A Framework for Evaluating Dynamic Methods of Multimodal Arterial Traffic Control

### Ted Morris<sup>1</sup>, John Hourdos<sup>2</sup>, Vassilios Morellas<sup>1</sup>, and Nikos Papanikolopoulos<sup>1</sup>

<sup>1</sup>Department of Computer Science <sup>2</sup>Department of Civil, Environmental, and Geo Engineering







# Synopsis

- Project Background and Goals
- Study Area
- Field Deployment and Sensor Acquisition
- Traffic Measurement Strategies
- Traffic Simulation Model
- Future build-out plans and testing



# Background

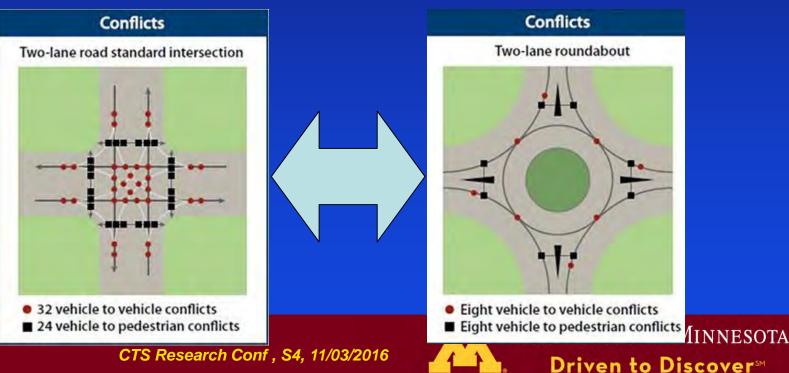
- Significant research has focused on controlling congestion on freeways and major highway networks.
- Traffic control within urban network of streets and arterials presents challenging problems due to varied mode choices, route choice selection, and traffic dynamics.
- Need for creating framework for testing and evaluating new urban traffic control strategies for arterial networks.
- Couple sensor traffic measurements with simulation, to build signal and sensor 'in-the-loop' simulation testbed.

CTS Research Conf , S4, 11/03/2016



## Roundabout Utilization for Arterial Traffic Control

- Urban corridor intersection adaptation to roundabouts.
- Lower cost than signalized intersections.
- 16 turning movements.
- Safety benefits pedestrians & vehicles.
- Integrate with 'complete street' designs.



## City of Richfield Corridor 'Test-bed'

2-Lane Roundabouts Under

Construction

ANINS. Richfield e a beamined at Richfield Links W SELL SI 66th 5t 0 Augaleur Ward Links Richfield Legend Town Hall Signalized Intersection Transit Routes Pedestrian Areas Park Project Area 3,080 .500 Aetro politz

CTS Research Conf , S4, 11/03/2016



## **Roundabout Capacity & Traffic Control**

- Available capacity affected by:
   Pedestrian crossing events (*Kang & Hideki, 2014, Dahl et. al*)
  - Origin/Destination flow variation through roundabout (Z. Qu et. al, 2014)
  - Heavy vehicle traffic volumes (Dahl et. al 2012)
  - □ Approach vehicle gap selection and follow-up time variation (*Polus et. al, 2003, HCM 2010*)
- Near entrance capacity ( > 0.95) creates instabilities (queues). (Z. Qu et. al, 2014)

CTS Research Conf , S4, 11/03/2016



## **Roundabout Capacity Control**

- Signalize turning movements or rate control an approach leg (Yang et. al 2004, Davies et. al, 1980, SIG-NABOUTS- several deployments in UK and Austrialia: Akcelik, 2003, Akcelik etl al, 1997, 1998)
- Add push-button beacons or signals at pedestrian crossings (Baranowksi, 2005)



# **General Traffic Control Strategy**

- Don't signalized the roundabout, instead:
- 'Observe' roundabout capacity, pedestrian crossing events, and approach traffic volume
- Estimate gap times
- Develop and 'test' traffic control laws to extend green phases at adjacent signalized intersections to regulate incoming traffic volumes
- Evaluate intersection total system delay and pedestrian crossing gap opportunities

