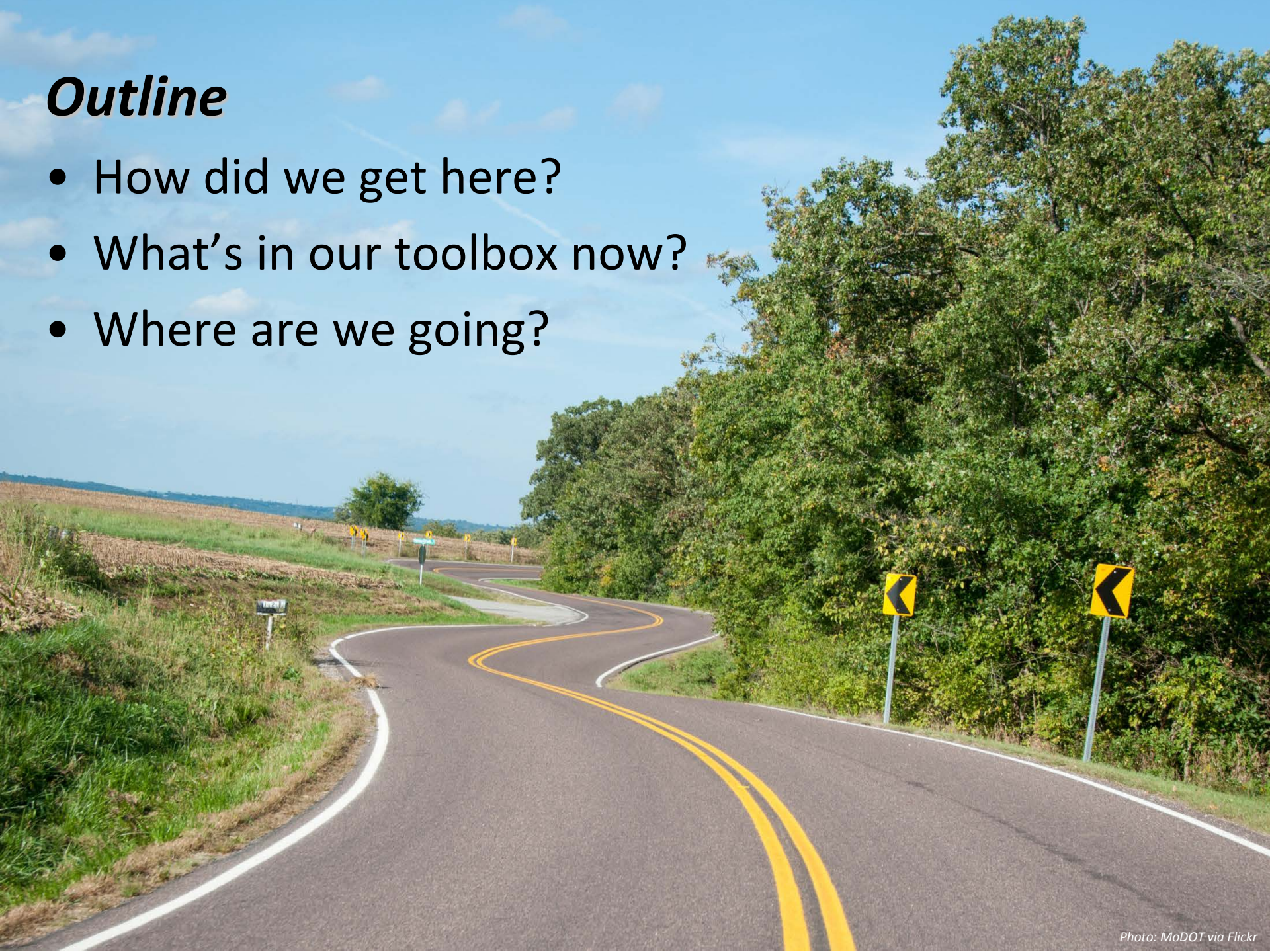
# Curve Advisory Speed Tools

## The Past, Present, and Future

**Oregon Department of Transportation**
Traffic-Roadway Section
Traffic Standards Unit

*Photo: Al Case via Flickr*



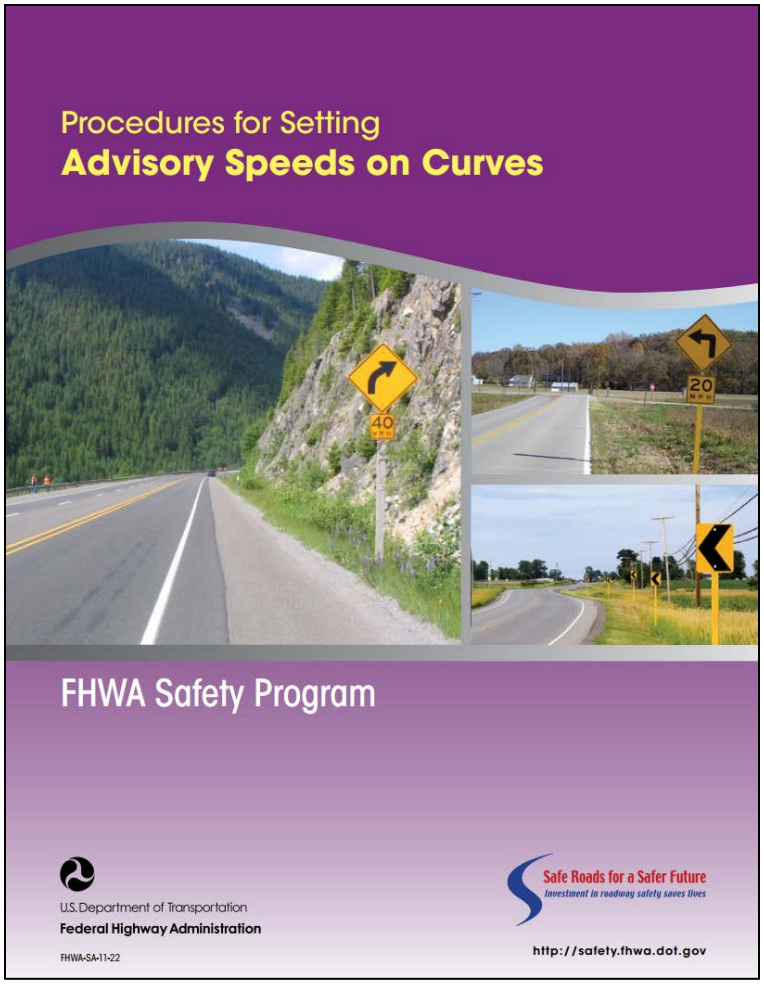
# *Outline*

- How did we get here?
- What's in our toolbox now?
- Where are we going?

Photo: MoDOT via Flickr

# *Methods*

- Direct Method
- Compass Method
- GPS Method
- Design Method*
- Ball-Bank Method*
- Accelerometer Method*
- Etc. etc. etc…




Milstead, R., X. Qin, B. Katz, J. Bonneson, M. Pratt, J. Miles, and P. Carlson.
**Procedures for Setting Advisory Speeds on Curves.** Washington, D.C., FHWA-SA-11-22, 2011.
http://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasa1122/fhwasa1122.pdf.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# *Evolving Limits - Nationally*

**Moyer & Berry (1940)**

| Speed (mph) | Limit (degrees) |
|---|---|
| ≤20 | 14 |
| 25 ≤ speed ≤ 30 | 12 |
| 35 ≤ speed ≤ 60 | 10 |

**2009 MUTCD**

| Speed (mph) | Limit (degrees) |
|---|---|
| ≤20 | 16 |
| 25 ≤ speed ≤ 30 | 14 |
| ≥35 | 12 |

Source: Dixon, K., and J. Rohani. **Methodologies for Estimating Advisory Curve Speeds on Oregon Highways.** School of Civil and Construction Engineering, Oregon State University, Corvallis, OR, SPR 641, 2008. http://www.oregon.gov/ODOT/TD/TP_RES/docs/reports/2007/spr_641.pdf.

