Oregon Department of Transportation

Surveying in a Machine Control World

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Oregon Department of Transportation

ODOT Engineering Automation Conference

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Surveyors are not being replaced by Machines

- Surveyors are as important as ever
- AMG requires <u>skilled</u> survey support
- Many tasks still require traditional staking

Surveying is needed in four phases of a typical project

- Planning, Engineering & Design
  - Years to months before construction (ODOT)
- Pre-Construction
  - At or near Bid Letting date (ODOT)
- Construction
  - Full length of the Construction Project (Contractor)
- Post Construction
  - Starts during construction and continues through the end of the project (Contractor & ODOT)

AMG Requires great Control

- It is all about Control, Control, Control!
- ODO d, durable contr the proje
- All fu initial contr st const

Good enough, isn't good enough.

- 2015 ODOT Survey Policy and Procedures

3.22 Accuracy of Control Points

Determine point locations for project control within the error tolerances in the following absolute accuracy table.

	Horizontal	Vertical
Horizontal Network Points	0.03 ft. (10 mm)	N/A
Vertical Points (TBM)	N/A	0.03 ft. (10 mm)
3D Network Points	0.03 ft. (10 mm)	0.03 ft. (10 mm)
Controlled Strategic Points	0.06 ft. (20 mm)	0.06 ft. (20 mm)
Strategic Points	0.06 ft. (20 mm)	0.06 ft. (20 mm)

Table 3C - Accuracy of Control Points

Good enough, isn't good enough.

- Current ODOT Construction Survey Manual for Contractors

4.1 Construction Staking Tolerances - Set stakes or other devices at an adequate frequency and within the following tolerances. The Engineer may check the stakes in accordance with Chapter 1.4.

Item	Horizontal	Vertical
Box Culverts	+/- 0.10 ft.	+/- 0.05 ft.
Bridge Substructures	+/- 0.03 ft.	+/- 0.03 ft.
Bridge Superstructures	+/- 0.02 ft.	+/- 0.02 ft.
Clearing and Grubbing Stakes	+/- 1.00 ft.	n/a
Construction Centerline Control Points	+/- 0.05 ft.	n/a
Construction Centerline Station Points	+/- 0.10 ft.	n/a
Curbs, Walks, and Bike Paths	+/- 0.03 ft.	+/- 0.02 ft.
Grade Stakes - Roadway Subgrade	+/- 0.20 ft.	+/- 0.05 ft.
Grade Stakes - Top of Rock	+/- 0.20 ft.	+/- 0.03 ft.
Grade Stakes - Roadway Finish	+/- 0.10 ft.	+/- 0.02 ft.
Manholes, Inlets, and Culverts	+/- 0.10 ft.	+/- 0.03 ft.
PCC Pavement	+/- 0.10 ft.	+/- 0.02 ft.

Good enough, isn't good enough.

- 2015 Oregon Standard Specifications for Construction

00756.23

(c) Paving Machine - If a paving machine riding on stationary side forms is used, conform to the following:

- The machine used for initial strike-off and consolidation of PCC shall be self-propelled, screening type and shall ride on and be guided by steel side forms or the edge of contiguous PCC pavement. The machine shall be designed and operated to strike-off, consolidate and compact the PCC to prescribed line, grade and cross section. Make provision to prevent chipping or marring previously placed PCC.

If the control is off +/- 0.05' how can you build it to 0.01'-0.02'?

