Oregon Department of Transportation

GNSS Surveying Update in Oregon

Civil GPS Service Interface Committee

States & Local Government Session

20 September, 2010

Ken Bays, PLS

Lead Geodetic Surveyor, Oregon DOT

Oregon DOT Geometronics Unit

Ron Singh, Chief of Surveys, Manager

Geometronics

- Photogrammetry
- Survey Operations
- Right-of-Way Engineering
- Geodetic Control

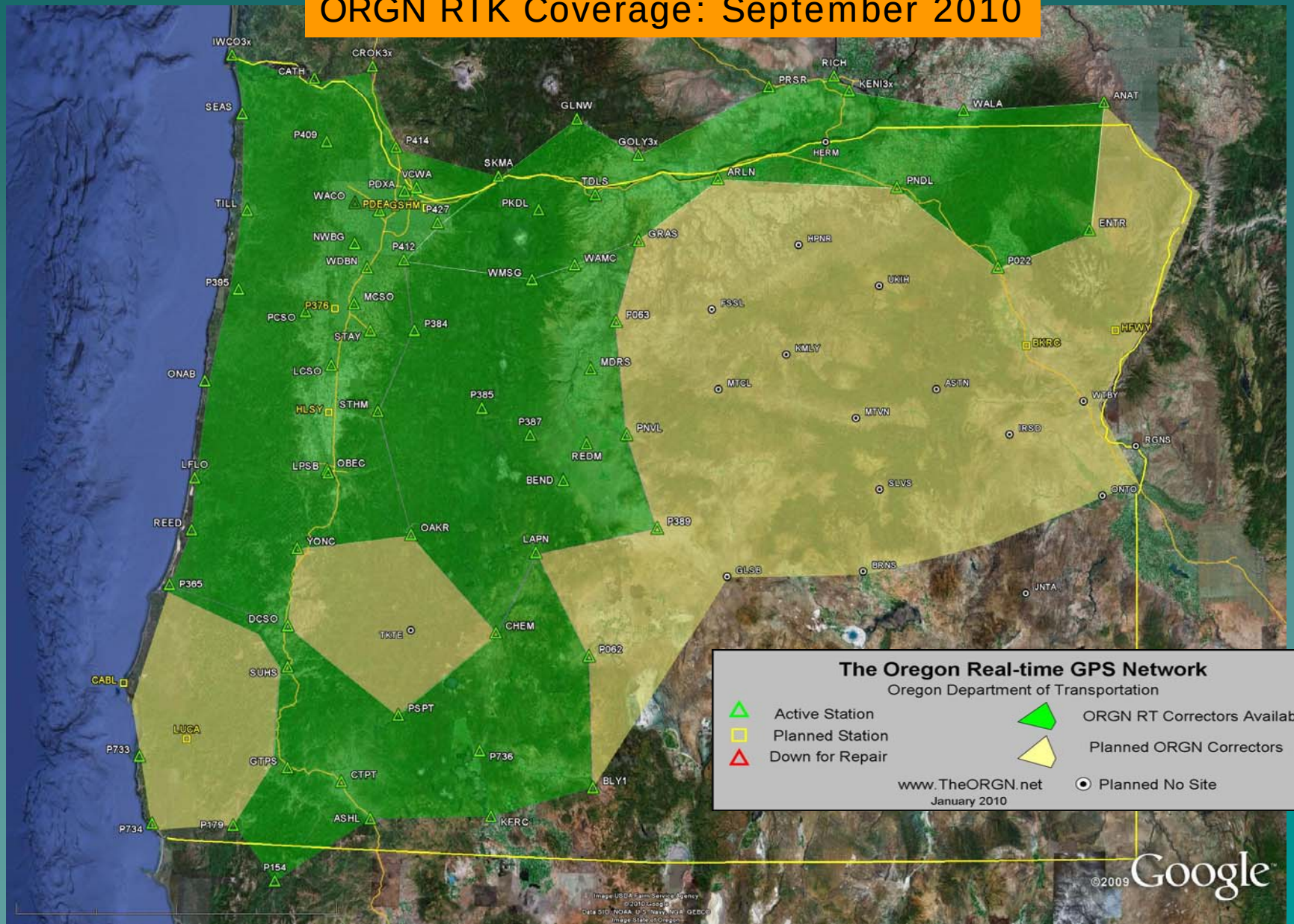
Oregon DOT Geometronics Unit Geodetic Team's Mission

- Revive and enhance Vertical and Horizontal Geodetic Control in Oregon
  - Application of Height Modernization to move towards accurate GPS-derived heights rather than replacing passive benchmarks
- Develop a state network of Continuously Operating GPS Stations

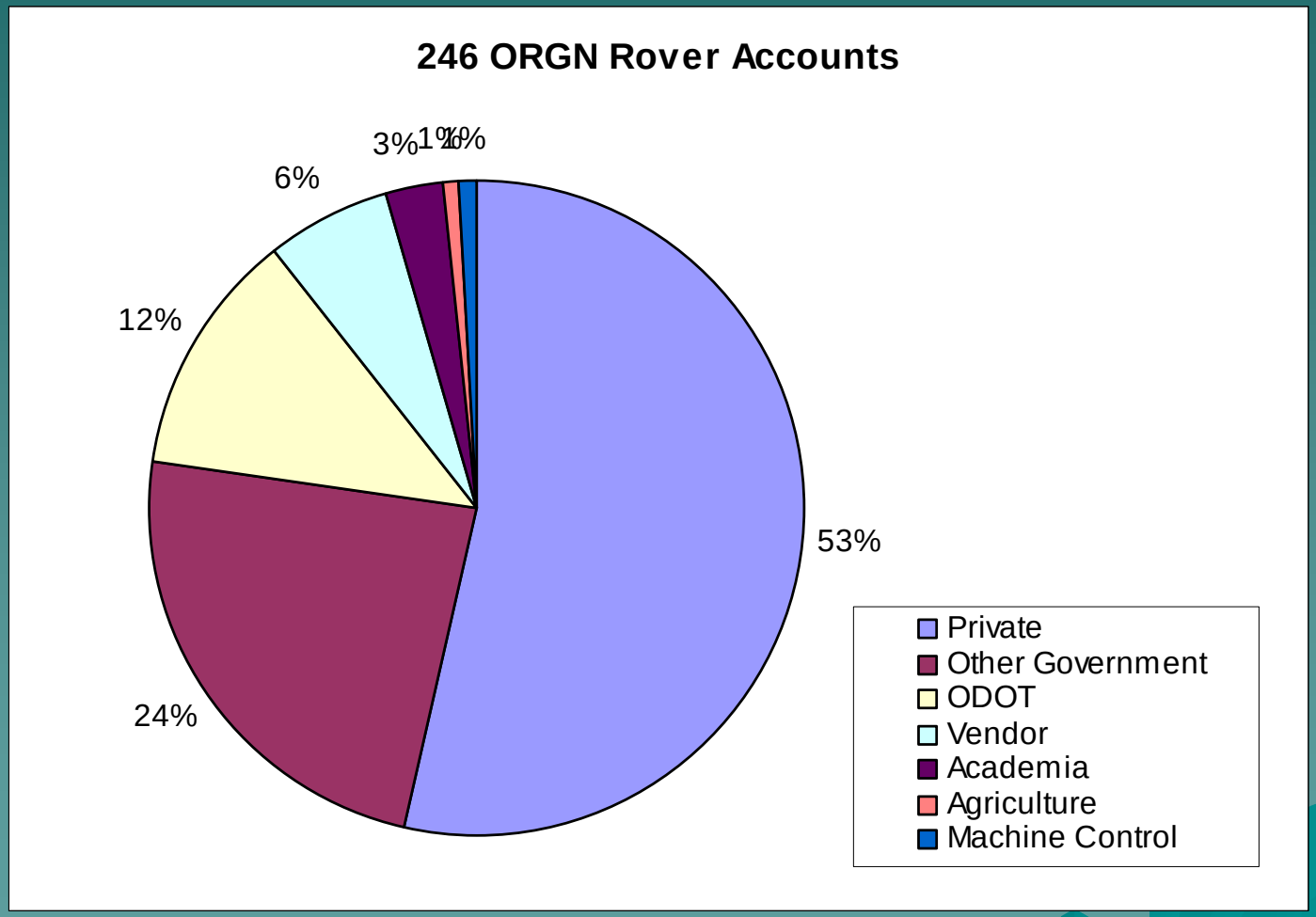
Summary

- Update on status of the Oregon Real-time GPS Network (ORGN)
- The Oregon Coordinate Reference System (OCRS)
  - Low distortion mapping projections
- Design to Dozer: Computer Controlled Heavy Machinery Demo
- ORGN preparations for the upcoming change in NAD 83 datum realization for the NGS National Spatial Reference System:
  - a software “tool” for data conversion between the new and the superseded datum realizations.