# *Evolving Limits – ODOT*

### 1957 & 1966 Oregon MUTCD

| Speed (mph) | Limit (degrees) |
|---|---|
| ≤ 30 | 13 |
| ≥ 35 | 10 |

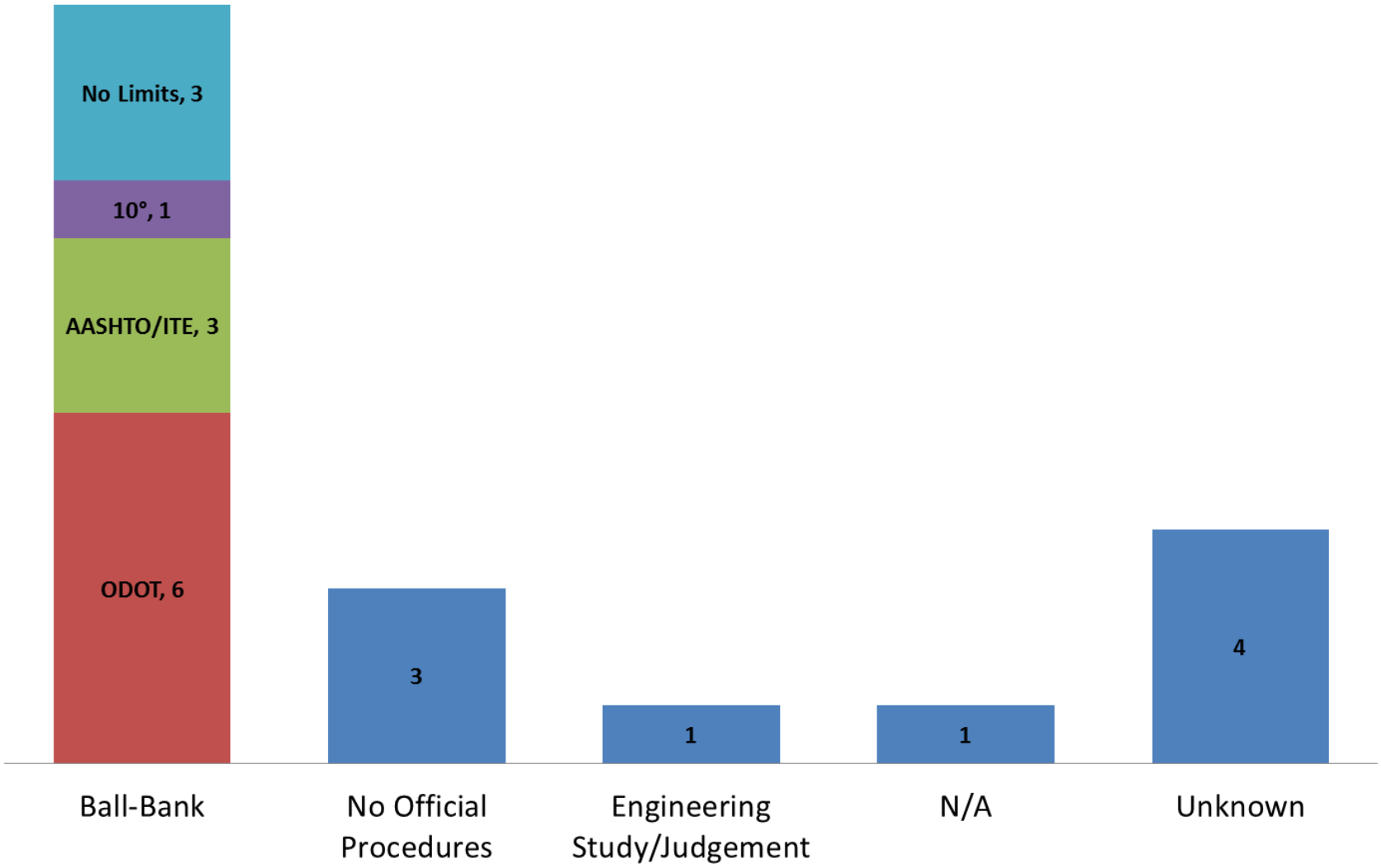
### ???-2011 ODOT Policy

| Speed (mph) | Limit (degrees) |
|---|---|
| ≤ 30 | 13 |
| 35 ≤ speed ≤ 55 | 10 |
| ≥ 60 | 7 |

### 2011-Now – 2009 MUTCD

| Speed (mph) | Limit (degrees) |
|---|---|
| ≤ 20 | 16 |
| 25 ≤ speed ≤ 30 | 14 |
| ≥ 35 | 12 |

# Oregon County Practices (2007)




22 out of 36 counties responding

Source: Dixon, K., and J. Rohani. **Methodologies for Estimating Advisory Curve Speeds on Oregon Highways.** School of Civil and Construction Engineering, Oregon State University, Corvallis, OR, SPR 641, 2008. http://www.oregon.gov/ODOT/TD/TP_RES/docs/reports/2007/spr_641.pdf.

