An Update on Superstreet Implementation and Research

Joseph E. Hummer,
Ph.D., P.E.

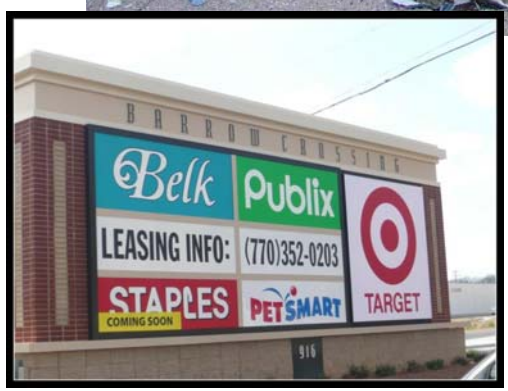
North Carolina State University
Raleigh, NC

February 23, 2011

Problems in Rural Four-Lane Corridors

- Collisions
  - Angle
  - High-speed
  - Severe
- Treatments?
  - Flashers?
  - Interactive devices?
  - Signalize?
- Accommodating future growth

http://blog.fleetowner.com/trucks_at_work/wp-content/uploads/2010/06/crash2.jpg



http://activerain.com/image_store/uploads/9/1/6/2/2/ar123637708322619.jpg

Problems in Urban Arterial Corridors

- Growing demand
- Conventional solutions exhausted
- Widening?
- Bypasses?
- Structures?
- ITS, transit, demand management, etc.?

www.life.com

www.shutterstock.com

Potential Solution: Superstreets

- FHWA: “RCUT” – Reduced Crossing U-turn intersection
- An arterial with only one-way median openings
- Left turn and through movements from side streets redirected
- Part of a menu of unconventional arterial designs
- Published extensively in peer-reviewed literature

US-74 and Elmore Road, Scotland County

Google Earth ©

Superstreet is One Item on Menu

- 15 designs on current intersection "menu"
  - Most published
  - Most in use in U.S.
- Several promising unconventional interchange designs as well
- Superstreet among most promising new designs

Superstreets Across the US

- Michigan – 1000 miles of median u-turns, one superstreet
- Texas – Extensive one-way frontage roads, one superstreet
- New Orleans – Many median u-turns
- Minnesota – One superstreet
- Maryland – US-301 “J-Turn intersections” since 2001

Median u-turns on Hall Road, Sterling Heights, MI

www.google.com/maps

Superstreets in NC

- Extensive use of leftovers
- At least 10 signalized sites
  - US-15/501 in Orange Co.
  - US-17 in Brunswick Co.
  - Several others
- At least 20 unsignalized sites
  - US-23/74 in Haywood Co. since 2000
  - US-1 in Moore Co.
  - Several others