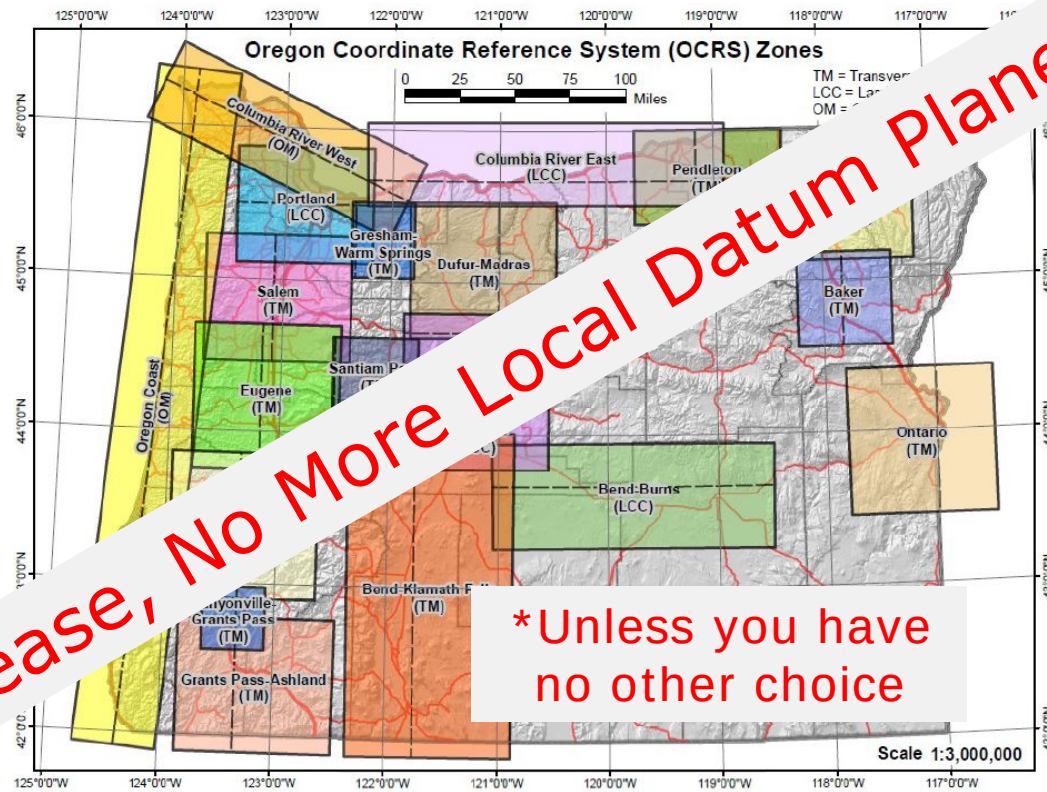
We have the equipment and the procedures in place to produce excellent results, we must put forth the effort.

Set the Project up to Succeed

- Use the right tools
- [illegible]
- [illegible]

Project Coordinates

- Oregon Coordinate Reference System
  - Low Distortion Projections, cover most of Oregon
  - Survey, design, construct, maintain in one coordinate system



