

### **NORTH CAROLINA** Department of Transportation



# Updates on DLTi, SaFID, and Reverse RCI

For RTA Innovations and Solutions Forum Joe Hummer, PhD, PE, State Traffic Mgmt Engineer April 15, 2020

## Problem



Dynamic Left Turn Intersection

## Potential Solution--DLTi Peak Off-Peak



# **Dynamic Left Turn Intersection**

- Operate as dual left turn lane during peak
   Protected (green arrow) left turn signal
- Close second lane during off-peak
  - Operate as single left turn lane
  - Protected/permitted (flashing yellow arrow)
     left turn signal
  - Positive offset left turn
- Use lane control signs



- Like on Edwards Mill Road near PNC Arena

# Site Selection Criteria

- Dual left turn lane
- Goldilocks demand
  - Enough demand to matter
  - Do not need dual left turn lanes off-peak
- Plentiful sight distance
   Could have been permitted left turn
- Compatible signal software

# Tryon at Cary Parkway, Cary



# **Estimated Benefits**

Dimension	Tryon Road
Left turns in DLTi lanes/day	3,200
Left turns in DLTi lanes, % of total demand	7
Hours/day operated with DLTi	15
Left turn delay savings, sec/veh	7
All vehicle delay savings, sec/veh	0.4
All vehicle delay savings, veh-hr/year	2,100
Delay savings benefit, \$/year	27,000
Installation cost, \$	33,000

# **Current Status**

- Operational February 14, 2020
   20 hours per day
- PR campaign
- Changeable message sign
- Additional work so Cary cameras can view



# **Compliance and Reaction**

- Some negative public reaction
- Leaders have held steady
- Based on several informal observations, we think we are getting about 80 percent compliance on average



## Clueless?



That-a-way!



# Lessons Learned Already

- Need to clearly convey expected benefit
- Need to add sign explaining X
- Heavy demand on right side just after DLTi
- Trucks "trapped" in left lane
- What is target compliance level?

# Down the Road

- After study to be completed asap
- Potential second site, US-70 Business at Walmart in Clayton
- If reasonable cost, maintenance needs, safety impact, public reaction, ...
- Publish our findings for other states
- Look for other sites statewide
  - Build into TIP projects
  - Retrofit with Spot Mobility funds
- Think about other time-of-day innovations

# Thank You!

- Joe Milazzo and RTA
  - Had the idea, cleared devices with FHWA, gently pushed
- NCDOT Board and management
  - Fostering a culture of innovation
- Town of Cary, Division 5, Division 4
- Many professionals trying to help

# Selecting an Intersection Design

- We have funding to improve an intersection
- We have a traffic forecast
- There are several design alternatives
- We can do modelling to estimate travel times for each alternative
- We can see what fits
- Before we choose an alternative, shouldn't we also consider safety?



# Happily, We Live in the Golden Age of CMFs

- Crash modification factor (CMF)
   Before crash freq \* CMF = after crash freq
- Hundreds of millions of dollars on safety research during past 25 years
- Thousands of CMFs stored at the Clearinghouse at UNC-CH
  - Hundreds of countermeasures
  - Variety of crash types, location types, etc.
  - Quality of study ratings

### Good Clearinghouse CMFs for Intersections

Changing from	Changing to	Average CMF for	Average CMF for	
		all crashes	injury crashes	
Two-way stop control	All-way stop control	0.32	0.28	
	Conventional signal	0.81	0.74	
	One-lane roundabout	0.51	0.16	
	Unsignalized reduced conflict	0.58	0.42	
	intersection (RCI)			
Conventional signal	One-lane roundabout	0.74	0.45	
	Two-lane roundabout	0.89	0.54	
	Signalized RCI	0.85	0.78	

- Good CMFs available outside the Clearinghouse for median u-turns and continuous flow intersections
- Other than quadrant roadways and offset intersections, we now have a pretty full set of intersection CMFs!

# Safest Feasible Intersection Design (SaFID) for All Crashes

				Minor street						
			Number through lanes:	2			4		6 or 8	
Major street		Low AADT:	0	5,000	7,500	10,000	10,000	25 000 and		
Number through lanes	Low AADT	High AADT	High AADT:	5,000	7,500	10,000	15,000	25,000	above	Any
2	0	7,500		All-way stop	All-way stop	n/a	n/a	n/a	n/a	n/a
	7,500	15,000		One-lane roundabout	One-lane roundabout	One-lane roundabout	One-lane roundabout*	n/a	n/a	n/a
4	10,000	15,000		Unsignalized RCI	Unsignalized RCI	Unsignalized RCI	Signalized RCI	Signalized RCI	n/a	n/a
	15,000	20,000		Unsignalized RCI	Unsignalized RCI	Signalized RCI	Signalized RCI	Signalized RCI	n/a	n/a
	20,000	25,000		Unsignalized RCI	Signalized RCI	Signalized RCI	Signalized RCI	Signalized RCI	n/a	n/a
25,000 and above			Unsignalized RCI	Signalized RCI	Signalized RCI	Signalized RCI	Signalized RCI	Median u- turn	n/a	
6 or 8	Ar	ny		Unsignalized RCI	Signalized RCI	Signalized RCI	Signalized RCI	Signalized RCI	Median u- turn	Median u- turn

\* One-lane roundabouts are generally feasible if the combined AADT is less than 25,000. If a one-lane roundabout is infeasible a signal is the safest feasible design.