Courtesy of NCDOT

NC Signalized Superstreets –
US-15/501 Orange County

Google Earth

NC Unsignalized Superstreets –

NC-87 at SR-1150/Peanut Plant Road

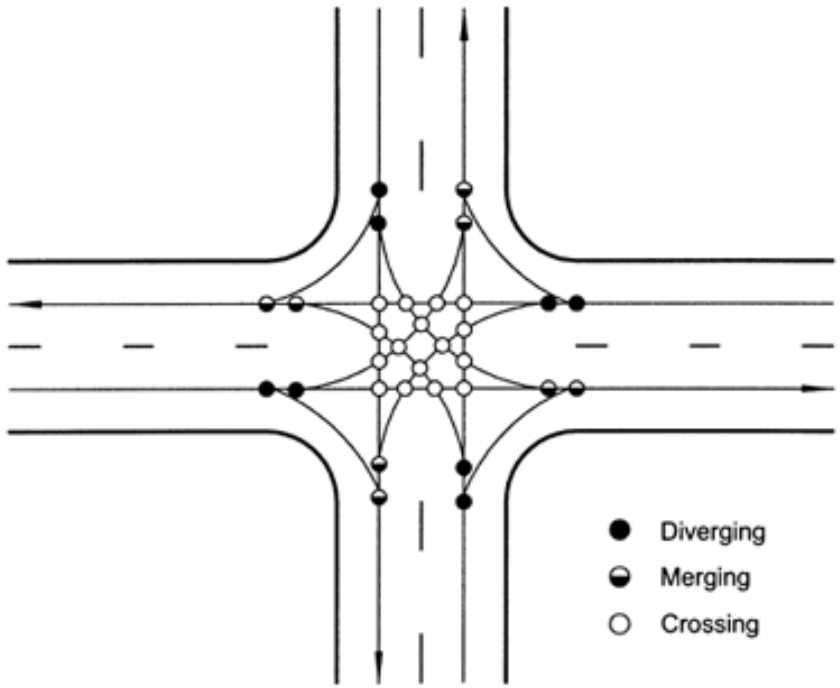
Courtesy of NCDOT

NC Unsignalized Superstreets –
US-74 Jackson County

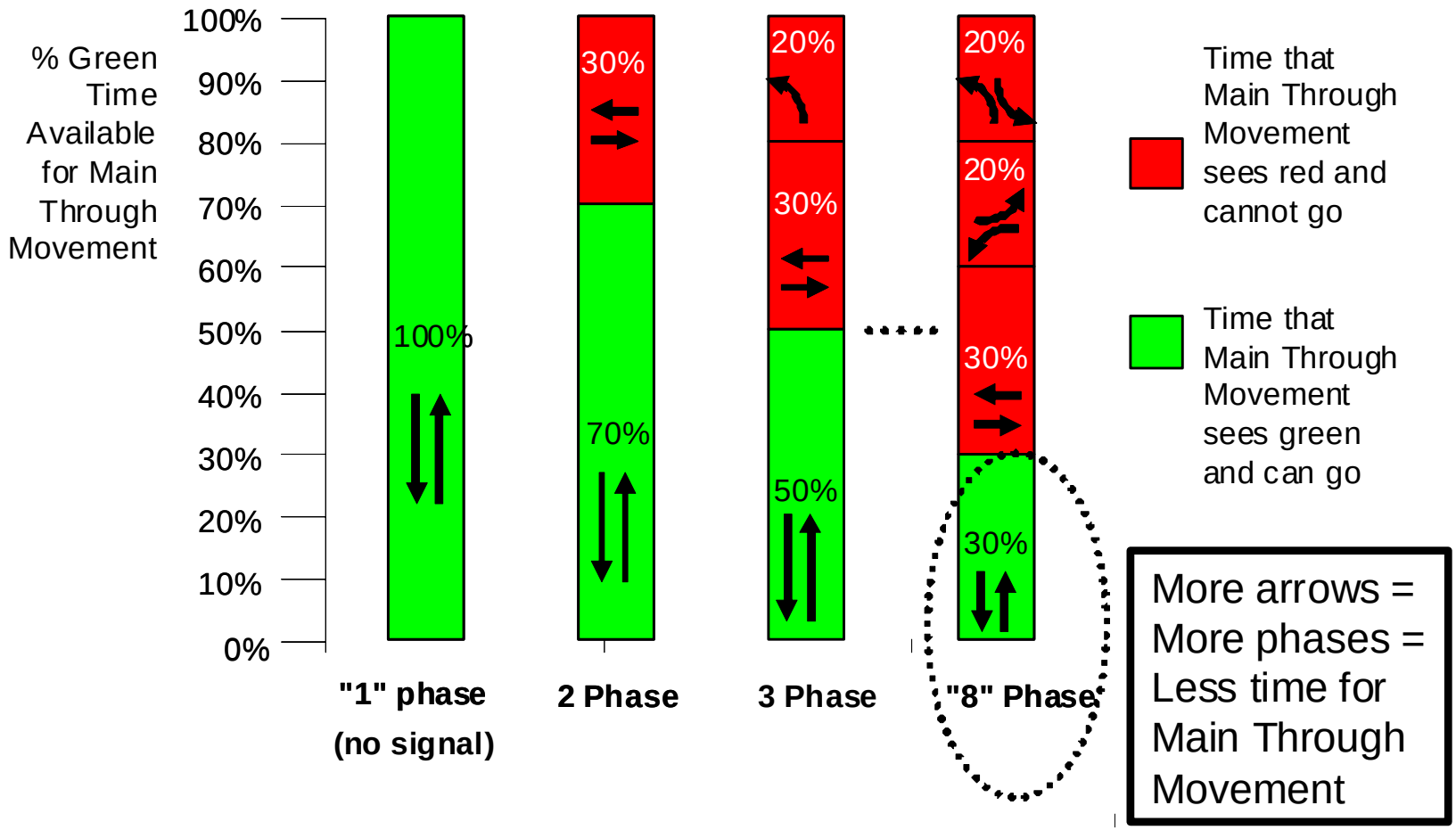
Courtesy of NCDOT

Conventional Intersection

- Two-way median opening
- 32 conflict points
- “Eight-phase” signal

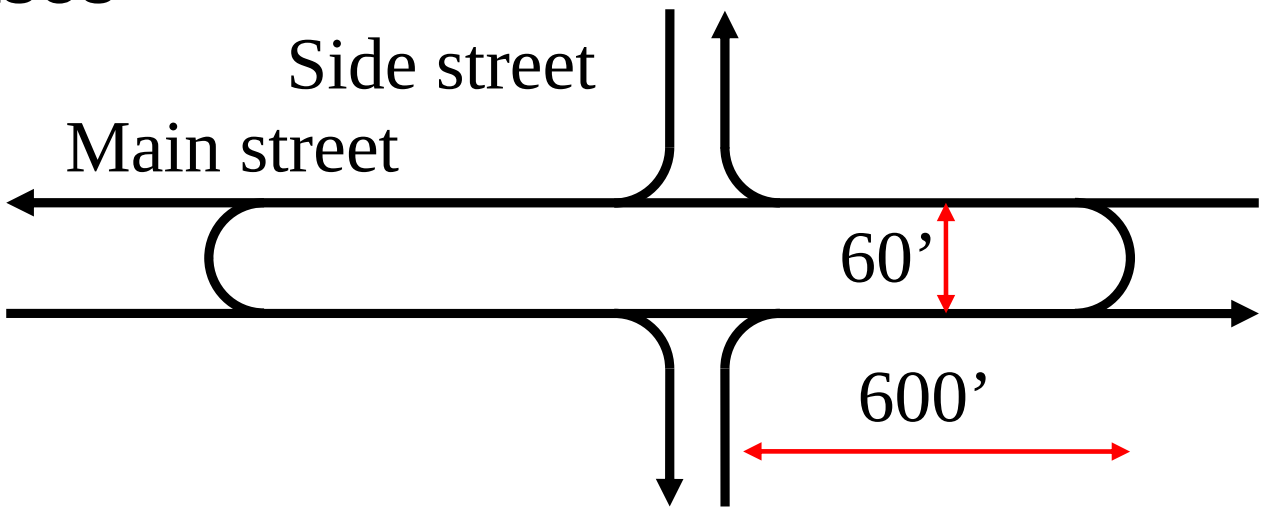


The Magic of Two-Phase Signals



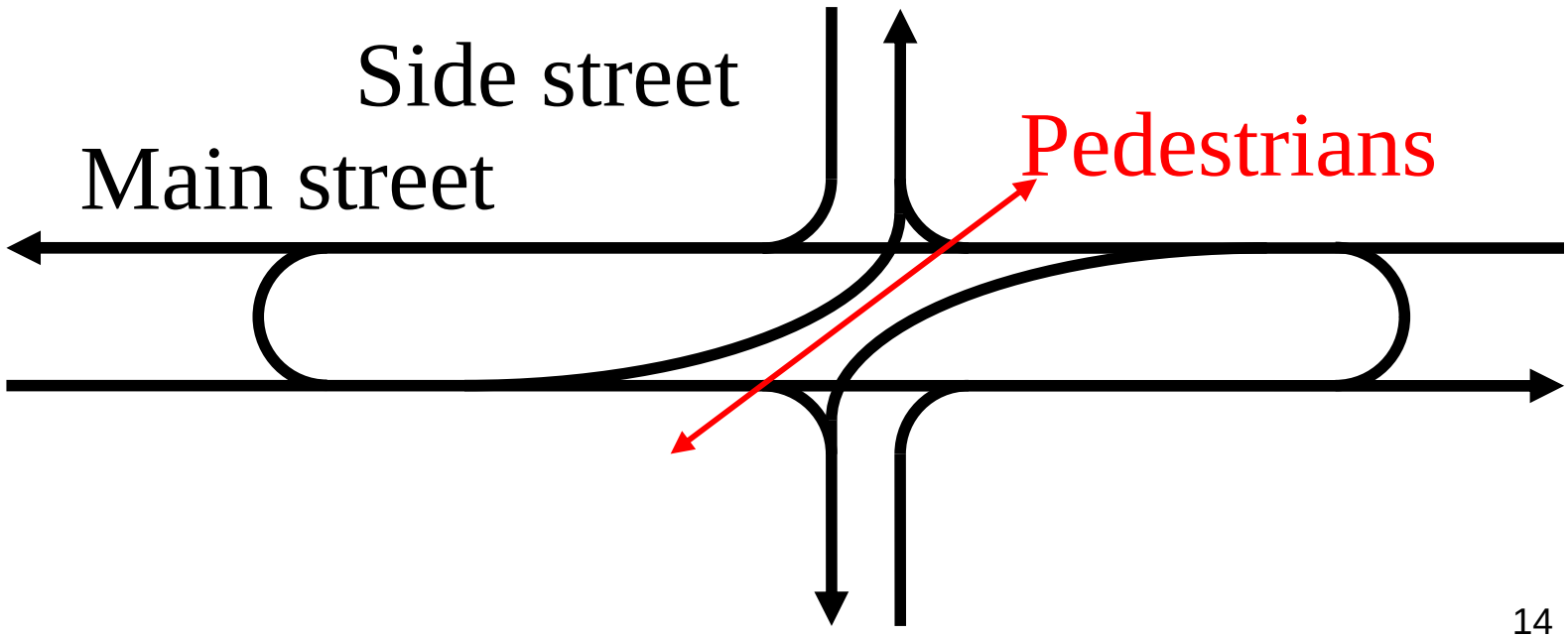
Basic Superstreet Intersection

- Left turn and side street through movements redirected
- 8 conflict points
- 2 signal phases



