Simulation of Pedestrian-Vehicle Interactions at Roundabouts

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TRB National Roundabouts Conference
Vail, Colorado

May 24, 2005

Outline

- **Sponsor: National Eye Institute / NIH through Western Michigan University**
- **Introduction and problem statement**
- **Observational studies**
  - Data collection
  - Data extraction
  - Sample results
- **Simulation studies**
  - Why simulation
  - Sample results
- **On-going activities**

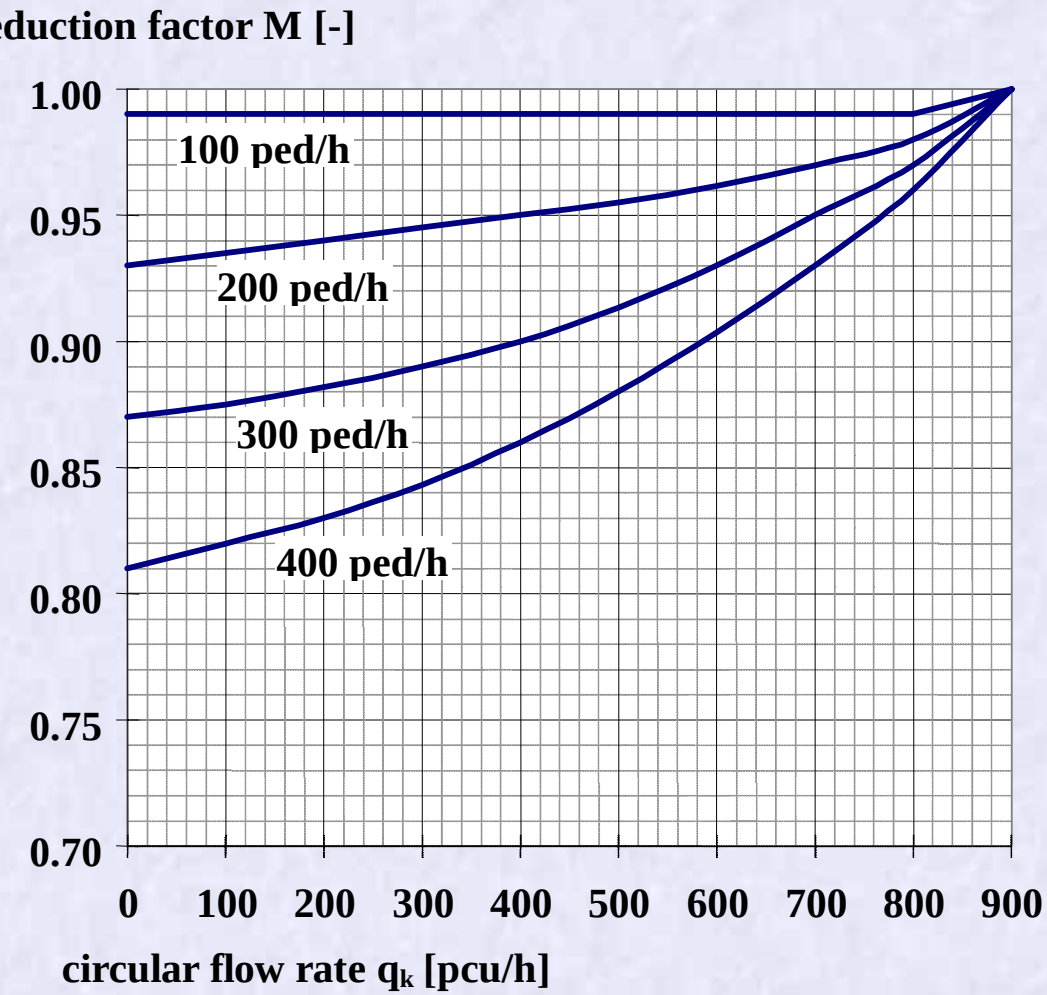
Introduction

- **Purpose: Analyze mutual impact of pedestrians and vehicles @ roundabouts w.r.t. traffic operations and potential safety**

- **Why?**
  - Poorly documented in the literature
  - Assumed right-of-way priorities unconfirmed with empirical observations (e.g., HCM TWSC, AWSC ; Roundabout informational guide).
  - Blind pedestrians' access (US Access Board)
  - Assess possible treatments to improve operations and safety
  - Traffic simulation models rarely consider ped-veh. interactions in the analysis of urban streets

Entry capacity reduction effect of pedestrians

- Assumes pedestrians always have priority
- Based on German data (Brilon et al) in KREISEL
- Other models: HCM, aaSIDRA, RODEL,NCHRP 3-65



