NCHRP 3-65: Applying Roundabouts in the United States

Design: Preliminary Findings

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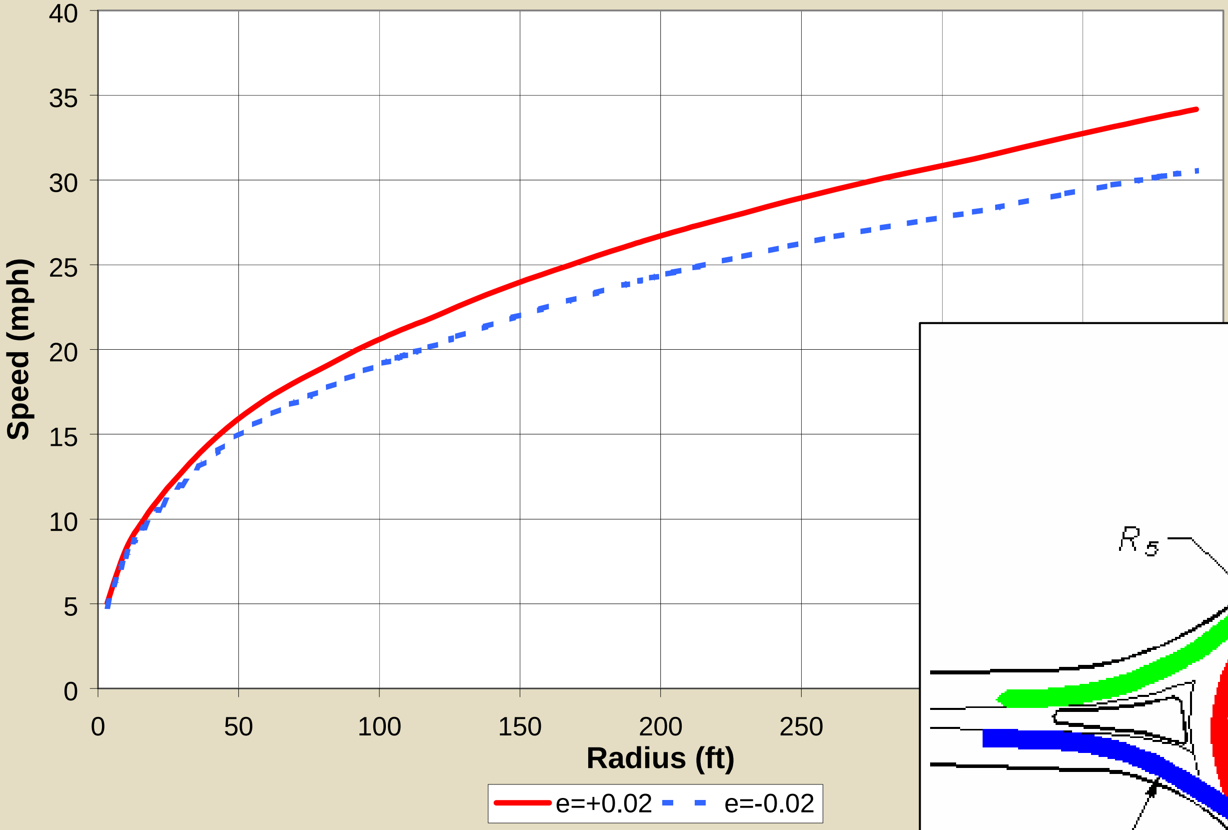
Topics of Discussion

