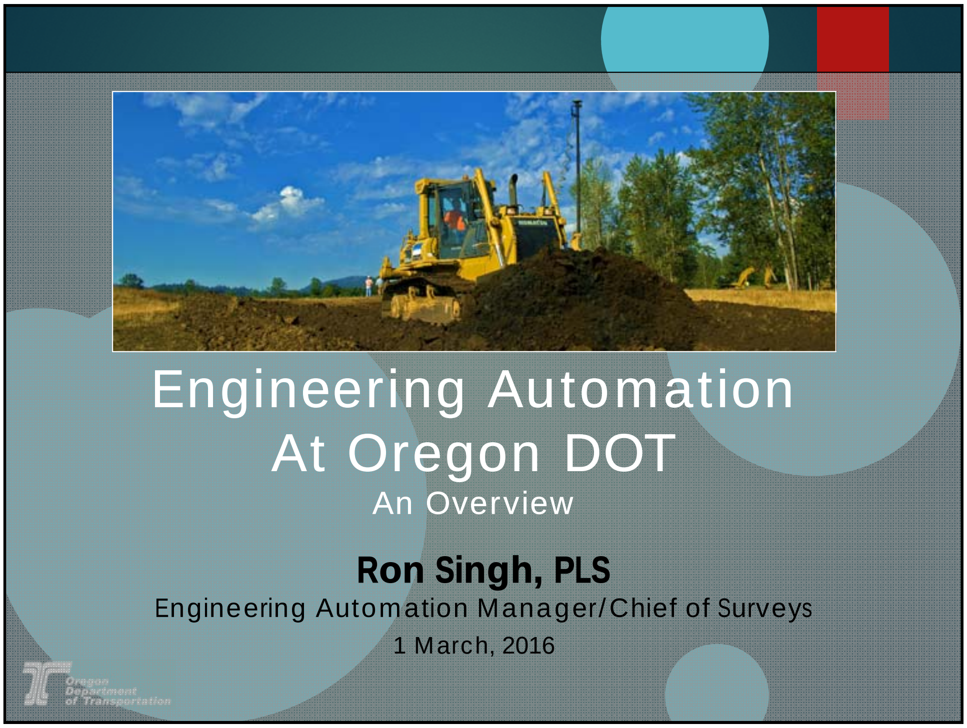
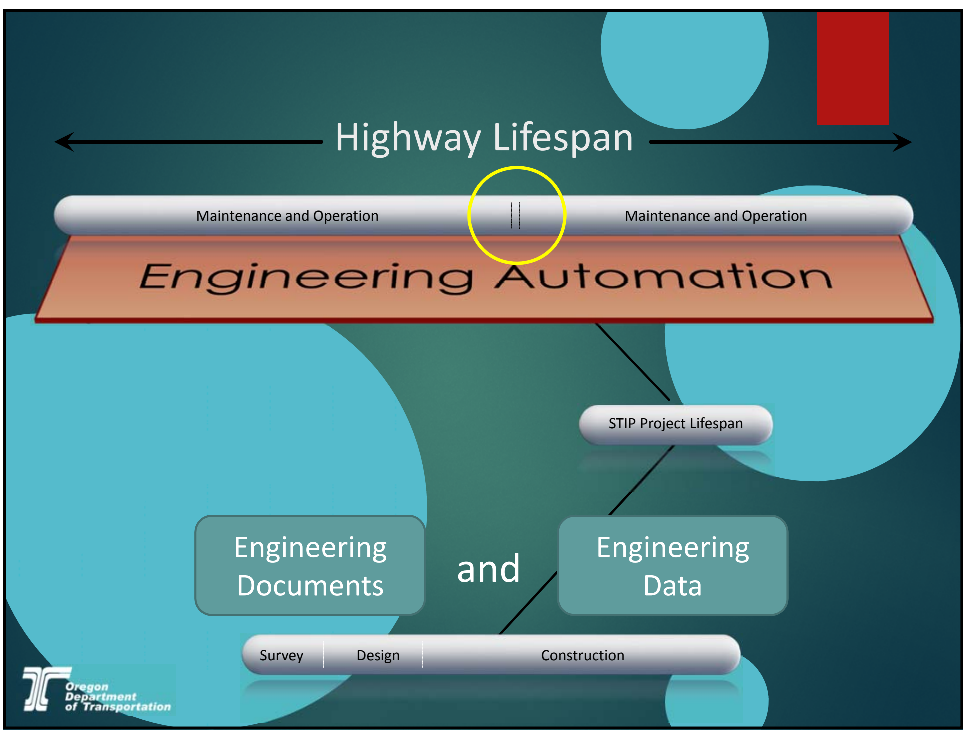
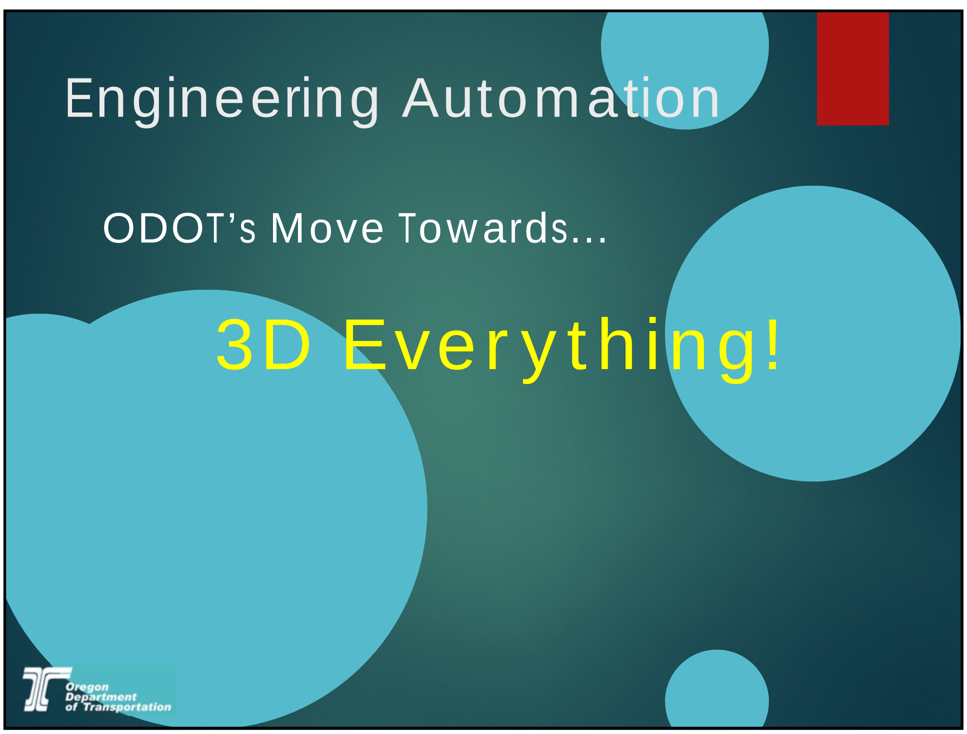
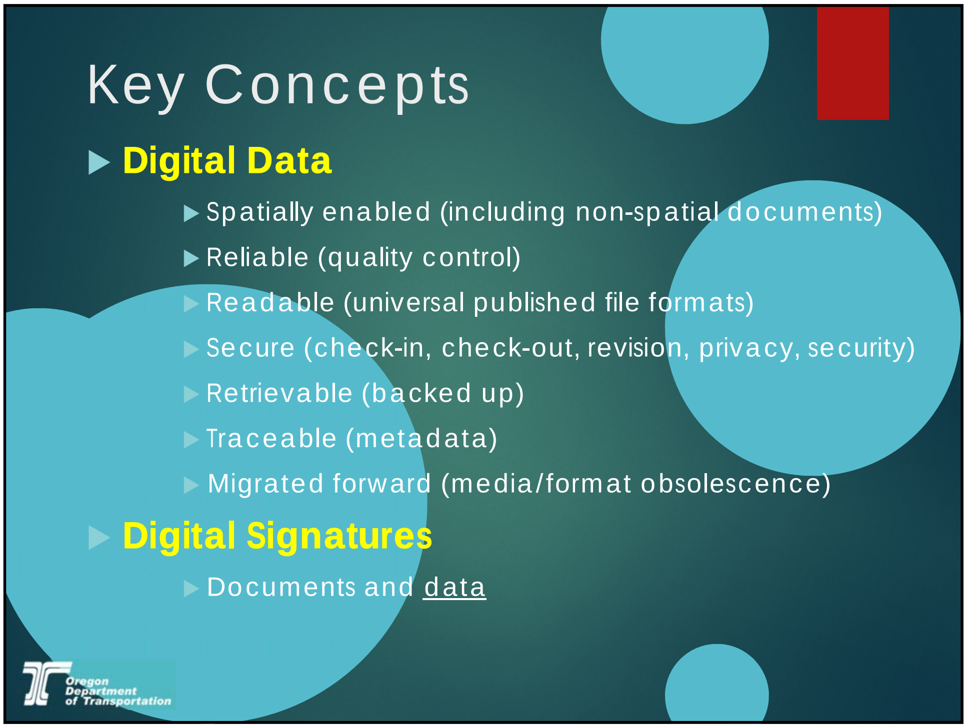
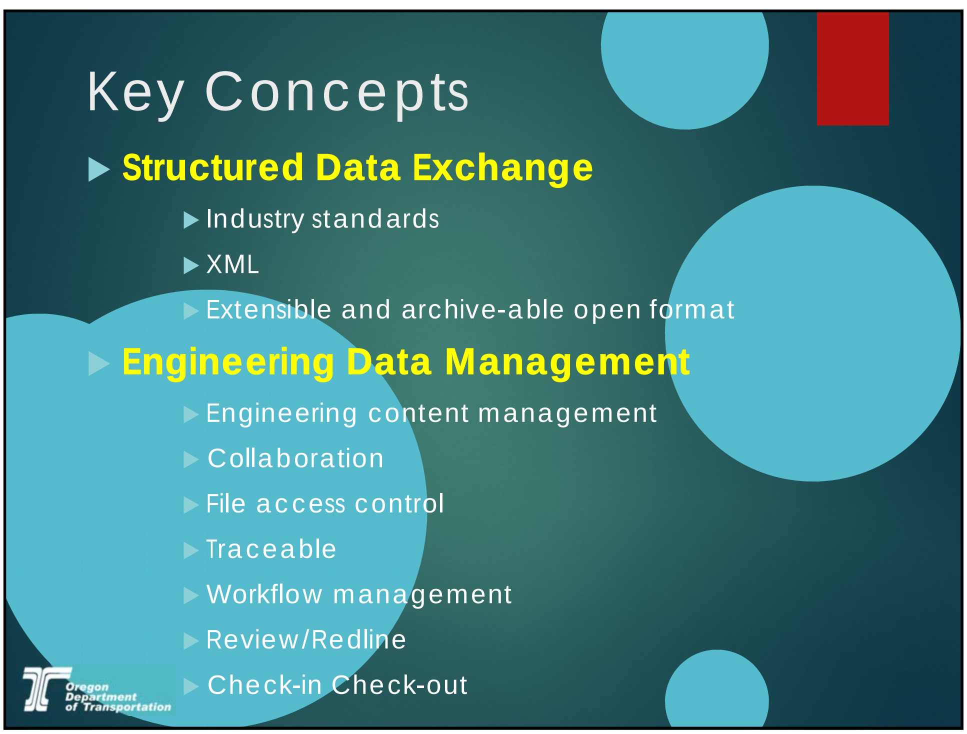