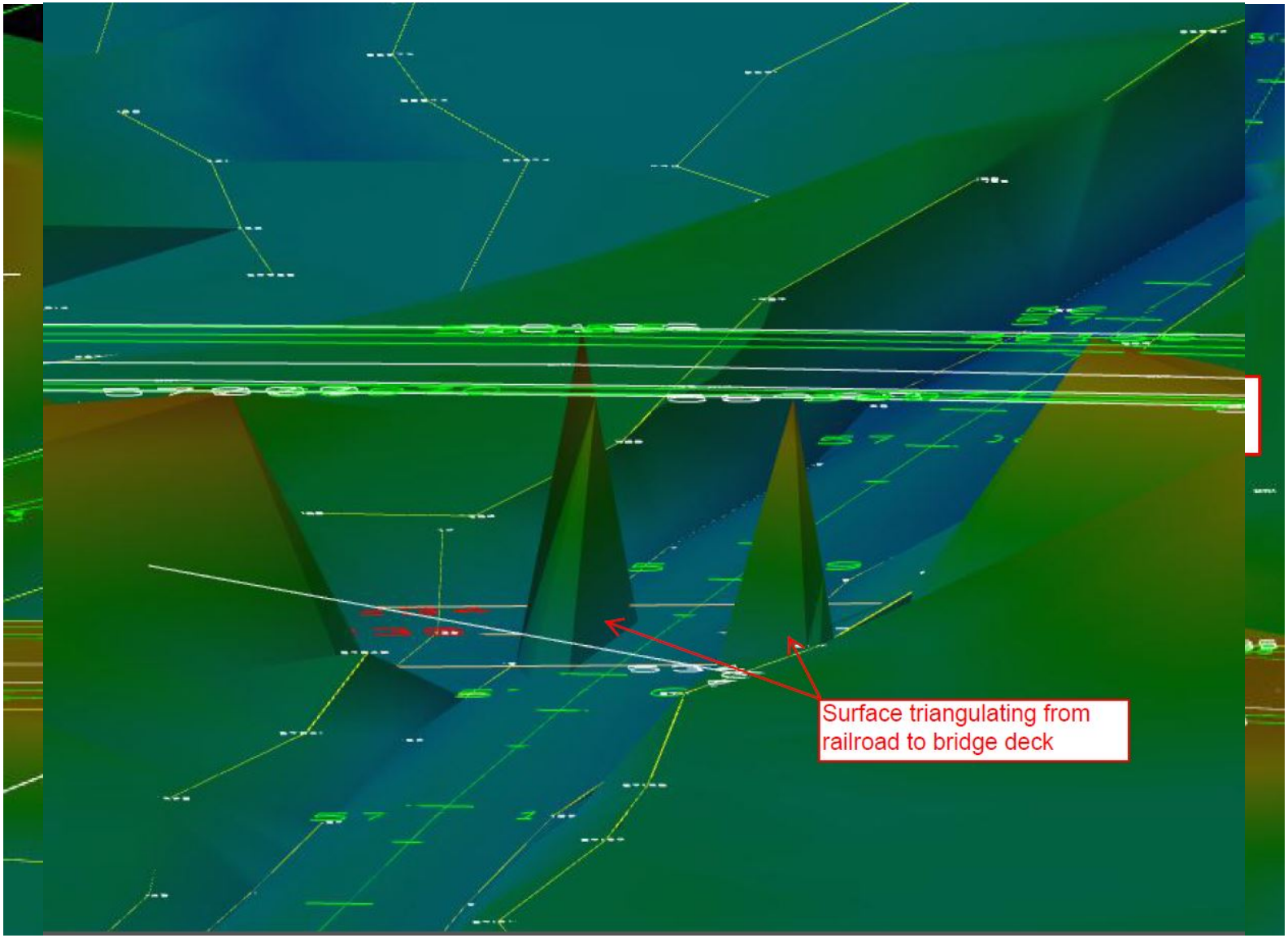
Please, No More Local Datum Planes!

*Unless you have no other choice

Role of the ODOT Location Crew

- Accurate Base map
- Accurate Original Ground (OG) DTM
- Communication between Survey & Design
  - Goal is to allow 100% Design

We said Accurate OG DTM…



Original Ground DTM Tips

- Consistent vertex spacing on breaklines
- Getting the right breaklines in the DTM
  - Only include ‘real’ breaklines
  - Be careful with striping
- LiDAR
  - Enough setups to avoid shadows
  - Build hard surfaces with cross section in mind
  - Avoid having ‘extra’ items in scan data
    - Sweep roadway/mow ditch
    - Note where ‘extra’ items are if scanned

Original Ground DTM Tips

- Increase accuracy at fixed tie in points
  - Bridges
  - Side streets
  - Intersections
  - Existing curb
  - Driveways
  - Match Points
  - As required by project scope