Higher-Volume Superstreet Intersection

- Direct left turns from main street to side street
- 14 conflict points

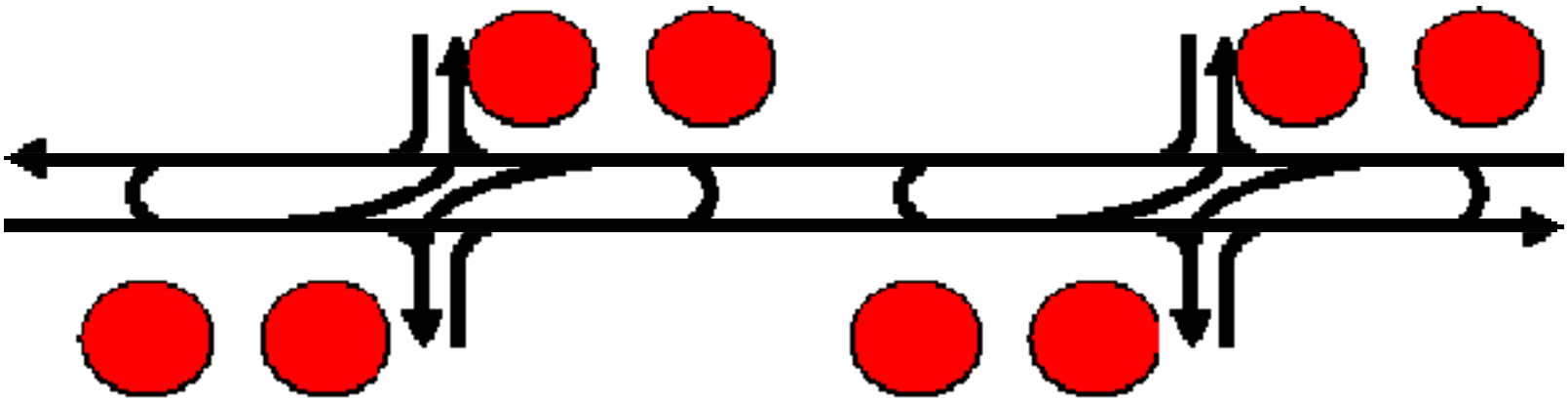


Superstreet Advantages

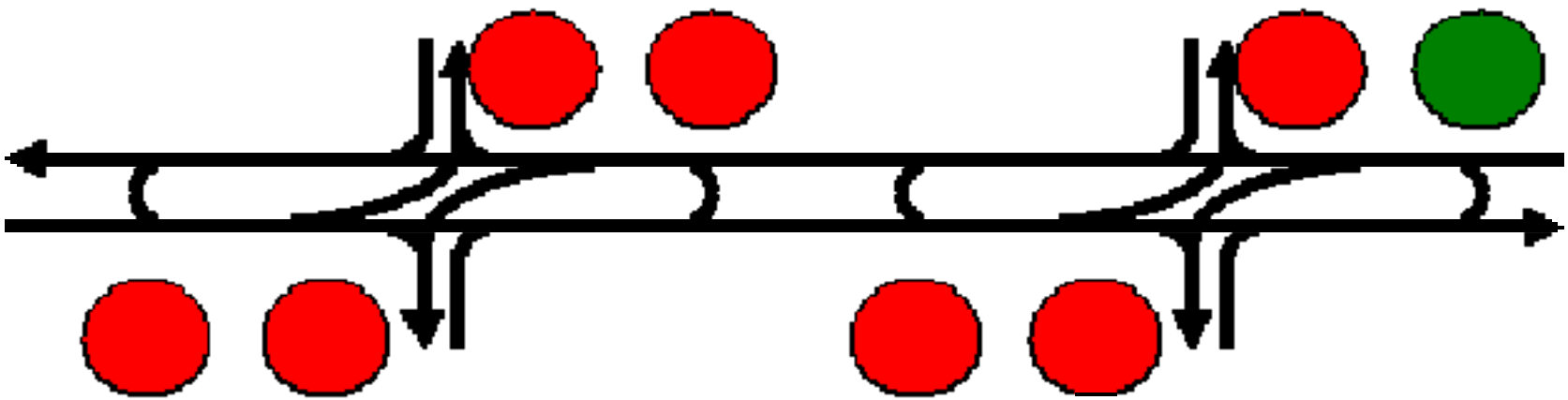
- Perfect two-way progression with any signal spacing
- Speed control
- Pedestrian crossing
- Safety
- Efficient travel
  - Lower delay, higher capacity, lower emissions…