Source: FHWA Roundabout Informational Guide

Methodology

- **Observational studies of crossing behavior**
  - Document interactions
  - Provide input for model calibration and validation

- **Simulation studies**
  - Incorporate interaction models in simulation
  - Allow for system-wide evaluation
  - Extend the observational studies beyond the range of empirical data (volumes, geometries, etc.)
  - Low-risk platform for assessing treatments prior to field implementation

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- **Initial findings:** Rouphail, N., R. Hughes and K. Chae (2005), "Exploratory Simulation of Pedestrian Crossings at Roundabouts", ASCE Journal of Transportation Engineering, Vol. 131 (3), pp. 211-218.

Data Collection

- **Method: Videotaping**
- **Sites: Two-single lane roundabouts**
  - Pullen-Stinson, NC State University campus
  - NC 751, Durham, NC
- **Purpose:**
  - Gather basic veh-veh & ped-veh interaction data
  - Calibrate basic model (no peds)
  - Validate basic model

The Pullen-Stinson Roundabout

- Approach speed= 35 mph
- Circulating speed= 18mph
- Inscribed diameter= 88 ft
- Central Island diameter= 52 ft
- Entry Width = 14 ft
- Peak Hour Volume ~ 1400 veh, 160 peds.

Credit:www.skysiteaerial.com

Data Extraction

- **Customized Video-Image Processing (VIP) software code (ITRE-mv)**
- **Coded in C language**
- **Process**
  - Development of X-Y grid system of field of view
  - Identification of fixed, reference points
  - Convert digital video into image frames (20 frames /sec)
  - Detects all objects in the field of view at specified detector locations
    - Vehicles
    - Pedestrians
  - Tracks all object movements in the field of view
- **Ratio of Processing: Real Time = 6:1 (vs. 24:1 using manual data extraction)**

ITRE-mv run sample

ITRE-mv Outputs and Use (i=for model input; v= for validation)

- **Vehicle Related**
  - Origin and destination (O&D) counts by vehicle type (i)
  - Vehicle speed profile by O&D (v)
  - Entry and exit headway distributions (i,v)
  - Yield line accepted and rejected gaps and lags (i)
  - Delays at yield line, and approach queues (v)

ITRE-mv Outputs and Use (i=for model input; v= for validation)

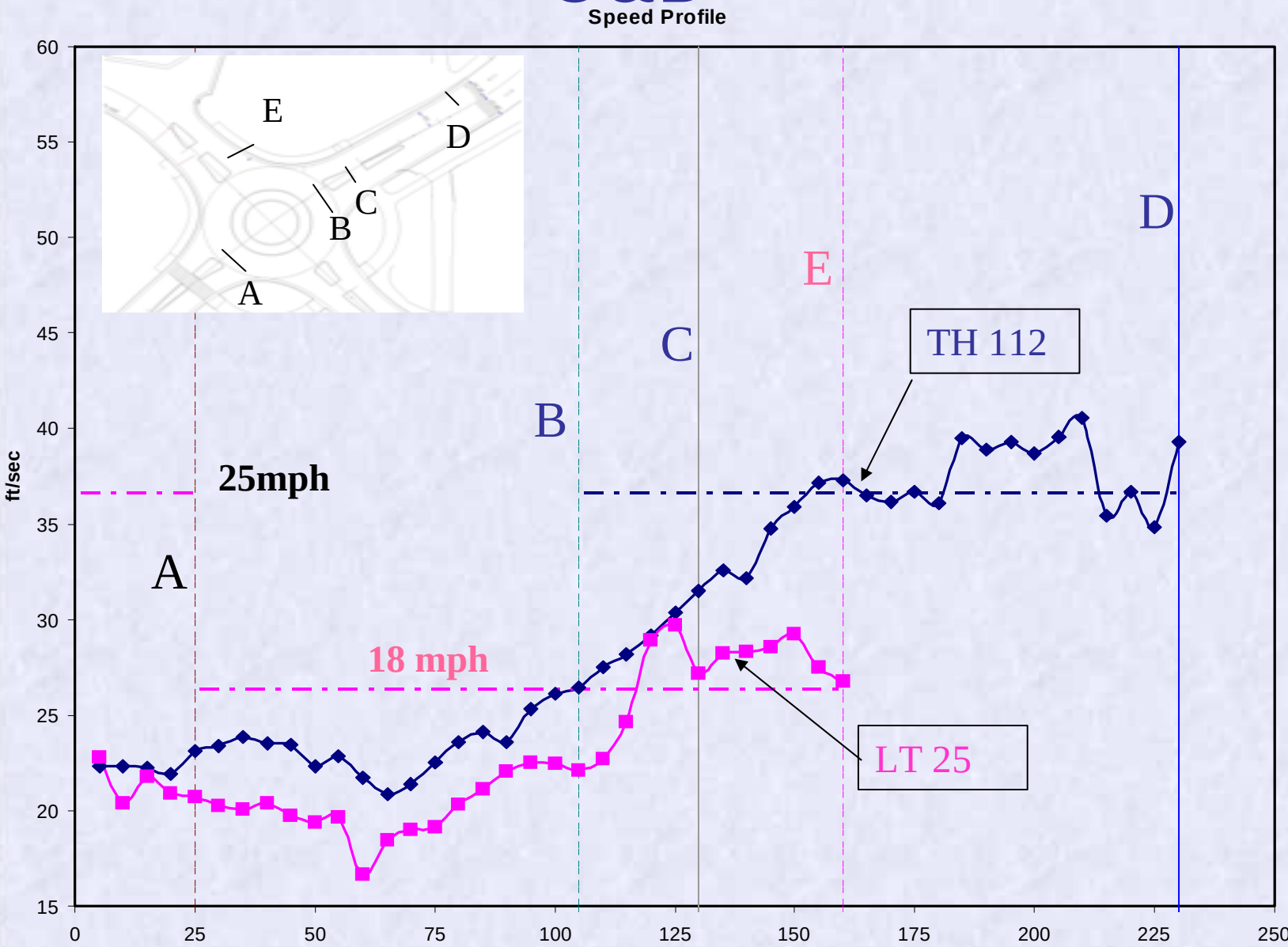
- **Pedestrian Related**
  - Pedestrian waiting time at curb and splitter island (v)
  - Pedestrian crossing time by direction (i)
  - Fraction of drivers yielding to pedestrians (i)
  - Time lag between pedestrian crossing and vehicle arrival at crosswalk
  - Pedestrian accepted & rejected vehicle gaps and lags (i)
  - Position of yielding vehicle from crosswalk location (i)