Engineering Automation
At Oregon DOT
An Overview
Ron Singh, PLS
Engineering Automation Manager/Chief of Surveys
1 March, 2016
Oregon Department of Transportation

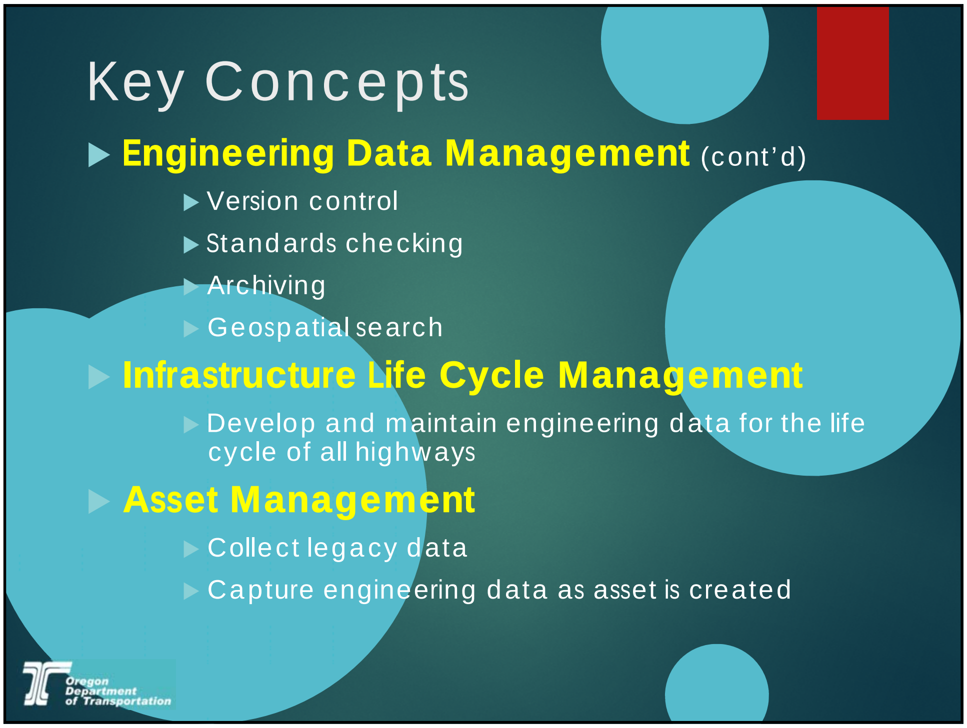

Highway Lifespan
Maintenance and Operation
Maintenance and Operation
Engineering Automation
STIP Project Lifespan
Engineering Documents
and
Engineering Data
Survey
Design
Construction
Oregon Department of Transportation

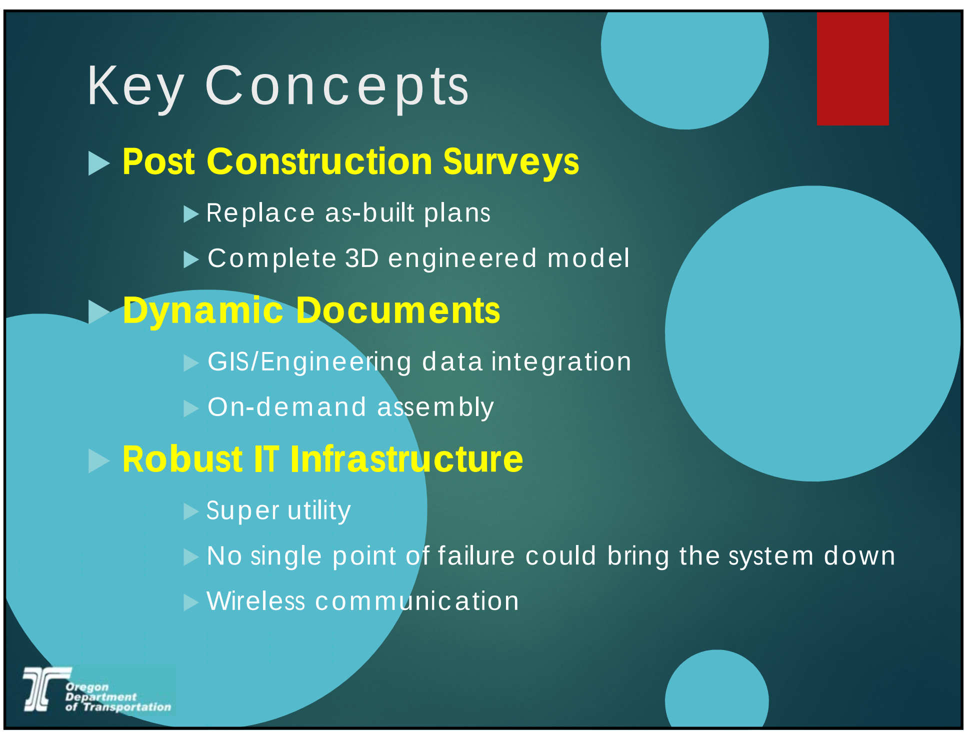

Engineering Automation
Oregon
Department
of Transportation


Engineering Automation
ODOT's Move Towards...
3D Everything!
Oregon
Department
of Transportation


Key Concepts
Digital Data
Spatially enabled (including non-spatial documents)
Reliable (quality control)
Readable (universal published file formats)
Secure (check-in, check-out, revision, privacy, security)
Retrievable (backed up)
Traceable (metadata)
Migrated forward (media/format obsolescence)
Digital Signatures
Documents and data
Oregon Department of Transportation


Key Concepts
Structured Data Exchange
Industry standards
XML
Extensible and archive-able open format
Engineering Data Management
Engineering content management
Collaboration
File access control
Traceable
Workflow management
Review/Redline
Check-in Check-out
Oregon Department of Transportation


Key Concepts
Engineering Data Management (cont'd)
Version control
Standards checking
Archiving
Geospatial search
Infrastructure Life Cycle Management
Develop and maintain engineering data for the life cycle of all highways
Asset Management
Collect legacy data
Capture engineering data as asset is created
Oregon Department of Transportation


Key Concepts
Post Construction Surveys
Replace as-built plans
Complete 3D engineered model
Dynamic Documents
GIS/Engineering data integration
On-demand assembly
Robust IT Infrastructure
Super utility
No single point of failure could bring the system down
Wireless communication
Oregon Department of Transportation

Key Concepts

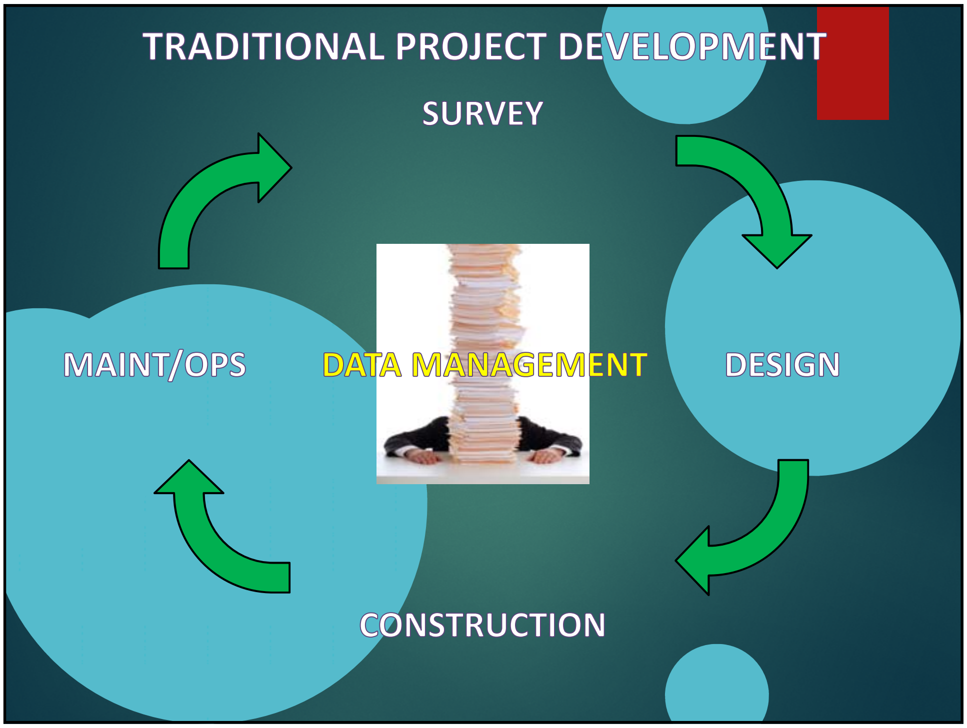
- **Real Time Networks (active control)**
  - Oregon Real-time GPS Network
- **Improved Coordinate System**
  - Low distortion projections (today)
  - Earth Centered Earth Fixed Coordinates without projections (future)
  - The Oregon Coordinate Reference System
- **3D Point Cloud Data**
  - Industry standards – ASTM E57
  - Point level metadata
  - Smart compression
  - Intelligent (classification, material, increased observables)