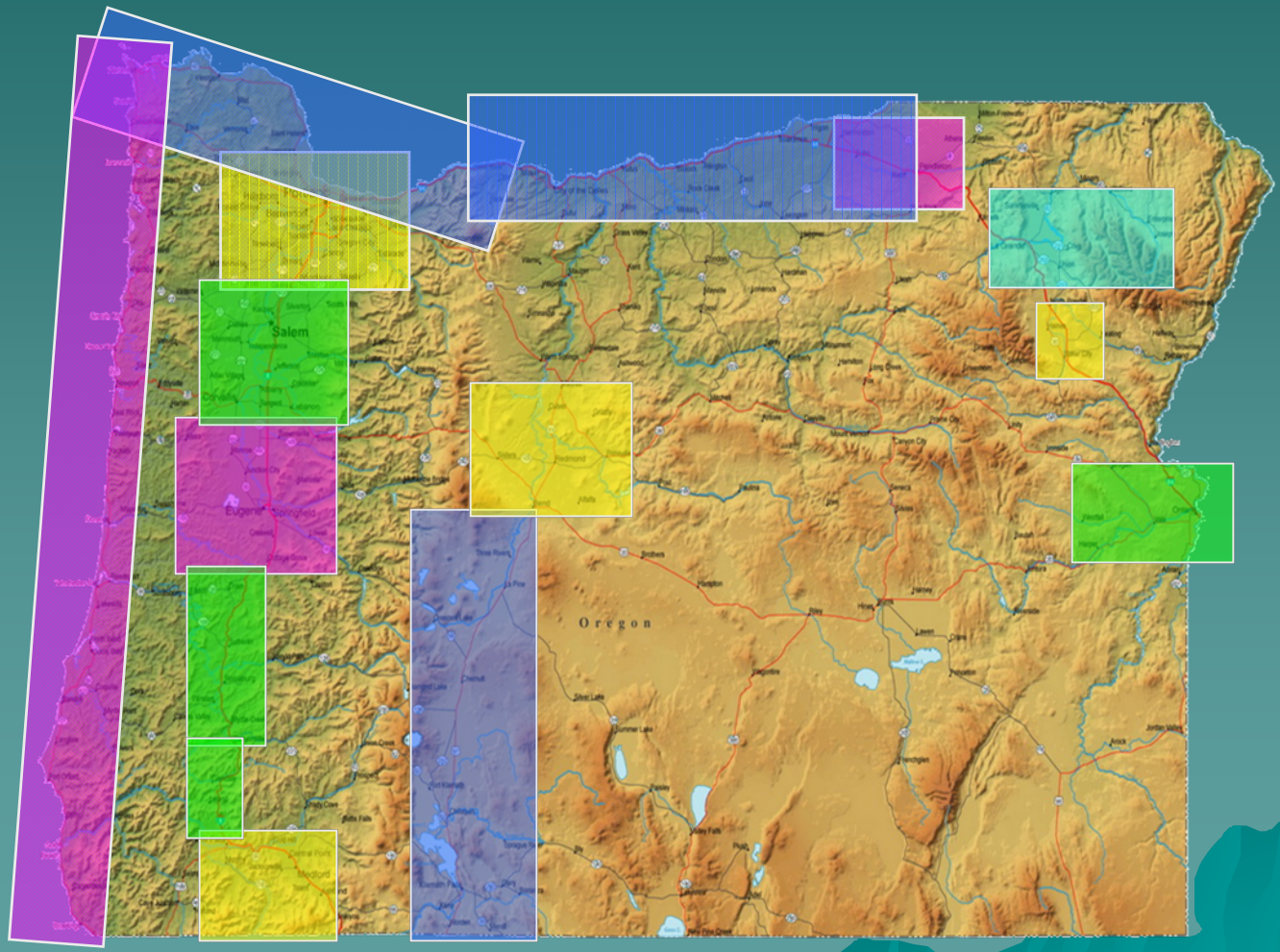
ORGN RTK Coverage: September 2010



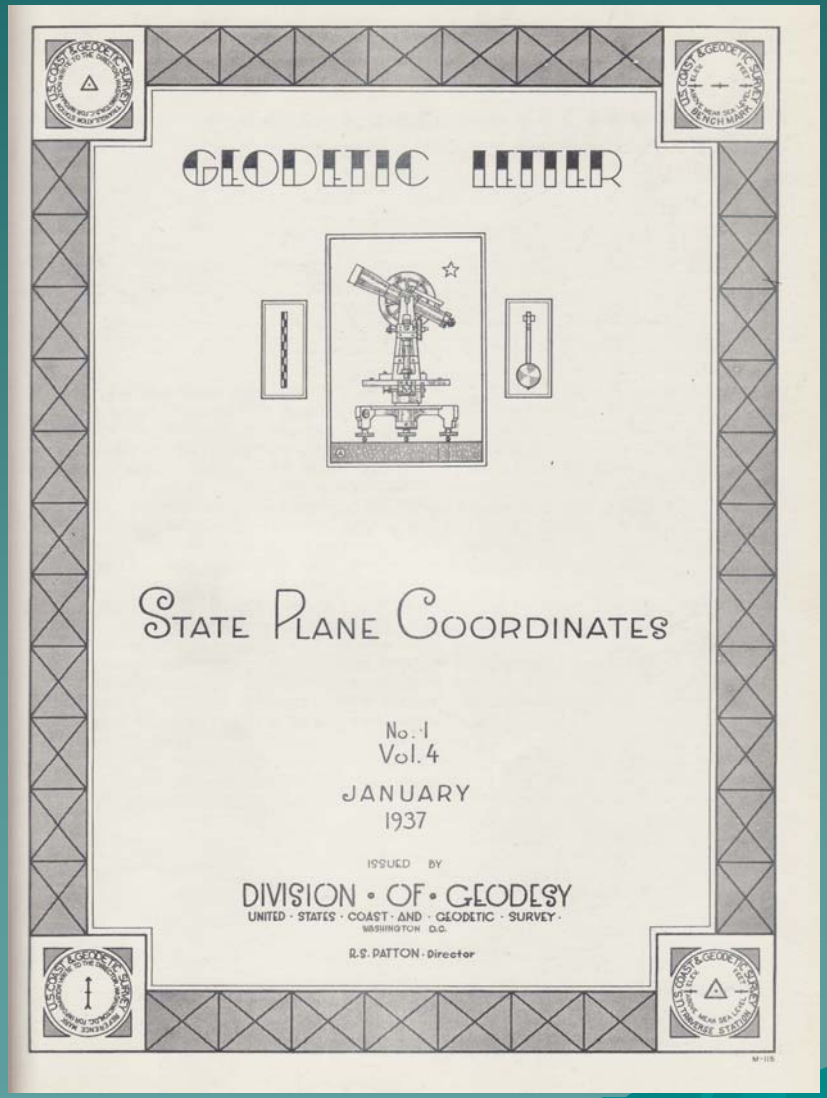
ORGN Rover Accounts: Sept 2010



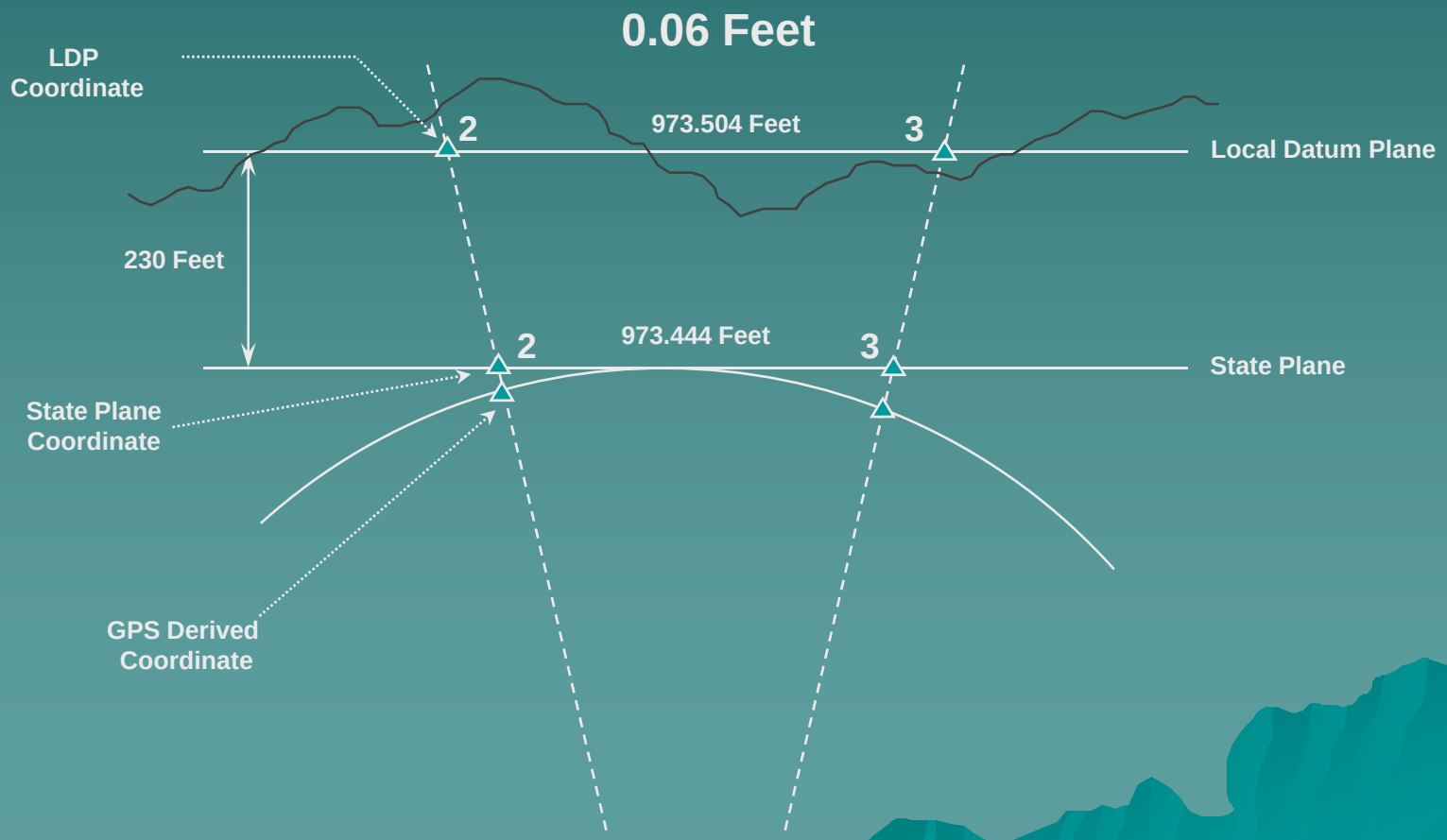
Oregon Coordinate Reference System



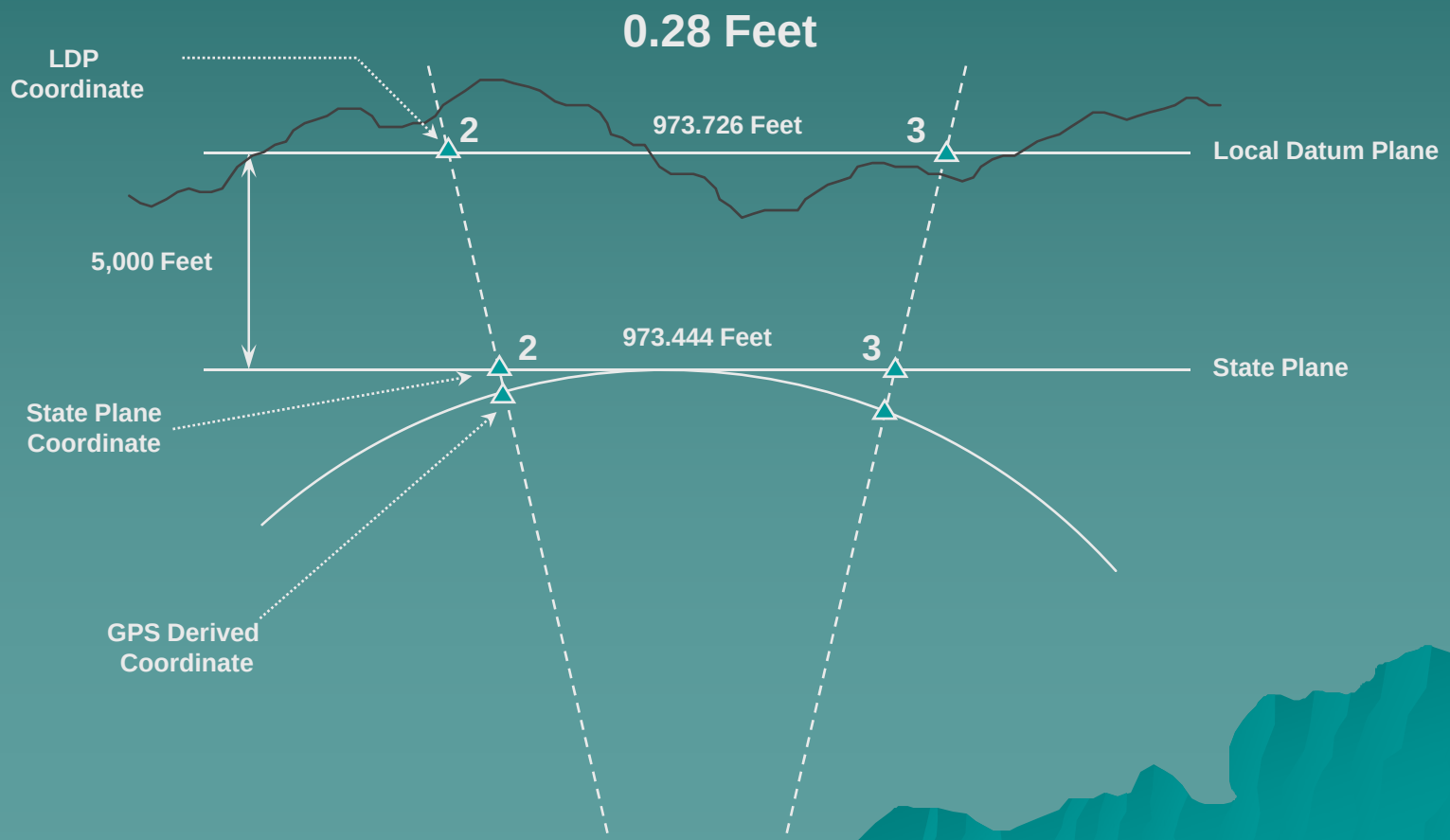
Oregon State Plane Coordinate System

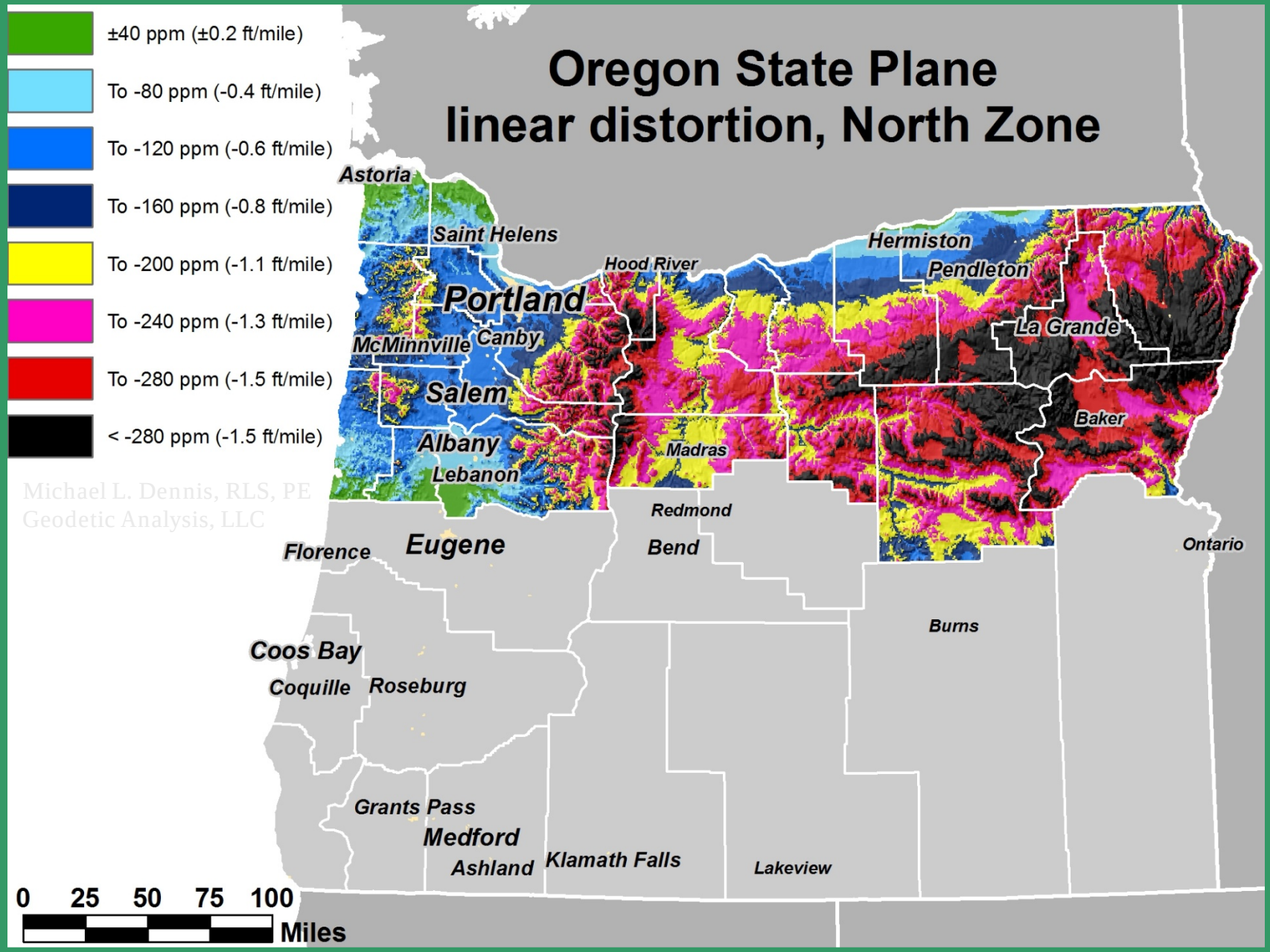


Distortion Due to Elevation



Distortion Due to Elevation




Oregon State Plane
linear distortion, North Zone
±40 ppm (±0.2 ft/mile)
To -80 ppm (-0.4 ft/mile)
To -120 ppm (-0.6 ft/mile)
To -160 ppm (-0.8 ft/mile)
To -200 ppm (-1.1 ft/mile)
To -240 ppm (-1.3 ft/mile)
