

Unconventional Arterial Intersection Design

Dan Ormand

CE 550

April 9, 2007

Arterial Congestion

- Delay due to:
 - Longer clearance intervals (high volume)
 - Vehicles turning left
 - Permitted left: vehicles & through traffic behind them wait for a gap
 - Protected left: through vehicles wait for signal phase
 - Longer pedestrian clearance times
 - Turn lanes widen roadway

Arterial Intersection Treatments

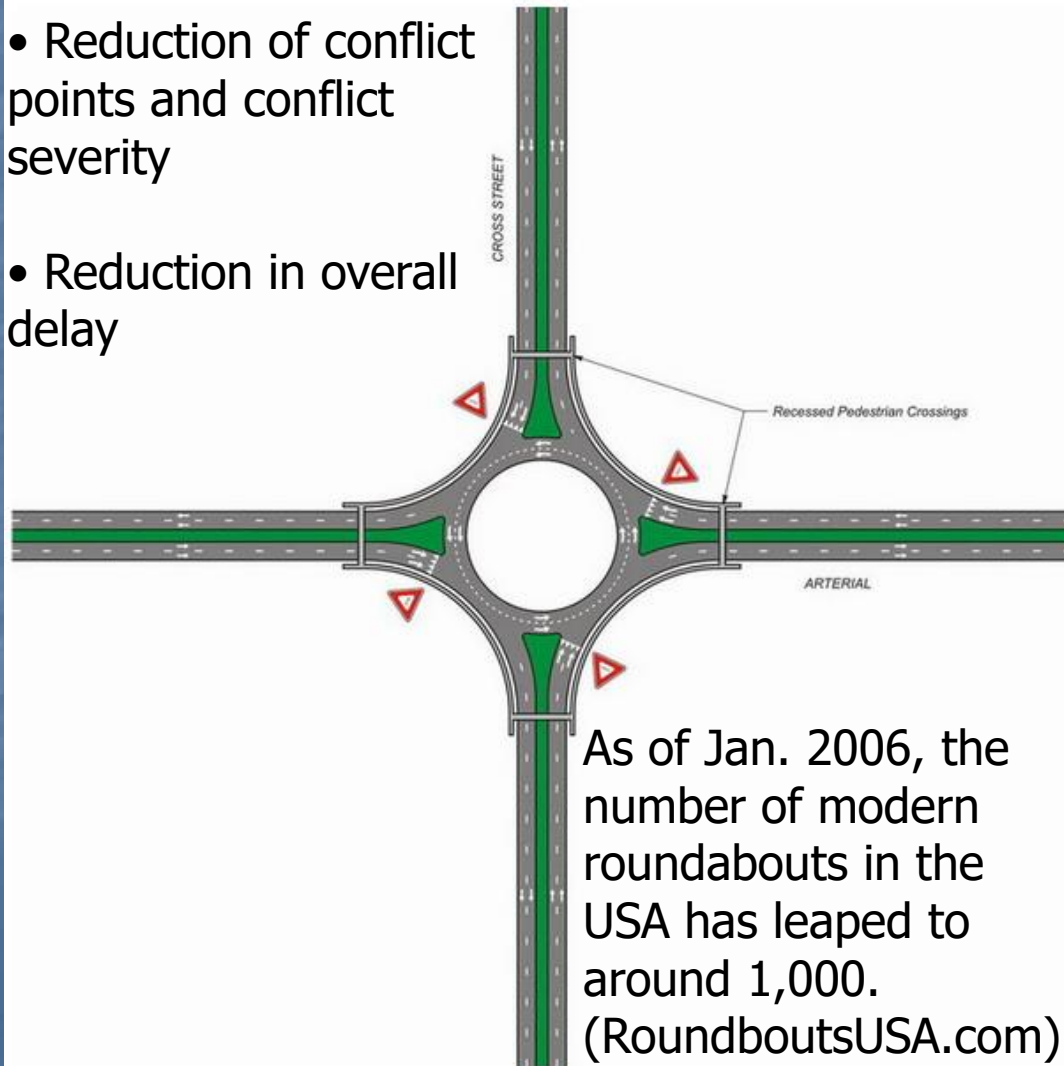
- Conventional Intersection Treatments
 - Turn Lanes
 - Update signal timing & phasing
- Unconventional Intersection Treatments
 - Indirect left-turns
 - Remove left-turns from main intersection
 - Reduction in conflict points

Unconventional Arterial Intersection Designs

1. Roundabout
2. Median U-Turn (MI)
3. Bowtie
4. Superstreet
5. Jughandle (NJ)
6. Continuous Flow Intersection
7. Continuous Green T-Intersection (FL)

Roundabout

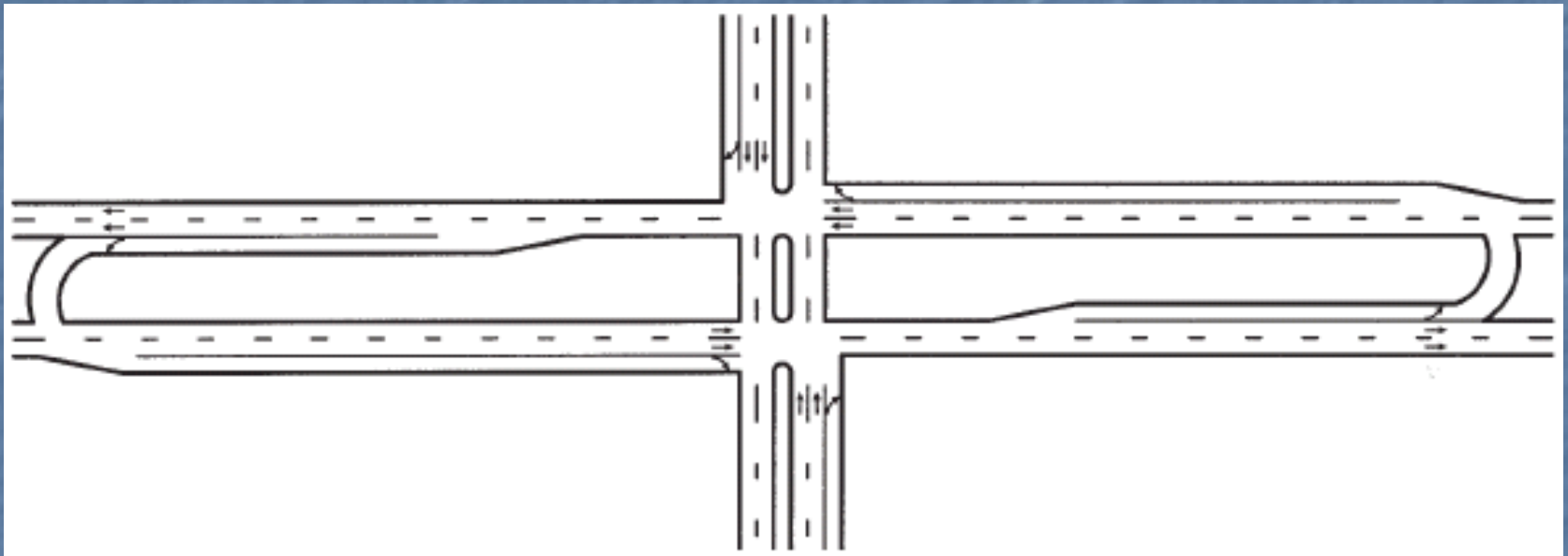
- Reduction of conflict points and conflict severity
- Reduction in overall delay