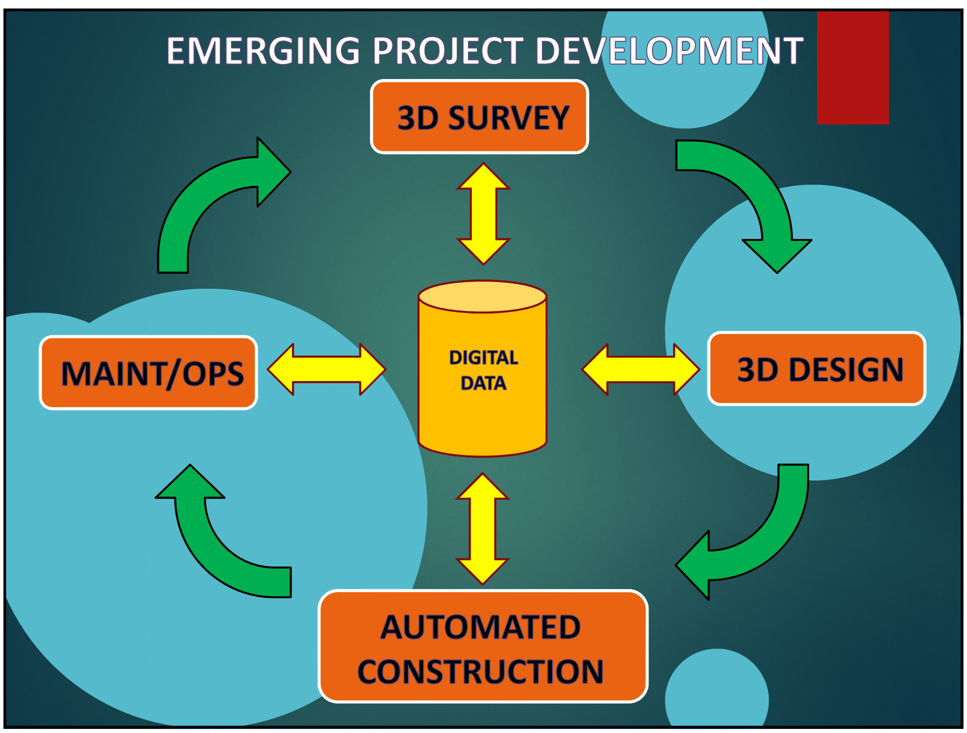
Oregon Department of Transportation

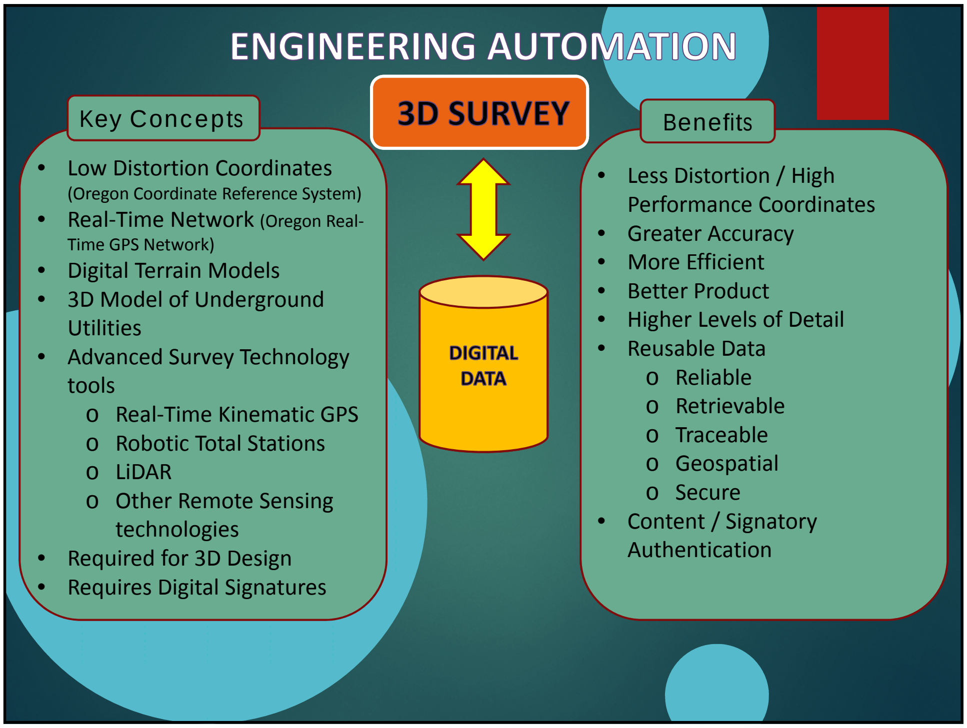
Key Concepts

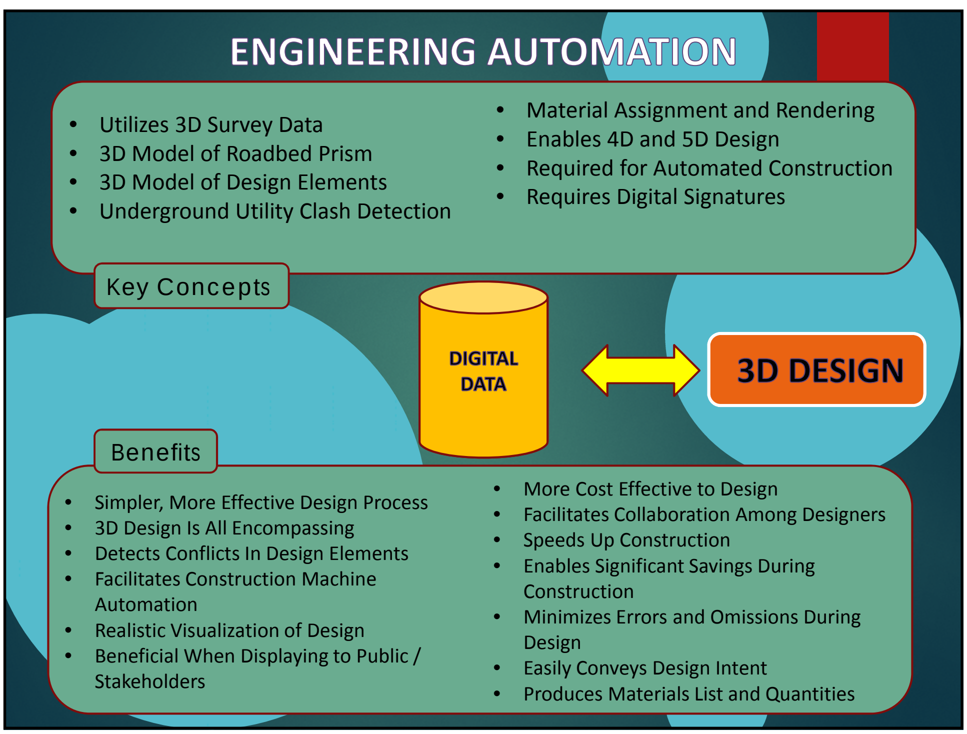
- **Underground Utility 3D Location** (SUE)
- **High Resolution** (vertical and oblique) **Ortho-rectified Imagery**
- **Full 3D/4D/5D Design**
- **Visualization**
- **Construction Automation**
  - Construction machine guidance and control
  - Inspection tools
  - Enhanced use of GPS (RTN, IMU)
  - Remote construction site monitoring
  - Materials delivery and certification