www.google.com/maps

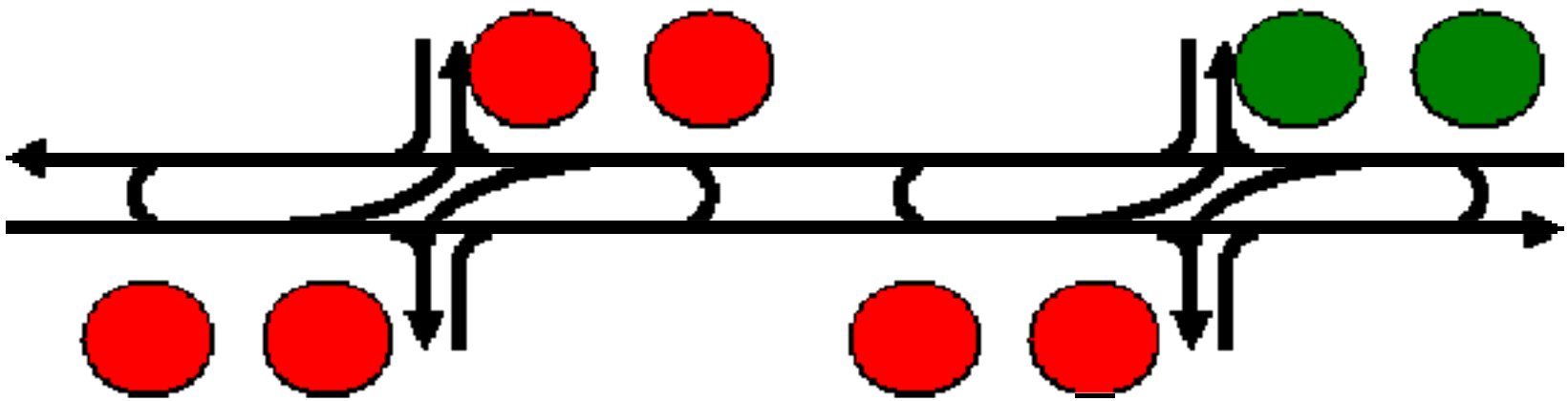
Perfect Progression



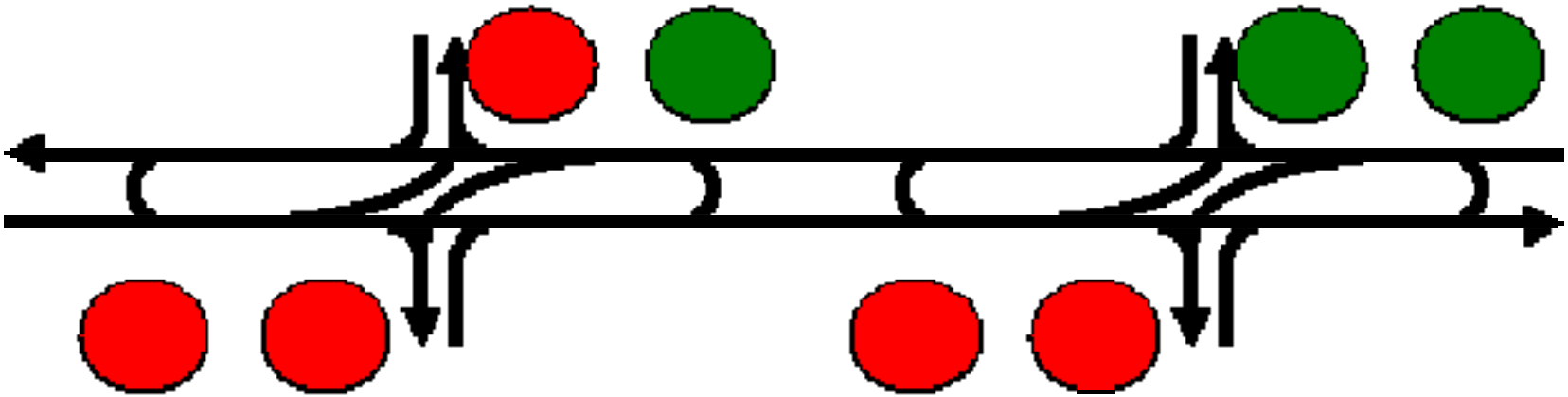
Perfect Progression



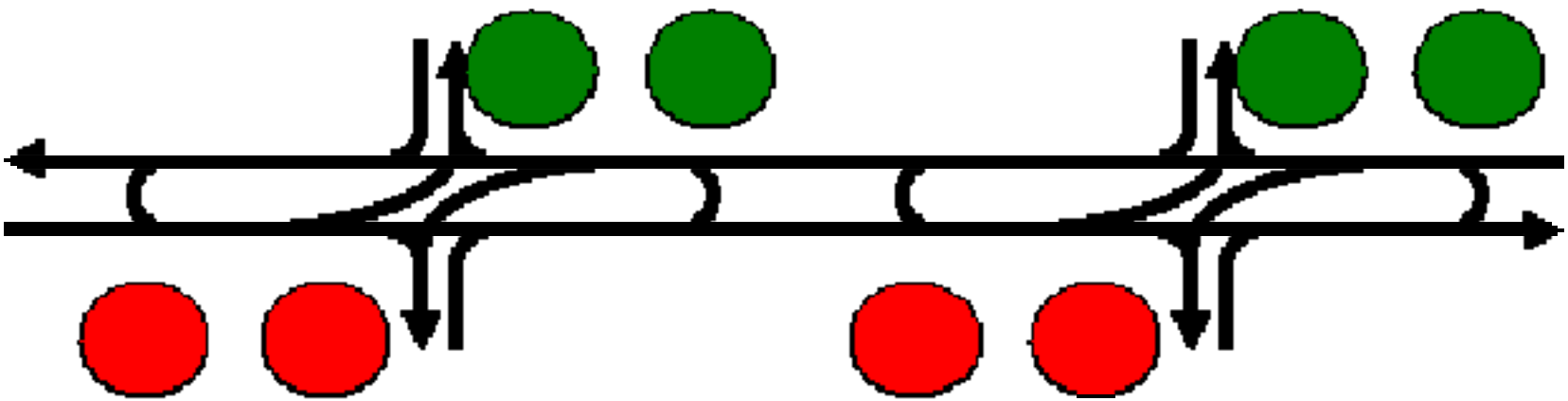
Perfect Progression



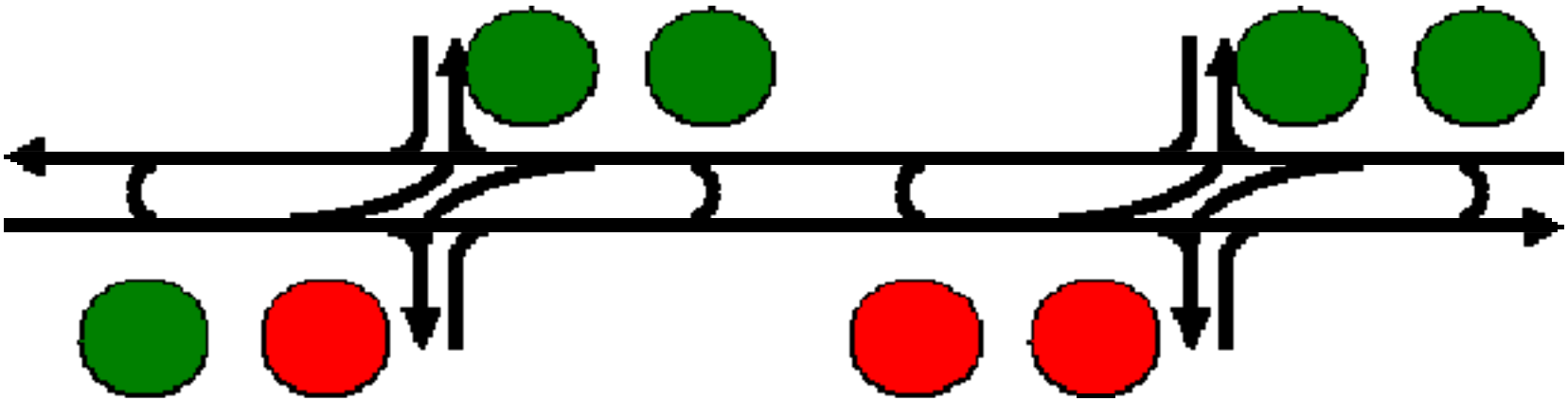
Perfect Progression



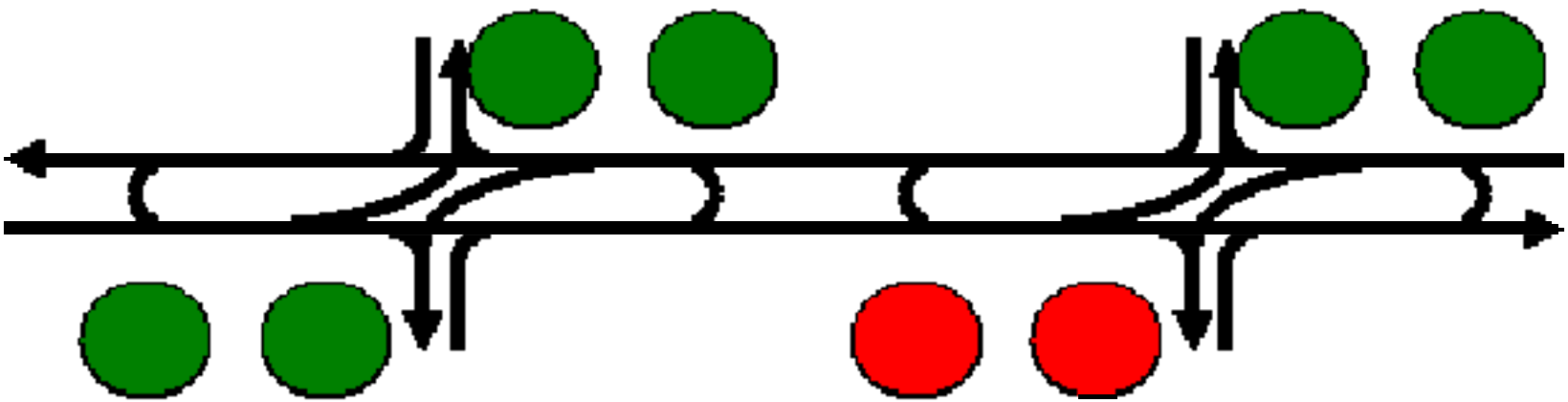
Perfect Progression



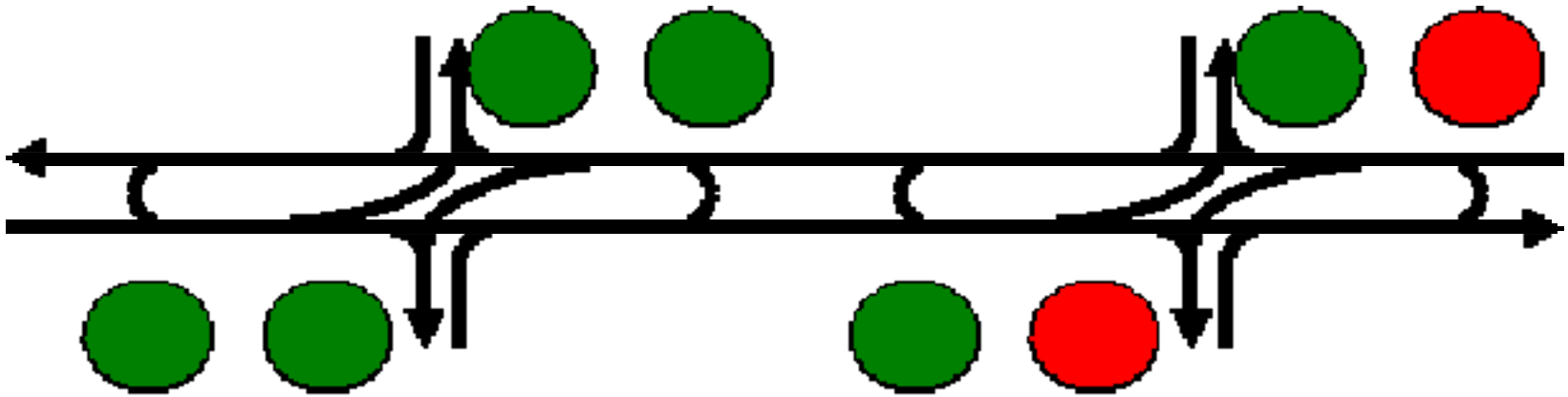