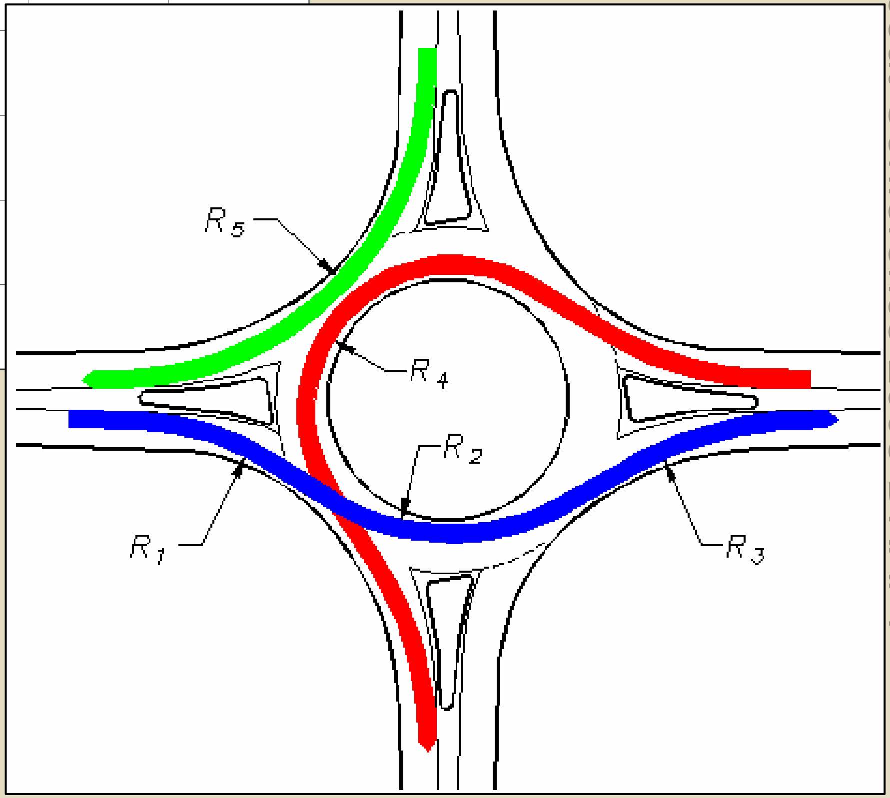
- **Design speed modeling**
- **Other design findings for motor vehicles**
- **Pedestrian and bicycle observations**

Acknowledgements

- Karen Giese – assisted in the speed analysis
- Ed Myers – assisted in design review
- David Harkey – led the ped/bike analysis

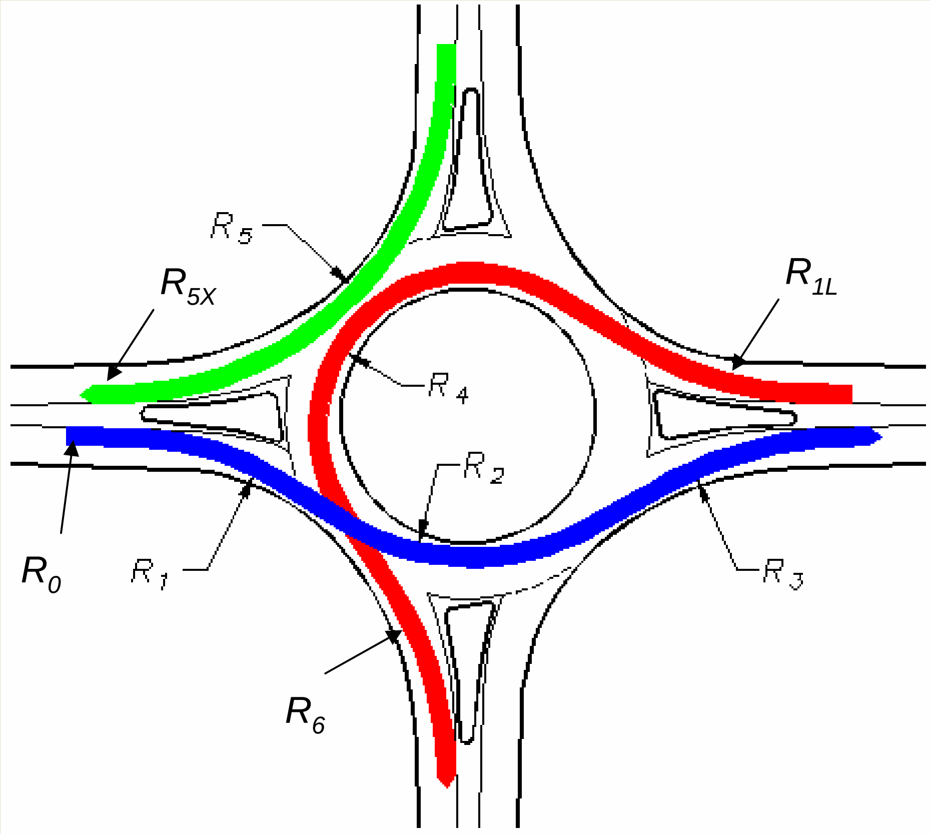
Current FHWA speed prediction method is based on AASHTO speed-radius function.