To -280 ppm (-1.5 ft/mile)
< -280 ppm (-1.5 ft/mile)
Michael L. Dennis, RLS, PE
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McMinnville
Canby
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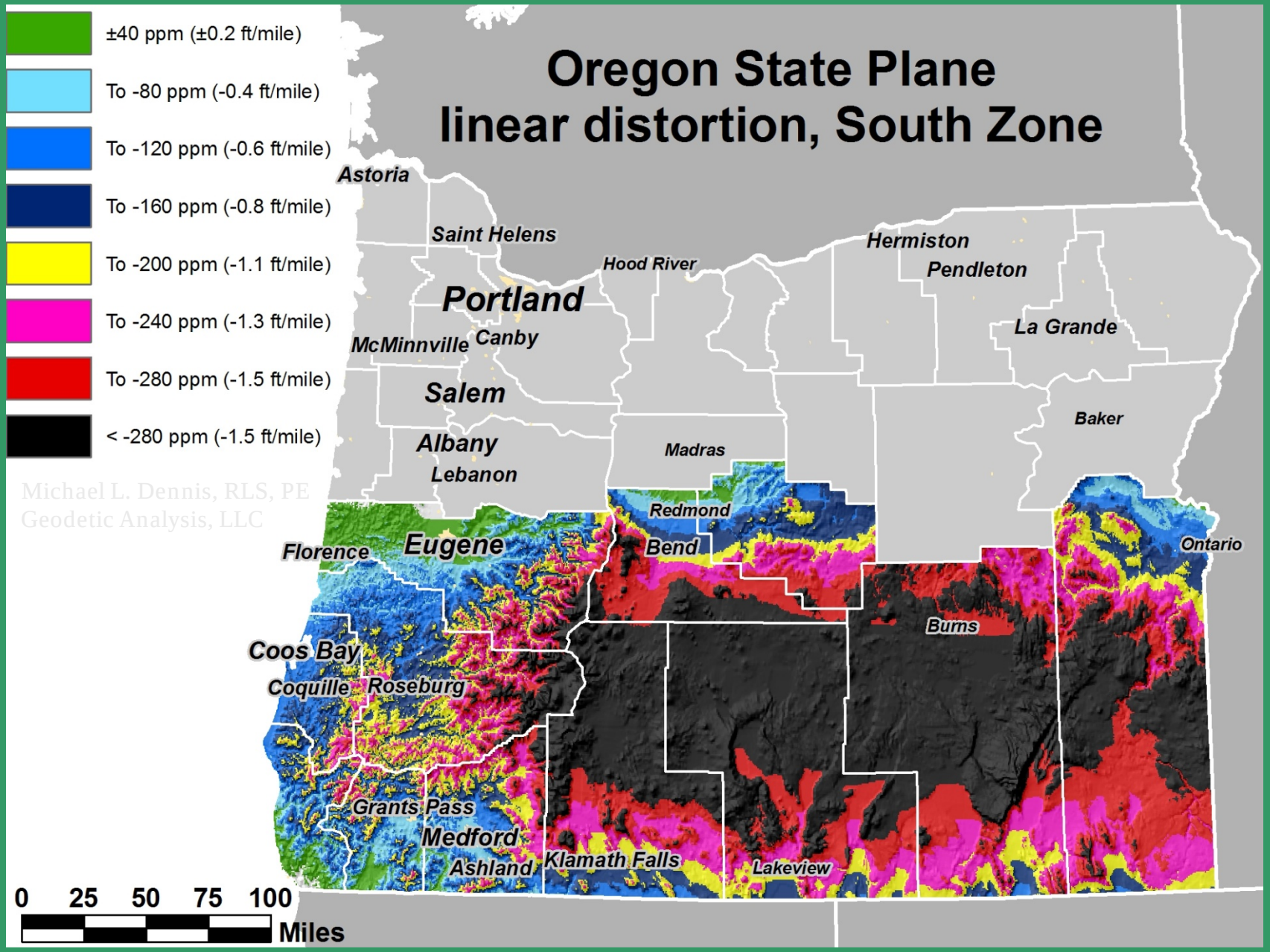
Albany
Lebanon
Hood River
Hermiston
Pendleton
La Grande
Baker
Madras
Redmond
Bend
Florence
Eugene
Ontario
Burns
Coos Bay
Coquille
Roseburg
Grants Pass
Medford
Ashland
Klamath Falls
Lakeview
0 25 50 75 100
Miles


Oregon State Plane
linear distortion, South Zone
±40 ppm (±0.2 ft/mile)
To -80 ppm (-0.4 ft/mile)
To -120 ppm (-0.6 ft/mile)
To -160 ppm (-0.8 ft/mile)