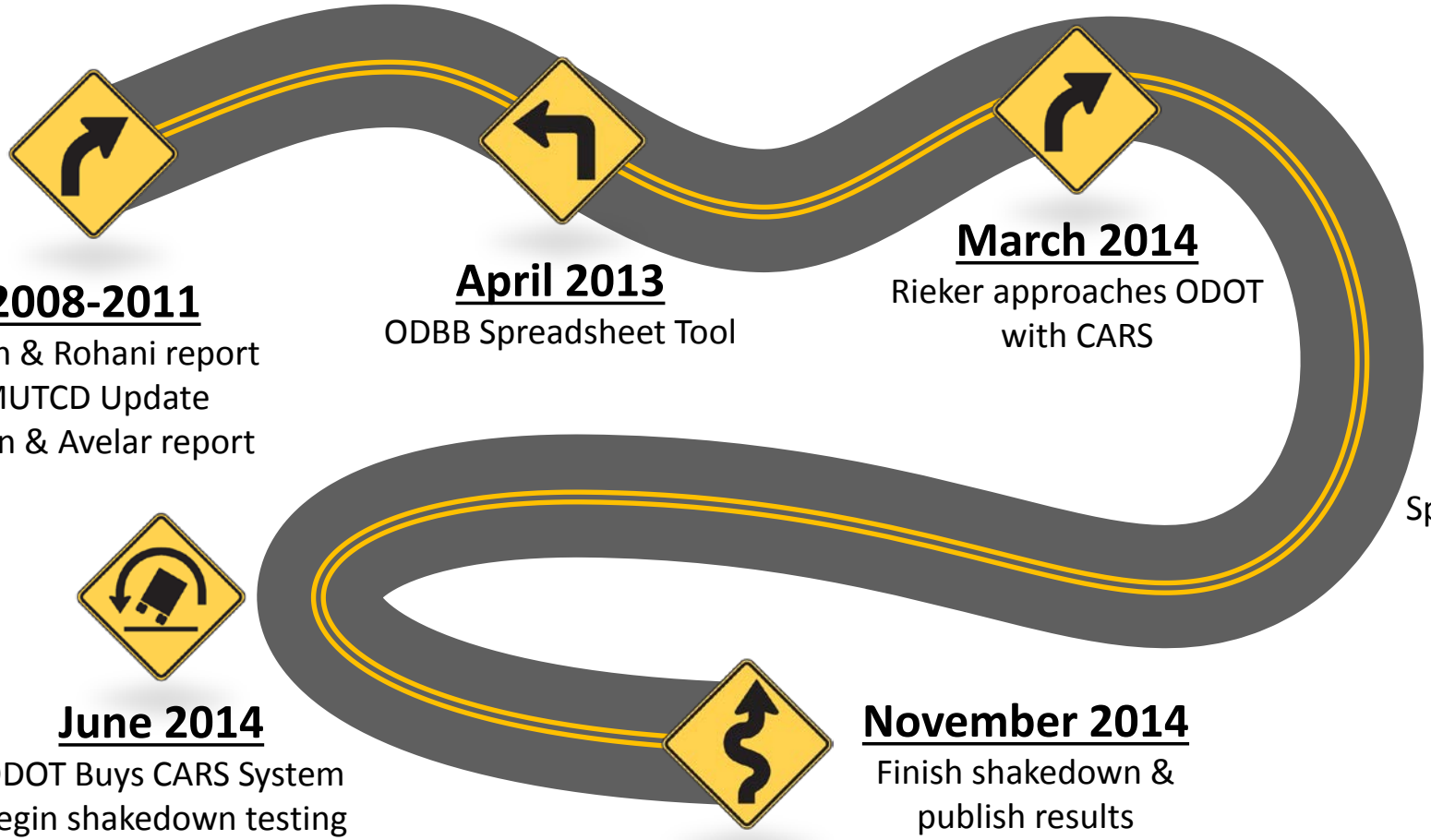

Photo: Worldpress.com

# *MUTCD Changes (2C.06-2C.14)*

- Increased requirements for signing curves
  - Based on speed reduction (Table 2C-5)
  - Chevron Requirements
  - Added supporting language for tools
    - Accelerometer
    - Design Speed Equation
    - Ball-bank limits
- Compliance Date – December 31, 2019

# Curve Evaluation Tools

Photo: John Allspaw via Flickr