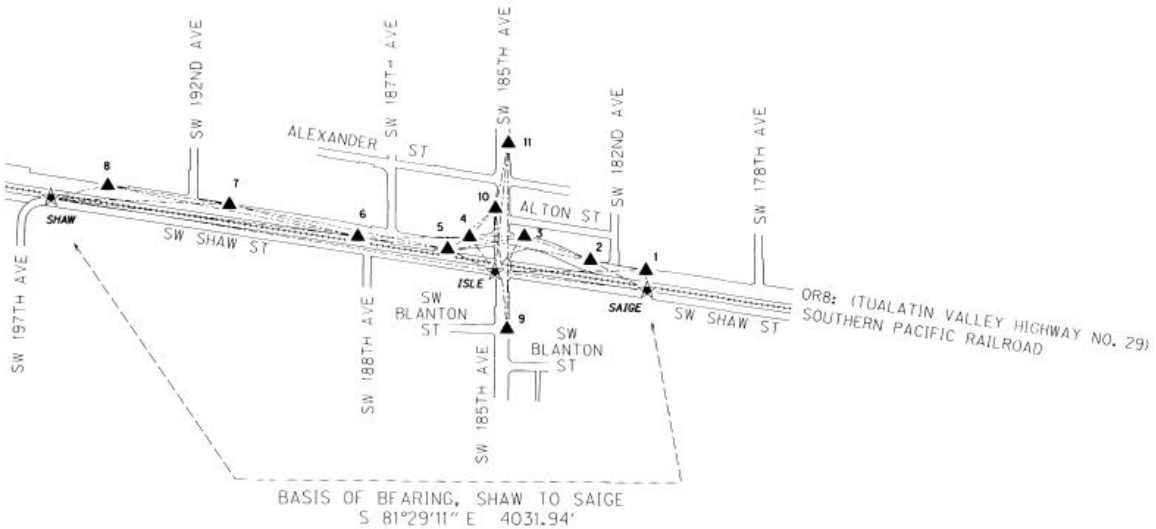
Pre-Construction Survey

- To be completed by ODOT prior to Pre-Survey Conference with Contractor
- Outlined in Construction Survey Manual for Contractors, Chapter 7
- Final quality control check before construction
- First item?
- Control, Control, Control!
  - Recheck horizontal & vertical control

Pre-Construction Survey

SW 1/4 SEC. 7
EDWARD BARTON D.L.C NO. 37
JAMES H. McMILLEN D.L.C NO. 38, T.1S, R.1W, W.M.
SW 1/4 AND SE 1/4 SEC. 12
JAMES H. McMILLEN D.L.C. NO. 58
T.1S, R.2W, W.M.
WASHINGTON COUNTY, OREGON

32429
3/13



NOT TO SCALE

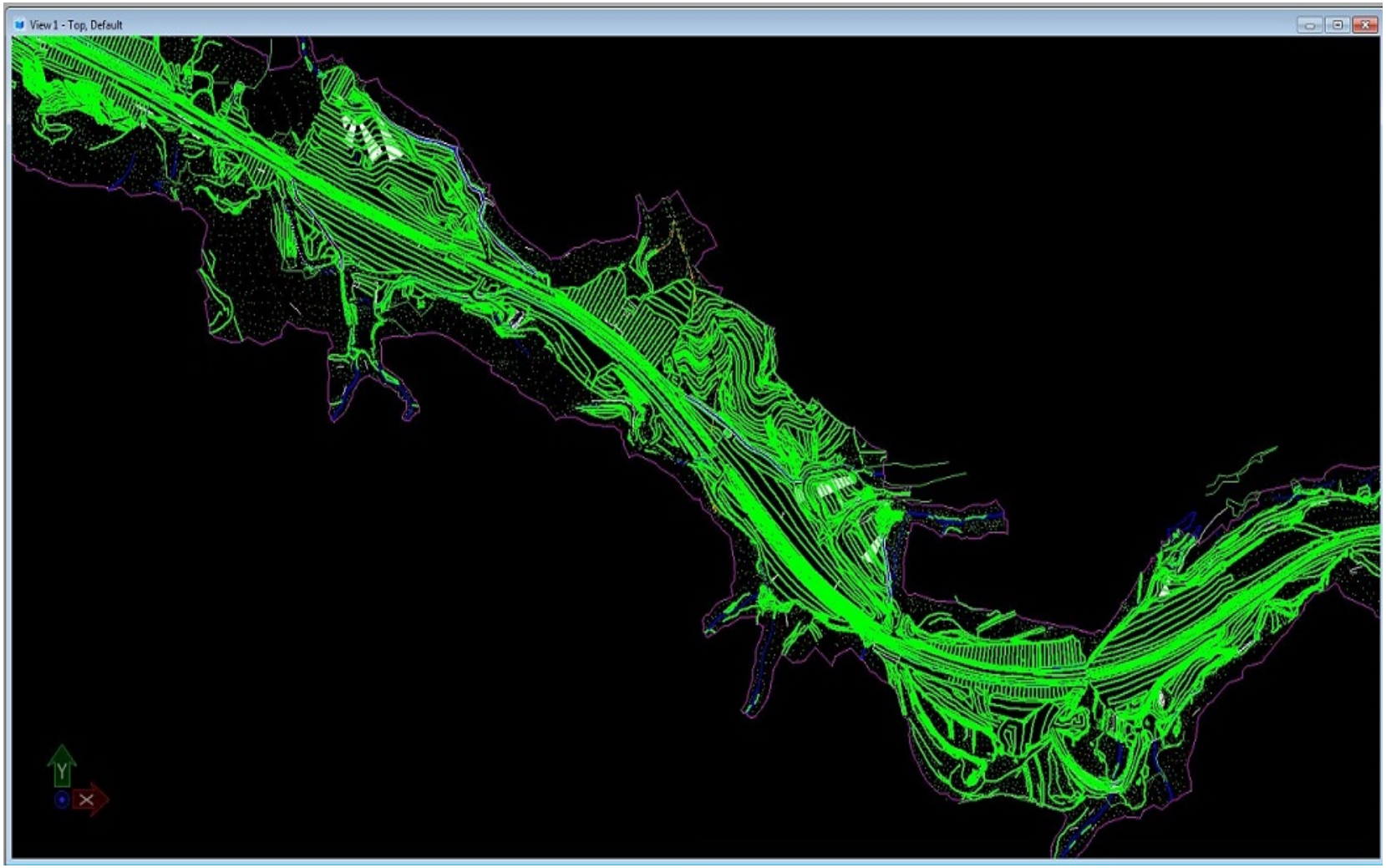
CONTROL LIST, OREGON COORDINATE REFERENCE SYSTEM (OCRS), PORTLAND ZONE, NAD 83 (2011) EPOCH 2010.00