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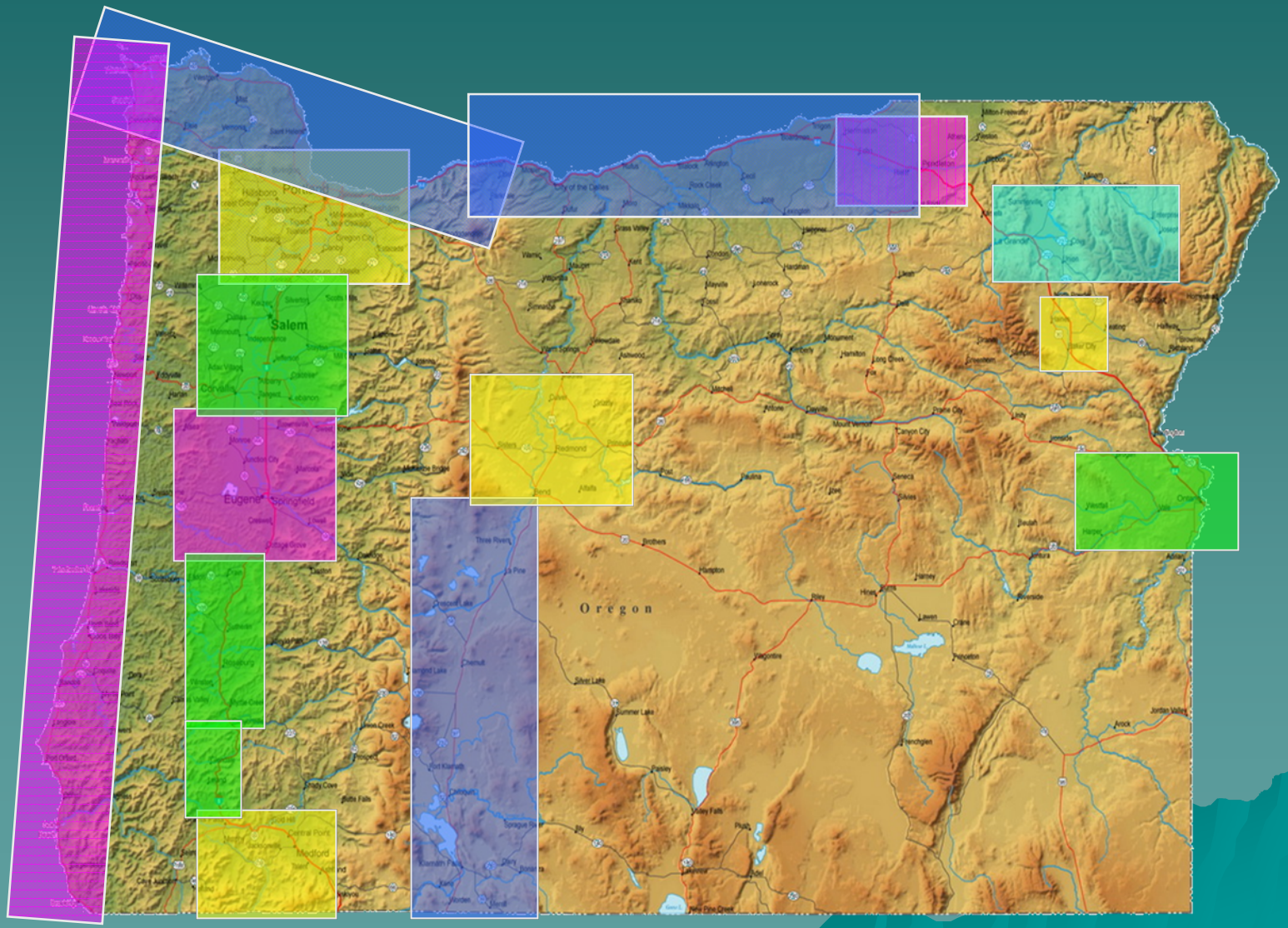
Baker
Ontario
0 25 50 75 100
Miles

Problems with SPC System

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

Oregon Coordinate Reference System (OCRS)



Initial Steps

- Determined interest amongst the Surveying and GIS community in Oregon
- ODOT/ Oregon GPS User Group Co-sponsored statewide informational workshop on low distortion projections
  - Speakers from NGS, academia, private
- Developed test zones
- Field tested initial zones
- Developed 15 initial zones to cover major transportation corridors.