**2008-2011**
Dixon & Rohani report
MUTCD Update
Dixon & Avelar report

**April 2013**
ODBB Spreadsheet Tool

**March 2014**
Rieker approaches ODOT with CARS

**May 2014**
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Begin shakedown testing
Eric's son is born ☺

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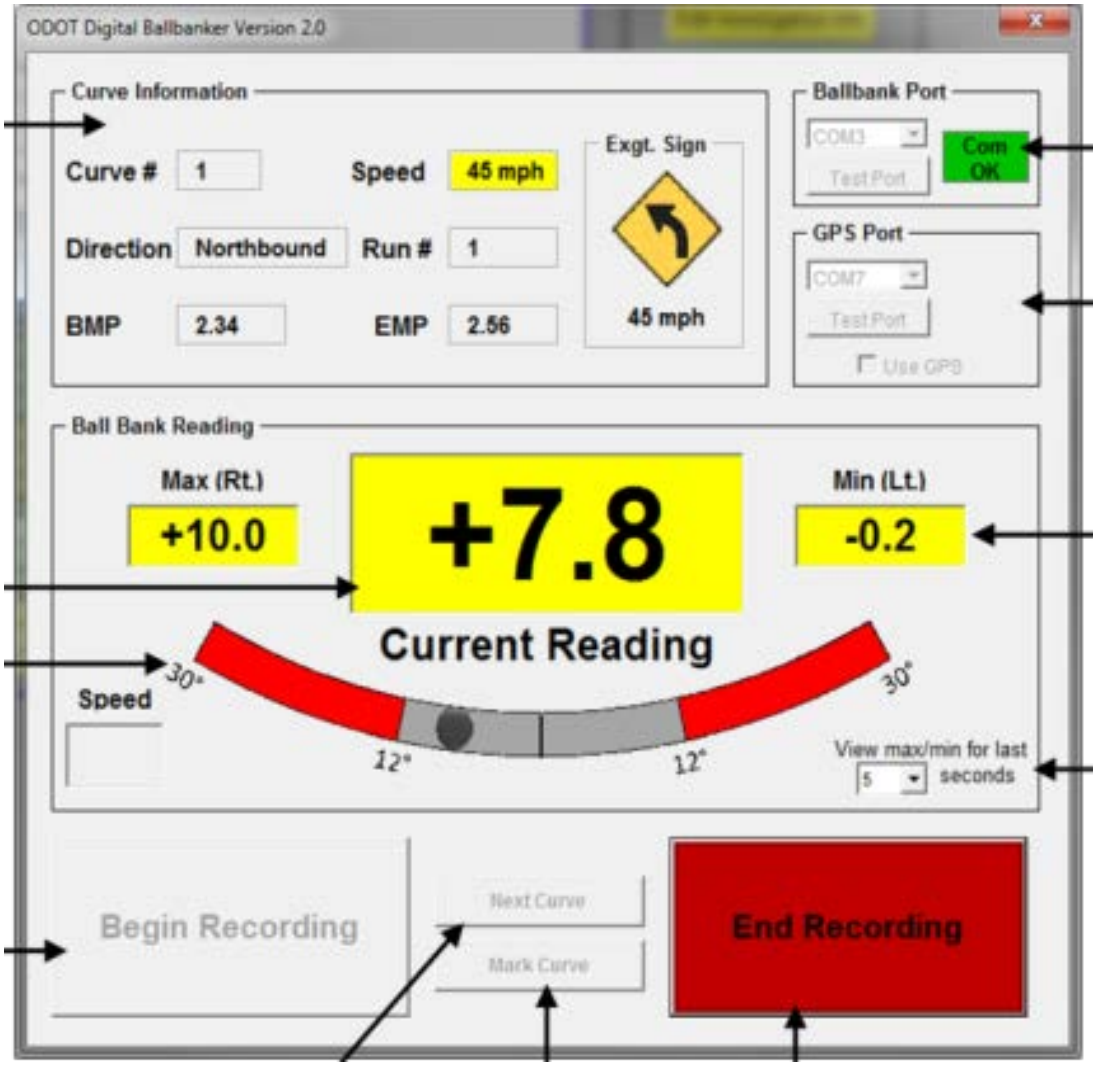
Finish shakedown & publish results