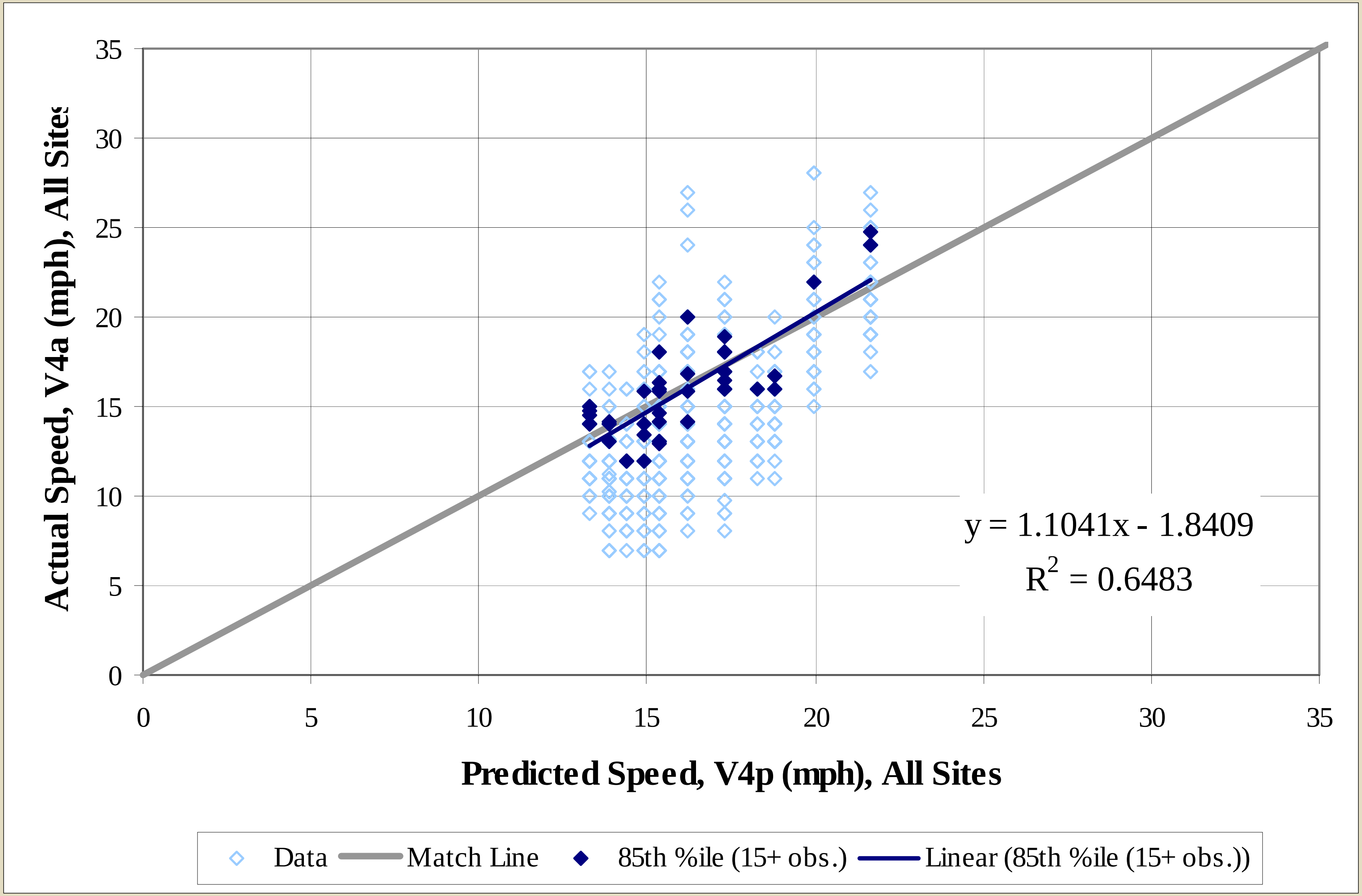
Design speed modeling: Vehicle path definitions

- V_0: approach path radius
- Through movements
  - ***V1: entry path radius***
  - ***V2: circulating path radius***
  - ***V3: exit path radius***
- Left turns
  - ***V1L: entry path radius***
  - ***V4: circulating path radius***
  - ***V6: left turn path exit radius***
- Right turns
  - ***V5: entry path radius***
  - ***V5x: exit path radius***