Best Practices

- Should be tied to the National Spatial Reference System
- Must be a collaborative effort with Federal, State, Local, academic, and private parties
- The Oregon Real-Time GPS Network must facilitate the use of the OCRS
- Not constrained to monuments

Best Practices

- Identify all custom projections in use in Oregon
  - Attempt to incorporate these existing projections into the statewide system
- Involve NGS
- Involve GIS community
- Involve the local users
- Involve the software vendors

Best Practices

- Use a single reference ellipsoid – GRS80
- NAD83 utilizes GRS80
- Use 3 projections types:
  - Lambert Conformal Conic
  - Oblique Mercator
  - Transverse Mercator

Best Practices

- Select maximum distortion values
- Select D
  - Meters
  - 1 Inte 0.3048 meters exactly

Although the projection is defined in meters, the resulting coordinates are in International Feet

- Metadata – document thoroughly
- Register OCRS with NGS

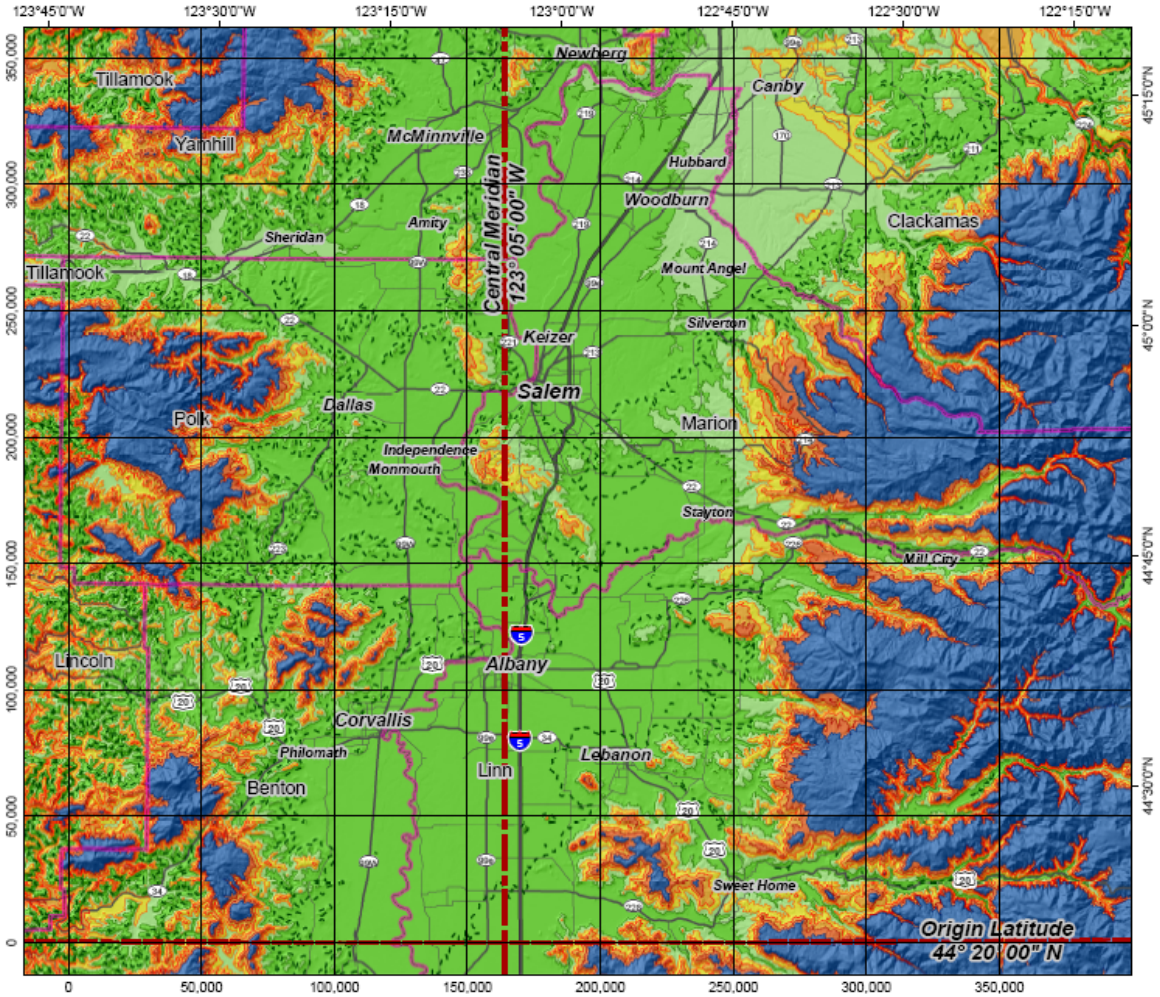
Next Steps

- Supplement – not replace - the existing Oregon State Plane System with multiple predefined Low Distortion Projections
- Evaluate integration with the ORGN
- Develop User Handbook
- Roll-out and Training
- Legislative changes to authorize use
  - Revise Oregon Revised Statutes 93 and 209

History


Mar, 2008
Presentation to ODOT
July, 2008
Presentation to OGUG
Nov, 2008
ODOT/OGUG Workshop
Jan, 2009
Presentation to PLSO
Apr, 2009
Created Technical Development Team
July, 2009
Developed Test Projections
Jan, 2010
Developed 15 Projections
Jan, 2010
Presentation to PLSO
Apr, 2010
Roll out/Workshop
Jan, 2011
Make official and legal
Revise ORS 93

Oregon Coordinate Reference System



Oregon Coordinate Reference System
Salem Zone

Transverse Mercator projection
North American Datum of 1983

Latitude of grid origin:	44° 20' 00" N
Central meridian:	123° 05' 00" W
False northing:	0.000 m
False easting:	50 000.000 m
Central meridian scale:	1.000 010 (exact)

Grid North

0 5 10 15 20 25 Miles

Linear distortion

- Zero distortion
- < -50 ppm (< -0.25 ft/mi)
- ±10 ppm (±0.05 ft/mi)
- 10 - 20 ppm (0.05 - 0.1 ft/mi)
- 20 - 30 ppm (0.1 - 0.15 ft/mi)
- 30 - 40 ppm (0.15 - 0.2 ft/mi)
- 40 - 50 ppm (0.2 - 0.25 ft/mi)
- > +50 ppm (> +0.25 ft/mi)

NOTE: Map grid is shown in units of international feet.