# ODOT Spreadsheet



OREGON DEPARTMENT OF TRANSPORTATION
Digital Ballbanker Version 2.0 - Beta Test

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# BALL-BANK SUMMARY REPORT - CURVE 5

## CURVE INFORMATION SUMMARY

| | | | |
|---|---|---|---|
| Highway | 032 THREE RIVERS | Date | Wednesday, April 30, 2014 |
| Route | OR 22 | Weather | SUNNY |
| Location | E OF HEBO | Surface Type | Asphalt |
| BMP | 6.69 | Surface Condition | DRY |
| EMP | 6.95 | Vehicle No. | 07-0136 |
| Recorder(s) | WR | Make | 2007 CHEVY |
| | | Model | 2500 HD PU |

### EXISTING SIGNING SUMMARY

| SB | NB |
|---|---|
| Rider 45 mph<br>Regulatory 55 mph | Rider 45 mph<br>Regulatory 55 mph |

## AVERAGE BALL-BANK VALUES (DEGREES)

| DIRECTION | VALUE | Speed (mph) 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SB | Smoothed | | | | | | | | 8.8 | 11.1 | 13.5 | | |
| | Max Right | | | | | | | | 2.5 | 2.3 | 2.2 | | |
| | Max Left | | | | | | | | -9.4 | -12.0 | -14.0 | | |
| | **Final** | | | | | | | | **No Entry** | **No Entry** | **No Entry** | | |
| NB | Smoothed | | | | | | | | 6.7 | 9.6 | 12.2 | | |
| | Max Right | | | | | | | | 7.7 | 10.6 | 13.0 | | |
| | Max Left | | | | | | | | -2.9 | -2.9 | -3.2 | | |
| | **Final** | | | | | | | | **No Entry** | **No Entry** | **No Entry** | | |

*Note: Yellow highlighted values exceed 2009 MUTCD limit.

## INVESTIGATION RECOMMENDATION

| RECOMMENDED SIGN + RIDER | | |
|---|---|---|
| SB | Sign | Edit |
| | Rider | |
| NB | Sign | Edit |
| | Rider | |

NOTES



## CHEVRON REQUIREMENTS*

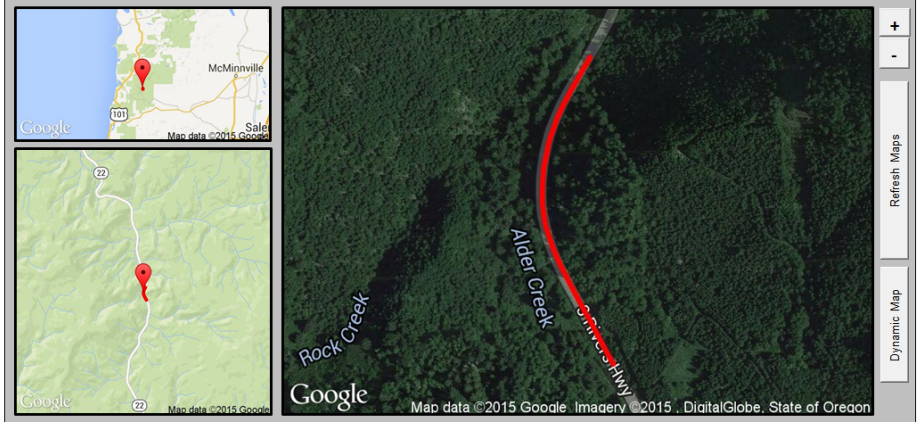
| Direction | Regulatory Speed | Recom. Rider | Difference (mph) | Chevrons |
|---|---|---|---|---|
| SB | 55 mph | | | |
| NB | 55 mph | | | |

*Requirements per 2009 MUTCD Table 2C-5.