CTS Research Conf , S4, 11/03/2016



## **Urban Arterial Redesign**

#### Current







CTS Research Conf , S4, 11/03/2016





Driven to Discover<sup>sm</sup>

9



- Omnidirectional outdoor 9 MP net camera
- Low Cost, single sensor solution
- Avoids multi-cam frame synch issues
- Traditional loops or 'trip-wire' sensors cannot be used to solve O/D problem
- Other COTSI Traffic Sensors have closed architecture (GridSmart, Inc.)
- Develop open architecture real-time tracking, calibration, and image stream acquisition

CTS Research Conf , S4, 11/03/2016



UNIVERSITY OF MINNESOTA Driven to Discover™ 10

#### Roundabout sensor field deployment

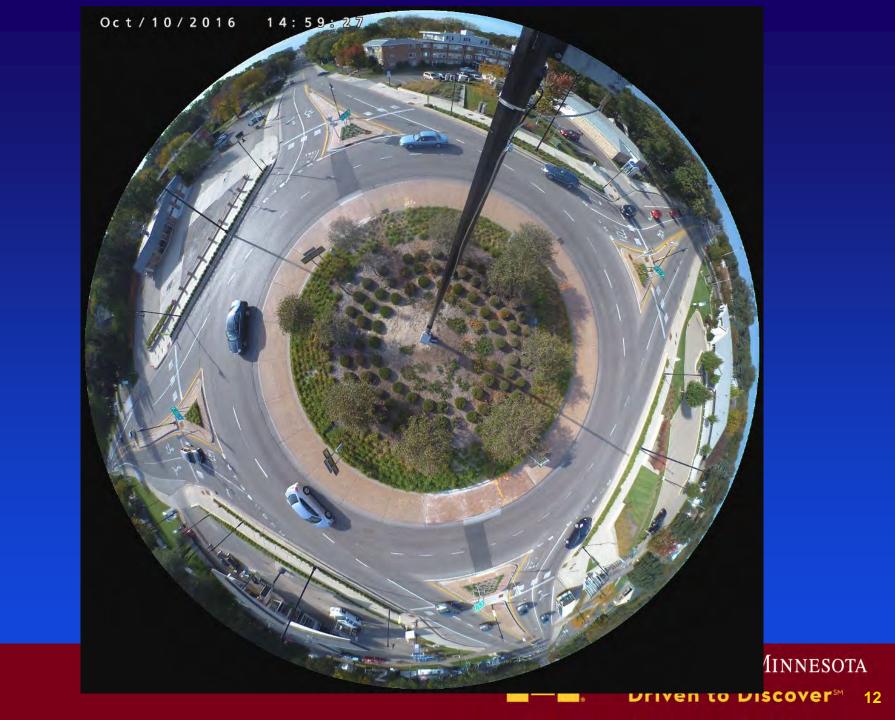
- Deploy computational hardware at roadside (in cabinet).
- Wireless link to roadside cabinets and adjacent intersections.
- Broadband wired service to UMN.
- 'Blend in' with existing infrastructure.





CTS Research Conf , S4, 11/03/2016







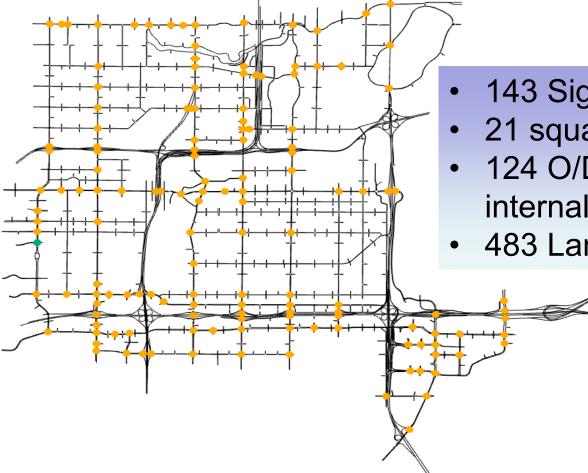
## **Roundabout Sensor Field Deployment**



CTS Research Conf , S4, 11/03/2016



## **Traffic Simulation Model, Richfield**



- **143 Signalized Intersections**
- 21 square miles
- 124 O/D centroids (33 internal + 91 external)
- 483 Lane miles

CTS Research Conf , S4, 11/03/2016



## **Traffic Simulation Model Calibration**

Quantify approach gap acceptance variations

Simulation Vehicle: 10047117 (Temporary) (Layer: ...

