Geospatial Positioning at Oregon DOT

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Oregon Dept. of Transportation

Civil GPS Service Interface Committee
U.S. States & Local Government Session
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Oregon DOT Geometronics Unit

Ron Singh, Chief of Surveys, Manager
Overview of ODOT Updates

- Oregon Coordinate Reference System
- Oregon Real-time GPS Network
  - Oregon DOT transition to NAD83(2011)(Epoch 2010.00)
- Moving towards Engineering Automation
- LIDAR Scanning
Distortion Due to Elevation

LDP Coordinate
230 Feet

State Plane Coordinate

GPS Derived Coordinate

Local Datum Plane

State Plane

0.06 Feet

2
973.504 Feet

3
973.444 Feet

973.444 Feet
Distortion Due to Elevation

- LDP Coordinate
- 5,000 Feet
- State Plane Coordinate
- GPS Derived Coordinate
- Local Datum Plane
- State Plane

Distortion: 0.28 Feet

GPS Derived: 973.444 Feet
State Plane: 973.726 Feet
LDP Coordinate: 973.726 Feet
Oregon State Plane linear distortion, South Zone

Michael L. Dennis, RLS, PE
Geodetic Analysis, LLC
Problems with SPC System

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

- 20 zones created in Oregon
- Enabling legislation passed by Oregon State Legislature
- On-line OCRS Tool has been developed
- Several software manufacturers have added the OCRS zones in their coordinate system managers
Oregon Real-time GPS Network

- Update to NAD83(2011)Epoch 2010.00
  - Plan developed
  - NGS Guidelines for Real Time Networks/ possible "certification"
  - OPUS-Projects Least Squares Adjustment
    - Fix "computed" CORS in and surrounding Oregon
  - User Support for epoch change:
    - Fiducial passive marks for users
    - Oregon State U: NAD83 Epoch Converter
Guidelines for Positioning the Oregon Real Time Network
With NGS National Spatial Reference System Validation

Mark L. Armstrong, Lead Author

DRAFT v.1.0, 7-01-2011
Major Elements of ODOT’s Plan

- Process/Adjust with NGS OPUS Projects online
- Pick NGS MYCS sites to fix in adjustment
  - All are “computed sites” with at least 2 ½ years of data
  - Versus “modeled sites” with less than 2 ½ years of data.
- Use 5 days of data during high pressure period over the state
- Check adjustment with other least squares software
- A minimum of 10% of the stations in the ORGN will be NGS CORS
- Site standards meet NGS CORS requirements
- Test final coordinates using ORGN real-time correctors
- Provide fiducial points on passive control that users of ORGN real-time correctors can check in to.
- Provide user support to ease changeover
A valuable addition to the NGS OPUS suite

Currently in beta format
- Has integrated Epoch 2010.00 positions for CORS
- Has integrated ANTEX IGS08 antenna calibrations

OP Provides:
- Uploading of GPS data via the OPUS portal
- Processing baselines via NGS PAGES software
- Least squares adjustment of data via GPSCOM software
- Google Earth-based map view of project and baselines
- Improved positioning over OPUS-Static averaging of single base line positions

Software author: Dr. Mark Schenewerk, NGS
Oregon Data Conversion Tool
Shift between datum realizations shown at each CORS—(exaggerated distance)
What the “Tool” will do:

- Converts users positions back and forth from:
  - NAD 83 (CORS96) Epoch2002.00
  - NAD 83 (2011) Epoch2010.00
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
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 my phone from ringing off the hook!”
- Note: For surveying/engineering accuracy, should perform an calibration/localization and not rely on this tool.
Oregon DOT is poised for field-to-finish automation:
- Surveying: pre-design & construction
- 3-D Digital Design: machine control ready
- 3-D Digital As-Builts
- Digital Signature technology & legislation
- Construction Administration
2010 Design to Dozer Demonstration
Computer Controlled Heavy Equipment
Pre-design Survey

- Geodetic Control:
  - Oregon Real-time GPS Network
- Coordinate System:
  - Oregon Coordinate Reference System
- Digital signatures for Professional Filed Documents
3-D Design
3-D Design
Design input into heavy equipment
Computer Controlled Construction
Section of Sub-grade completed
Visualization of Paved Surface
Engineering Automation, i.e., 3-D digital as-builts contribute to the enabling technology for “connected vehicle” highway safety programs.
LIDAR Use in Oregon

