NCHRP 3-65: Applying Roundabouts in the United States

Preliminary Safety Findings

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Purpose

- **Develop roundabout level accident models**
- **Develop approach level accident models**
- **Conduct a before-after study of roundabouts converted from signal or stop control**

Overview

- **Model development process**
- **Roundabout level models**
  - *Data Summary*
  - *Models*
  - *Applications*
- **Approach level models**
  - *Data Summary*
  - *Models*
  - *Applications*
- **Speed Models**
- **Before-After Study**
- **Summary**

Model Development Process

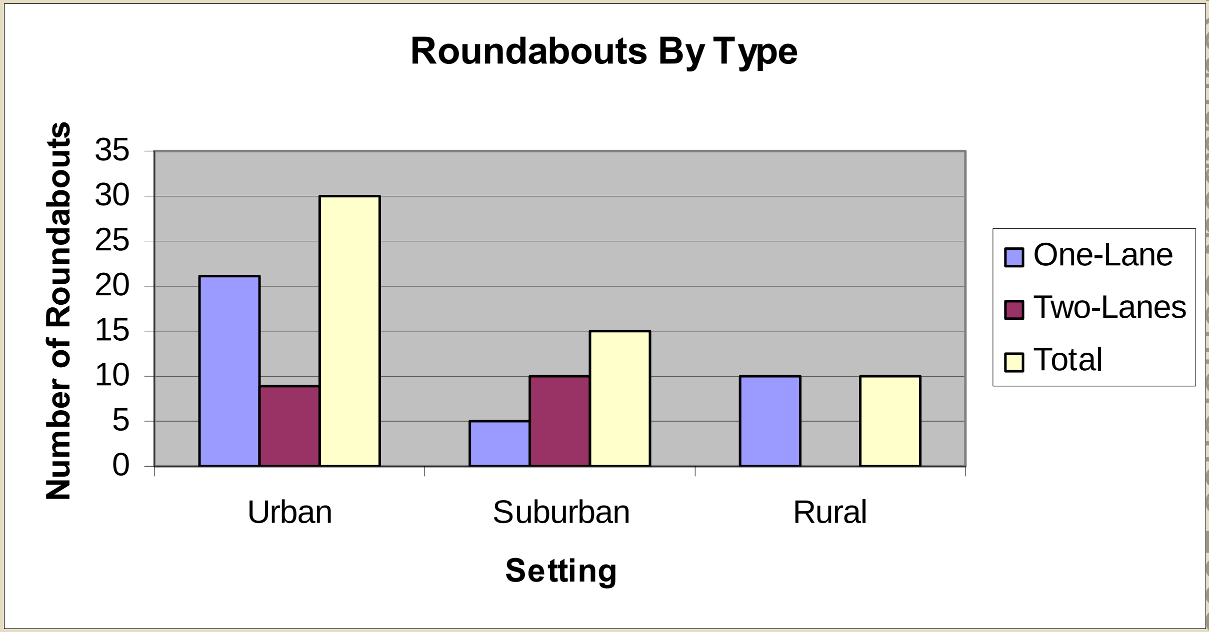
Model development process

- **Assemble volume, geometric and crash data**
  - *Required variation in characteristics*
  - *Needed large enough sample size of crashes*
- **Postulate model forms and identify possible variables from literature review**
- **Use PROC GENMOD of SAS software**
  - *Negative binomial error structure*
- **Model form: Accidents = α (AADT) $^{\beta}$exp($\delta_1 X_1$ +…)**
- **Also estimates dispersion parameter of negative binomial distribution that is used in accident prediction**