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Design to Dozer Demonstration

Computer Controlled Heavy Equipment

17-18 August, 2010

- Oregon DOT is poised for automation of:
  - Surveying
  - Design
  - Construction Administration

Demo Team

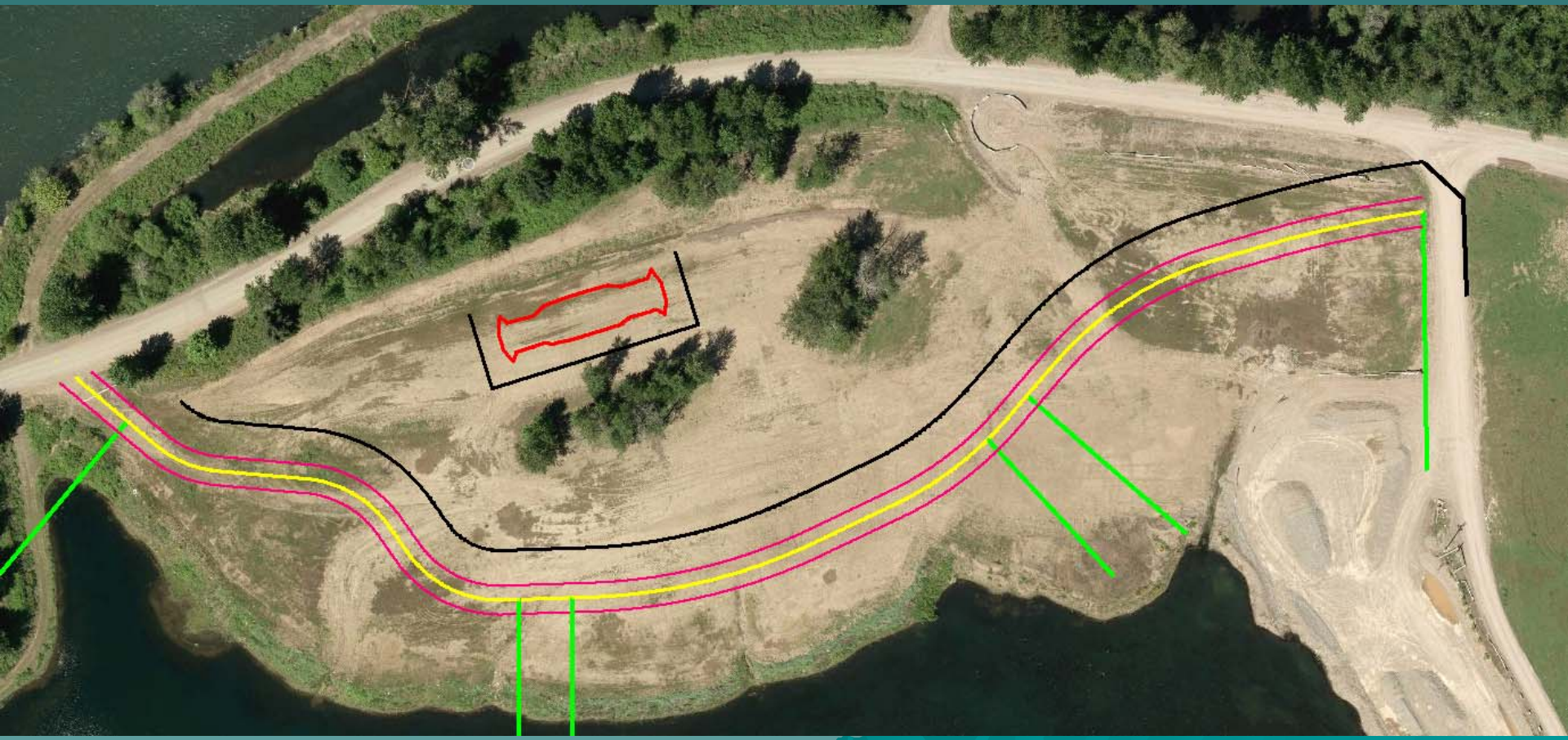
- Oregon Department of Transportation –
  - – Geometronics Unit Staff
  - – Brian Ngo – Region 1 Design
- Wildish Companies - Land Use and Dozer
- K&E Excavating, Inc. - Machine Control Construction
- Pacific Excavation, Inc. - Machine Control Construction
- PPI Group - Machine Control Support
- Bentley Systems - 3D Design Support
- SiTech Norcal - Machine Control Support

Undeveloped site

Pre-design Survey

- Geodetic Control:
  - Oregon Real-time GPS Network
- Coordinate System:
  - Oregon Coordinate Reference System

3-D Design



3-D Design

Design input into heavy equipment

Computer Controlled Construction

Section of Sub-grade completed

Visualization of Paved Surface

Datum Realization Conversion Software "Tool" for Oregon

What Datum is the ORGN on?

NAD 83 (CORS 96) (Epoch 2002)

The ORGN is aligned with the NGS CORS via OPUS solutions on ORGN stations.

What the “Tool” will do:

- **Converts users positions back and forth from:**
  - NAD 83(CORS96)Epoch2002
    [The current OPUS (and ORGN) datum realization]

    to/from

  - NAD 83(CORS96’a’)Epoch2010.5(?)
    [The future OPUS (and ORGN) datum realization]

Who will benefit from the “Tool”

- An ODOT project for the benefit of:
  - Oregon Real-time GPS Network (ORGN) users
  - Oregon OPUS-Static users
  - Oregon high accuracy GIS users
  - Other surveying, engineering stakeholders in the State of Oregon

We are planning ahead!

Who is developing the “Tool”

- Michael Olsen, Assistant Professor of Geomatics, Oregon State University is developing the mathematical algorithms and software.
- Cooperation, input, and assistance from:
  - Oregon DOT Geometronics Unit
  - Mark Armstrong, NGS State Geodetic Advisor for Oregon

We are planning ahead!

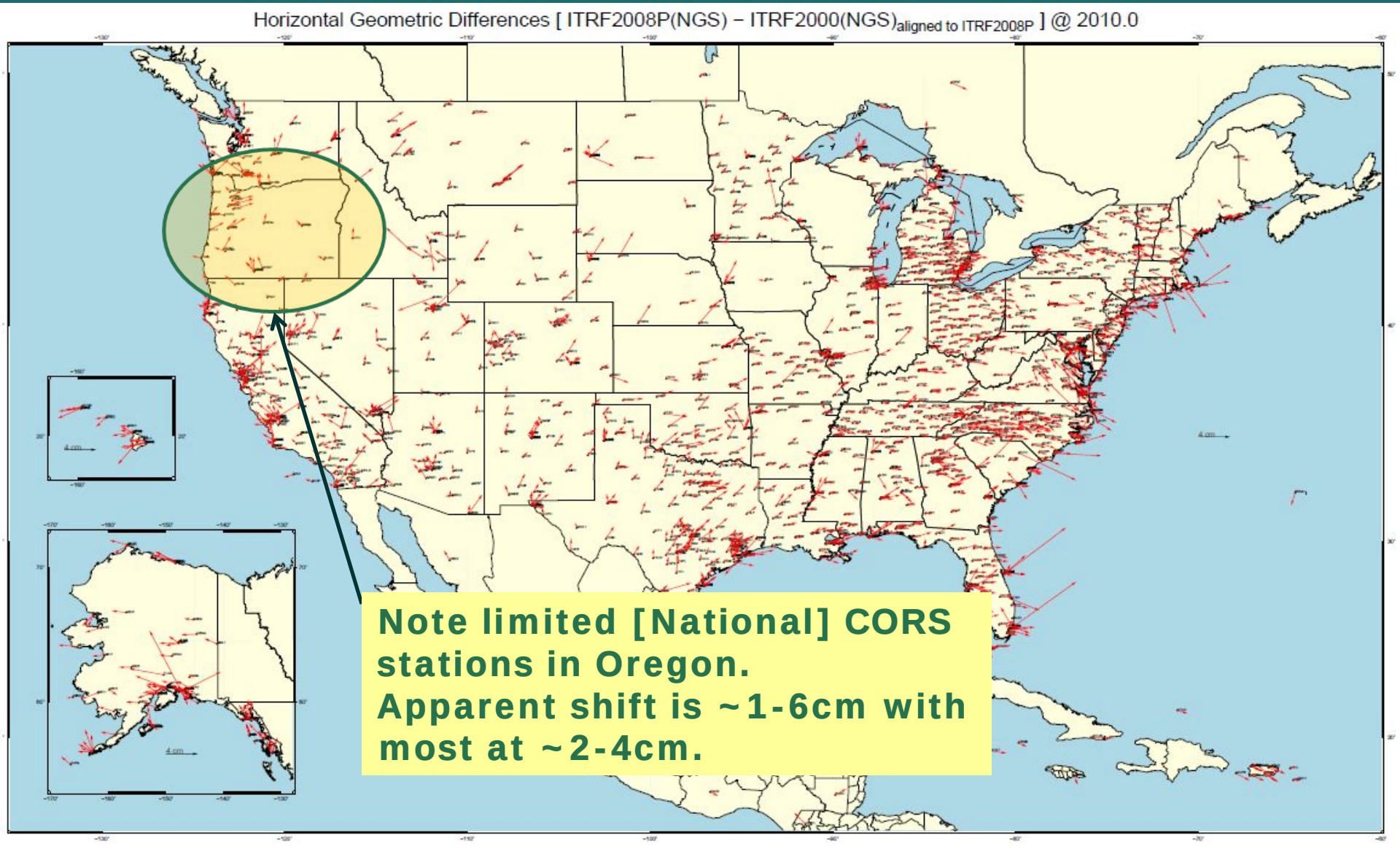
Why do ORGN users in Oregon need this Tool?

- Will ensure continuity within projects
  - User may keep a single datum realization for a project spaced over the change from the superseded to the new datum realization.
- Provides an immediate datum realization transition solution until user projects are solely within the new datum realization
- Keep ORGN Manager's phone from ringing off the hook!