Perfect Progression



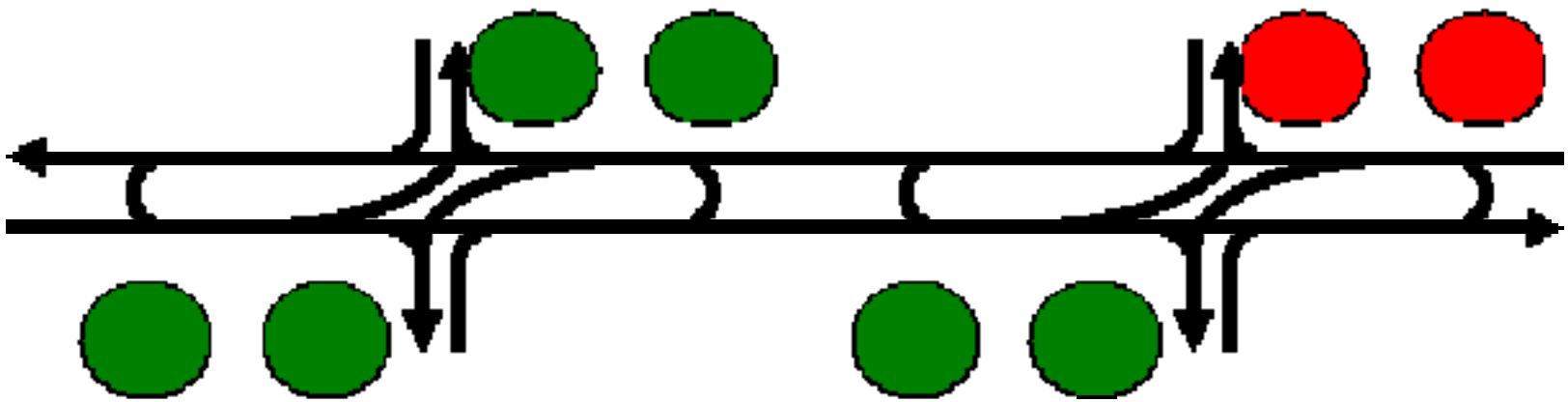
Perfect Progression



Perfect Progression



Perfect Progression



You Control Speeds

- Set progression speed as high or low as you wish
- Vary the progression speed by location, direction, time, day,…
- Drivers will adjust quickly
- No fancy signal hardware or software needed
- Reassign enforcement resources