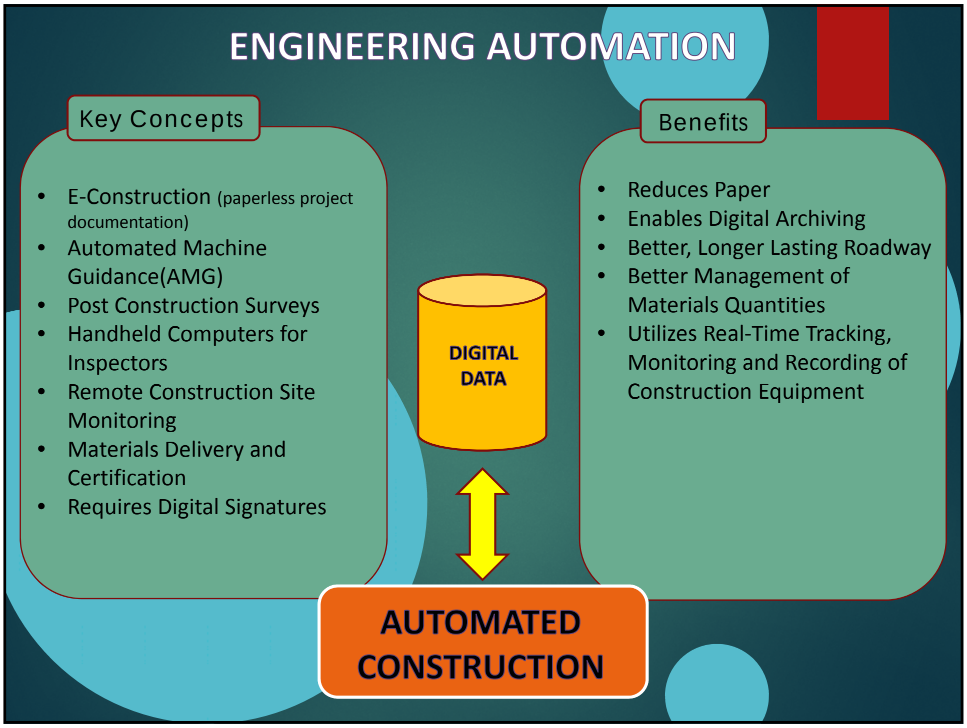
Oregon Department of Transportation

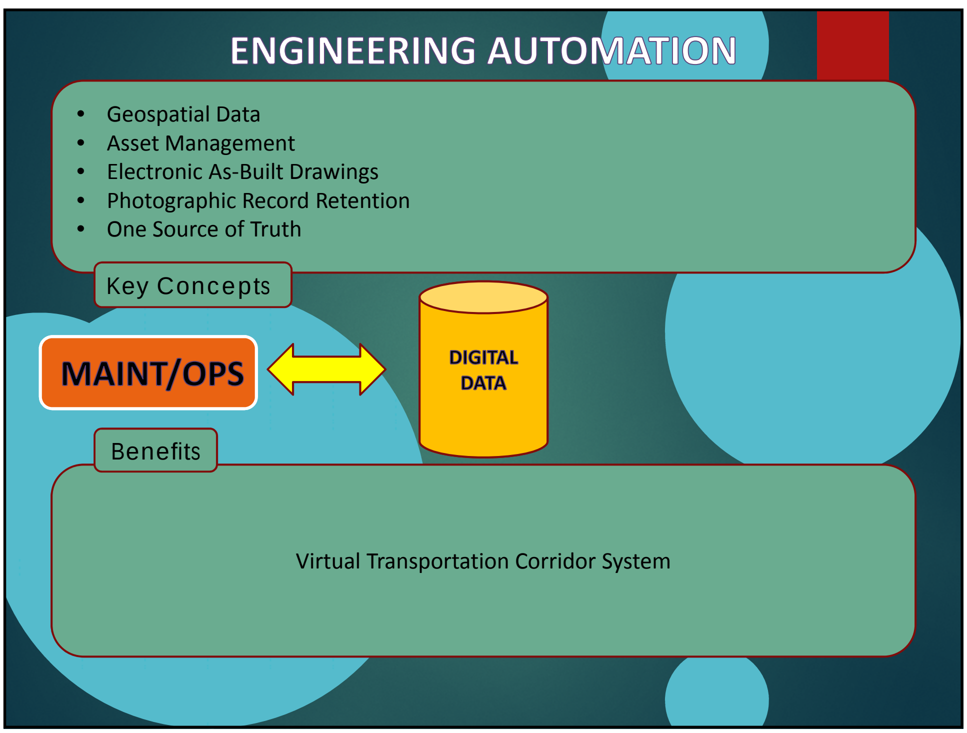

TRADITIONAL PROJECT DEVELOPMENT
SURVEY
MAINT/OPS
DATA MANAGEMENT
DESIGN
CONSTRUCTION

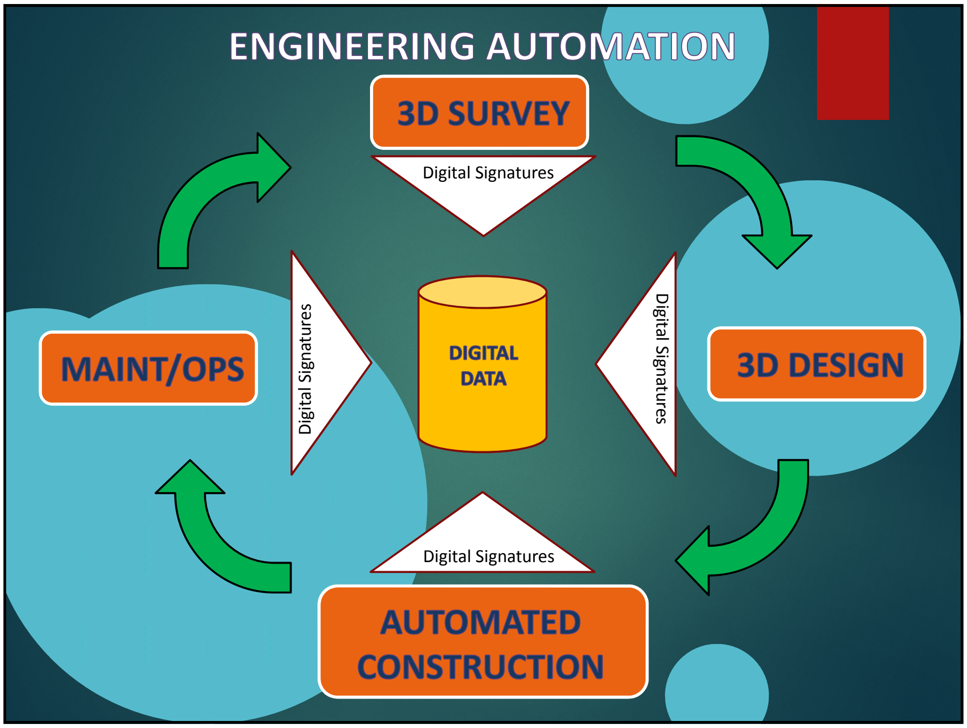

EMERGING PROJECT DEVELOPMENT
3D SURVEY
MAINT/OPS
DIGITAL DATA
3D DESIGN
AUTOMATED CONSTRUCTION

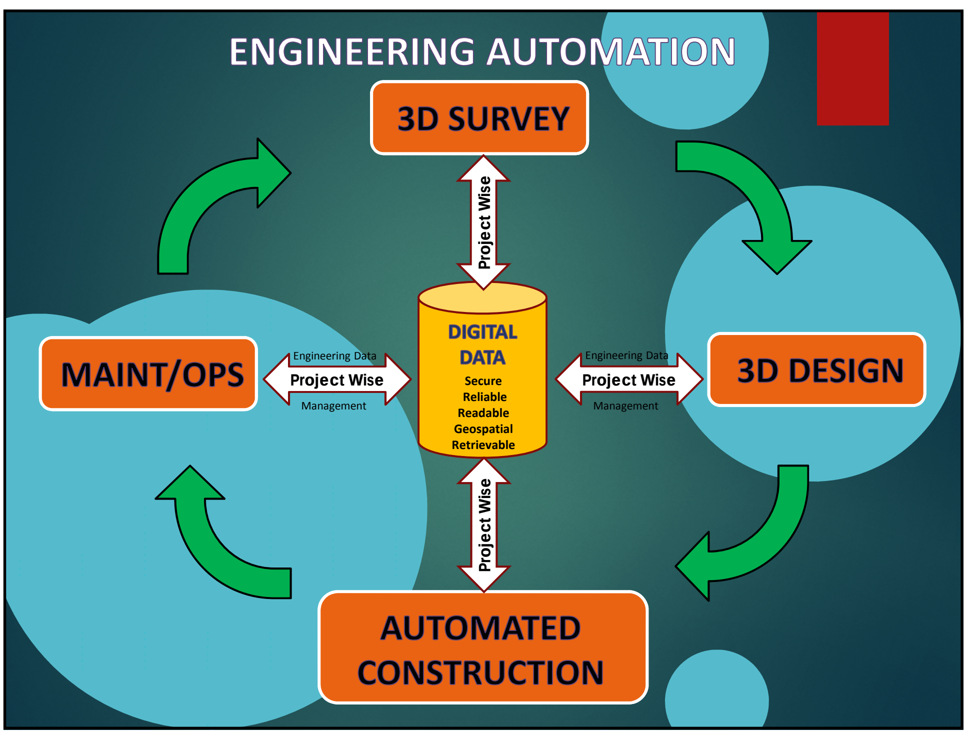

ENGINEERING AUTOMATION
3D SURVEY
Key Concepts
• Low Distortion Coordinates (Oregon Coordinate Reference System)
• Real-Time Network (Oregon Real-Time GPS Network)
• Digital Terrain Models
• 3D Model of Underground Utilities
• Advanced Survey Technology tools
o Real-Time Kinematic GPS
o Robotic Total Stations
o LiDAR
o Other Remote Sensing technologies
• Required for 3D Design
• Requires Digital Signatures
DIGITAL DATA
Benefits
• Less Distortion / High Performance Coordinates
• Greater Accuracy
• More Efficient
• Better Product
• Higher Levels of Detail
• Reusable Data
o Reliable
o Retrievable
o Traceable
o Geospatial
o Secure
• Content / Signatory Authentication