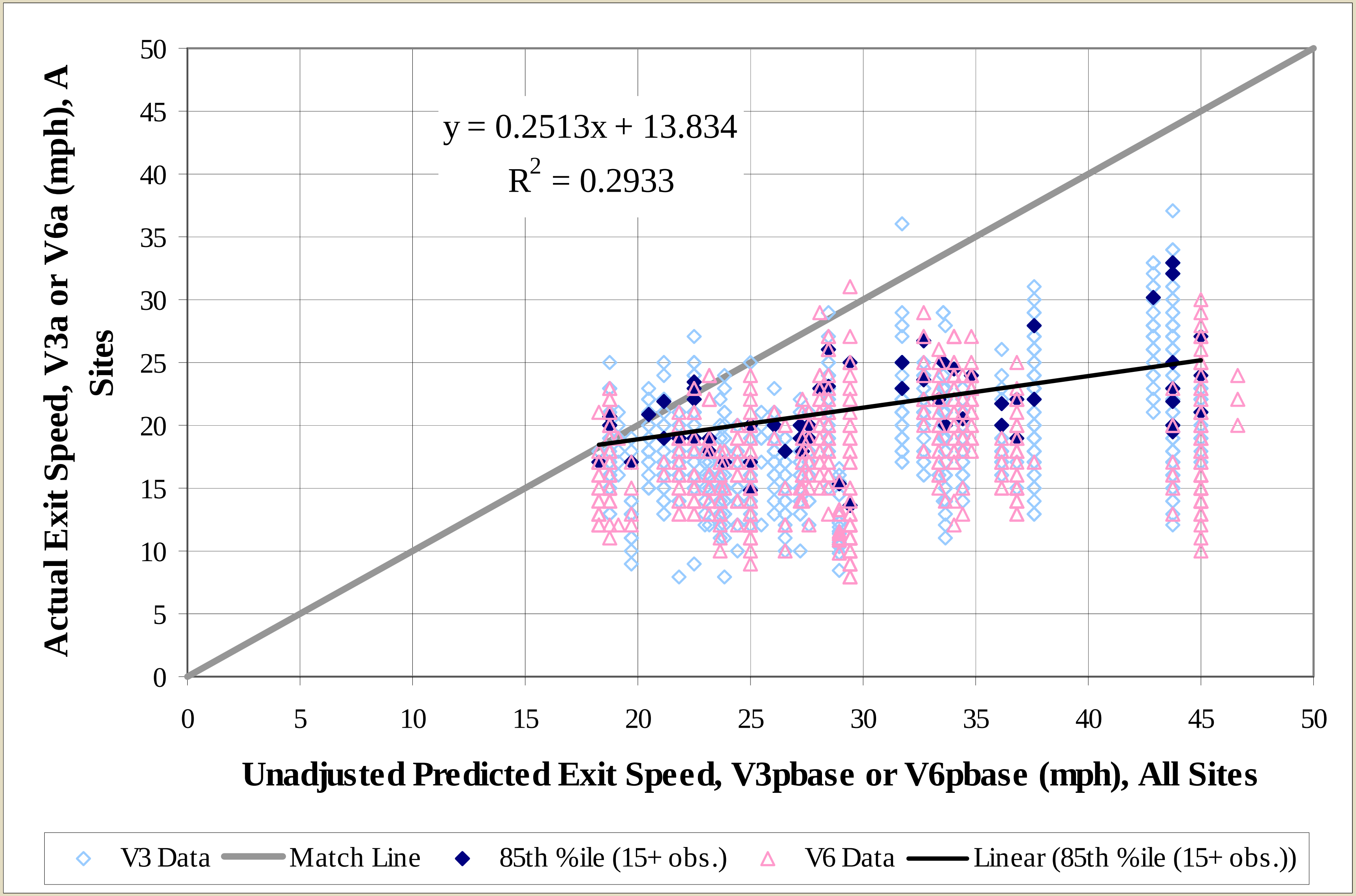


FHWA, Exhibit 6-12, p. 139

Design speed modeling:
V4, Left-turn circulating speed (all sites)



