dual coordinate grids
- Requirement for higher accuracy
- Eliminate the need to convert from grid to ground
- Inclusion of geodetic surveying in our work
- Blending of GPS and TPS positioning
- Blending of Survey/Engineering and GIS Data

Low Distortion Projections

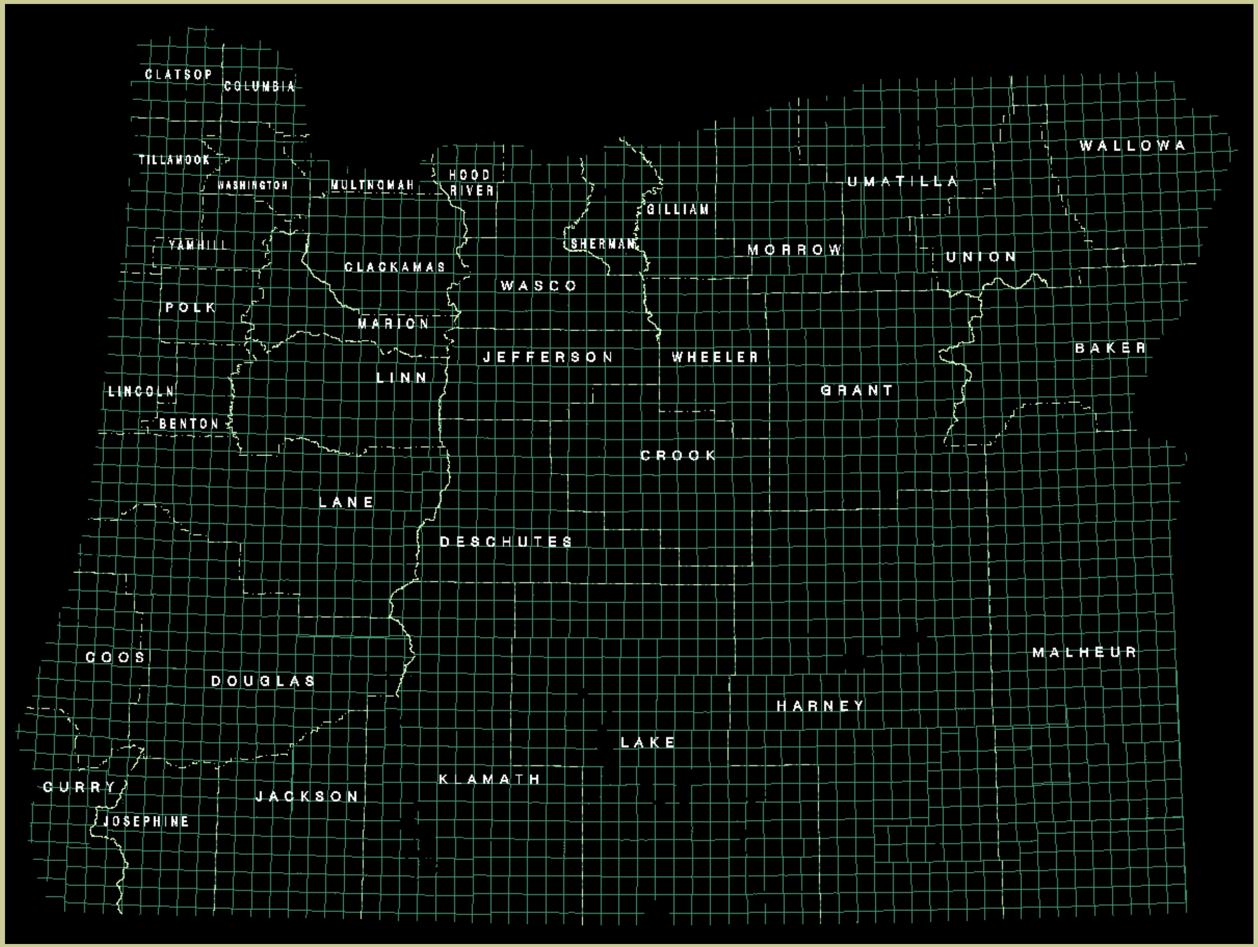
- Minimizes difference between “Grid” and “Ground”
- Central Meridian and Latitude near site, reducing distortion and Convergence Angle
- Well documented – easy to transform between LDP and NSRS


Ground Surface
Extent of Low Distortion Coverage
Projection Surface
Height Limits for Low Distortion
Representative Ellipsoidal Height
Ellipsoid Surface
Local Projection Axis

Proposed Implementation

- Replace (or supplement) the existing Oregon State Plane System with multiple predefined LDP Zones
- Make official and legal – Revise ORS 93

Organize by Township?