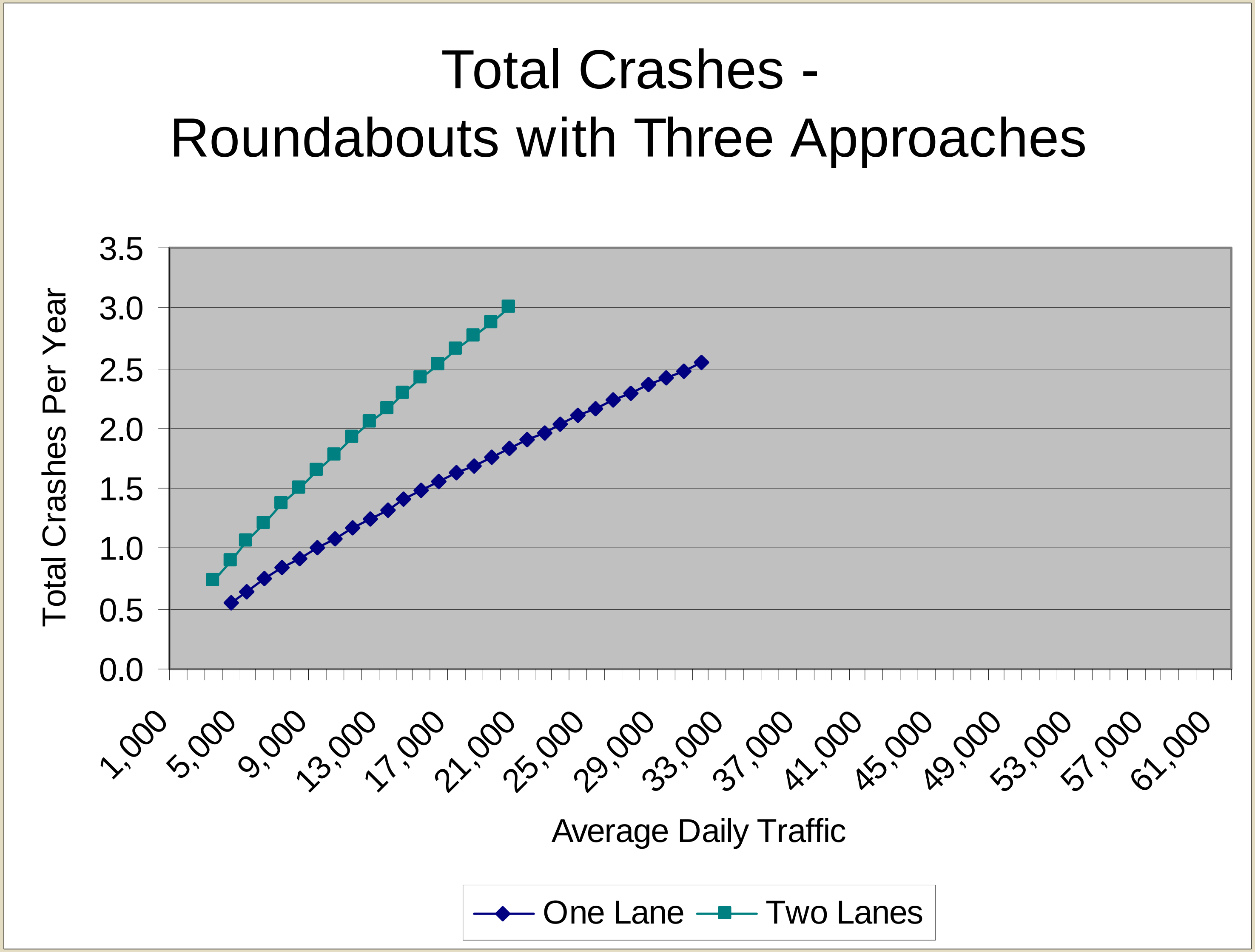
Roundabout Level Models

Roundabout Level Volume and Geometric Data

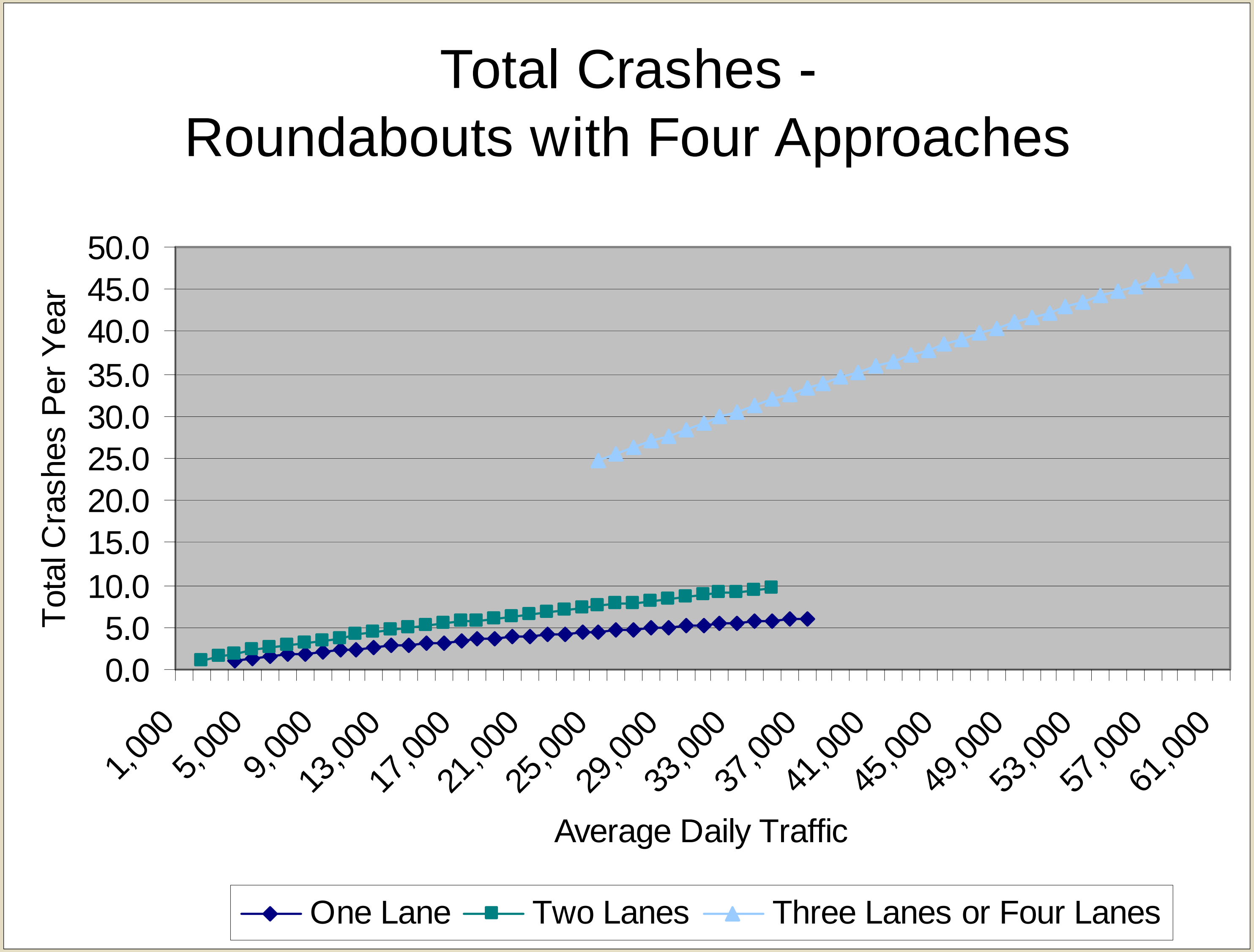
- **AADT Range**
  - *Minimum – 2,700 vpd*
  - *Maximum – 58,600 vpd*
  - *Mean – 16,725 vpd*



Roundabout Level SPF –
Total Crashes Per Year – Three Approaches



Roundabout Level SPF
Total Crashes Per Year – Four Approaches



Roundabout Level Model Applications

- **Intended for estimating the expected number of collisions per year at a roundabout.**
- **Primarily intended for doing a comparative analysis of the safety performance of a roundabout to other roundabouts or other intersection types.**
- **The models can be used in estimating the expected safety of a contemplated roundabout.**