PT. NO.	OCRS NORTHING	OCRS EASTING	DATE	DESCRIPTION
ISLE	161695.568	297984.303	04-26-13	SET 1-3/16" COPPER ALLOY DISK STAMPED "ODOT CONTROL ISLE" FLUSH IN CONCRETE ISLAND
SAIGE	161575.615	299002.001	04-26-13	SET 5/8" IRON ROD WITH 1-1/2" BRASS CAP STAMPED "ODOT CONTROL SHAW" DOWN 0.1'
SHAW	162172.522	295014.486	04-26-13	SET 5/8" IRON ROD WITH 1-1/2" BRASS CAP STAMPED "ODOT CONTROL SAIGE" FLUSH
1	161707.583	298993.872	05-03-13	SET 1-3/16" COPPER ALLOY DISK STAMPED "ODOT CONTROL 1" FLUSH IN TOP OF CURB
2	161773.255	298623.124	05-03-13	SET 1-3/16" COPPER ALLOY DISK STAMPED "ODOT CONTROL 2" FLUSH IN TOP OF CURB
3	161932.975	298180.420	05-03-13	SET 1-3/16" COPPER ALLOY DISK STAMPED "ODOT CONTROL 3" FLUSH IN TOP OF CURB
4	161928.244	297813.508	05-03-13	SET 1-3/16" COPPER ALLOY DISK STAMPED "ODOT CONTROL 4" FLUSH IN TOP OF CURB
5	161844.773	297667.563	05-03-13	SET 5/8" IRON ROD WITH 1-1/2" BRASS CAP STAMPED "ODOT CONTROL 5" DOWN 0.1'
6	161922.318	297068.111	05-03-13	SET 1-3/16" COPPER ALLOY DISK STAMPED "ODOT CONTROL 6" FLUSH IN TOP OF CURB
7	162131.751	296208.967	05-03-13	SET 1-3/16" COPPER ALLOY DISK STAMPED "ODOT CONTROL 7" FLUSH IN TOP OF CURB
8	162253.025	295394.946	05-03-13	SET 1-3/16" COPPER ALLOY DISK STAMPED "ODOT CONTROL 8" FLUSH IN FLUSH IN SIDEWALK
9	161311.685	298065.977	05-03-13	SET 1-3/16" COPPER ALLOY DISK STAMPED "ODOT CONTROL 9" FLUSH IN TOP OF CURB
10	162120.114	297986.119	05-03-13	SET 1-3/16" COPPER ALLOY DISK STAMPED "ODOT CONTROL 10" FLUSH IN TOP OF CURB
11	162555.519	298071.871	05-03-13	SET 1-3/16" COPPER ALLOY DISK STAMPED "ODOT CONTROL 11" FLUSH IN TOP OF CURB