Courtesy of NCDOT

Easy and Safe Pedestrian Crossing

US-15/501 in Orange County

Courtesy of NCDOT

- Can install ped signals easily, almost anywhere
- Can create perpendicular rather than diagonal crossing

Recent Research for NCDOT

- Two-year project by NCSU
- Complete December 2010
- Report on NCDOT website:

https://apps.dot.state.nc.us/Projects/Research/ProjectInfo.aspx?ID=2461

- Safety
- Travel time
- Perceptions

Safety Analysis Overview

- Unsignalized superstreets
- Three methods
  - Naïve Method
  - Comparison-Group (C-G) Method
    - Accounts for conditions changing with time
  - Empirical Bayes (EB) Naïve Method
    - Accounts for possible bias in site selection
    - Used calibrated crash prediction model from new “Highway Safety Manual”

Unsignalized Superstreet Sites

- 12 individual sites and 1 corridor
- Located in 9 counties across the state
- 4 lane divided major road, 2 lane undivided minor road

US-74 and Elmore Road, Scotland County

Google Earth ©

Data Collection

- Site data
  - Distances to crossovers
  - Construction periods
  - Road names
  - Road geometry and traffic control measures
- Traffic volume data
  - AADT of major and minor roads
- Crash data
  - Reviewed all crash reports for:
    - Work zones
    - Geometry
    - Traffic control

Naïve Analysis Results

Collision Type	% Change, Conventional to Superstreet
Total	-34
Fatal and injury	-60
Angle and right turns	-86
Rear-end	22
Sideswipe	14
Left turns	-75
Other	9

8 of 13 sites had statistically significant reduction in total collisions.

C-G Analysis Results

- 10 unsignalized sites showed reduction (9 significant)

Collision Type	% Change, Conventional to Superstreet
Total	-46
Fatal and injury	-63
Angle and right turns	-75
Rear ends	-1
Sideswipes	-13
Left turns	-59
Other	-15

EB Naïve Analysis

- Reduction at all 13 sites (12 statistically significant)

Collision Type	% Change, Conventional to Superstreet
Total	-27
Fatal and injury	-51
Angle and right turns	-86
Rear ends	12
Sideswipes	-12
Left turns	-76
Other	8

Safety Study Conclusions

- Superstreet intersections on rural four-lane roads are safer than conventional intersections
  - Reduced collisions at most sites
  - C-G method best
  - 46% reduction recommended for use
- Reduced angle and right turn, left turn, and fatal and injury collisions

Operational Analysis Overview

- Signalized superstreets
- Saturation flow study of median u-turns and directional crossovers
- Comparison of superstreets and conventional intersections
  - Calibrated and validated superstreet models in VISSIM using field data
  - Compared superstreet models to the equivalent conventional intersection
  - Examined travel time

Superstreet Sites

Arterial	No. of Intersections	Cross Street(s)	Location
US-15/501	1	Erwin Rd./Europa Dr.	Chapel Hill, NC
US-17	5	Ploof Rd./Olde Waterford Way	Leland, NC
		Gregory Rd./Walmart entrance	
		West Gate Dr./Grandiflora Dr.	
		Brunswick Forest Pkwy	
		Lanvale Rd./Brunswick Forest Dr.	
US-421	1	Myrtle Gardens Dr./Carolina Beach Rd.	Wilmington, NC

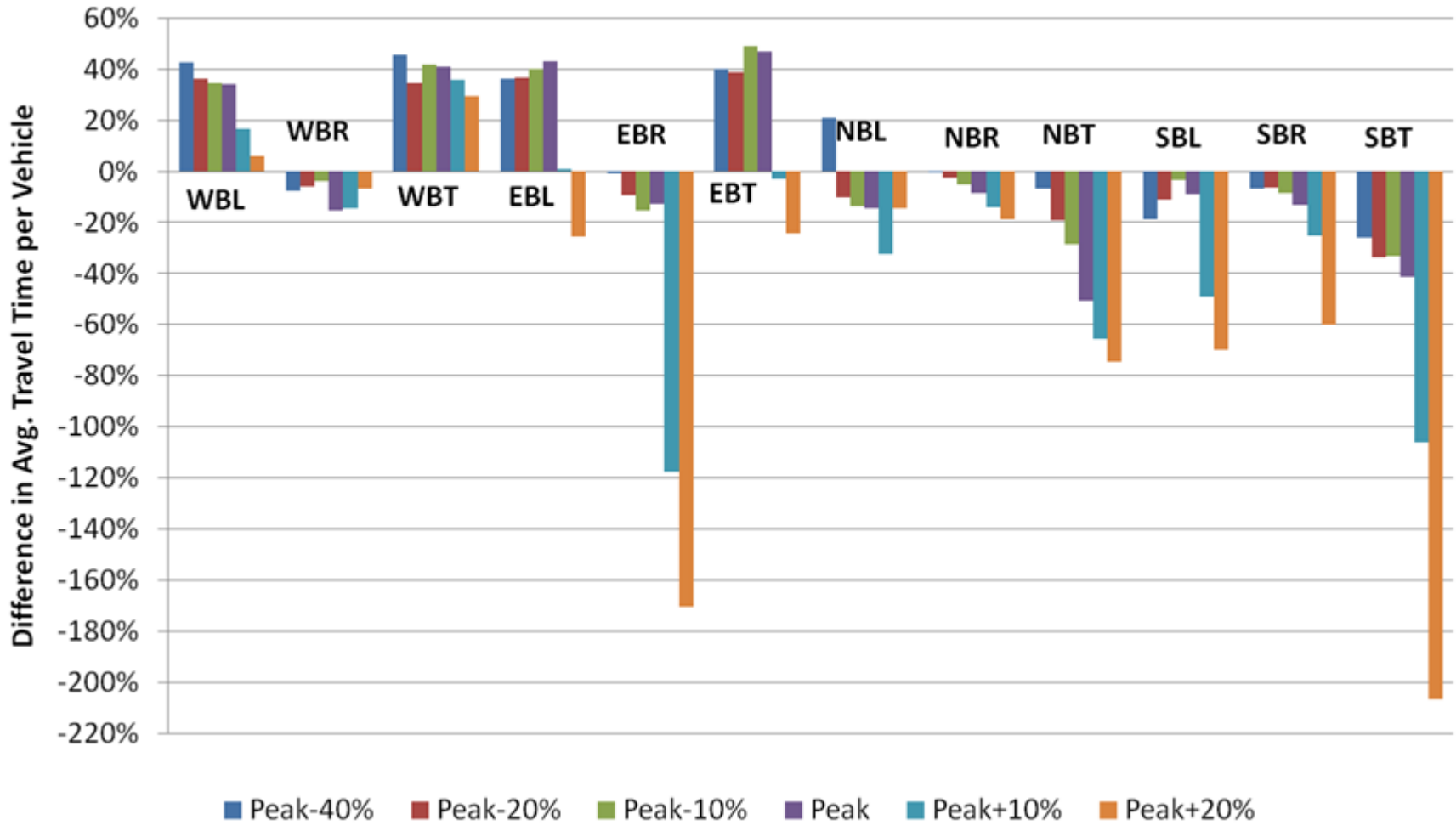
Superstreet vs. Conventional: Experiment Setup