As of Jan. 2006, the number of modern roundabouts in the USA has leaped to around 1,000.
(RoundaboutsUSA.com)

Median U-Turn

"Michigan Left"

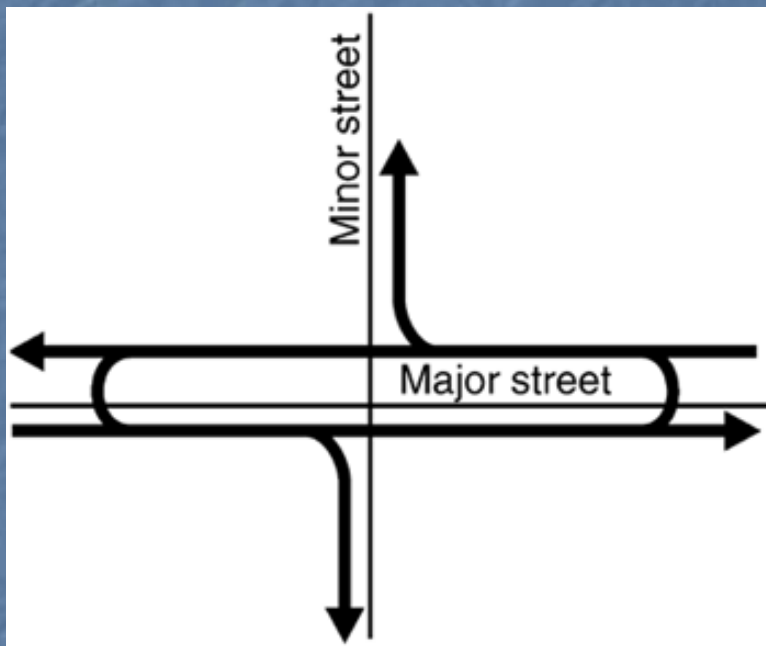


Median U-Turn Diagram

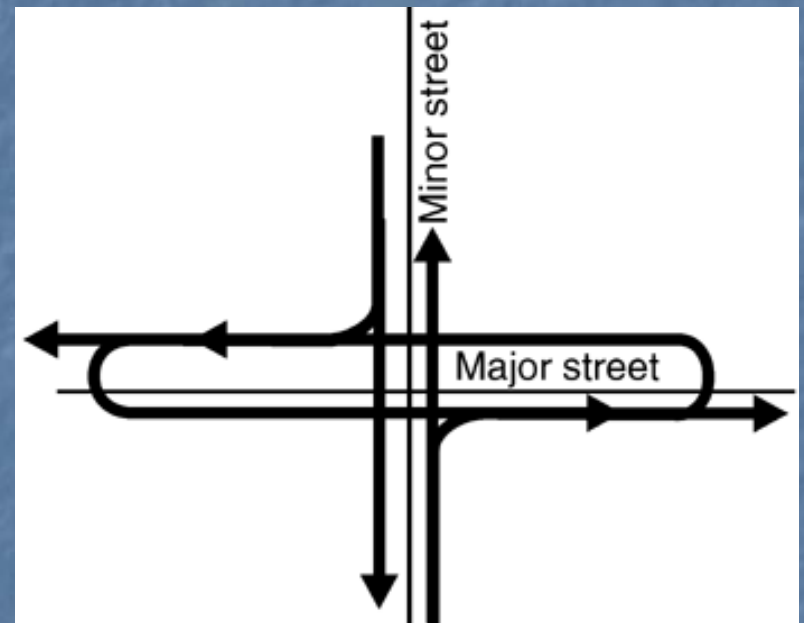
Source: FHWA

- Median U-Turn intersections have been used in MI for more than 30 years
- Optimum distance between intersection and U-turn is ~600ft