Design speed modeling:
Exit speed (all sites), unadjusted



Proposed exit speed equation

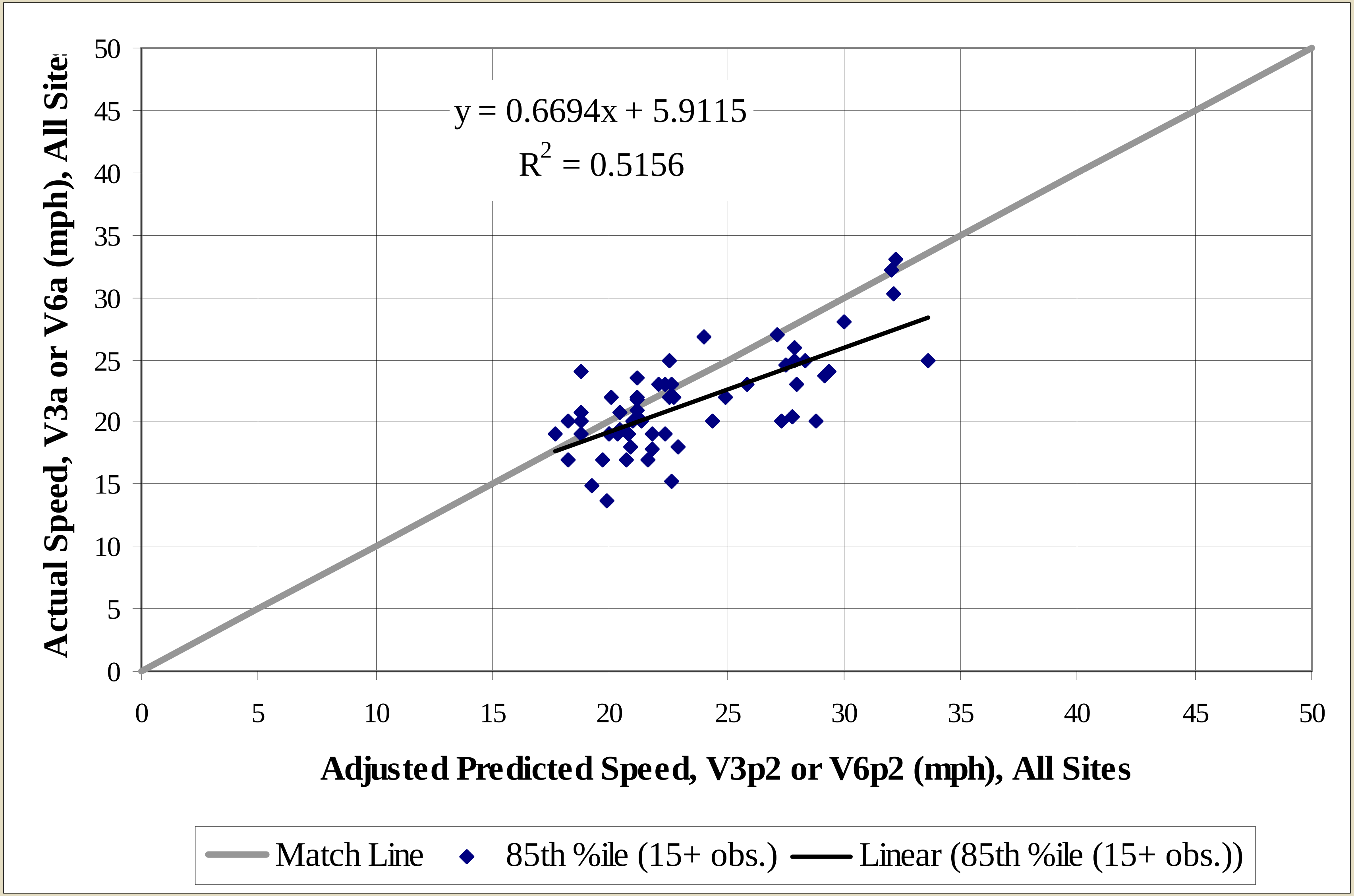
$$V_3 = \min\begin{Bmatrix} V_{3pbase} \\ \frac{1}{1.47}\sqrt{(1.47V_2)^2 + 2a_{23}d_{23}} \end{Bmatrix}$$

Speed where exit radius is limiting factor (V_{3pbase})