- Fair comparison:
  - Updated geometries for conventional
  - Optimized signal timing using Synchro
- Travel time comparison for various demand levels:
  - Peak
  - Peak – 10% Peak + 10%
  - Peak – 20% Peak + 20%
  - Peak – 40% Peak + 40%

Superstreet vs. Conventional: Results

- Travel time effects on arterial:
  - Reduced travel time for major through movements
  - Reduced travel time for major left movements at Myrtle Grove and US-17
  - Increased travel time for major lefts at Chapel Hill (no direct left turn)
- Travel time effects on minor road:
  - Minor through and left turn movements negatively impacted

US-17 @ Ploof/Poole



**Note: travel times not weighted by volume*

Operational Study Results

- Superstreet reduced average travel time per vehicle by about 20%

Intersection	Pk-40%	Pk-20%	Pk-10%	Peak	Pk+10%	Pk+20%
US-15/501 @ Erwin/Europa	-1.6%	-16.2%	-4.8%	-1.6%	-13.8%	-16.8%
US-421 @ Myrtle Gardens Dr.	-2.2%	-6.7%	-12.7%	-1.5%	-11.9%	-12.7%
US-17 corridor (avg. for all intersections)	-3.7%	-7.7%	-15.4%	-26.5%	-79.6%	-100.2%
US-17 @ Ploof/Poole	-2.8%	-15.1%	-18.6%	-27.8%	-71.8%	-106.3%
US-17 @ Walmart/Gregory	-3.9%	-10.9%	-27.8%	-54.0%	-89.6%	-99.2%
US-17 @ Grandiflora/West Gate	-7.2%	-8.3%	-5.6%	-19.2%	-122.8%	-146.6%
US-17 @ Brunswick Forest Pkwy	-2.6%	-0.6%	-20.2%	-23.4%	-80.8%	-104.3%
US-17 @ Lanvale/Brunswick Forest	-1.7%	-5.4%	-8.2%	-10.0%	-32.9%	-49.4%

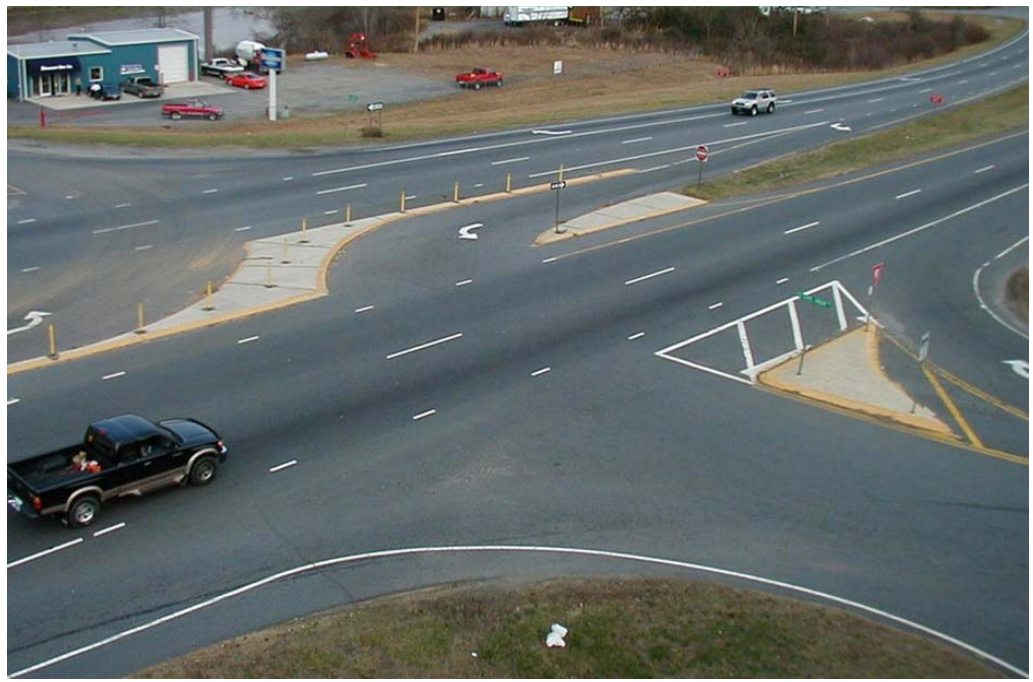
Operational Conclusions

- Superstreet outperformed conventional for overall travel time per vehicle
- Largest travel time savings during high demand periods
- Major road positively impacted
- Minor road negatively impacted, but volumes lower
  - Use another design if minor street volume too high
- More capacity – adds to intersection's useful life
- Superstreet successful at three very different locations

Perception Surveys

- To determine the perceived effects of superstreets on:
  - Nearby motorists
  - Commuting motorists
  - Business owners

Courtesy of NCDOT



Resident Survey

- Four waves of mailings
- Sent to 500 randomly-selected residents
  - Half near signalized sites, half near unsignalized sites
  - Residents within two-mile radius of the superstreet
- Response rate 29%

Resident Survey Results

- Navigation through the superstreet

	Signalized	Unsignalized	All
Easier/less confusing	33%	41%	36%
The same	17%	20%	19%
More difficult/more confusing	41%	31%	37%

Resident Survey - Results

- Ability to safely navigate the superstreet

	Signalized	Unsignalized	All
Positive	49%	61%	54%
Negative	22%	20%	22%
Same	28%	15%	23%

Resident Survey - Results

- Difference in travel time

	Signalized	Unsignalized	All
Less travel time	18%	13%	16%
No change	32%	50%	39%
More travel time	51%	33%	44%