Median U-Turn

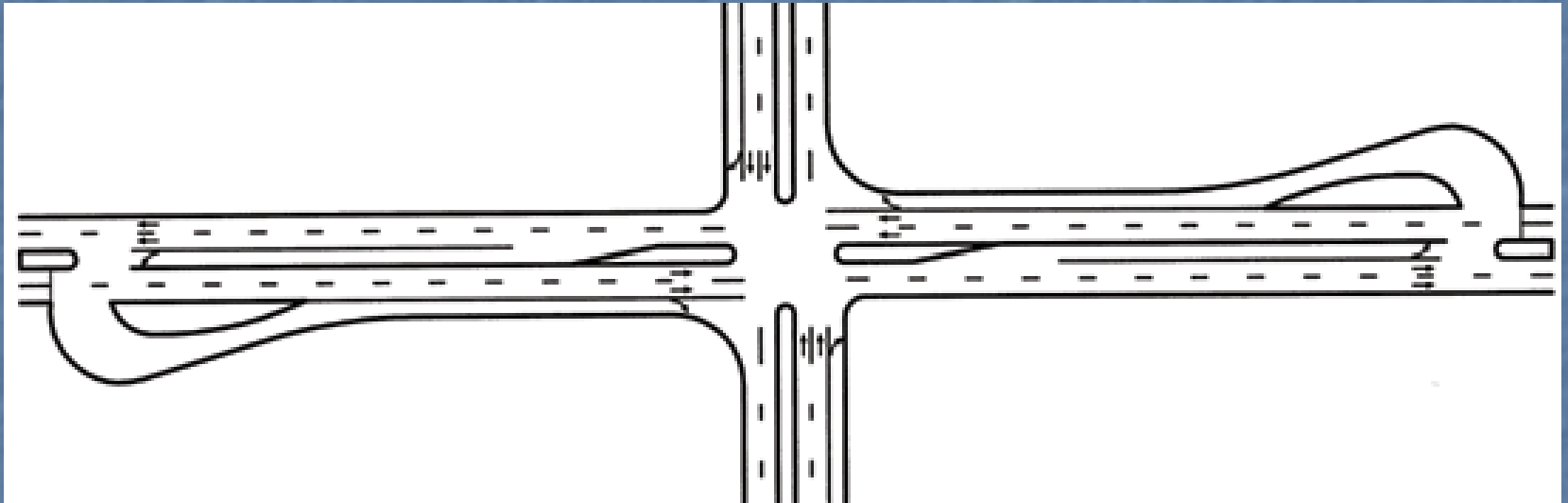


Major Street Movements



Minor Street Movements

Median U-Turn

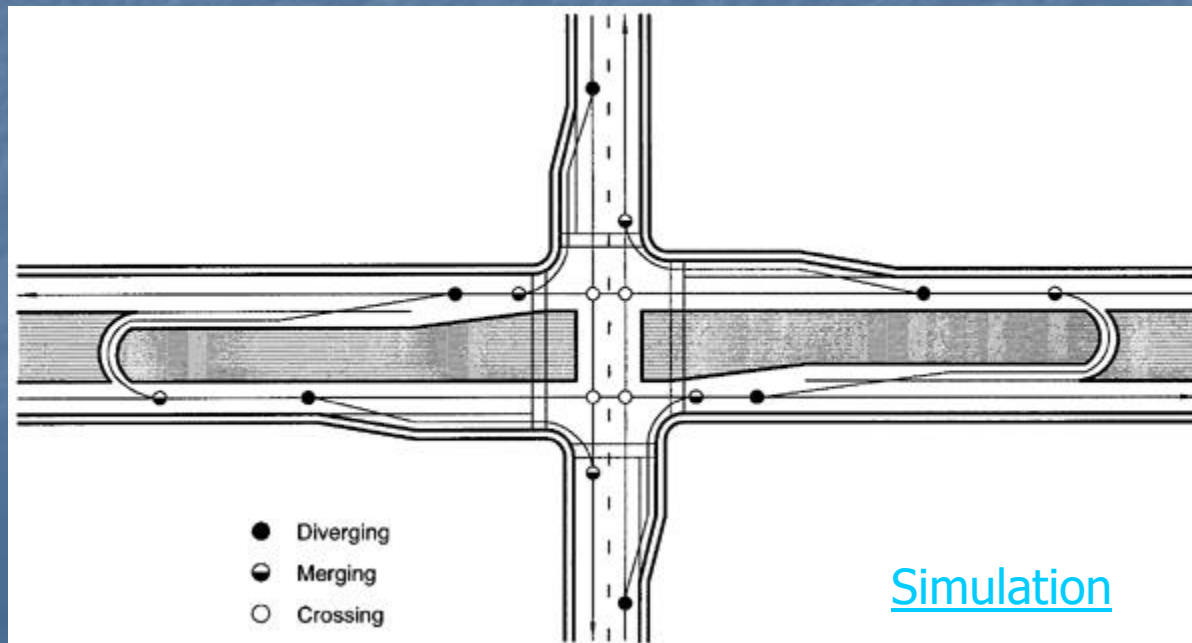


Median U-Turn with Narrow Median

Source: FHWA

Median U-Turn

Conflict type	Four-Leg Signalized Intersection	Median U-Turn Crossover Configuration
Merging/diverging	16	12
Crossing (left turn)	12	0
Crossing (angle)	4	4
Total	32	16



Median U-Turn

Summary of Issues Regarding Median U-Turns

Characteristic	Potential benefits	Potential Liabilities
Safety	Potential major reduction in left-turn collisions. Potential minor reduction in merging/diverging collisions.	None identified.
Operations	Potential reduction in overall travel time. <u>Reduction in stops for mainline through movements.</u> Mixed findings with respect to overall stops.	Mixed findings with respect to overall stops.
Multimodal	Number of conflicting movements at intersections is reduced.	Increased crossing distance for pedestrians. Turning paths of the median U-turn may encroach in bike lanes.
Physical	None identified.	May be additional right-of-way needs depending on width of existing median.
Socioeconomic	None identified.	Access may need to be restricted within the influence of the median U-turn locations.
Enforcement, Education, and maintenance	None identified.	Enforcement and education may be necessary to prevent illegal left turns at the main intersection.

Source: FHWA

Median U-Turn

- **When to consider implementation:**
 - High through volumes with moderate to low left turn volumes
 - ROW is available