## 2009 MUTCD LIMITS

| | |
|---|---|
| Speeds of 20 mph or less | 16 degrees |
| Speeds of 25 to 30 mph | 14 degrees |
| Speeds of 35 mph and higher | 12 degrees |

## VICINITY MAP



## TRIAL RUN SUMMARIES

### NB - SPEED 50

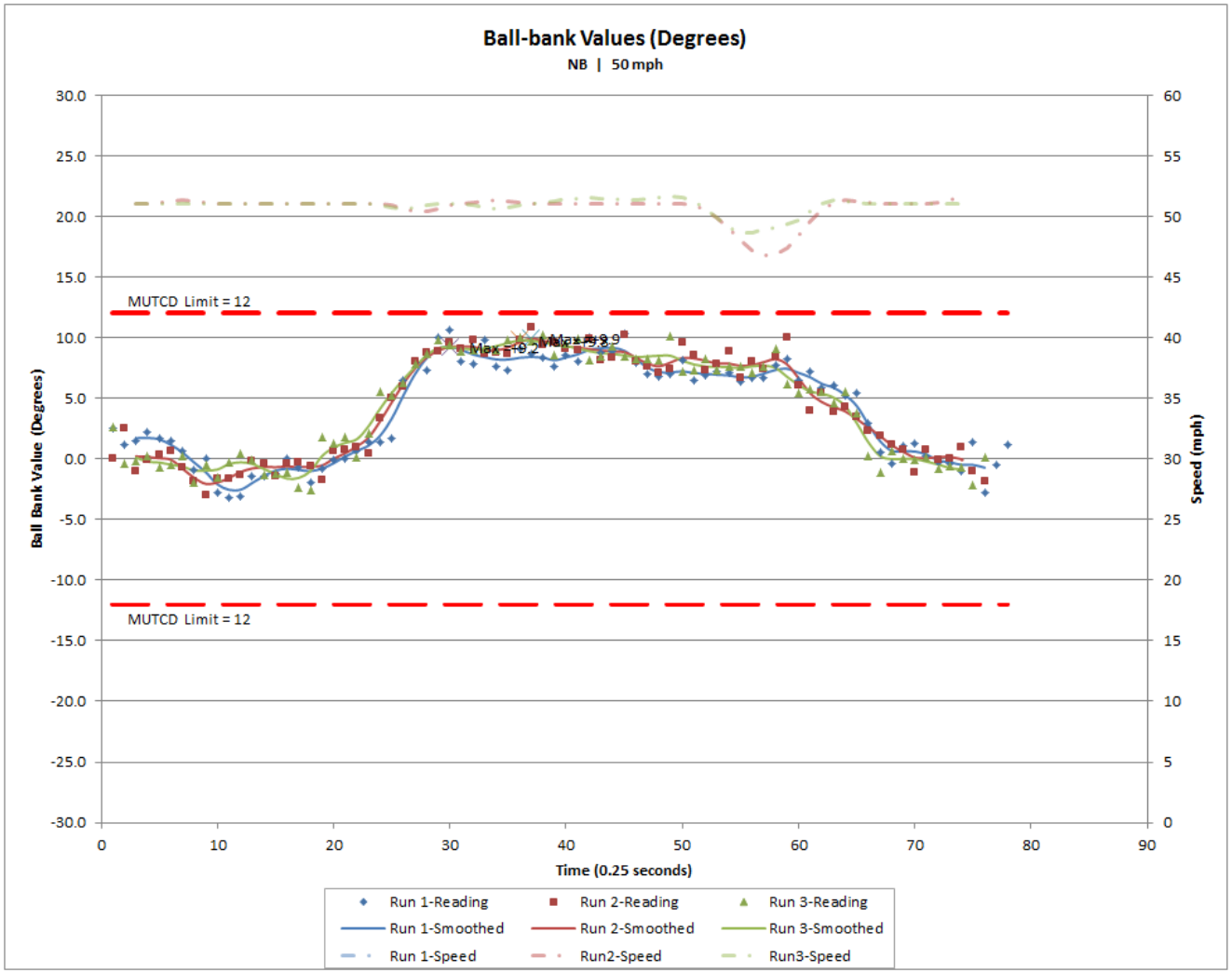
**BALL-BANK VALUE SUMMARY (Degrees of Ball-Bank)**

| SUMMARY VALUES | RUN 1 | RUN 2 | RUN 3 | AVERAGE | MUTCD Limit = 12 |
|---|---|---|---|---|---|
| Max Smoothed Value | 9.2 | 9.9 | 9.8 | 9.6 | Below MUTCD |
| Max Right | 10.7 | 10.8 | 10.2 | 10.6 | Below MUTCD |
| Max Left | -3.2 | -3.0 | -2.6 | -2.9 | Below MUTCD |
| Average Speed (mph) | Not Collected | 51 | 51 | Not Collected | |
| Date Collected | 5/7/2014 | 5/7/2014 | 5/7/2014 | | |
| Time Collected | 11:14 AM | 11:30 AM | 11:34 AM | | |

| FINAL VALUE |
|---|
| |

**DATA FEEDBACK**

| Graph | If Resigning Curve |
|---|---|
| All | Need 1 more run(s). |
| Show Speed | |