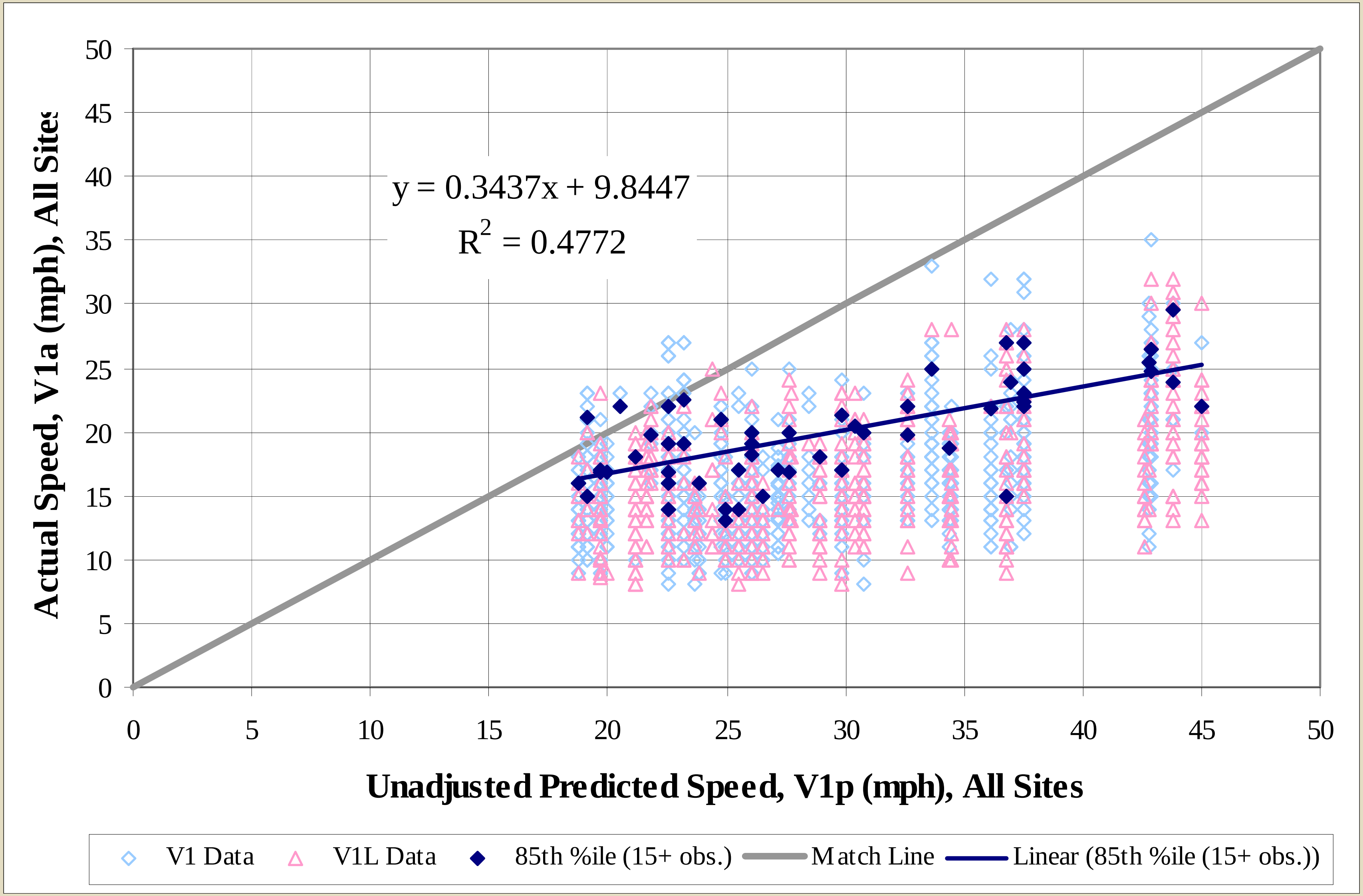
Speed where circulating speed and acceleration distance is limiting factor (second term)

- where:
- V_3 = V_3 speed, in mph
- V_{3pbase} = V_3 speed predicted based on path radius, in mph
- V_2 = V_2 speed predicted based on path radius, in mph
- a_{23} = acceleration along the length between the midpoint of V_2 path and the point of interest along V_3 path = **6.9 ft/s²**
- d_{23} = distance between midpoint of V_2 path and point of interest along V_3 path, in ft