Median U-Turn



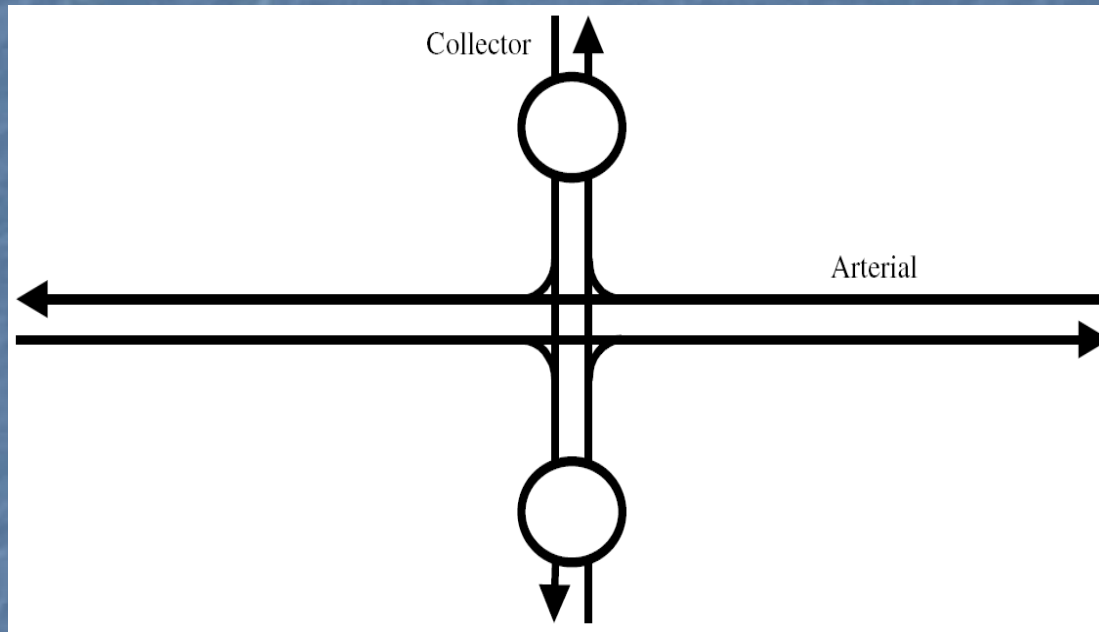
Left Turns Prohibited



Median U-Turn

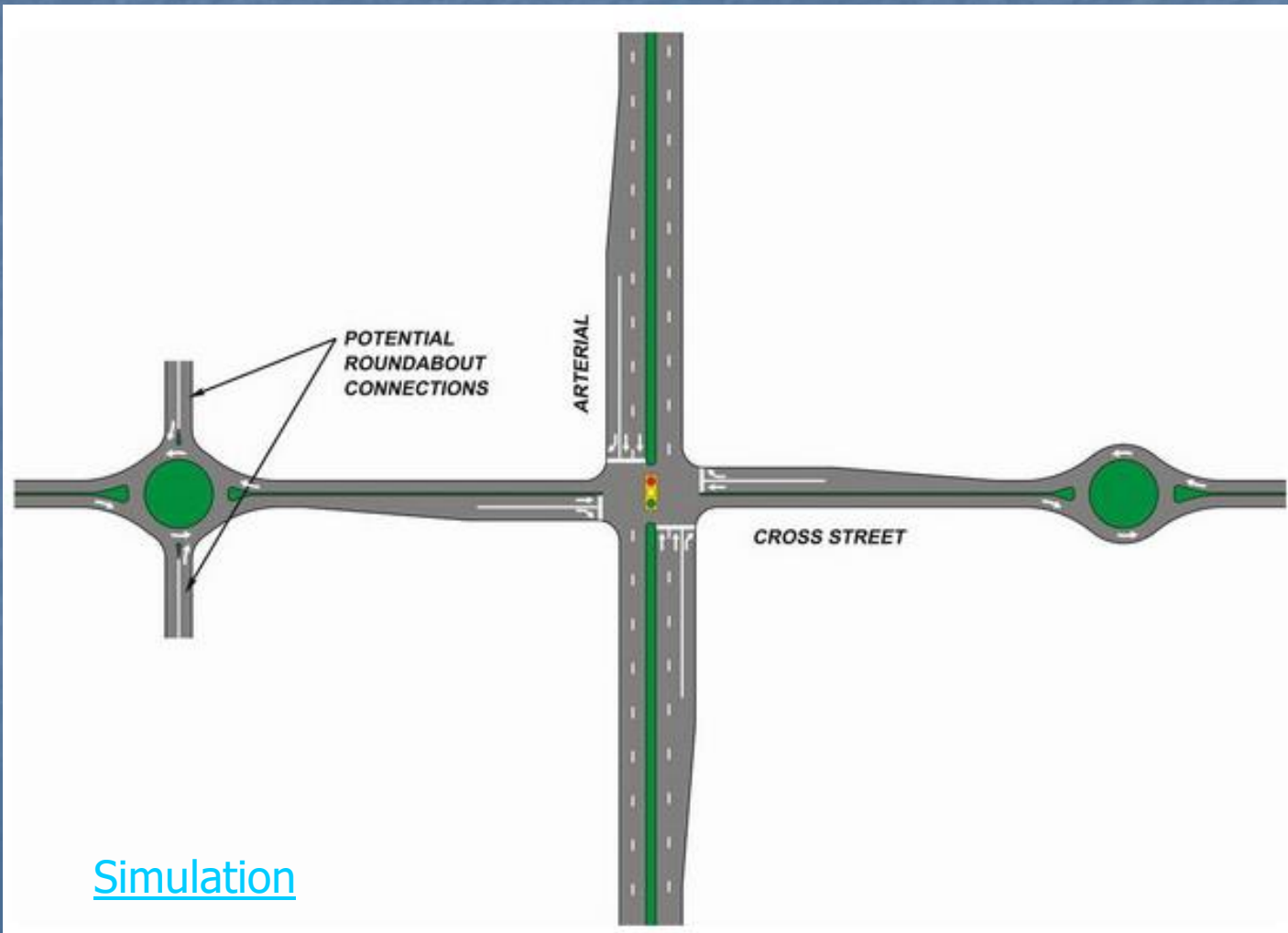


Bowtie Intersection



Design was inspired by the "teardrop" interchange

Bowtie Intersection



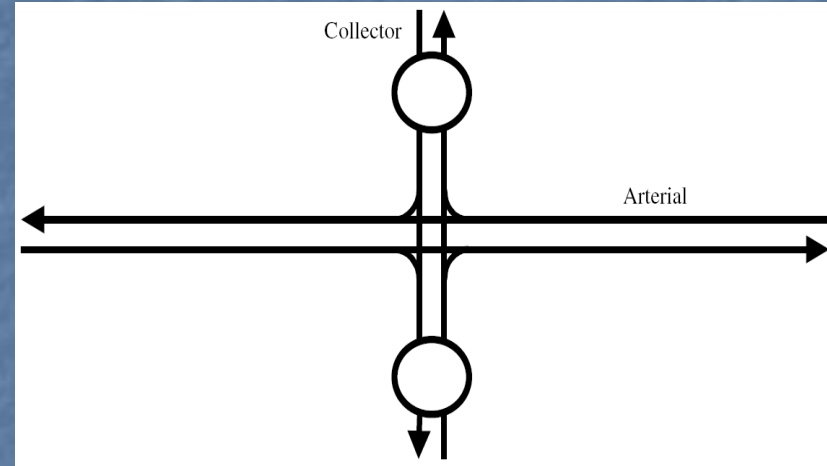
Bowtie Intersection

Advantages

- Reduced delay for through arterial traffic
- Increased capacity at the main intersection
- Easier progression for through arterial traffic
- Fewer threats to crossing pedestrians at main intersection
- Fewer and more separated conflict points