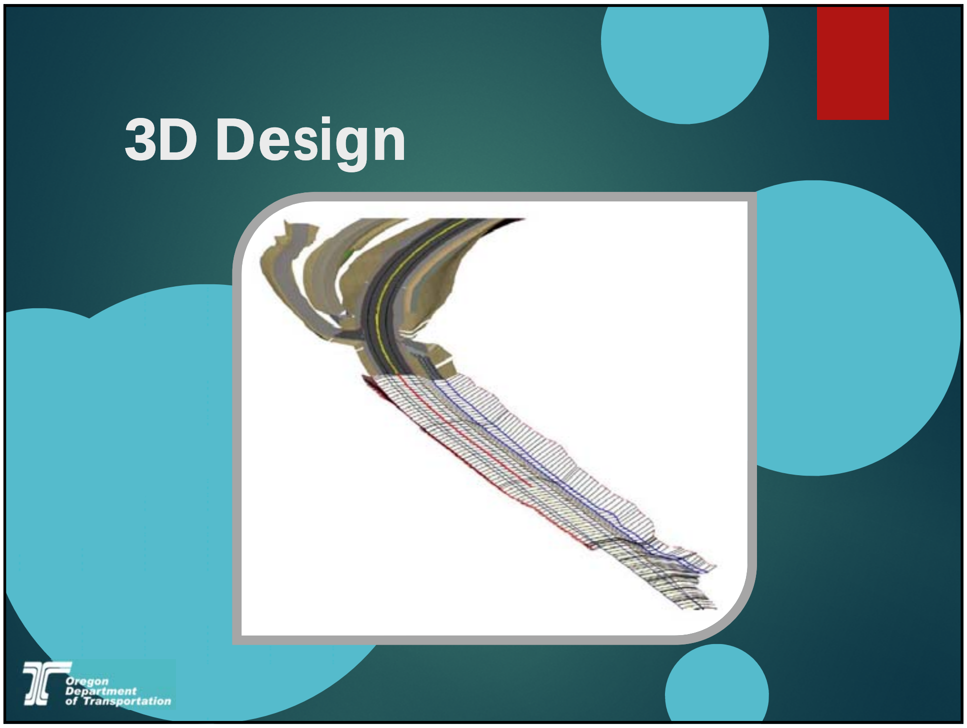

ENGINEERING AUTOMATION
• Utilizes 3D Survey Data
• 3D Model of Roadbed Prism
• 3D Model of Design Elements
• Underground Utility Clash Detection
• Material Assignment and Rendering
• Enables 4D and 5D Design
• Required for Automated Construction
• Requires Digital Signatures
Key Concepts
DIGITAL DATA
3D DESIGN
Benefits
• Simpler, More Effective Design Process
• 3D Design Is All Encompassing
• Detects Conflicts In Design Elements
• Facilitates Construction Machine Automation
• Realistic Visualization of Design
• Beneficial When Displaying to Public / Stakeholders
• More Cost Effective to Design
• Facilitates Collaboration Among Designers
• Speeds Up Construction
• Enables Significant Savings During Construction
• Minimizes Errors and Omissions During Design
• Easily Conveys Design Intent
• Produces Materials List and Quantities

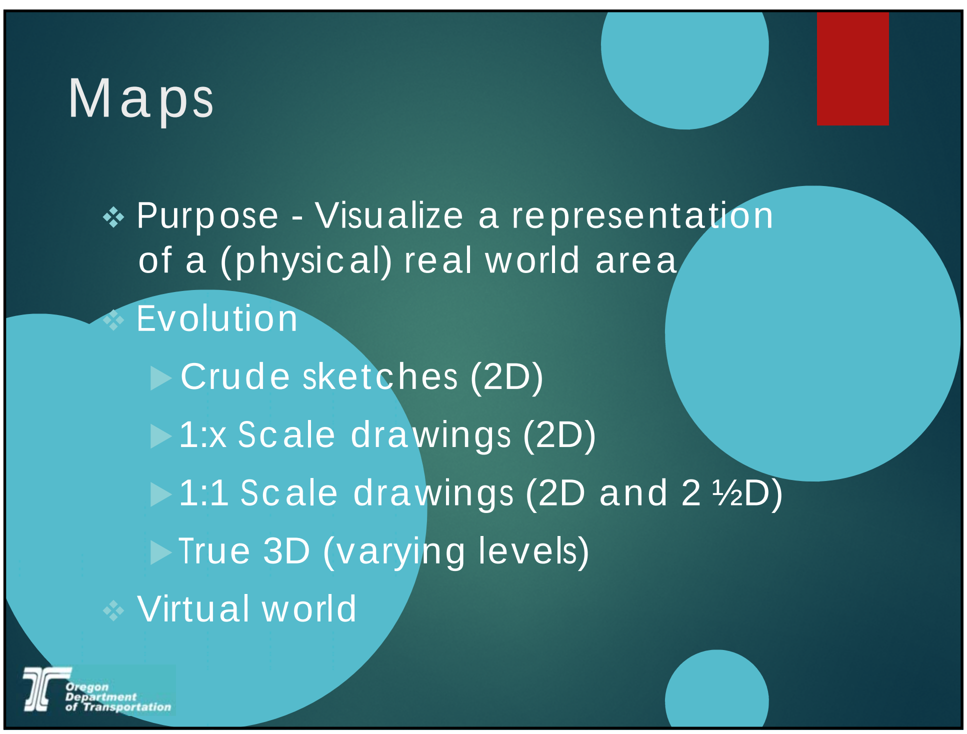

ENGINEERING AUTOMATION
Key Concepts
E-Construction (paperless project documentation)
Automated Machine Guidance(AMG)
Post Construction Surveys
Handheld Computers for Inspectors
Remote Construction Site Monitoring
Materials Delivery and Certification
Requires Digital Signatures
DIGITAL DATA
AUTOMATED CONSTRUCTION
Benefits
Reduces Paper
Enables Digital Archiving
Better, Longer Lasting Roadway
Better Management of Materials Quantities
Utilizes Real-Time Tracking, Monitoring and Recording of Construction Equipment


ENGINEERING AUTOMATION
Geospatial Data
Asset Management
Electronic As-Built Drawings
Photographic Record Retention
One Source of Truth
Key Concepts
MAINT/OPS
DIGITAL DATA
Benefits
Virtual Transportation Corridor System


ENGINEERING AUTOMATION
3D SURVEY
Digital Signatures
MAINT/OPS
Digital Signatures
DIGITAL DATA
Digital Signatures
3D DESIGN
Digital Signatures
AUTOMATED CONSTRUCTION


ENGINEERING AUTOMATION
3D SURVEY
Project Wise
MAINT/OPS
Engineering Data
Project Wise
Management
DIGITAL DATA
Secure
Reliable
Readable
Geospatial
Retrievable
Engineering Data
Project Wise
Management
3D DESIGN
Project Wise
AUTOMATED CONSTRUCTION


3D Design
Oregon Department of Transportation


Maps
Purpose - Visualize a representation of a (physical) real world area
Evolution
Crude sketches (2D)
1:x Scale drawings (2D)
1:1 Scale drawings (2D and 2 ½D)
True 3D (varying levels)
Virtual world
Oregon Department of Transportation

Design Workflow - PAST

- Referenced to alignment (“P” line, etc.)
- Site represented by 2D Base Map
- Terrain represented by Cross Sections
- Grade represented by Profiles
- Blind between data points
- 2D design
- Paper plans and specifications
- Wet signatures

Oregon Department of Transportation

Design Workflow - TODAY

- Geospatially referenced
- Coordinates projected to plane
- Site represented by 2 ½ D Base Map
- Terrain represented by Digital Terrain Model (DTM)
- Blind between data points – albeit closer
- 3D roadway prism design flattened to 2D
- Paper plans and specifications
- Wet or Digital signatures

Oregon Department of Transportation

Design Workflow - FUTURE

- Geospatially referenced
- 3D coordinate system – No projections
- Site/Terrain represented by virtual world
- Full 3D design
- Digital signatures
- 3D data utilized for construction
- Hierarchy – Data primary, plans secondary

Oregon Department of Transportation

Automated Machine Guidance

Oregon Department of Transportation

Machine Guidance

A **Machine Guidance** system uses automation to provide the equipment operator a **visual indicator** of the position of the cutting edge (blade, bucket, screed, etc.) relative to the design surface being constructed.

Oregon Department of Transportation

Machine Control

A **Machine Control** system positions the cutting edge of the equipment through automation.

The system is connected to and controls the hydraulics while the operator simply drives the equipment and manages the automation.

Oregon Department of Transportation

3 Components of Machine Control

1. The design and resulting data
2. The machine w/computer, sensors, hydraulic controls, and data communication
3. The positioning system – GPS, TPS, laser, or combination