Design speed modeling:
Exit speed (all sites), adjusted



Design speed modeling:
Entry speed (all sites), unadjusted



Proposed entry speed equation

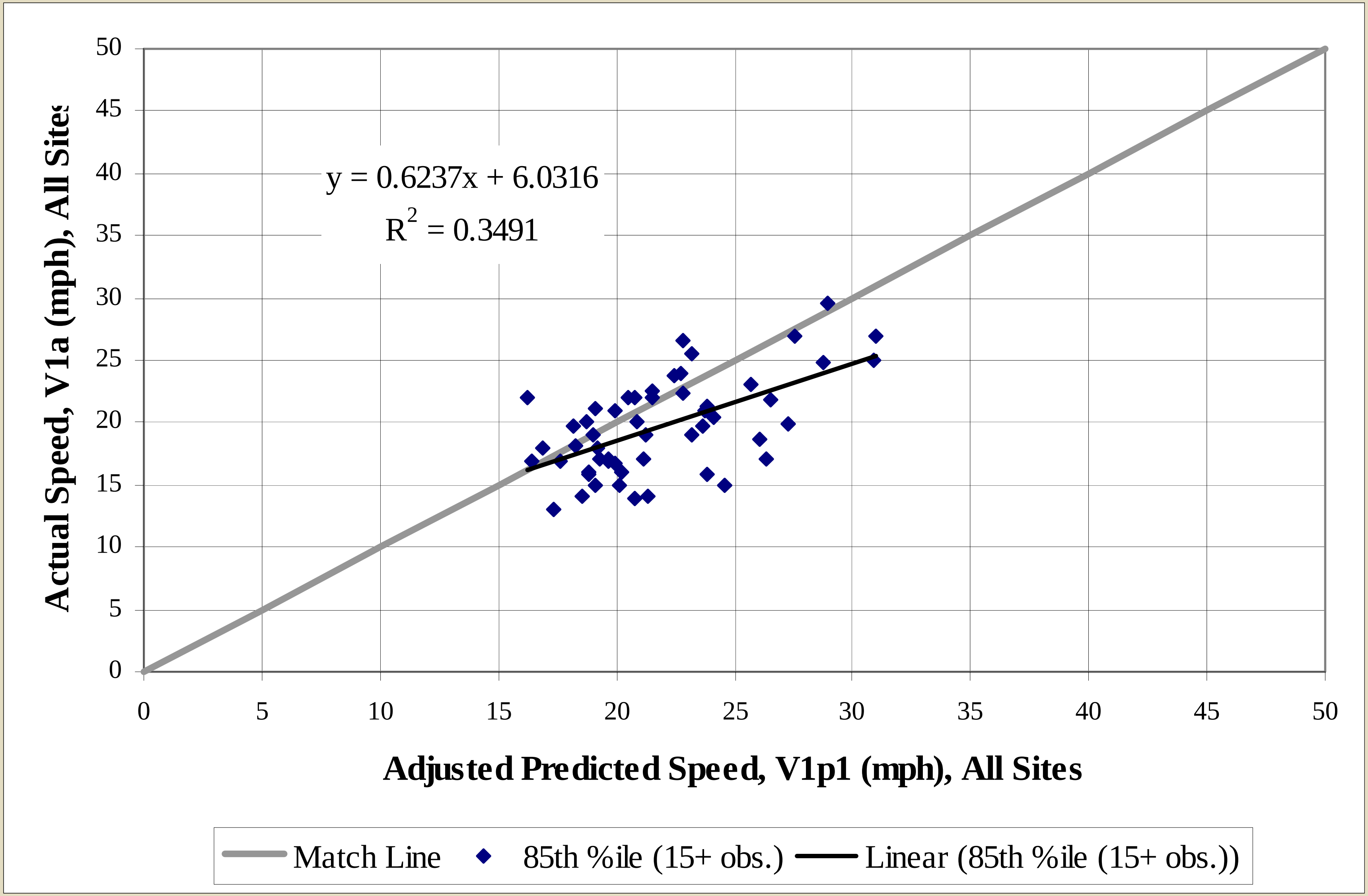
$$V_1 = \min\left\{ \begin{array}{c} V_{1pbase} \\ \frac{1}{1.47}\sqrt{(1.47V_2)^2 + 2a_{12}d_{12}} \end{array} \right\}$$