Pre-Construction Survey

- To be completed by ODOT prior to Pre-Survey Conference with Contractor
- Outlined in Construction Survey Manual for Contractors Chapter 7
- Final quality control check before construction
- First item?
- Control, Control, Control!
- Second item?
- OG DTM
  - Additional Confidence Points

Pre-Construction Survey



Survey Handoff Package

SAMPLE ROADWAY CONSTRUCTION SURVEY HANDOFF DELIVERABLE CHECKLIST*

Final list of handoff package contents will be negotiated between the roadway designer and the construction office staff. Some items on this list may not be needed; additional items may be needed.

ITEM	DESCRIPTION**	REQUIRED?	COMPLETE?
Computer File Index	List of computer file names with a brief description for all provided files	☐	☐
Bid Item Quantity Calculations	Spreadsheets containing computations	☐	☐
	Scanned pdf's of hand calculated quantities	☐	☐
	InRoads Volume Reports	☐	☐
Alignment Reports	Construction CL Reports (*.txt or *.html)	☐	☐
	Detour CL Reports (*.txt or *.html)	☐	☐
	Misc. Alignments (Curbs, EP radius, etc.)	☐	☐
Grade Reports	Cross Section Report at intervals agreed upon with construction and also containing critical points	☐	☐
	Report Contains Transition Control Name, Finish Grade Elevation, Offset, Original Ground Elevation, Slope	☐	☐
	List and descriptions of feature names	☐	☐
	Reports in XML format to accommodate different report styles	☐	☐
Cross Sections	Cross Sections every 25 feet and at critical points (i.e. taper points, guardrail flare transitions, impact panels, super elevation breaks, etc.) that contain Finish Grade, Existing Ground, and Subgrade	☐	☐
Design Files***	Existing Ground MicroStation File (to be provided by Surveyor)	☐	☐
	MicroStation Design File containing final drafting	☐	☐
	MicroStation Design Files displaying features and triangles of each roadway layer - e.g., subgrade, base, finish grade	☐	☐
	MicroStation Design File containing only construction alignments displayed & labeled (Horizontal & Vertical)	☐	☐
	MicroStation Cross Section File	☐	☐
	MicroStation Plan Sheet Files	☐	☐
	Existing Ground Surfaces (*.dtm) - to be provided by Surveyor	☐	☐
	Subgrade Surfaces (*.dtm)	☐	☐
	Top of Rock Surfaces (*.dtm)	☐	☐
	Finish Grade Surfaces (*.dtm)	☐	☐
	Geometry File (*.alg)	☐	☐
	Template Library (*.itl)	☐	☐
	Roadway Design (*.ird)	☐	☐