# *Curve Advisory Reporting System (CARS)*

- Ball-banking system
- Inclination + GPS + website
- 1-pass in each direction
- Collect data with traffic, whole corridor
- Quick* in-office analysis + reporting

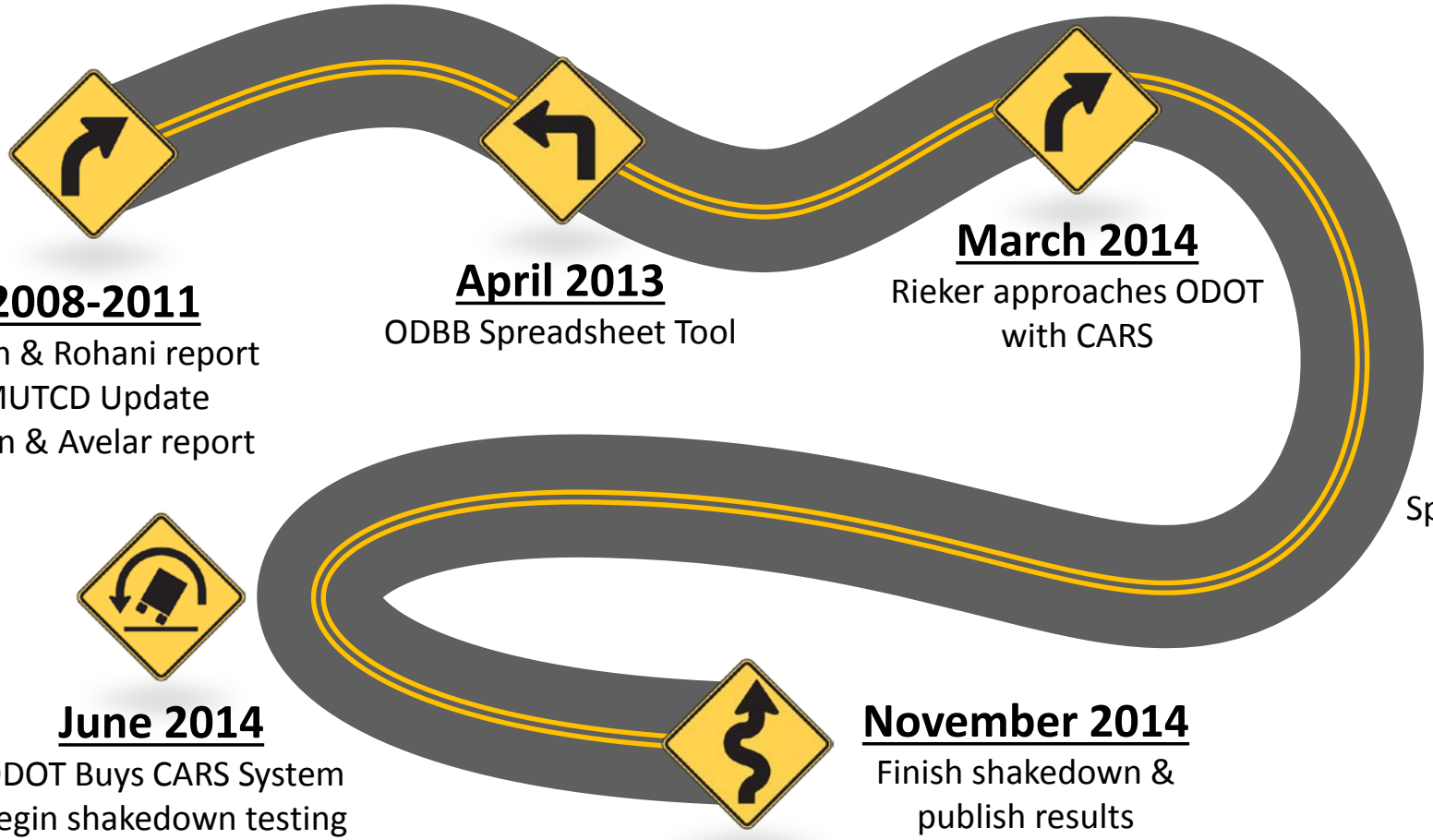


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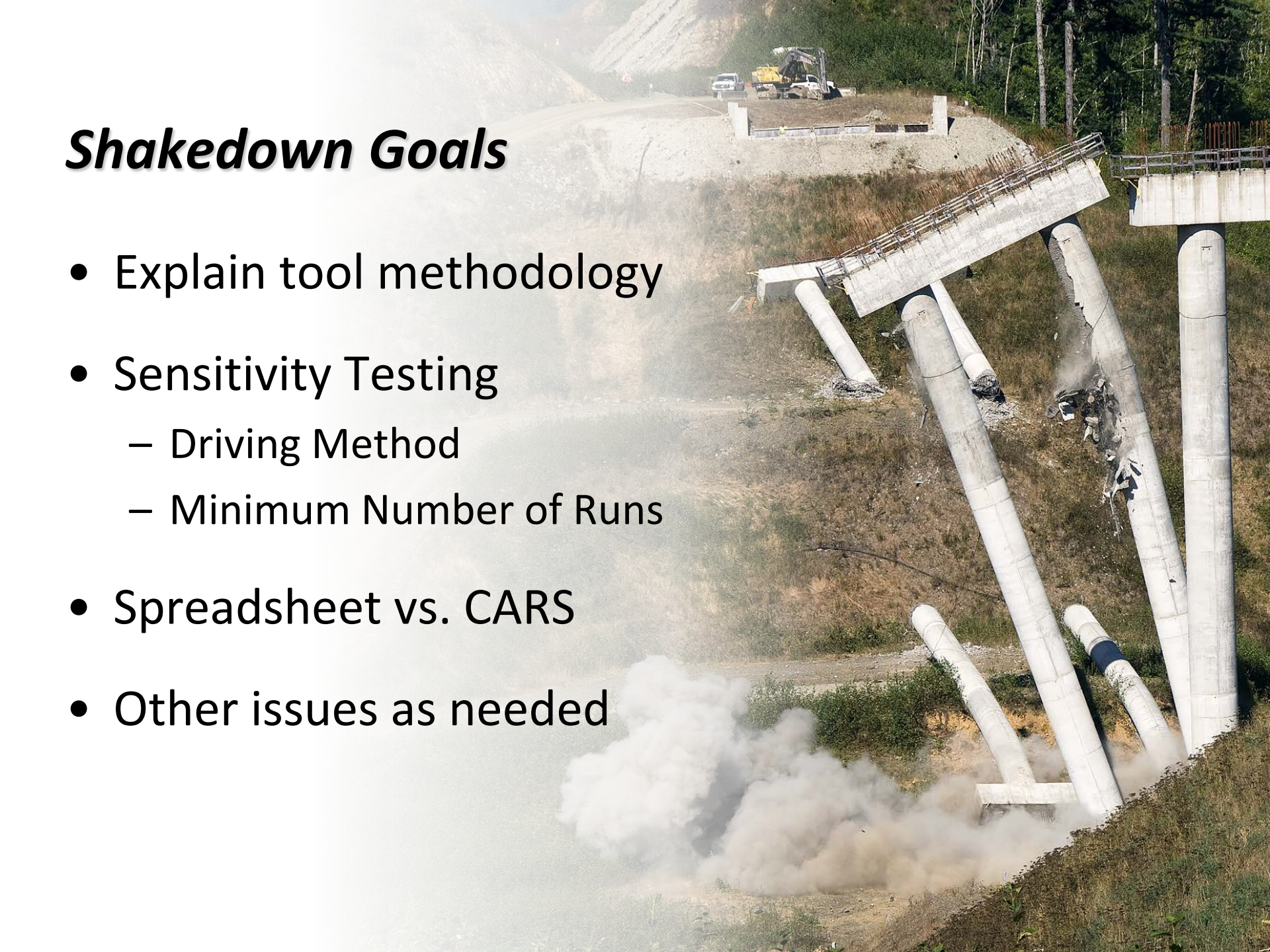
*Photo: Skip Gosnell*

# *Shakedown Goals*

- Explain tool methodology
- Sensitivity Testing
  - Driving Method
  - Minimum Number of Runs
- Spreadsheet vs. CARS
- Other issues as needed



# *Sensitivity Testing*

- Goals
  - Variety of curve speeds
  - High curve density (minimize collection efforts)
  - Curves tested with Spreadsheet v2.0
  - Segments with heavy foliage/against hillsides
- Test Highways
  - 428 curve approaches
  - 3 Rivers Highway No. 032 (OR 22)
  - Oregon Coast Highway No. 009 (US 101)
  - Mist-Clatskanie Highway No. 110 (OR 47)
  - Siletz Highway No. 151 (OR 229)
  - Cascade Highway No. 160 (OR 213)
  - Yamhill-Newberg Highway No. 151 (OR 240)

# *Findings*

- Significant time savings for field collection
- Software + connectivity issues (fixable…)
- Drive slow + very smooth
- Speed from run-to-run can vary
- Inexperienced investigator OK with training + practice

# *Findings (continued)*

- Error (95%)~ ±3.5% at 3 runs
- Spreadsheet vs. CARS
  - Same at 50% of 76 curve approaches
  - Within 5 mph at 91% of 76 curve approaches
  - If different, CARS generally higher than spreadsheet

# *Traditional Ball-banking vs. CARS*

- Data Collection
  - Driving Style
  - Body Roll
- Post Processing
  - Weighted moving average of 1 variable
  - Parabolic best-fit of 3 variables
- CARS more
  - Precise + Repeatable
  - Time efficient (field)
  - Safe for investigators
  - Defendable

# *Recommendations*

- Use CARS method for curve advisory investigations
- Use average calculated advisory speed of ≥3 runs
- Collect CARS data on all highways (consistency)
- Projects already designed: OK if used spreadsheet

# *Future*

- Tool Availability
- Re-Signing Efforts
- Research Opportunities


*Photo: DaveynIn via Flickr*

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**Speed Zone Investigator, R2**
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**503-986-2992**

**http://www.oregon.gov/ODOT/HWY/TS/Pages/signing.aspx**

*Photo: Joe Parks via Flickr*