Speed where entry radius is limiting factor

Speed where circulating speed and deceleration distance is limiting factor

- where:
- V_1 = V_1 speed, in mph
- V_{1pbase} = V_1 speed predicted based on path radius, in mph
- V_2 = V_2 speed predicted based on path radius, in mph
- a_{12} = deceleration between the point of interest along V_1 path and the midpoint of V_2 path = **-4.2 ft/s^2**
- d_{12} = distance along the vehicle path between the point of interest along V_1 path and the midpoint of V_2 path, in ft

Design speed modeling:
Entry speed (all sites), adjusted



Implications for design

- **Tangential or nearly tangential exits do not appear to cause excessive vehicle exit speeds if the following conditions are met:**
  - *The speed of circulation (V2 and V4) is kept low*
  - *The distance between the start of the exit path and the point of interest (e.g., crosswalk) is kept short*
- **Entry speed appears to be limited by drivers' anticipation of the speed needed for circulation**
  - *However, recommend continued reliance on entry path curvature as a primary method to control entry speed*

Additional findings regarding design and safety

- The single-lane sites included in the study have better crash frequencies and crash rates than the multilane sites in the study
- The majority of the multilane sites were designed before the concept of path overlap was included in any documentation (FHWA Roundabout Guide)

Additional findings regarding design and safety

- **Narrow lane widths (entry and circulating) at multilane roundabouts appear to have a detrimental effect on safety**
- **Entry width:**
  - *Aggregated entry width (number of lanes) has a clear safety and operational effect*
  - *Variations of lane width appear to be second-order effects*

Additional findings regarding design and safety

- **Angle between legs:**
  - *Found to be a significant effect in US data*
  - *As angle to next leg decreases, number of entry-circulating crashes increases*
- **Splitter island width**
  - *No strong effect between splitter island width and entry capacity found*

Multilane path overlap

- **Apparent contributor to high crash frequencies at multilane roundabouts**
- **Anecdotal evidence suggests that its correction can substantially improve safety performance**

Non-motorized Users

- **Examination of observed field behaviors for two groups:**
  - *Pedestrians*
  - *Bicyclists*
- **Pedestrian data:**
  - *10 approaches at 7 sites; 769 events*
- **Bicyclist data:**
  - *14 approaches at 7 sites; 690 events*
- **Geographic diversity:**
  - *California, Florida, Maryland, Nevada, Oregon, Utah, Vermont, Washington*

How do motorists behave when encountering pedestrians?

- **Motorists failing to yield to pedestrians**
  - *All sites: 30 percent*
  - *Entry leg: 23 percent*
  - *Exit leg: 38 percent*
  - *1-lane approaches: 17 percent*
  - *2-lane approaches: 43 percent*

Are there conflicts between motorists and pedestrians?

- **Only 4 conflicts observed out of 769 pedestrian crossings (0.5%)**
- **Conflict rate: 2.3 conflicts per 1000 opportunities**

How do behaviors at roundabouts compare to other forms of control?

Crossing control	Percent of "normal" crossings	Percent of non-yielding vehicles
Uncontrolled	70%	48%
Roundabout	85%	32%
Signal-controlled	90%	15%
Stop-controlled	100%	4%

- No practical differences in walking speed

What are the roundabout characteristics that tend to cause problems or tend to be safer?

- **Motorists less likely to yield on 2-lane approaches compared to 1-lane approaches**
- **Motorists less likely to yield on exit leg compared to entry leg**
- **Pedestrians more likely to hesitate when starting crossing from exit leg**
- **Review of geometric features did not yield additional insights**

How do motorists and bicyclists interact?

- **Lane position on approach:**
  - *Edge of lane/bike lane: 73%*
  - *Claim lane: 15%*
  - *Sidewalk: 12%*
- **Lane position on exit:**
  - *Edge of lane: 61%*
  - *Claim lane: 16%*
  - *Sidewalk: 23%*
- **Little observed interaction between modes**
  - *Bikes tended to wait for gaps in circulating traffic*

Are there conflicts between motorists and bicyclists?

- **Only 4 conflicts observed in 690 bicyclist events (0.5%)**
- **Small number of observed events of wrong-way riding (7)**

Conclusions

- **Adjustments to speed model improve predictive ability**
- **Statistical and anecdotal evidence that various geometric factors influence safety**
- **Little observed safety problem for pedestrians and bicyclists, although some roundabout characteristics make use more challenging**

Questions?

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