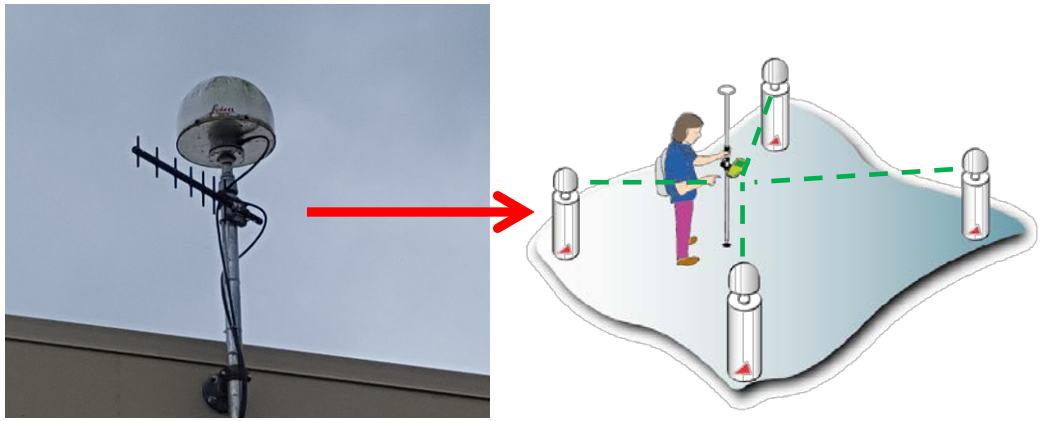
Construction Surveying

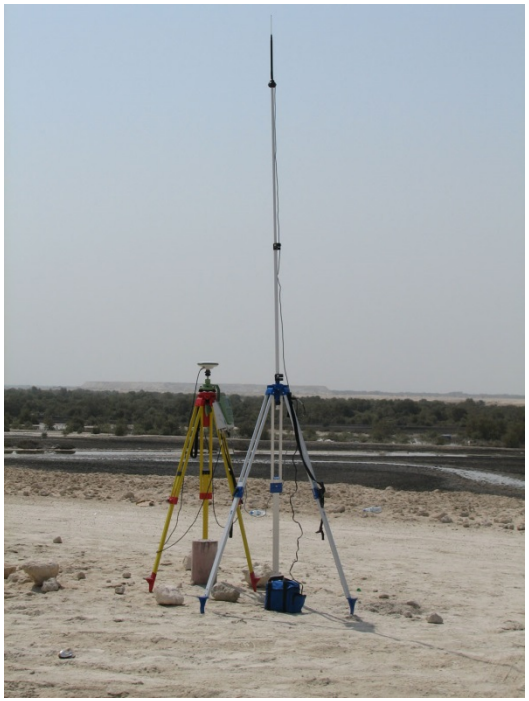
- First requirement for successful AMG Equipment?
- Control, Control, Control!

- ODOT sets original control ever 1500ft
- TPS guided AMG equipment - control every 800ft
- TPS guided Concrete paving - control every 400ft
- Contractor should densify the control and lay it out to match the equipment they plan to use
  - Proper procedures using proper equipment
  - Maintain control for the life of the project

Contractor Surveying Decisions

- Coordinate System
  - Localization/Transformation
  - vs. OCRS Zone
- RTK Base for AMG
  - Local Radio Base
  - vs. ORGN





Surveying for Machine Setup

- Benchmarks to calibrate the machines

Surveying for Quality Control

- Checking the work of the machines

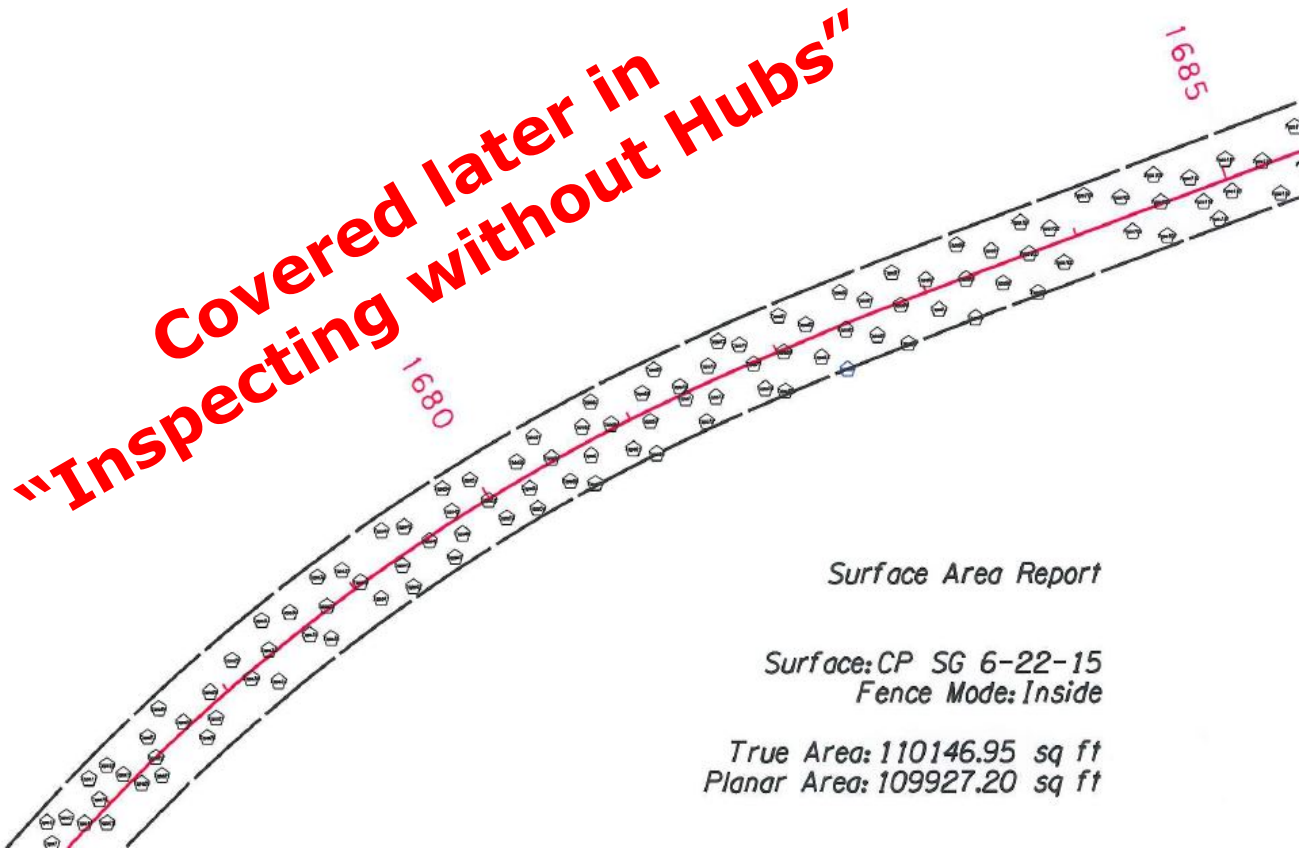
- Diligent checks by contractor will virtually eliminate “survey” mistakes
- Checks should be made with tools of same or higher accuracy