Approach Level Models

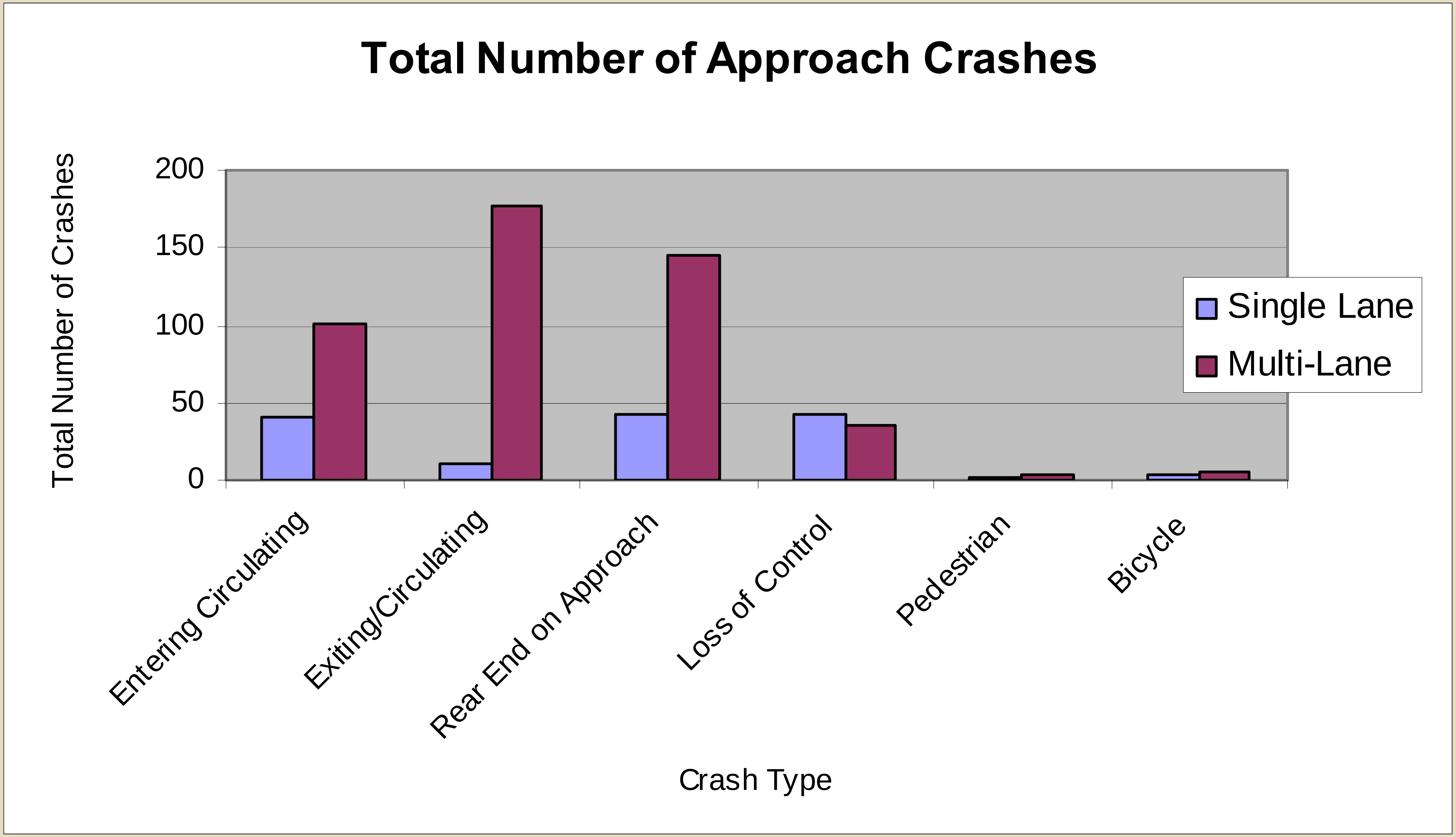
Summary of Approach Level Geometric Data (120-139 arms)

Variable	Minimum	Maximum	Mean
Inscribed Circle Diameter (ft.)	36	300	142.3
Entry Width (ft.)	7.5	49	22.0
Approach Half Width (ft.)	10	49	20.0
Circulating Width (ft.)	11.5	45	25.8
Angle To Next Leg	27	180	89.3
AADT	220	19,593	4,637

Other variables considered for candidate models

- **Effective Flare Length (ft.)**
- **Entry Radius (ft.)**
- **Entry Angle**
- **Exit Width (ft.)**
- **Departure Width (ft.)**
- **Exit Radius (ft.)**
- **Central Island Diameter (ft.)**
- **1/Entry Path Radius (1/ft.)**
- **1/Circulating Path Radius (1/ft.)**
- **1/Exit Path Radius (1/ft.)**
- **1/Left-Turn Path Radius (1/ft.)**
- **1/Right-Turn Path Radius (1/ft.)**