Disadvantages

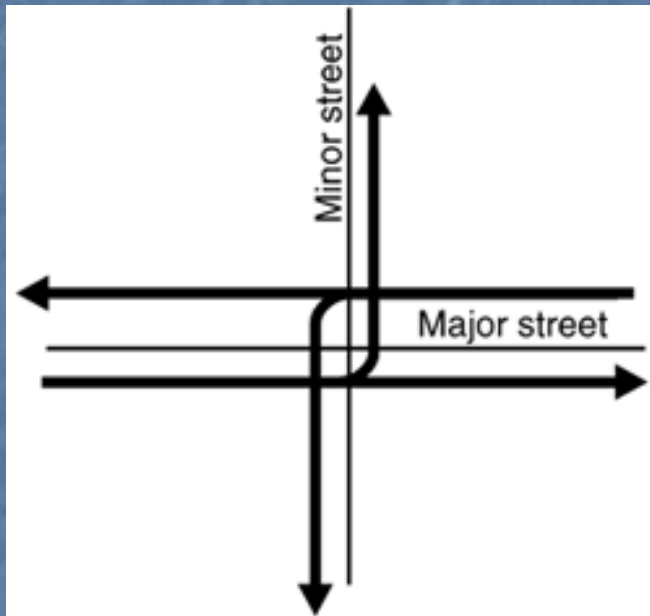
- Driver confusion
- Driver disregard for prohibited left-turn at main intersection
- Increased delay for left-turning traffic and possibly cross street through traffic
- Increased travel distances for left-turning traffic
- Increased stops for left-turning and cross street through traffic
- Additional right-of-way requirements for roundabouts
- Difficult arterial U-turns



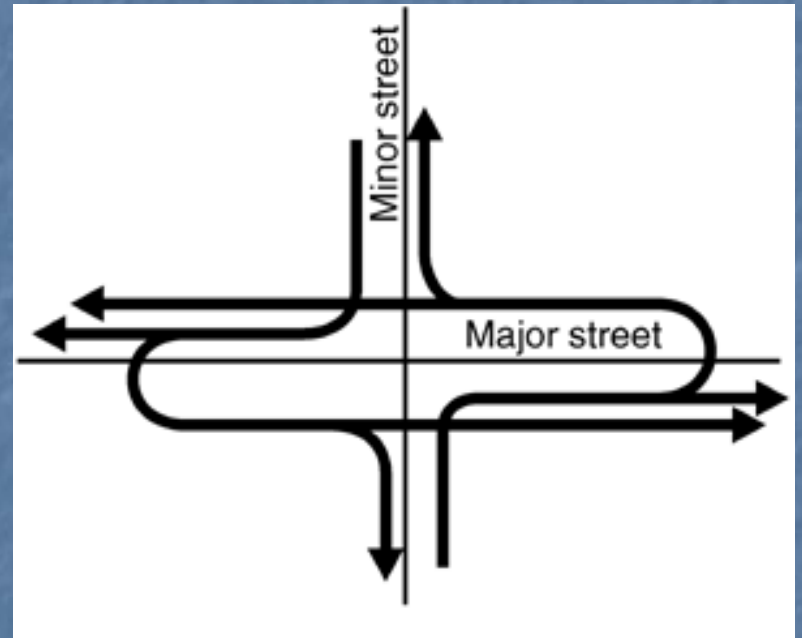
Bowtie Intersection

- When to Consider Implementation:
 - When high arterial through traffic suffers due to moderate to low left turning and cross street traffic
 - When right-of-way along arterial is not available
 - NOT a good choice if left-turn or cross street through volumes are high (increased delay)
 - NOT a good choice when the additional necessary ROW for the roundabouts is not easily available