And not all tasks are Automated

- Traditional Staking for non AMG tasks

We didn't even touch on…

- Grade Verification Points



We didn't even touch on…

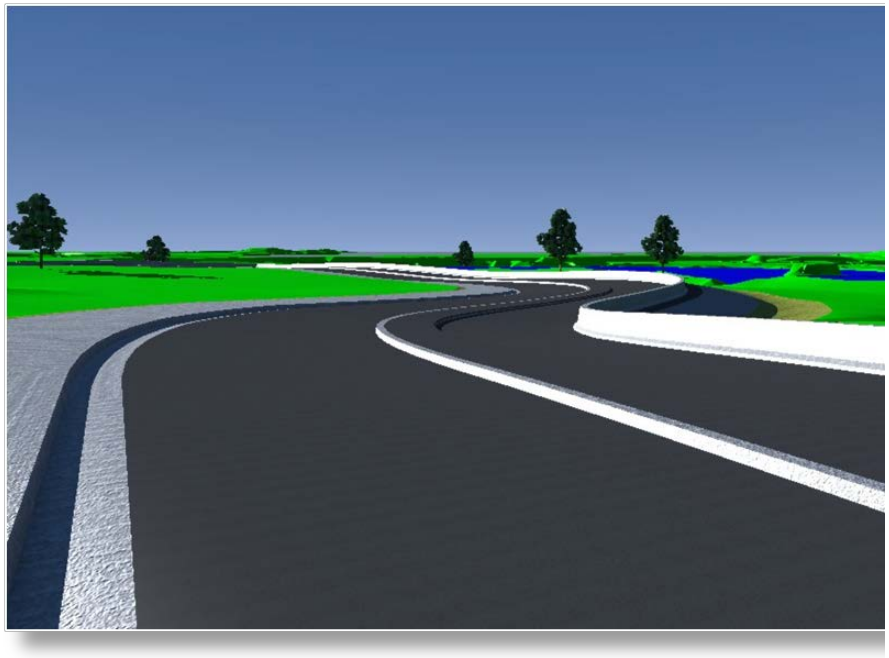
- Post Construction Surveys/As-Builts
  - Transition from Paper As-Built to 3D Digital Model of the Constructed Project

Keys to Success

- Start with a clear scope
- Establish and maintain solid control
- Follow proper procedures
- Clear communication at each phase
- Document what you've done

- Easier to solve problems during survey & design then to wait until equipment is bearing down on you

Thank You!



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