- **Airborne**
  - Fixed Wing (high altitude)
  - Helicopter (low altitude)
- **Terrestrial**
  - Static
  - Mobile
OLC DATA PRODUCTS

3 ft pixel bare earth DEM ESRI format (quad tiles)

Point cloud, LAS format 1/100 quad tiles
All returns
Ground Points

1 ft pixel intensity images (tiled by \(1/100\)th quad)

Ground point density grid

Aircraft Trajectories and date-stamped flightlines

3 ft pixel first return DEM ESRI format (quad tiles)

Report and metadata !!
AIRBORNE (FIXED WING)

- Find landslides, old cuts and grades
- Measure and estimate fills and cuts
- Find stream channels, measure gradients
- Measure the size and height of buildings, bridges
- Locate and measure every tree in the forest
- Characterize land cover
- Model floods, fire behavior
- Locate power lines and powerpoles
- Support archeological investigations
- Map wetlands and impervious surfaces
- Define watersheds and viewsheds
- Map road center and sidelines
- Find law enforcement targets
- Map landforms and soils
- Assess property remotely
- Monitor quarries, find abandoned mines
- Enhance any research that requires a detailed and accurate 2D or 3-D map
STATIC SCANNING
**STATIC SCANNING**

- Captures the geometry of existing physical objects
- Allows Virtual Surveying in office
- Facilitates Solid Object Modeling
STATIC SCANNING

- 2-6mm accuracy
- Structures: inaccessible, unsafe, delicate
- Complex Geometry
- Fast Data Collection (thousands of points/sec)
- Extensive Detail
- Immediate Results
STATIC USES

- Virtual Surveying
- Mapping
- Reverse engineering
- Non-contact inspection
- Structure analysis and testing
- Determine fit before shipping to site
- As-built surveys
- Historical archive
Oregon Department of Transportation

**STATIC SCANNING PRODUCTS**

| Photo | Scan | Vector | Solid Objects |
|-------|------|--------|---------------|--------------|

A bridge illustration showing different stages of the scanning process.
STATIC SCANNING
STATIC SCANNING
Registered scans of rock face with projection lines from total station
MOBILE SCANNING DATA
MOBILE SCANNING

- GPS Positioning
- Inertial Measurement Unit (IMU)
  - Roll
  - Pitch
  - Yaw
- Extremely Fast Data Collection (millions points/sec)
IP-S2 HD System

HD Laser Scanner

GNSS Antenna

Prosilica HD Camera Array

360° Camera

IP-S2 Box

Hydraulic Lift Mount

Internal IMU
How it all works

IP-S2 uses data from various sensors to obtain an accurate position and orientation.

**GNSS Receiver** Delivers the Position Information to the System (Latitude, Longitude and Altitude)
40 Channel GPS L1/L2 & GLONASS L1/L2

**IMU (Inertial Measurement Unit)** Supplies Accurate Altitude Data for the System (Roll, Pitch and Heading information)
Either 1°/hr or 3°/hr Gyro Bias

**Vehicle Odometry Information** is Obtained Via External Wheel Speed Sensors or From the Vehicle’s CAN Bus
(Used to estimate the velocity and position based off a known location)
MOBILE SCANNING USES

- Long Linear (from the road viewpoint) Mapping
- Virtual Surveying
- Asset Inventory & Management
  - Faster, safer than GPS handhelds in roadway
  - Approaches
  - Culverts
  - Signs
  - Guardrails
CURRENT LIMITATIONS AND OBSTACLES
LIMITATIONS AND OBSTACLES

- Massive Files
- Limited Lossless Compression
- Limited Data Transmission Bandwidth
- Lack of Standards
- Limited use in Civil Design Software
CAUTIONS
STAY CURRENT

- Low Maturity
- Hardware Ahead of Software
- Rapidly Changing
BE AWARE OF...

- Data Sources (often combined)
- Limitations
- Accuracies
- Coordinate Systems
- Metadata
Summary

- Status of the Oregon Coordinate Reference System
- Status of the Engineering Automation Efforts
- Status of Mobile Scanning
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Oregon Real-time GPS Network
www.TheORGN.net