Comparing 15 min O&D Counts Noon Peak- Manual vs. ITRE-mv

From \ To	South	North	East	West	Total
South	1(1)	113(113)	6(6)	25(25)	145(145)
North	133(132)	2(4)	4(3)	29(20)	168(159)
East	0(0)	0(1)	0(0)	0(0)	0(1)
West	23(24)	13(13)	0(0)	0(0)	36(37)
Total	157(157)	128(131)	10(9)	54(45)	342(349)

- **ITRE-mv** (Manual)
- Max absolute error = 9veh
- Mean overall error ~ 2%

Average Speed Profile (ft/sec) by O&D



Pedestrian Travel Time Distribution

Travel Time Includes:

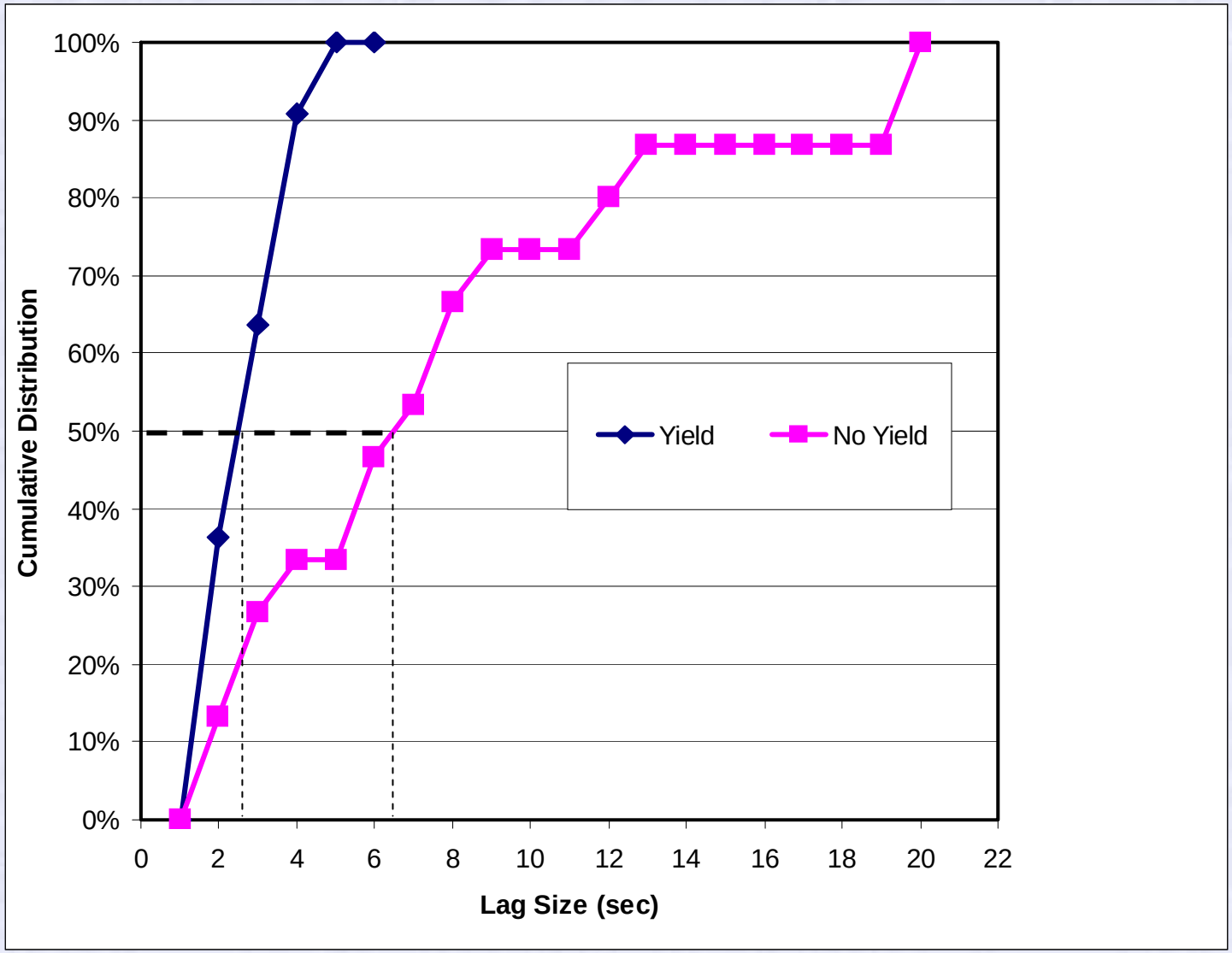
- Waiting time @ curb and splitter island
- Actual crossing time

Drivers Yielding to Pedestrians Sample- 15 min observations

Driver → / Location	Yield**	No Yield	Total
Entry Leg	7 (35%)	13 (65%)	20
Exit Leg	5 (21%)	19 (79%)	24
Total	12	32	44

**Statistically significant at the 95% CL

Time lag between crossing initiation and vehicle on crosswalk



Sighted and Blind Ped. Crossings

Sighted:

- Natural gap acceptance (visual)
- Yield detection (visual)
- Traffic signal

Blind:

- Natural gap acceptance (auditory)
- Yield detection (assisted only)
- Traffic signal (APS)

Assisted Yield Detection

Micro-simulation model

- VISSIM model (PTV)
- Models pedestrian and vehicle movements
- Priority / interaction rules must be defined by the user.. otherwise
- Requires extensive calibration & validation
- Simulates various traffic crossing scenarios,
  (1)natural gap acceptance,
  (2) signal control and