Approach Level Crash Data – Total Number of Crashes



Approach Level Model Results

- **Several candidate models with logical variables**
  - *none with more than a few variables*
  - *estimated effects in the expected direction*

- **Specific collision types (TOTAL collisions only)**
  - *entering/circulating*
  - *exiting/circulating*
  - *approaching*

Approach Level Safety Peformance Functions

- **Entering/Circulating Crashes Per Year**

$$e^{-7.2158}(EnteringAADT)^{0.702}(CirculatingAADT)^{0.132}e^{(0.051 EntryWidth - 0.028 AngletoNextLeg)}$$

- **Exiting/Circulating Crashes Per Year**

$$e^{-11.6805}(ExitingAADT)^{0.280}(CirculatingAADT)^{0.253}e^{(0.022 InscribedCircleDiameter + 0.111 CirculatingWidth)}$$

- **Approaching Crashes Per Year**

$$e^{-5.1527}(EnteringAADT)^{0.461}e^{(0.03 ApproachHalfWidth)}$$

Recommended approach level models for crashes/year

Entering/Circulating = $\exp(-7.2158)$

$(\text{Entering AADT})^{0.702}(\text{Circulating AADT})^{0.132}$

$\exp(0.051 \times \text{Entry Width} - 0.028 \times \text{Angle to Next Leg})$

Exiting/Circulating = $\exp(-11.6805)$

$(\text{Exiting AADT})^{0.280}(\text{Circulating AADT})^{0.253}$

$\exp(0.022 \times \text{ICD} + 0.111 \times \text{Circulating Width})$

Approaching = $\exp(-5.1527)$

$(\text{Entering AADT})^{0.461}$

$\exp(0.03 \times \text{Approach Half Width})$

Approach Level Model Applications

- **To understand the impacts of geometric design decisions on various collision types.**
  - *IHSDM applications*
  - *HSM applications*
- **Not intended as predictive models**
- **If so used, it is desirable to calibrate a multiplier to reflect local conditions.**

% change in crashes from candidate approach level models per unit change in variable

Variable	Entering/ Circulating	Exiting/ Circulating	Approach
Entry Radius (ft.)	1% reduction		
Entry Width (ft.)	5% increase		
Approach Half Width (ft.)			3% increase
Inscribed Circle Diameter (ft.)		2.2% increase	
Central Island Diameter (ft.)	0.5 to 0.8% reduction	1.4% increase	
Circulating Width (ft.)		12% increase	
Angle To Next Leg (degree)	3% reduction		

Speed Based Models

Speed Based Models for Approach Level

- **Hypothesis:**

  Speed profile – design model

  PLUS

  Crash - speed profile model

  ➔ *Alternative crash prediction model*

- **Crash models developed with AADT and observed speeds at approach, entry point, exiting point**

- **Models not recommended – more data needed**

Before-After Study

BEFORE-AFTER RESULTS – ALL SITES (55)

	All	*Injury*
Crashes recorded in after period	*726*	*72*
EB estimate of accidents expected after without roundabouts	*1122*	*296*
Reduction (Standard error)	*35.4 % (3.4)*	*75.8 % (3.2)*

RESULTS BY CONTROL TYPE BEFORE CONVERSION

CONTROL BEFORE	All	Injury
SIGNALS (9)	48%	78%
TWO WAY STOP (34)	44%	82%
ALL-WAY STOP (10)	Insignificant increase	

Results by setting and number of lanes

ALL CRASH SEVERITIES

	SINGLE LANE	MULTILANE
RURAL	72% (9)	No sample
URBAN/ SUBURBAN	56% (16)	18% (11)

Before after study - Additional insights

- **Safety benefit appears to decrease with increasing AADT**
  - *irrespective of control type before, number of lanes and setting*

- **No apparent relationship to inscribed or central island diameter.**

CONCLUSIONS

- **Models are reasonable and usable, but could be better**
- **Speed-based safety models promising but require additional data and research effort**
- **Solid before-after crash benefits support us being here at this conference!**