# SaFID for Injury Crashes

				Minor street						
			Number through lanes:	r 1 :			4		6 or 8	
Major street		Low AADT:	0	5,000	7,500	10,000	10,000	25 000 and		
Number through lanes	Low AADT	High AADT	High AADT:	5,000	7,500	10,000	15,000	25,000	above	Any
2	0	7,500		All-way stop	All-way stop	n/a	n/a	n/a	n/a	n/a
	7,500	15,000		One-lane roundabout	One-lane roundabout	One-lane roundabout	One-lane roundabout*	n/a	n/a	n/a
4	10,000	15,000		Unsignalized RCI	Unsignalized RCI	Unsignalized RCI	Two-lane roundabout	Two-lane roundabout	n/a	n/a
	15,000	20,000		Unsignalized RCI	Unsignalized RCI	Two-lane roundabout	Two-lane roundabout	Two-lane roundabout	n/a	n/a
	20,000	25,000		Unsignalized RCI	Two-lane roundabout	Two-lane roundabout	Two-lane roundabout	Two-lane roundabout**	n/a	n/a
	25,000 a	nd above		Unsignalized RCI	Two-lane roundabout**	Two-lane roundabout**	Two-lane roundabout**	Two-lane roundabout**	Median u- turn	n/a
6 or 8	Aı	лy		Unsignalized RCI	Median u-turn	Median u-turn	Median u-turn	Median u-turn	Median u- turn	Median u- turn

\* One-lane roundabouts are generally feasible if the combined AADT is less than 25,000. If a one-lane roundabout is infeasible a signal is the safest feasible design.

\*\* Two-lane roundabouts are generally feasible if the combined AADT is less than 45,000. If a two-lane roundabout is infeasible a median u-turn is the safest feasible design.

## What About...

- Two-way stop control
- Conventional signals
- Jughandles
- Continuous green T's





# Many Possible Reasons Not To Choose the SaFID

- The CMF does not apply

   Careful! No model is ever perfect
- Operations
- Right of way/cost/impact
- Pedestrians/bicycles

   NCHRP 7-25 report coming soon

# SaFID Conclusion

- SaFID charts are now available
   Good CMFs for many intersections
- The SaFID should be the default choice
  - Burden of proof should be on proponent of less-safe design
- Many reasons to choose another design
- We need more safety research
- Paper to appear in May ITE Journal

# Finally, Let's Talk Reverse RCI RCI Reverse RCI





# Tough Compromise

Parameter	RCI	Reverse RCI		
Purpose	Safety, efficiency, progression, pedestrians	Compromise with heavier minor left turn		
Number installed in NC	~150	~4		
Number of movements redirected	4	4		
Type of signal	Half	Full		
Number of signal phases	2	3		
CMF, signalized, all crash	0.85	Unknown		
Cost and impacts	Mostly at two bulb-outs	Same as RCI		
Pedestrians	31% score in "20-flag" analysis	35% score in "20-flag" analysis		



## Is a Partial Median U-Turn Better?

- Example at 36<sup>th</sup> and State, Boise, ID
- Only redirects major street left turns

   All minor street movements made directly
- Full signal
- Three phases
- Impacts same as RCI and reverse RCI
- Pedestrians one-stage crossing but longer cycle, 27% score in "20-flag" analysis

# Capacity Example

- Critical lane method
- Keeping numbers of lanes equal
- 2040 forecast, US-15/501 (54,000 vpd) at Elliott Road (10,000 vpd), Chapel Hill
- Conventional v/c = 0.92
- RCI v/c = 0.79
- Reverse RCI v/c = 0.81
- Partial MUT v/c = 0.79

# There Are Several Similar Three-Phase Alternatives

- "Maryland left" redirects side street throughs
- "Seven-phase signal" redirects one side street through
- Redirect one side street left and the adjacent side street through



# **Reverse RCI Conclusion**

- Tough compromise
- Partial median u-turn may be better
   Only redirects two movements
- There are many three-phase alternatives
- Will drivers understand?
- Need more research
  - Driving simulation, crash stats, software, ...

# Thank You!

- Let's go fix some intersections and interchanges
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