Superstreet Intersection

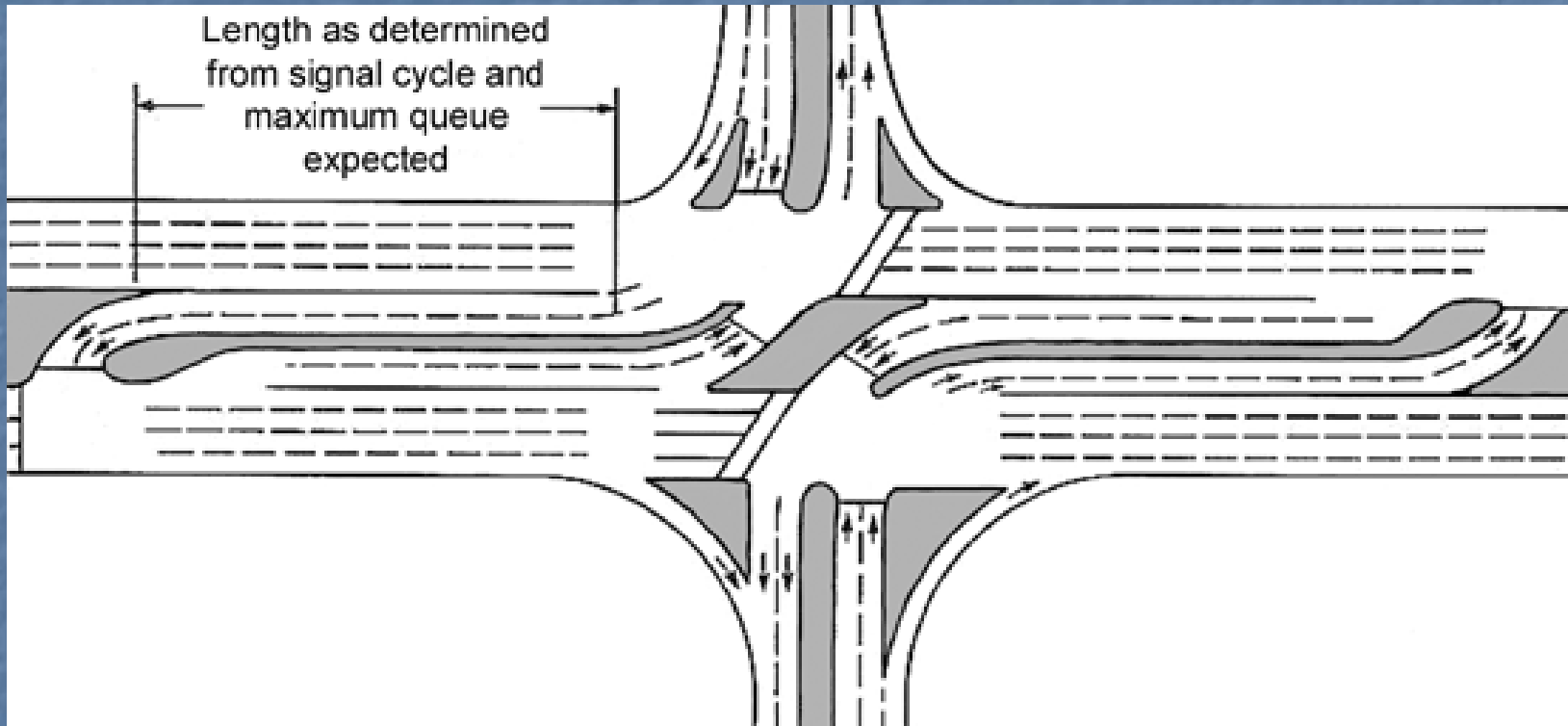


Major Street Movements



Minor Street Movements

Superstreet Intersection



Superstreet Intersection Illustration

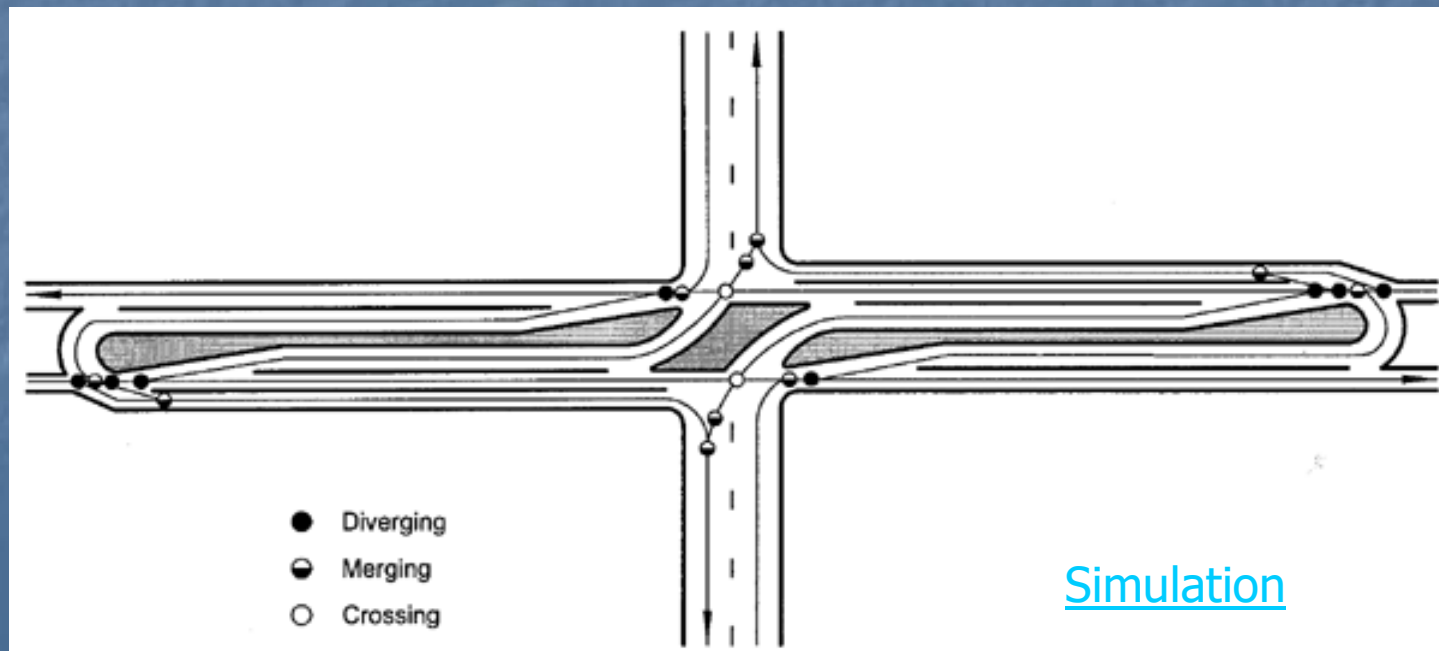
Source: FHWA

Superstreet Intersection



Superstreet Intersection

Conflict type	Four-Leg Signalized Intersection	Super-Street Median Crossover
Merging/diverging	16	18
Crossing (left turn)	12	2
Crossing (angle)	4	0
Total	32	20



Superstreet Intersection

Summary of Issues Regarding Superstreet Intersection

Characteristic	Potential benefits	Potential Liabilities
Safety	Fewer conflict points.	None identified.
Operations	Improved delay for major street movements.	Longer travel distance and time for minor street movements.
Multimodal	None identified.	Two-stage pedestrian crossing. Potential way-finding challenges.
Physical	None identified.	Wide median needed.
Socioeconomic	None identified.	May result in restrictions to access.
Enforcement, Education, and maintenance	None identified.	Potential for driver and pedestrian confusion.