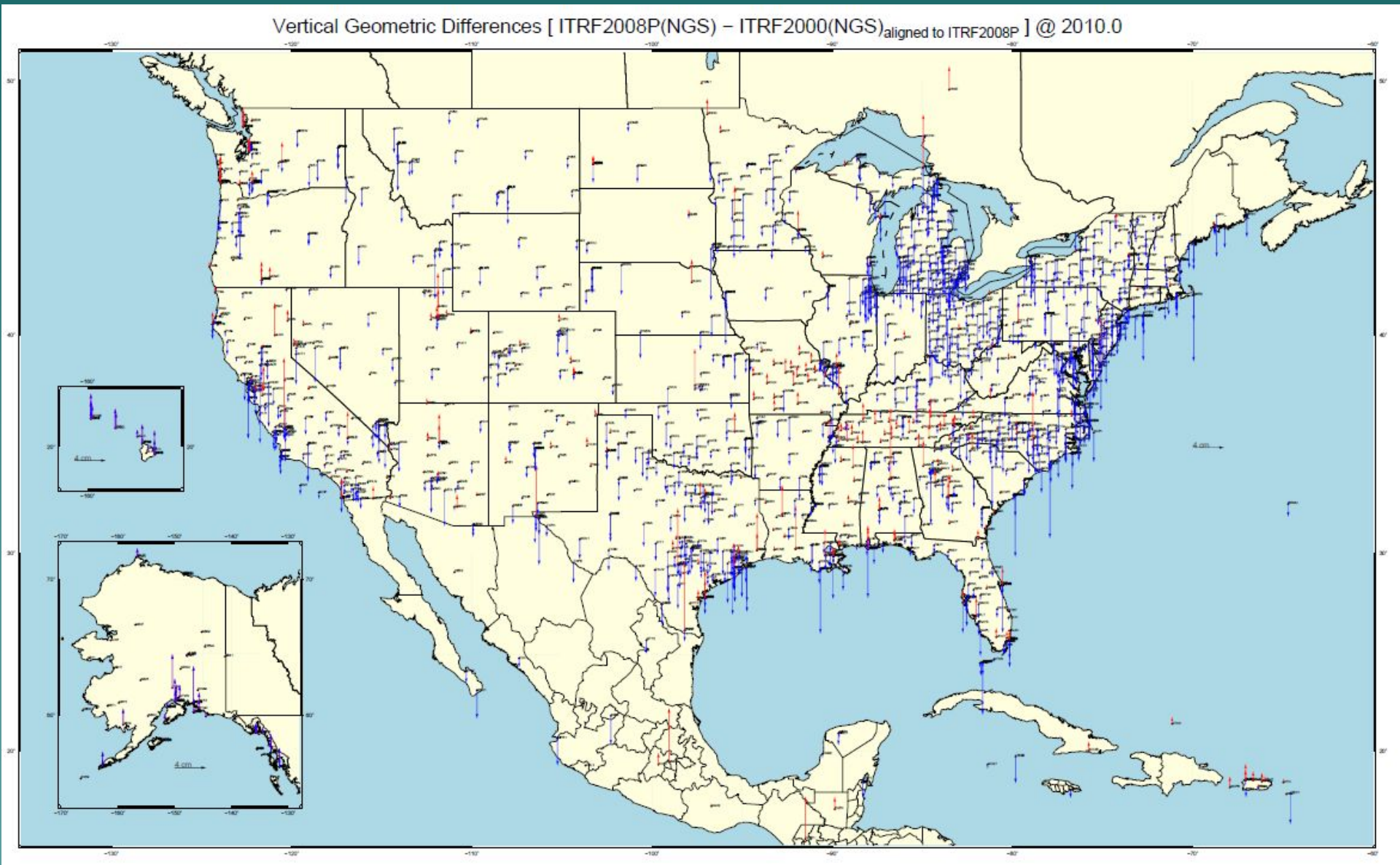
Details of the “Tool”

- To achieve the required sub-cm level of accuracy, data from **all** of the ~125 CORS in and surrounding Oregon, not only from the NGS National CORS, will be included in the data model for the “Tool”.
  - **Only ~25 NGS National CORS within Oregon** (not enough data points uniformly spaced for the best solution possible.)
  - The Oregon Real-time GPS Network makes use of many CORS which have not been submitted to the NGS as co-op CORS.
  - Generally speaking, OR, WA, CA (west coast) have more movement (shift) between the two datum realizations than other CONUS regions.

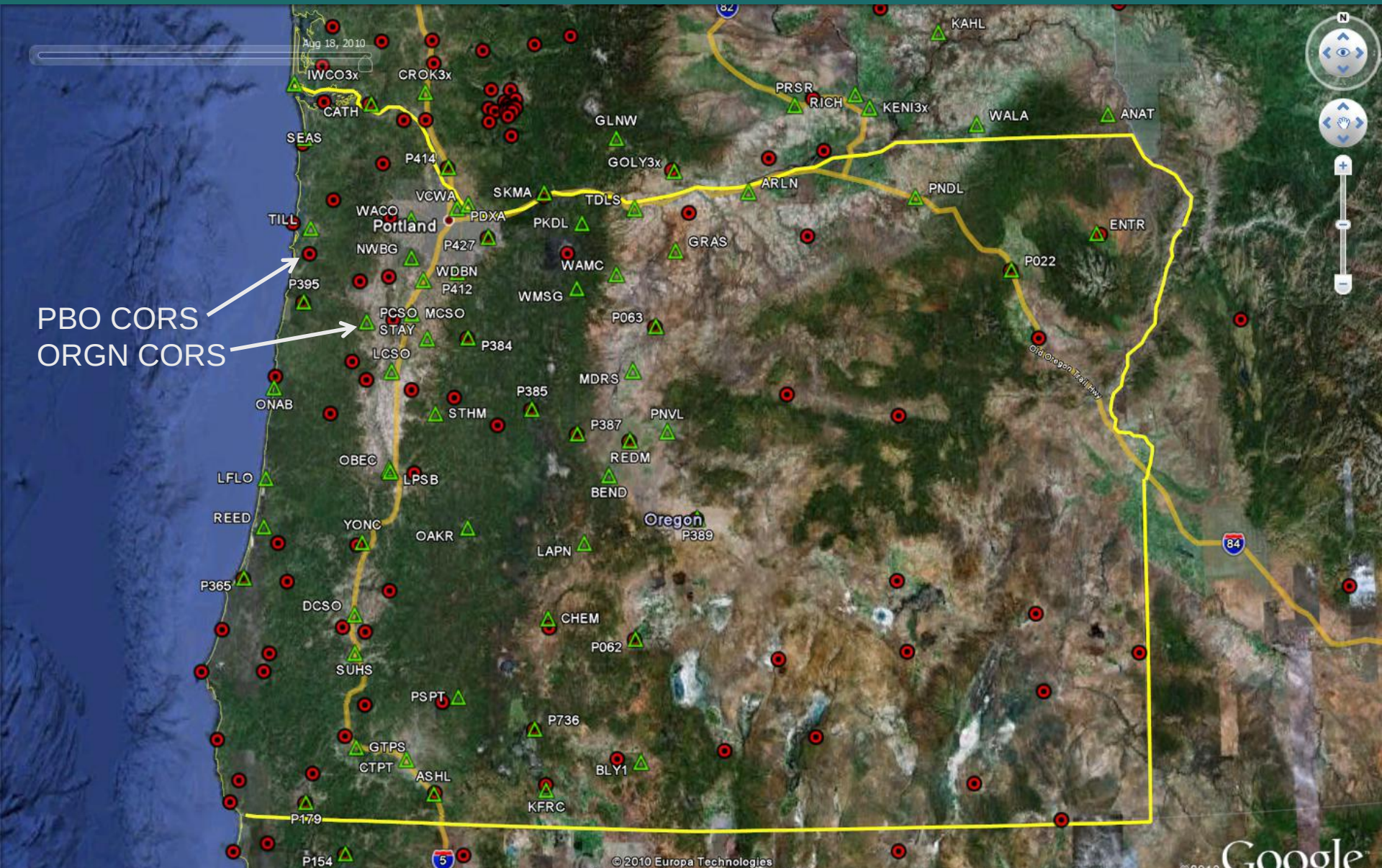
2D differences ITRF2008P(NGS) – ITRF2000 aligned to ITRF2008P @2010.0



Vertical Differences



CORS Used in the “Tool” data model



How the Oregon OPUS Datum Conversion Tool (ODCT-OR) is being developed

- **For the current OPUS datum realization:**
  1. For the period August 1-10, 2010, download 10 days of 24-hour RINEX files from the ~125 OR, WA, CA CORS stations: NGS, ORGN, PBO, ORGN, WSRN
  2. Submit the ~1250 files to present realization of OPUS-S
  3. Mean the 10 daily OPUS solutions for each CORS.
  4. The mean 3D position then entered into software as input data.