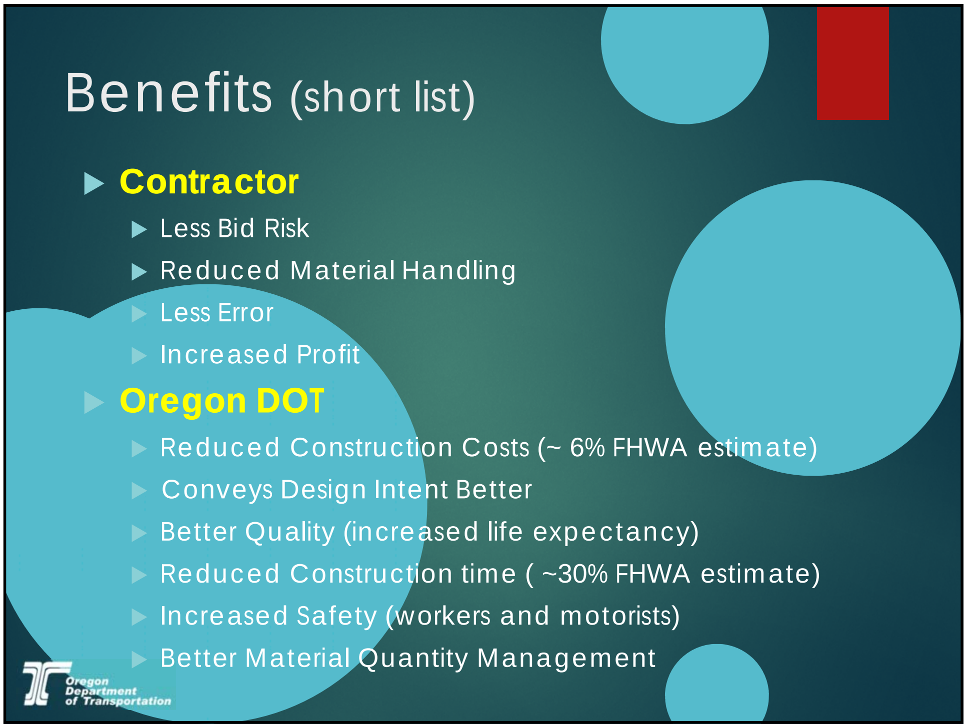
Oregon Department of Transportation

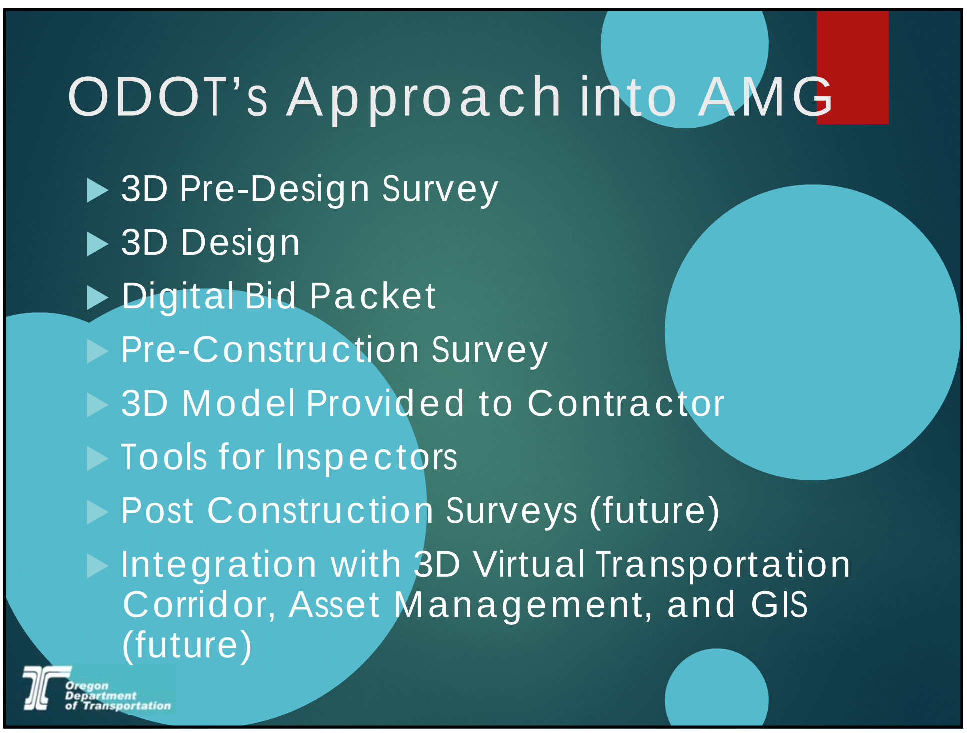
Machine Control

The ultimate system:

- No stakes required
- No grade checker required
- Records data for quality control
- Records data for volume computation
- Data could be transmitted to engineer, inspector, or surveyor for “real time” checks

Oregon Department of Transportation


Benefits (short list)
Contractor
Less Bid Risk
Reduced Material Handling
Less Error
Increased Profit
Oregon DOT
Reduced Construction Costs (~ 6% FHWA estimate)
Conveys Design Intent Better
Better Quality (increased life expectancy)
Reduced Construction time (~30% FHWA estimate)
Increased Safety (workers and motorists)
Better Material Quantity Management
Oregon Department of Transportation

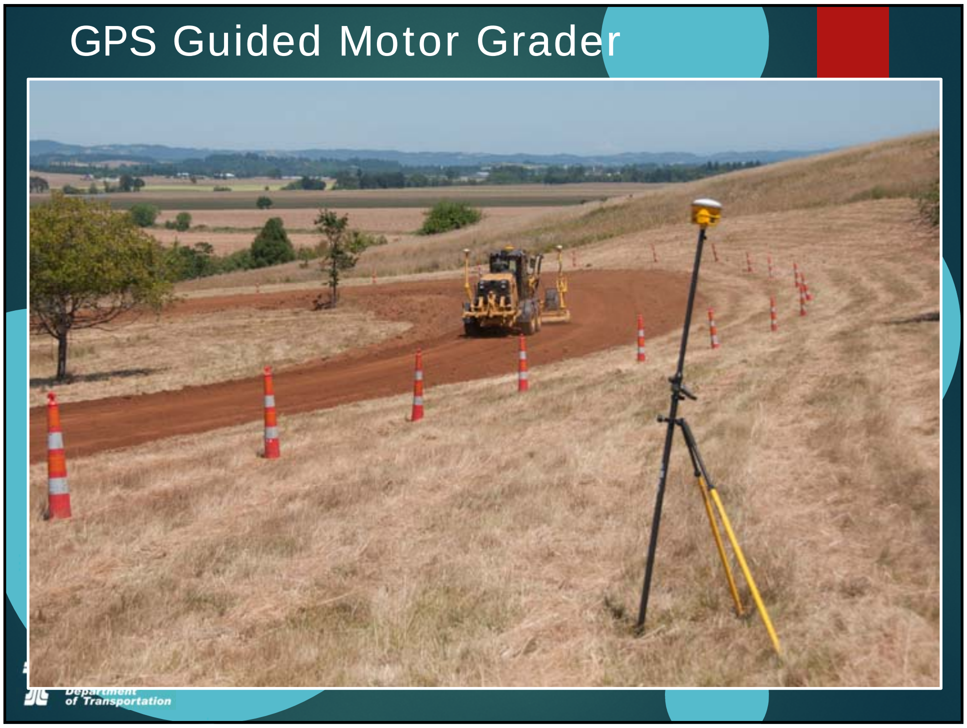

ODOT's Approach into AMG
3D Pre-Design Survey
3D Design
Digital Bid Packet
Pre-Construction Survey
3D Model Provided to Contractor
Tools for Inspectors
Post Construction Surveys (future)
Integration with 3D Virtual Transportation Corridor, Asset Management, and GIS (future)
Oregon Department of Transportation


GNSS
Base Station
Part of the Oregon
Real-Time GPS Network
Leica
Oregon
Department
of Transportation