Store Path in a Google Earth File

Floating data collected during 00:00:00

Attribute

Position Number of Missed Turns Zone

Current Speed

Previous Speed

Mean Speed Desired

Distance Travelled

Number of Stops

Total Stop Time

Mean Speed

Static Attributes Dynamic Attributes Path Attributes

 Follow
 Get Floating Vehicle Data
 Collect Time Series Data

Value

38 3657

32 3758

50.1319

38.3657

00:00:00

0

478869 4970038.59 m

Units

km/h

km/h

km/h

sec

m

sec

478837 49700

km/h

•

- In-roundabout (conflicting flow) vehicle speeds
  - Traffic entrance and O/D flows Pedestrian yield and gap acceptance variations

TA

## **Traffic Simulation Model Calibration**

Quantify approach gap acceptance variations

2

Static Attributes Dynam

Attribute Current Speed Previous Speed Mean Speed Desired Position Number of Missed Turn: Zone

Distance Travelled Mean Speed

Number of Stops Total Stop Time

Floating data collected during 00:00:00

20 7207

KPC.

km/h

- In-roundabout (conflicting flow) vehicle speeds
  - Traffic entrance and O/D flows Pedestrian yield and gap acceptance variations

tatic Attributes Dynamic Attributes	Path Attributes	
Attribute	Value	Units
Aimsun ID	3009	
Vehicle Type	Car	
nival Time	06:10:03	
as Been Enrouted	No	
racked	No	
guipped	No	
Ourdance Acceptance	100	15
Cooperation Degree	80.8059	96
Origin Centroid	34666 (7323672)	
Destination Centroid	34605: Portland Ave (7323961)	
Path Type	Route Choice Path	
Path	06:00:00 (1)	hh:mm:ss
Length	3.56588	m
Width	2	m
Maximum Desired Acceleration	2.99721	m/s2
Desired Deceleration	-4.02517	m/s2
Maximum Desired Deceleration	-6.37879	m/s2
Mean Desired Speed	111.93	km/h
Speed Limit Acceptance	1.00567	
Minimum Distance Between Vehicles	0.799568	m
Maximum Give Way Time	8.64329	
Reaction Time	0.8	
Reaction Time at Stop	1.2	
Reaction Time at Traffic Light	1.6	
Vehicle Class	None	
Stay in Fast Lane	No	
Gep	0	Secs
Sensitivity Factor	1	

**WINNESOTA** 

Driven to Discover<sup>54</sup> 17

C Simulation Vehicle: 10045938 (Temporary) (Layer: Network) (c90890e...

#### **Traffic Simulation**

 Need sensor and detection data for Parameter calibration as well as for Real-time traffic control.



CTS Research Conf , S4, 11/03/2016



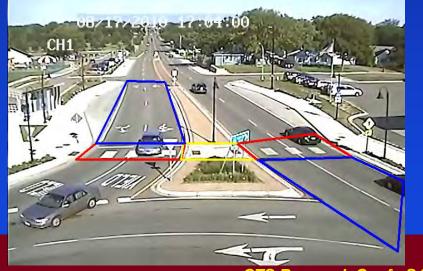
#### Real-time track vehicles and pedestrians

- Accurate manual extraction of measurements for calibration, and real-time O/D flow extraction is a challenging problem.
- Pedestrian crossing events.
- Origin/destination traces.
- Quantify gap selection and follow-up times.
- Quantify travel time/speed of conflicting flow vehicles.



#### **Event and Measurement Extraction**

- Define intersection regions of interest (ROI) to classify events and extract measurements
  - At exit/entrance boundary of each approach
  - Crosswalk regions
  - Internal roundabout



CTS Research Conf, S4, 11/03/2016



20

## Future Framework Development Efforts

- Deploy sensors at signalized adjacent intersections to measure traffic volume data from cross-arterial adjacent intersections
- Transfer 66<sup>th</sup> and Portland roundabout sensor design for reconstructed intersections.
- Refine real-time extraction of vehicle and computer vision pedestrian track algorithms for spherical panoramic vision sensors
- Calibration of Roundabout traffic dynamics
- Incorporate timing phase plans at signalized simulation intersection

CTS Research Conf , S4, 11/03/2016



#### **Thanks for listening!**

This research and field deployment system is funded through the National Science Foundation Cyber Physical Systems program, Grant #1544887



National Science Foundation WHERE DISCOVERIES BEGIN

CTS Research Conf , S4, 11/03/2016