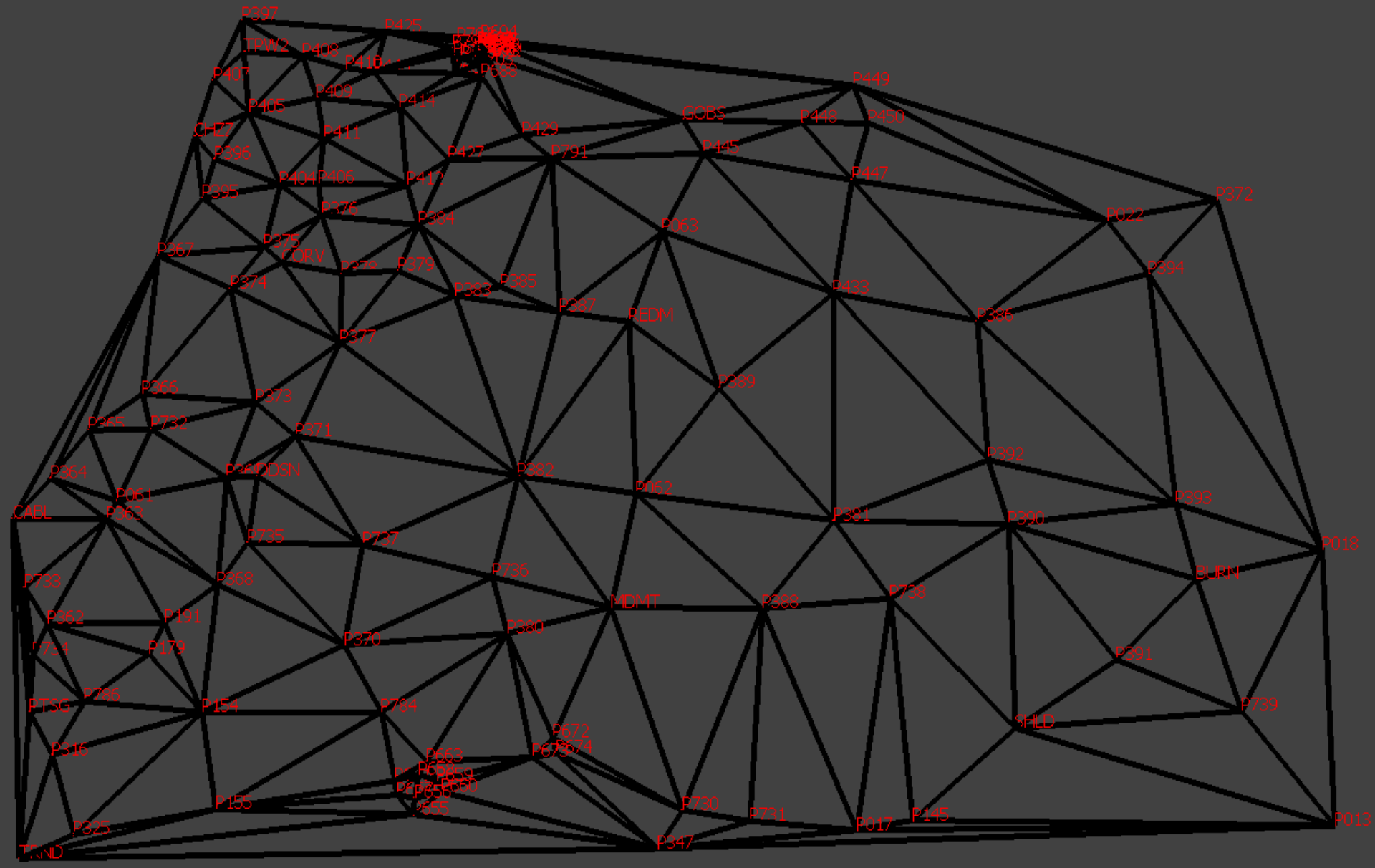
How the Oregon OPUS Datum Conversion Tool (ODCT-OR) is being developed

- For the <u>new</u> OPUS datum realization, input data per the same steps as before:
  - Note that for step (3), the submissions to OPUS will occur after OPUS reports solutions in the new NAD 83 (CORS96'a') Epoch 2010.5(?) datum realization.
  - Also, the OPUS engine may use a different process at that time.
- The two different geodetic positions recorded for each of the CORS will reflect the exact lat/long/elevation differences between the two datum realizations.

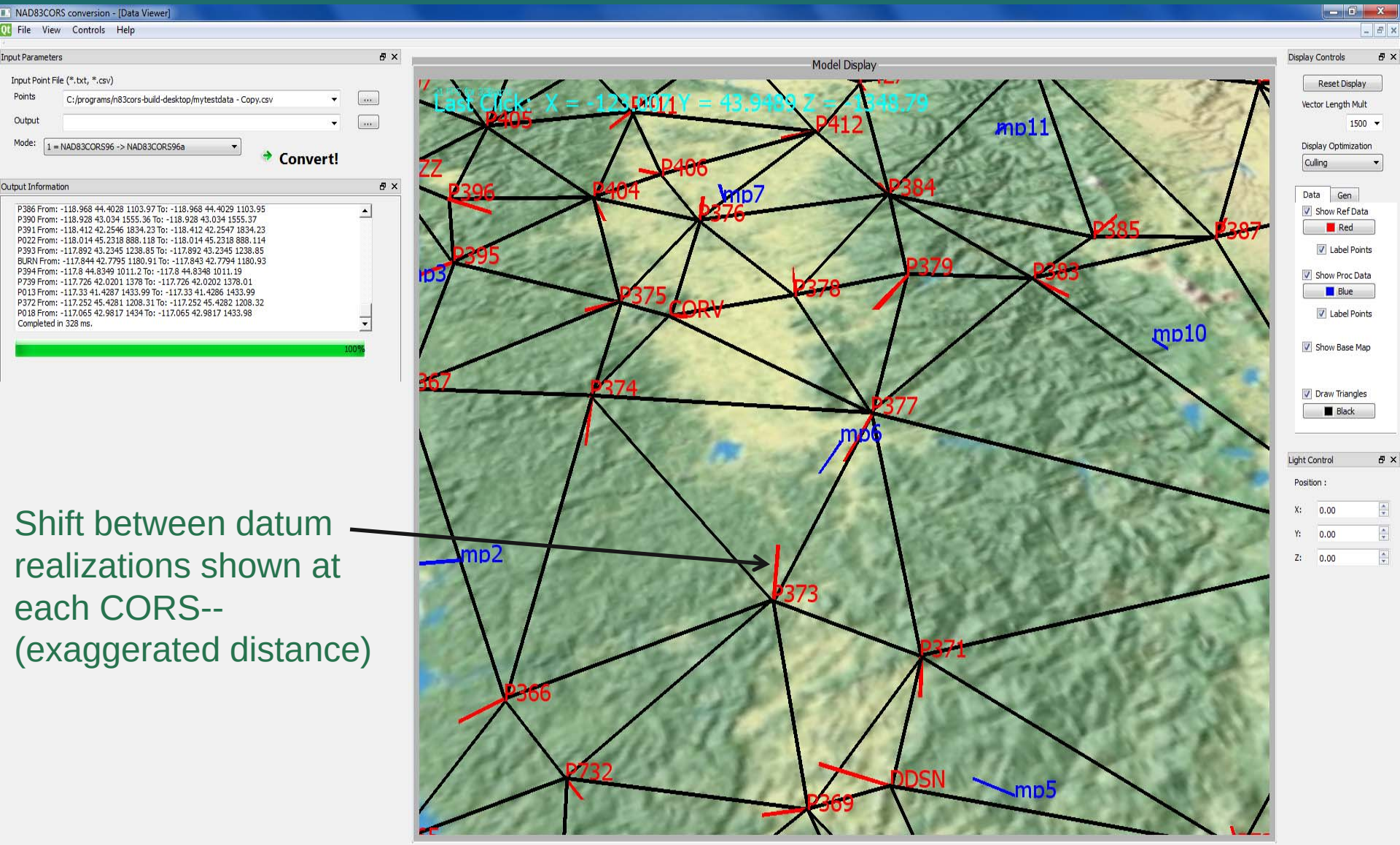
The Software "Tool" will:

- Calculate ΔX, ΔY, Δh for each CORS station (described previously)
- Create an optimized Delaunay triangulation using the ~125 CORS stations in Oregon
- Allow user input of a file of points to convert
- Program determines which triangle each input data point is in.
- For each point, ΔX, ΔY, Δh are interpolated from the CORS stations forming the triangle in which the point is located
- The shift may be applied forwards or backwards
- Testing of the program can only occur after the new datum realization is working within OPUS.

The CORS Position Delaunay Triangle Network



The Program User Interface



Shift between datum realizations shown at each CORS-- (exaggerated distance)

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- Oregon Real-time GPS Network
  - www.TheORGN.net
- Oregon Coordinate Reference System
  - www.oregon.gov/ODOT/HWY/GEOMETRONICS/ocrs.shtml
- Design to Dozer:
  - www.oregon.gov/ODOT/HWY/GEOMETRONICS/dozer.shtml


Questions??