Source: FHWA

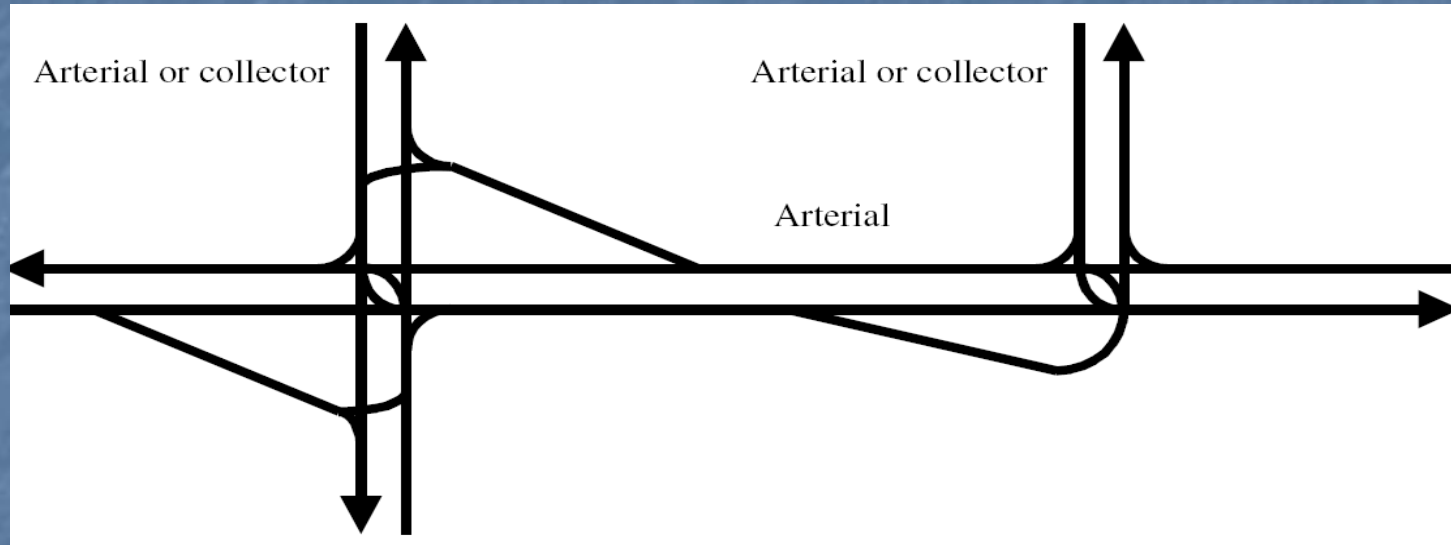
Superstreet Intersection

- When to Consider Implementation:
 - When high arterial through traffic suffers due to moderate to low cross street traffic
 - NOT a good choice when the additional necessary ROW is not easily available

Superstreet Intersection



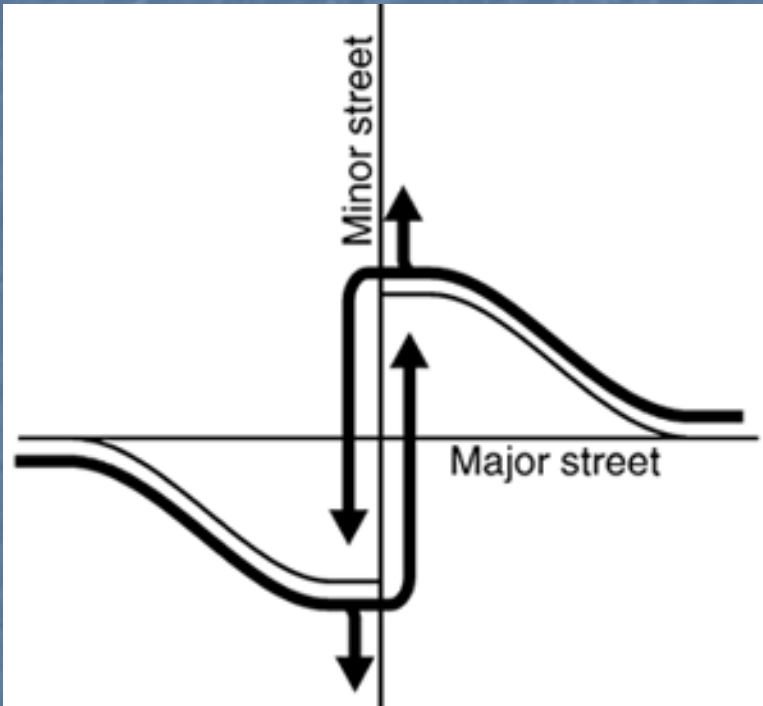
Jughandle Intersection



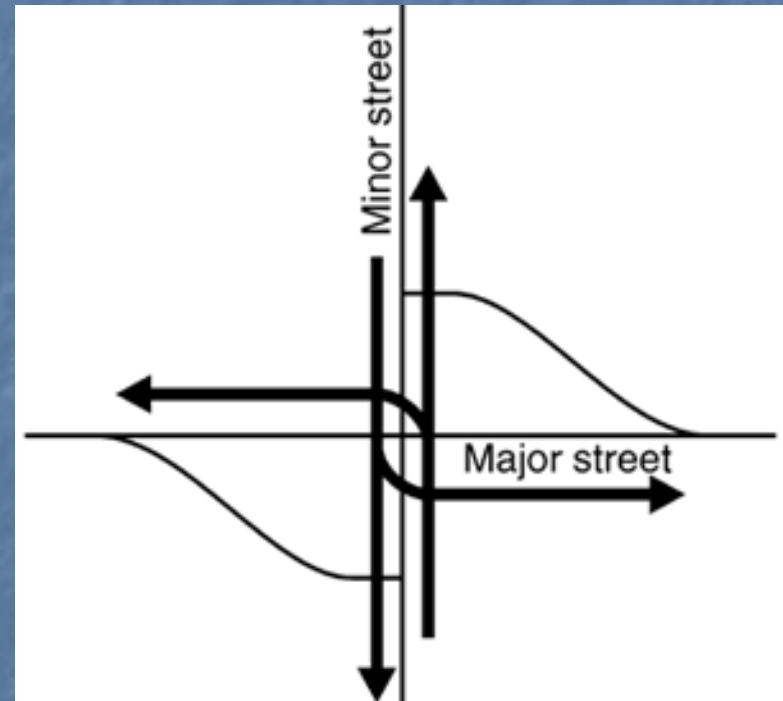
"The New Jersey Department of Transportation has used jughandles for years on hundreds of miles of heavy-volume arterial and continues to build new jughandle intersections." (Hummer, pg. 11)

NJDOT - A jughandle is "an at-grade ramp provided at or between intersections to permit the motorist to make indirect left turns and/or U-turns."