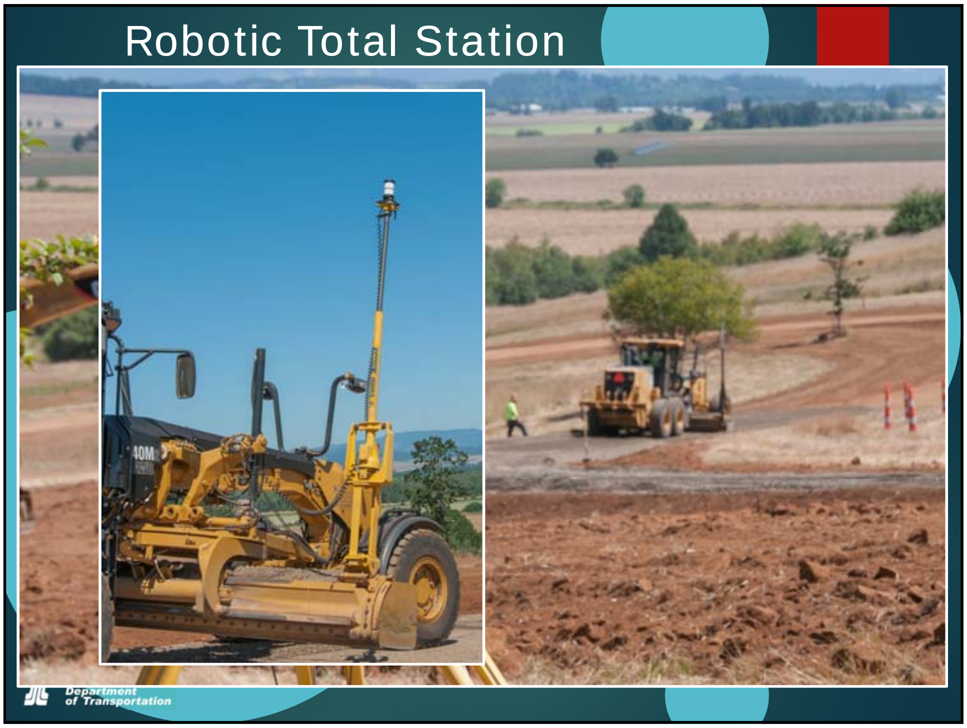

GPS Guided Bull Dozer
CAT
Department
of Transportation


GPS Guided Excavator
CAT
Department
of Transportation


GPS Guided Motor Grader
CAT
of Transportation


GPS Guided Motor Grader
of Transportation


3D Laser Scanner – Post Construction Survey
of Transportation


Robotic Total Station
Department
of Transportation


Intelligent Compactor
CAT
of Transportation

Intelligent Compactor

Robot Controlled Curb/Wall Machine

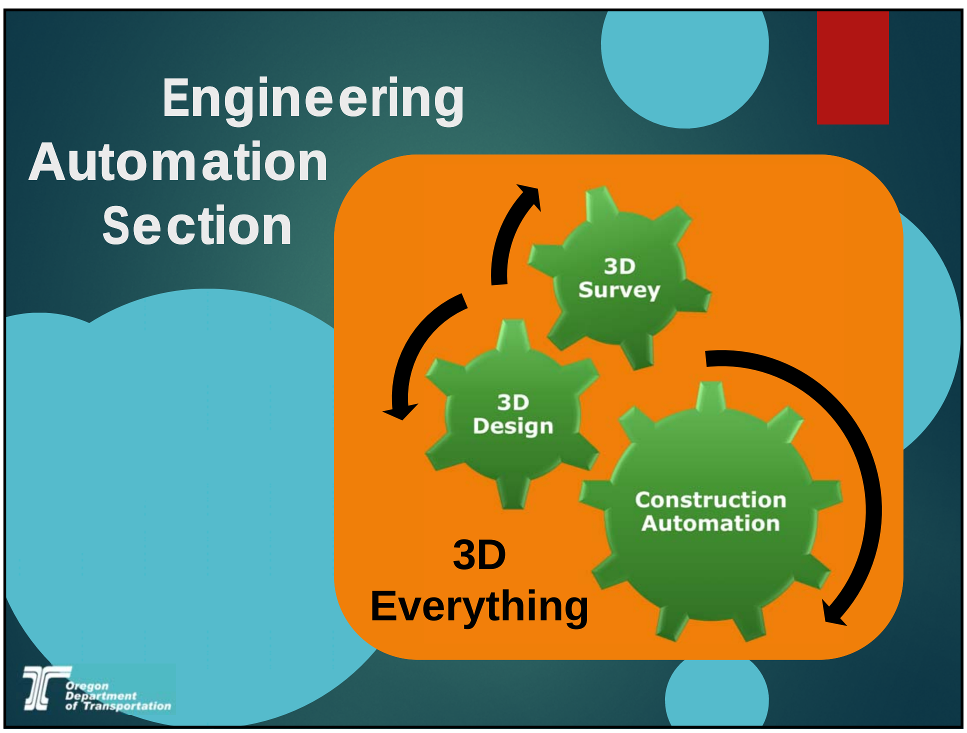
Robot Controlled Curb/Wall Machine

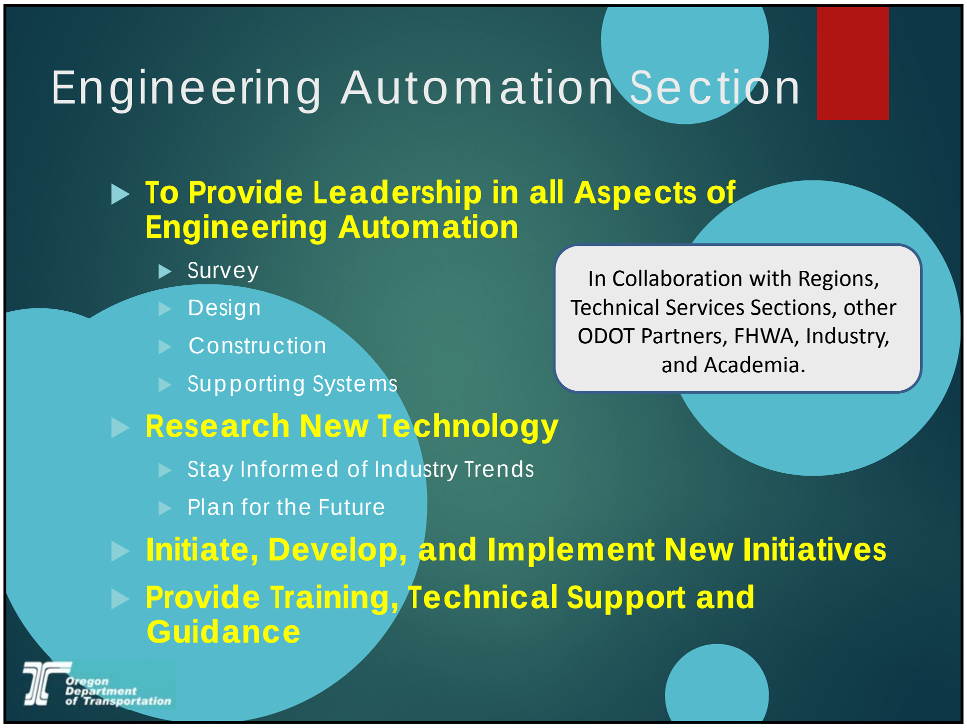
of Transportation

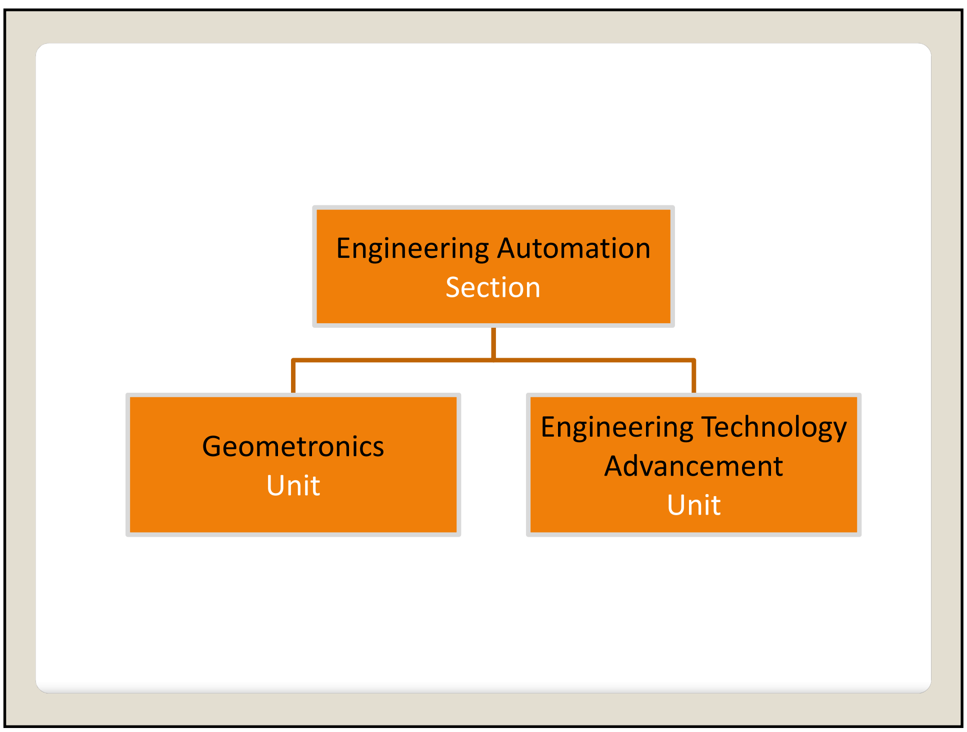
Robot Guided Paver

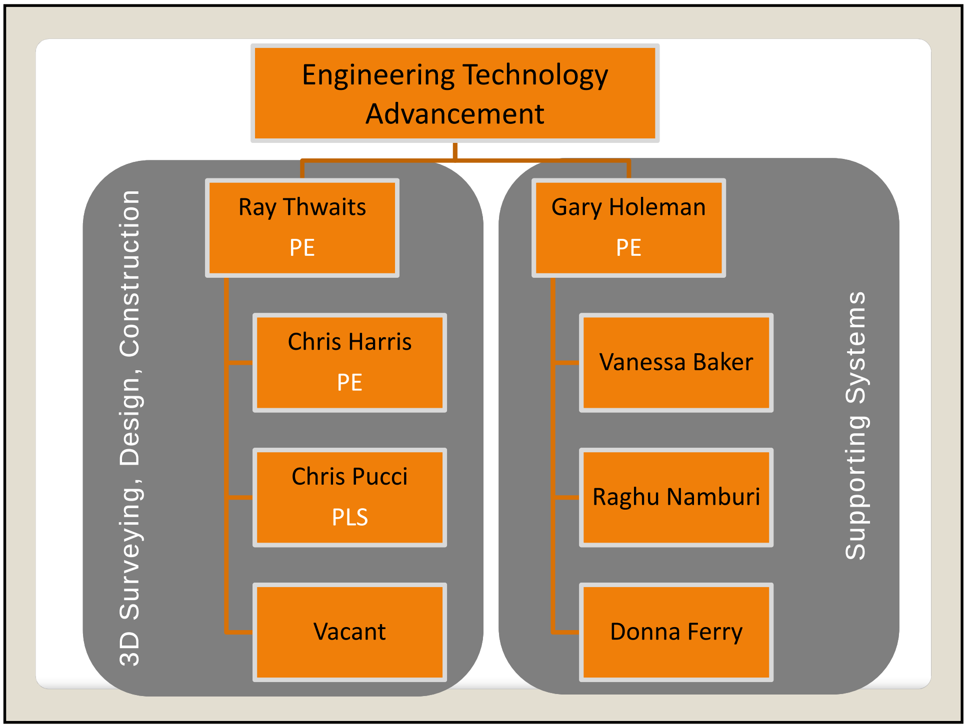
of Transportation

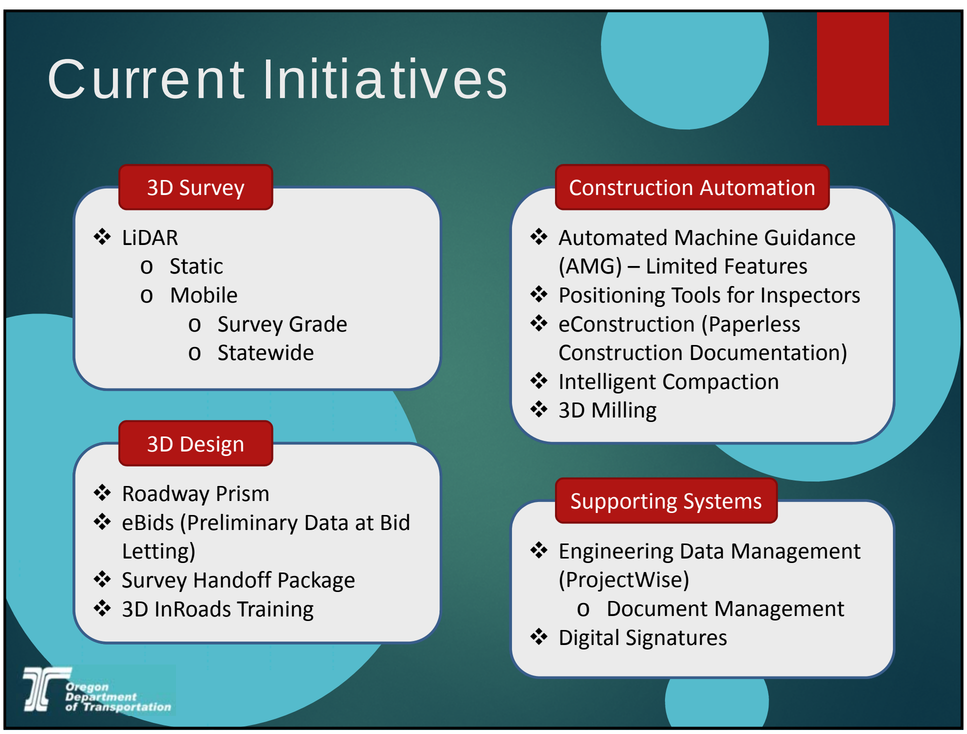

Robot Guided Paver


Engineering Automation Section
3D Survey
3D Design
Construction Automation
3D Everything
Oregon Department of Transportation