Resident Survey - Results

- Number of stopped vehicles

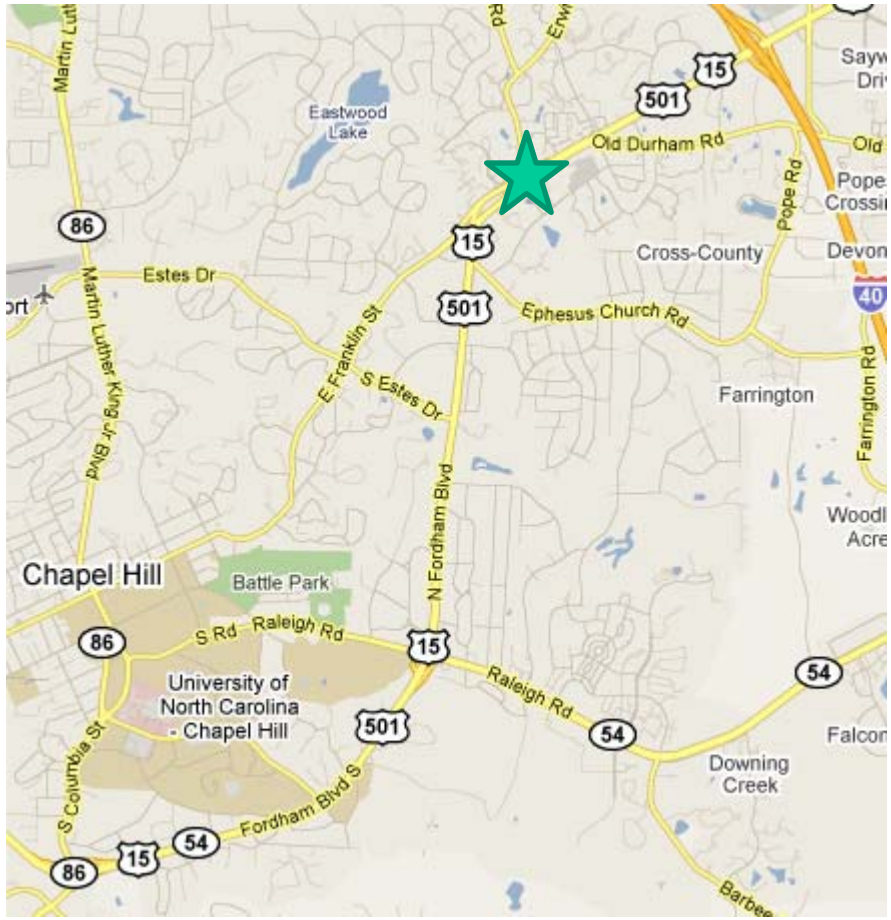
	Signalized	Unsignalized	All
More stopped vehicles	45%	25%	37%
No change	16%	27%	21%
Fewer stopped vehicles	36%	41%	38%

Resident Perception Summary

- Travel more safely
  - Both signalized and unsignalized sites
- More travel time
  - Both signalized and unsignalized sites
- Stopped vehicles
  - More at signalized sites, fewer at unsignalized sites
- Would like to make a legal left turn on red

Commuter Survey

- Process:
  - 4-waves of emails
  - Sent to 2520 UNC-CH faculty and staff
    - o US-15/501 major arterial into campus
    - o Immense campus directory
    - o Randomly selected from list
  - 513 responses



www.google.com/maps

Commuter Survey - Results

- Navigation through the superstreet

Response	Commuters	Non-Commuters
Easier	19%	18%
Same	36%	28%
More difficult	45%	54%

Commuter Survey - Results

- Effect on ability to safely navigate the superstreet

Response	Commuters	Non-Commuters
Positively	33%	36%
Same	44%	32%
Negatively	22%	32%

Commuter Survey - Results

- Difference in travel time (TT)

Response	Commuters	Non-Commuters
Less TT	36%	27%
No change	52%	39%
More TT	12%	35%

Commuter Survey - Results

- Number of stopped vehicles

Response	Commuters	Non-Commuters
Fewer stopped	45%	53%
No change	36%	22%
More stopped	20%	24%

Commuter Perception Summary

- Safer
- More difficult to navigate
- Fewer stopped vehicles
- Travel time
  - Greater for residents
  - Less for commuters

Business Owner Survey

- Personal interviews
- US-15/501 in Chapel Hill and US-421 in Wilmington
- Responses from 29 business owners or managers
  - Varied in type and size
  - No statistical analyses

Business Perception Summary

- Chapel Hill respondents recognized traffic flow and safety improvements
- Some negative impact on business growth and operations
- Some customer access and confusion problems

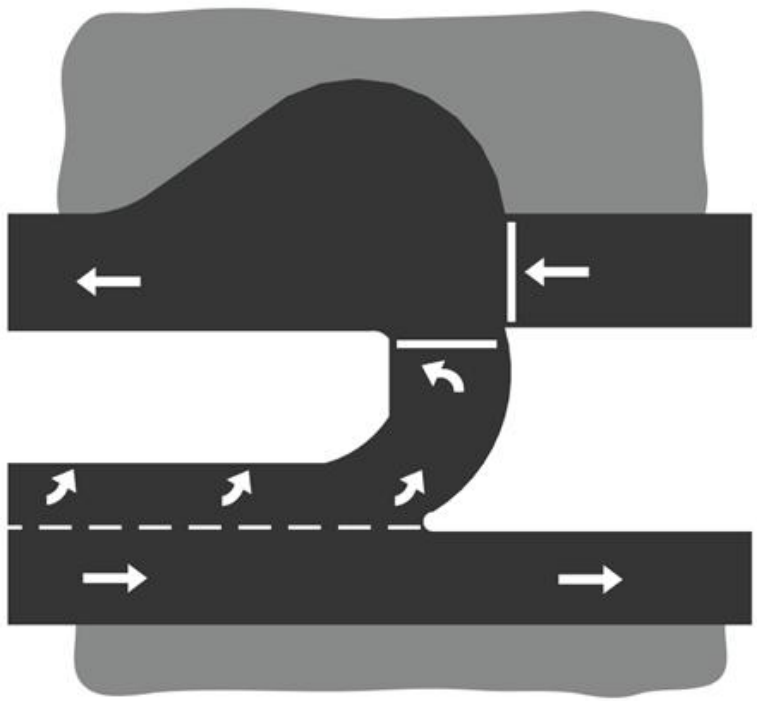
Superstreets Should Help Businesses Grow

- Safer, more efficient, and…

- Less need to reconstruct in future
- Flexible crossover location
  - May be able to line up to business driveway
- More aggressive to signalize
- Slower speeds

Other Superstreet Disadvantages?

- Wider median and right-of-way?
  - No, use loon
- Higher construction cost?
  - Marginal, costs coming down
- Difficult for crossing bicycles?
  - Research needed



Recommendations

- Consider superstreets for upgrading arterials similar to those studied
  - High volume, divided arterial
  - Low volume minor road
- Rural or urban
  - It is safe when unsignalized
  - It is efficient when signalized
- Better as a corridor than isolated intersection
- Evaluate the possibility for left turn on red

Recommendations

- Cite collision savings of 46%
- Cite travel time savings of 20%
- Take advantage of all superstreet features and potential
- Be proactive in education and public awareness of superstreet benefits

Questions?

US-74 in Jackson County

Courtesy of NCDOT