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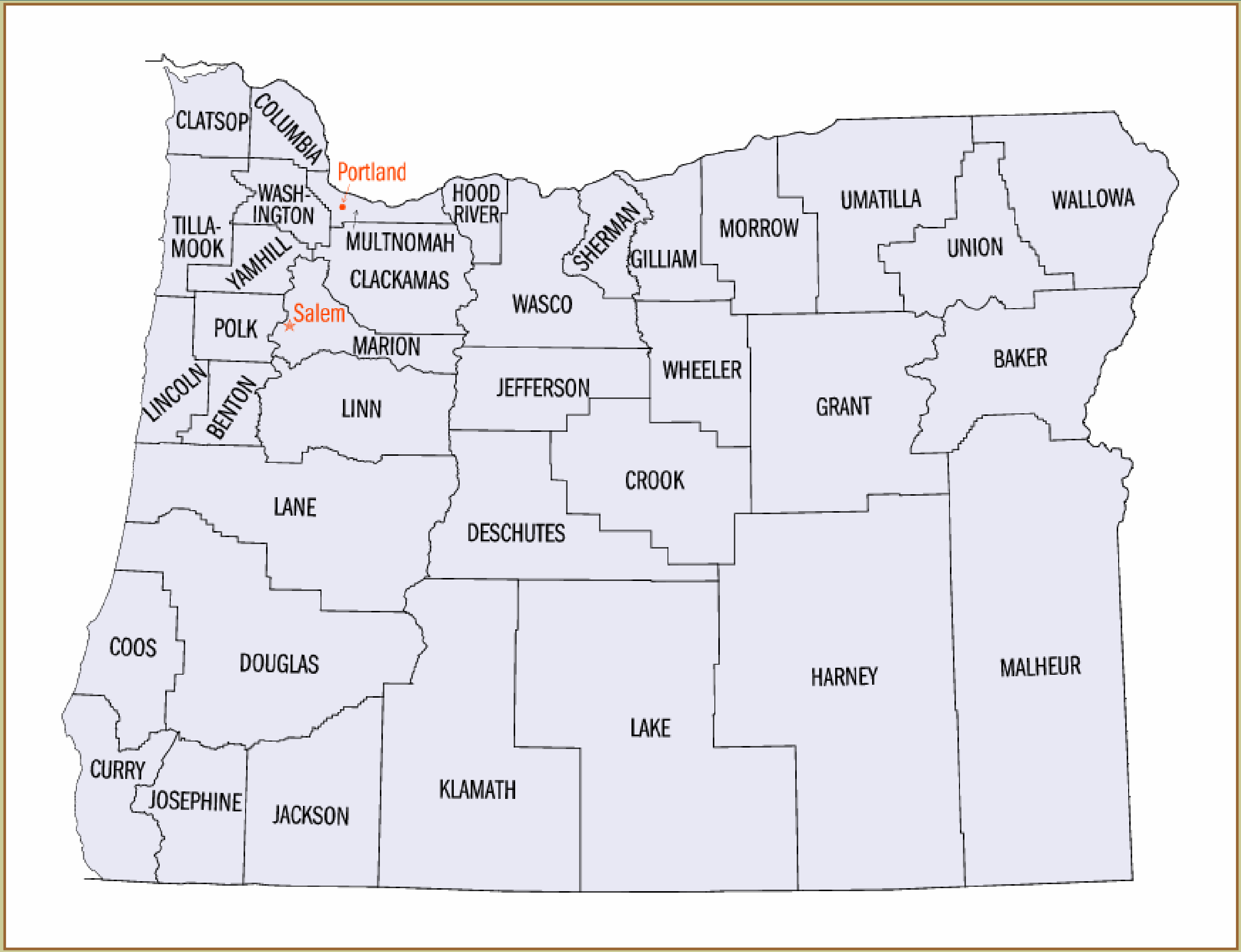
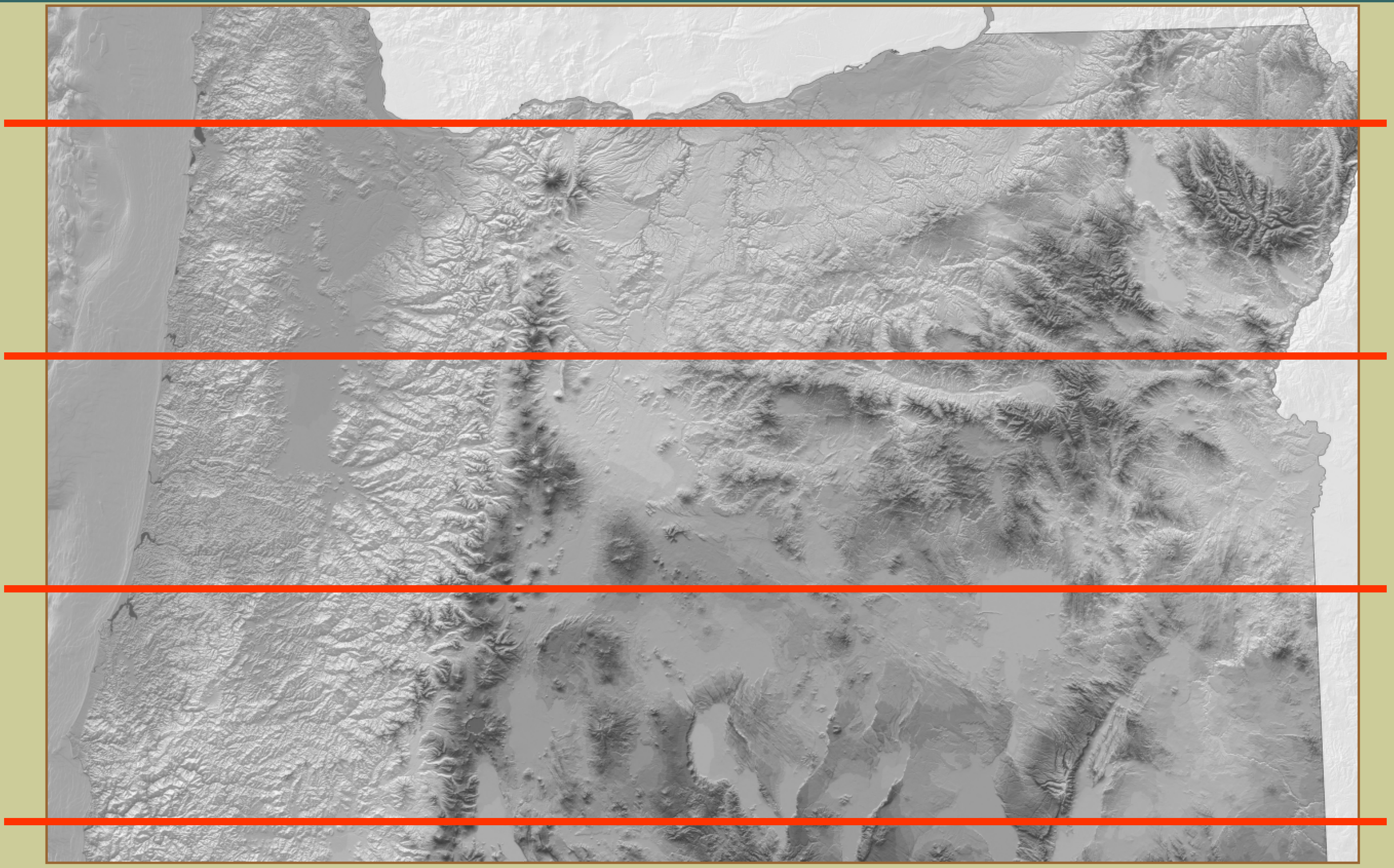
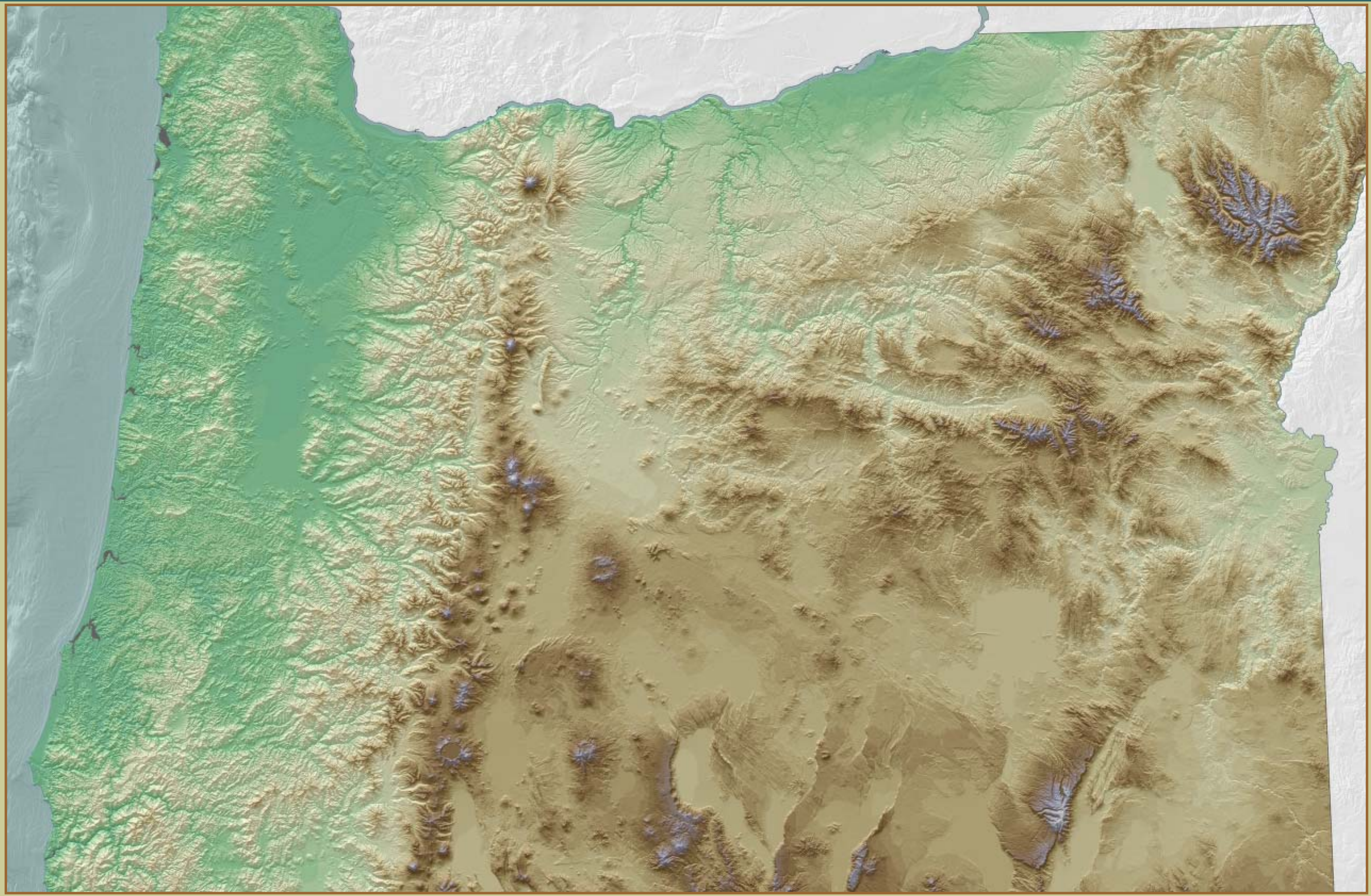
Organize by County?



Latitude Consideration



Elevation Consideration



Steps to Create Predefined Low Distortion Projections

1. Define Zone and choose representative Ellipsoid Height
2. Choose Projection Type
3. Define Linear Units and Geodetic Datum
4. Locate Projection Axis near centroid of zone
5. Scale Central Meridian to representative Height above Ellipsoid
6. Check distortion across zone
7. Document projection parameters

NGS Involvement

- Proposed by Dave Minkel (AZ Advisor) and Michael Dennis (Geodetic Analysis)
- LDP Design Tool – to ensure these projections are well designed using best practices
- LDP Registry – to ensure users are aware of LDP in the area and to publish LDP metadata
- LDP option in OPUS
- LDP Coordinates on Data Sheets
- NGS Currently Undecided

Issues

- Should be tied to the National Spatial Reference System
- Must be a collaborative effort with Federal, State, Local, academic, and private parties
- Oregon Revised Statutes
- Oregon Real-Time GPS Network

Next Steps

- Determine interest amongst the Surveying and GIS community in Oregon
- Encourage NGS to support LDP concept
- Develop test zone
- Evaluate integration with the ORGN
- Implement