Engineering Automation Section
To Provide Leadership in all Aspects of Engineering Automation
Survey
Design
Construction
Supporting Systems
Research New Technology
Stay Informed of Industry Trends
Plan for the Future
Initiate, Develop, and Implement New Initiatives
Provide Training, Technical Support and Guidance
In Collaboration with Regions, Technical Services Sections, other ODOT Partners, FHWA, Industry, and Academia.
Oregon Department of Transportation


Engineering Automation Section
Geometronics Unit
Engineering Technology Advancement Unit


Engineering Technology Advancement
3D Surveying, Design, Construction
Ray Thwaits PE
Chris Harris PE
Chris Pucci PLS
Vacant
Gary Holeman PE
Vanessa Baker
Raghu Namburi
Donna Ferry
Supporting Systems


Current Initiatives
3D Survey
❖ LiDAR
o Static
o Mobile
o Survey Grade
o Statewide
3D Design
❖ Roadway Prism
❖ eBids (Preliminary Data at Bid Letting)
❖ Survey Handoff Package
❖ 3D InRoads Training
Construction Automation
❖ Automated Machine Guidance (AMG) – Limited Features
❖ Positioning Tools for Inspectors
❖ eConstruction (Paperless Construction Documentation)
❖ Intelligent Compaction
❖ 3D Milling
Supporting Systems
❖ Engineering Data Management (ProjectWise)
o Document Management
❖ Digital Signatures
Oregon Department of Transportation

Near Future Initiatives

3D Survey

- Unmanned Aircraft
  - Quarry Mapping
  - Bridge Inspection
- Subsurface Utility Engineering (SUE)

Construction Automation

- Automated Machine Guidance (AMG) – More Features
- Post-Construction Surveys
- Data Integration
  - Asset Management
  - GIS/TransInfo

3D Design

- Beyond Roadway Prism
- Bridge
- Subsurface Features

Supporting Systems

- Engineering Data Management (ProjectWise)
  - Workflow Management
  - Geospatial Attributes and Search Capabilities

Oregon Department of Transportation

Work in Progress

DOCUMENTS, SPECIFICATIONS, TRAINING, ETC.

Oregon Department of Transportation

3D Roadway Design Web Site

Oregon Department of Transportation

3D Roadway Advanced Training

- Demonstrates the use of advanced InRoads modeling techniques that can be used in the creation of 3D engineered models
- The modules can be taken sequentially or as-needed
- Accessing the modules through iLearn.Oregon.gov will create a transcript that can be used to document PDHs.

Oregon Department of Transportation

3D Roadway Advanced Training

Title
Introduction To Use Of Training Modules/Lab Exercises
Visualization of InRoads Data
Working With InRoads Features
Rock Slope Benching Using InRoads
Overburden End Condition Using InRoads
Barriers Using InRoads
Retaining Walls Using InRoads
Abutments Using InRoads
Minor Approaches and Driveways Using InRoads
Guardrails Using InRoads
Overlay Tools and Widening Using InRoads
Modeling Gores Using InRoads
Intersection Modeling Using InRoads

www.oregon.gov/ODOT/CS/east/Pages/Training.aspx

Oregon Department of Transportation

3D Design Project Stats

2014 10 projects in 4 Regions

Contract No.	Project Name	Region
14658	OR39: MERRILL NCL - CALIFORNIA STATE LINE	4
14662	OR 42: COUNTY LINE CURVES PHASE 1	3
14671	FFO-US97@CHERRY LANE & FFO-US26@DOVER LANE MADRAS	4
14681	OR140: RITTER RD - DEER RUN RD (BLY MTN)	4
14705	OR18: NEWBERG-DUNDEE BYPASS (PHASE 1D)	2
14722	OR18: NEWBERG-DUNDEE BYPASS (PHASE 1E)	2
14742	US20 @ 8TH STREET (BEND)	4
14761	FFO-US97 @ 1ST STREET (LAPINE)	4
14766	US97:J STREET INTERSECTION (MADRAS SOUTH Y)	4
14765	I-205 AT SE STRAWBERRY LANE OVERCROSSING	1

Oregon Department of Transportation

3D Design Project Stats

2015 — 18 Projects in 5 Regions and 2 Consultant Partners

Contract No.	Project Name	Region
14769	US730: POWERLINE RD INTERSECTION IMPROVEMENTS SEC.	5
14777	I-5: ANLAUF - ELKHEAD RD PAVING	3
14785	I-5: EXIT 61 (LOUISE CREEK) INTERCHANGE IMPROVEMENTS	3
14793	US97: MORO-MADRAS SEC	4
14804	OR62: FORT KLAMATH SIDEWALK IMPROVEMENTS	4
14803	OR224 (CLACKAMAS HWY): SE 197TH AVE	1
14810	OR140: BOWERS BRIDGE AND QUARTZ CREEK CULVERTS	4
14808	FFO-OR 138E: CORRIDOR SOLUTIONS (ROSEBURG)	3
14825	OR8: SW 185TH AVE.	1
14834	I-5: SISKIYOU REST AREA (ASHLAND)	3
14843	EMPIRE BLVD: NEWMARK AVE-WASHINGTON RD (COOS BAY)	3 (by Consultant)
14842	OR224 (CLACKAMAS HWY): SE 232ND DR SECTION	1
14851	I-5 SB: BROADWAY-WEIDLER EXIT RAMP (PORTLAND) PROJECT	1
14853	ROGUE-UMPQUA SB: GUARDRAIL & TURNOUT IMPROVEMENTS	3
14859	LOOKINGGLASS CR RD: LOOKINGGLASS CR BR REPLACEMENT	3 (by Consultant)
14860	US97 @ WICKIUP JCT (LA PINE) SEC	4
14865	OR38: LUDER CR CULVERT REPLACEMENT	3
14861	US101 @ NE DEVILS LAKE RD	2

Oregon Department of Transportation

3D Design Project Stats

2016 (to date) — 6 Projects in 3 Regions

Contract No.	Project Name	Region
14786	OR 62: CORRIDOR SOLUTIONS UNIT 2 (MEDFORD)	3 (by Consultant)
14868	OR18:NEWBERG-DUNDEE BYPASS (PH 1G)(SPRINGBROOK RD) SEC.	2
14870	OR42: GRAY CREEK CULVERT REPLACEMENT	3
14875	17TH AVE TRAIL: SE OCHOCO - SE MCLOUGHLIN	1
14872	US20 PME: ENVIRONMENTAL MITIGATION MEASURES	2
14879	OR18 @ CHRISTENSEN ROAD SECTION	2

Oregon Department of Transportation

Intelligent Compaction

- Rollers equipped with GNSS positioning, thermal sensing, and/or accelerometer based measurement systems for soil, aggregate and asphalt.
- Advantages
  - Real-time monitoring of compaction efforts
  - On screen visibility for night work
  - Identification of weak spots, material changes
  - Evaluate efficiency of paving operations (paver stops/ lay down temperature)
  - Troubleshooting tool

Oregon Department of Transportation

Intelligent Compaction

- ODOT Pilot Projects
  - 2014: 1 Project, CCO
  - 2015: 3 Projects, CCO
  - 2016: 3 Projects, Special Provision
- Developing training for PM offices
- Pooled Fund Study for Veta Software
  - Provide input on future development of analysis software
  - Collaborate with other agencies on practices and specifications

Intelligent Compaction Users Guide

Oregon Department of Transportation

3D Milling

- Uses 3D model (line strings or surface) to adjust elevation and slope
- Accurately correct pavement cross slope without the use of an asphalt wedge

Oregon Department of Transportation

3D Milling

- Accurately construct pavement cross slope on shifted alignments
- Improve pavement smoothness
- Control PCC quantity on inlay projects
- Provide surface for uniform paving and compaction

White paper on the uses and benefits of 3D Milling

Oregon Department of Transportation

AMG Specifications

- Including reference to 3D Design Model
- Quality assurance and acceptance procedure for contractor model
- Construction tolerances
  - Proper references and unit uniformity
  - Appropriate tolerances for each construction activity
  - Separate OG DTM confidence points and construction grade checks
  - Clarify requirements for inside and outside roadway prism

Oregon Department of Transportation

Inspector Positioning Tablet

- Rugged Tablet with built in GNSS antenna +/- 2cm accuracy
- Can be used “handheld”
- Or with an external antenna and rod for higher accuracy
- Software to display and use XML files for alignment, surface and design files

Oregon Department of Transportation

Inspector Positioning Tablet

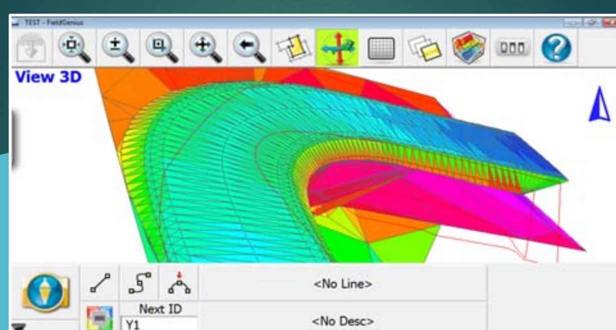
- Rugged Outdoor Tablet
- 9 ½” x 7” x 1 ½” body
- 9” Screen
- Touchscreen
- Full computer
- Survey tool

Deployed 9 Systems Statewide.

Evaluating Effectiveness and Benefits.

Oregon Department of Transportation

Inspector Positioning Tablets



- FieldGenius Survey Software
- Uses XML Files Directly, No Conversion
- Full Survey Software

Oregon Department of Transportation


STATE OF OREGON
1859
OREGON DEPARTMENT OF TRANSPORTATION
Oregon Department of Transportation - Salem, OR
July 9th - 11th, 2014
Work Zone Cam
Oregon
Department
of Transportation