  (3) natural gap acceptance with automated yield and gap detection for blind pedestrians
- Generates text and visual output for model verification and results presentations

VISSIM-Natural Gap Crossing

Color Codes
Veh: **Black** (YIELD) ; Other (NO YIELD)
Ped: **Black Top** (Blind) ; **Blue Top** (Sighted)

VISSIM- Signalized Crossing

Clip showing sighted and blind pedestrian crossings at remote APS signal location

VISSIM- Automated Yield and Natural Gap Detection

Color Codes

Veh: **Black** (YIELD) ; Other (NO YIELD)

Ped: **Black Top** (Blind) ; **Blue Top** (Sighted)

Summary &Conclusions

- VIP procedure developed to capture ped. veh interactions at roundabouts
- VIP estimate O&D flows at acceptable accuracy
- Initial results show that 35% of drivers yield to pedestrians at entry vs. 21% at exit leg
- Initial results show close to 28% of pedestrians crossing in gaps < nominal crossing time ***when drivers do not yield***
- Micro-simulation is a useful tool to integrate ped. veh. Interactions into the traffic system, and to assess the utility of treatments for blind pedestrians

An Invitation to Participate In NCHRP 3-78

Crossing Solutions at Roundabouts for Pedestrians with Vision Disabilities

- As a contributor of treatment concepts
- As a vendor who makes available system components
- As a state, city, or town willing to host treatments and their evaluation.

For Those Interested in Participating

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