Jughandle Intersection

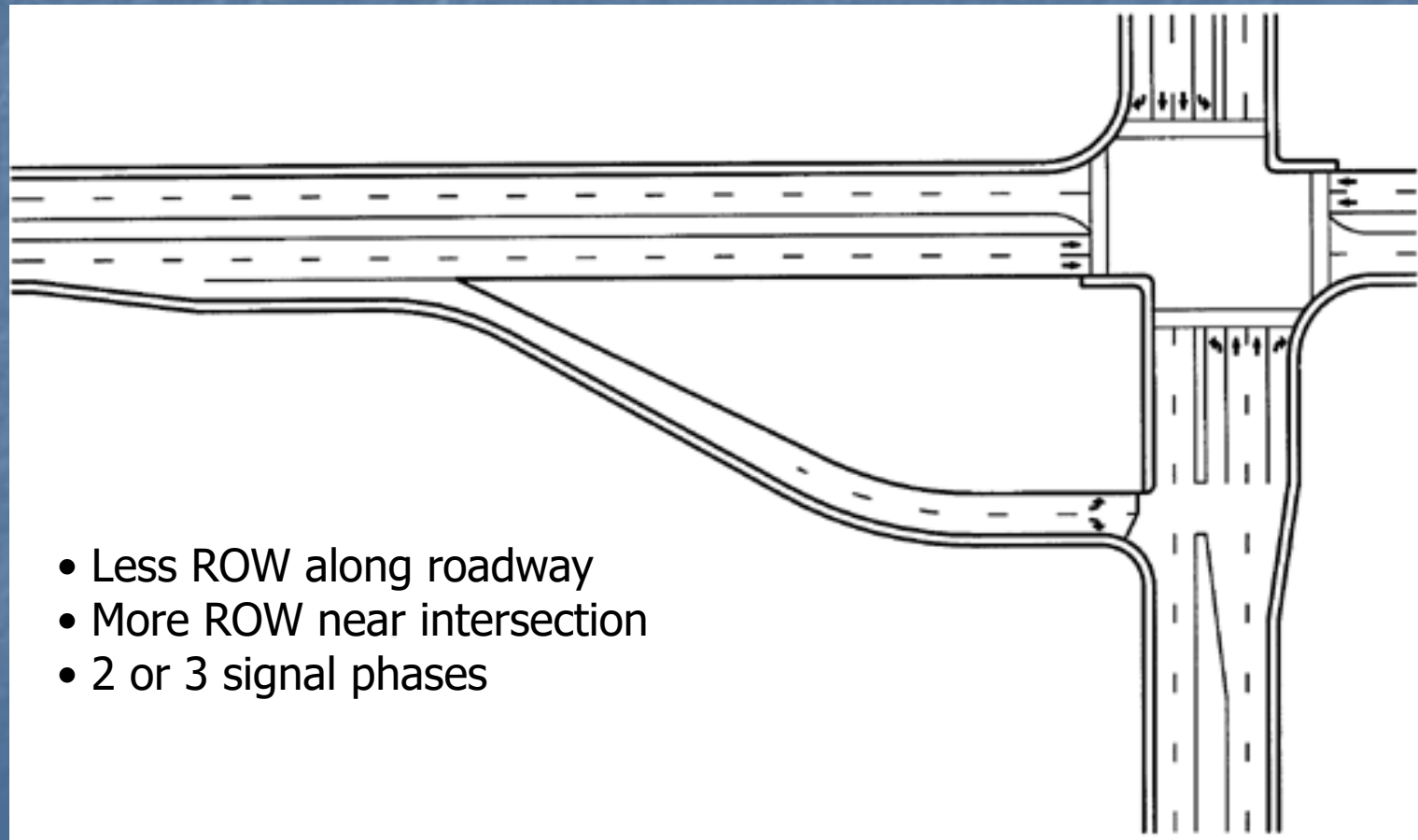


Major Street Movements

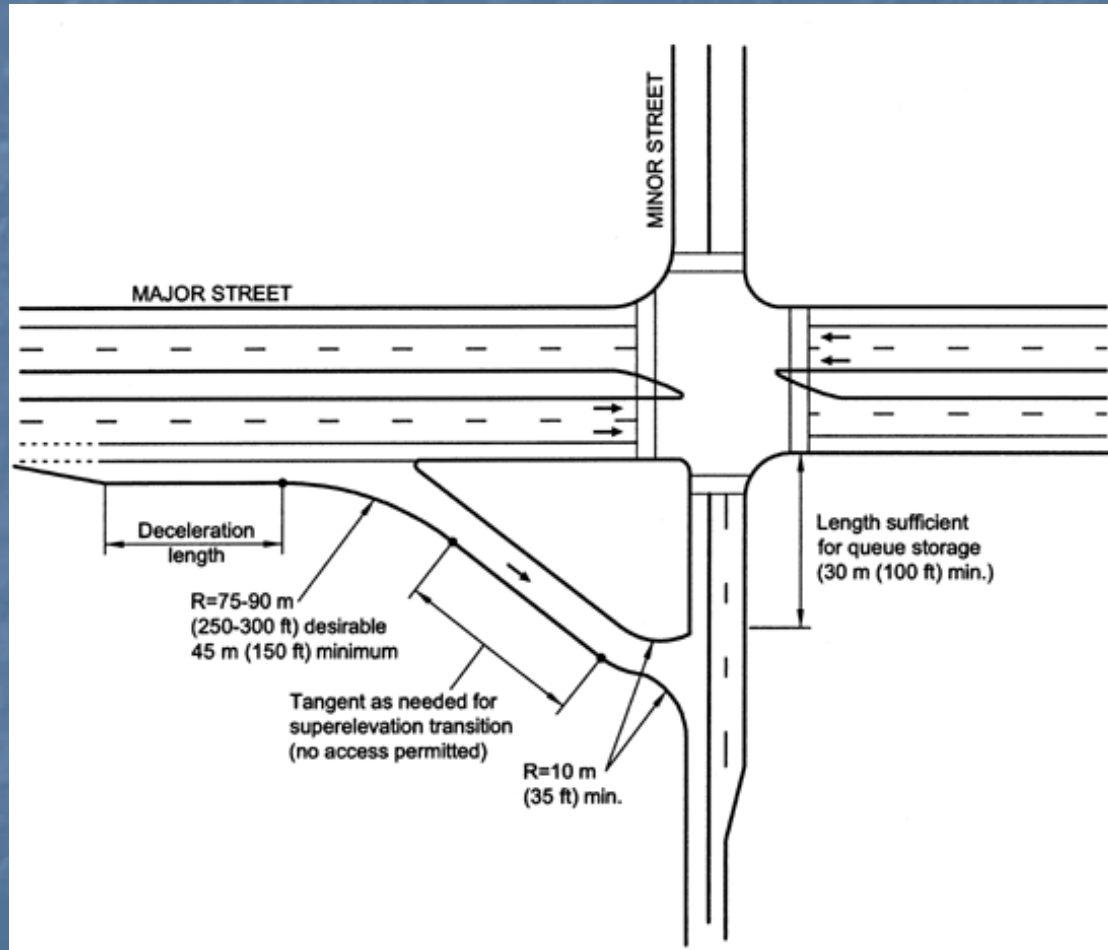


Minor Street Movements

Jughandle Intersection



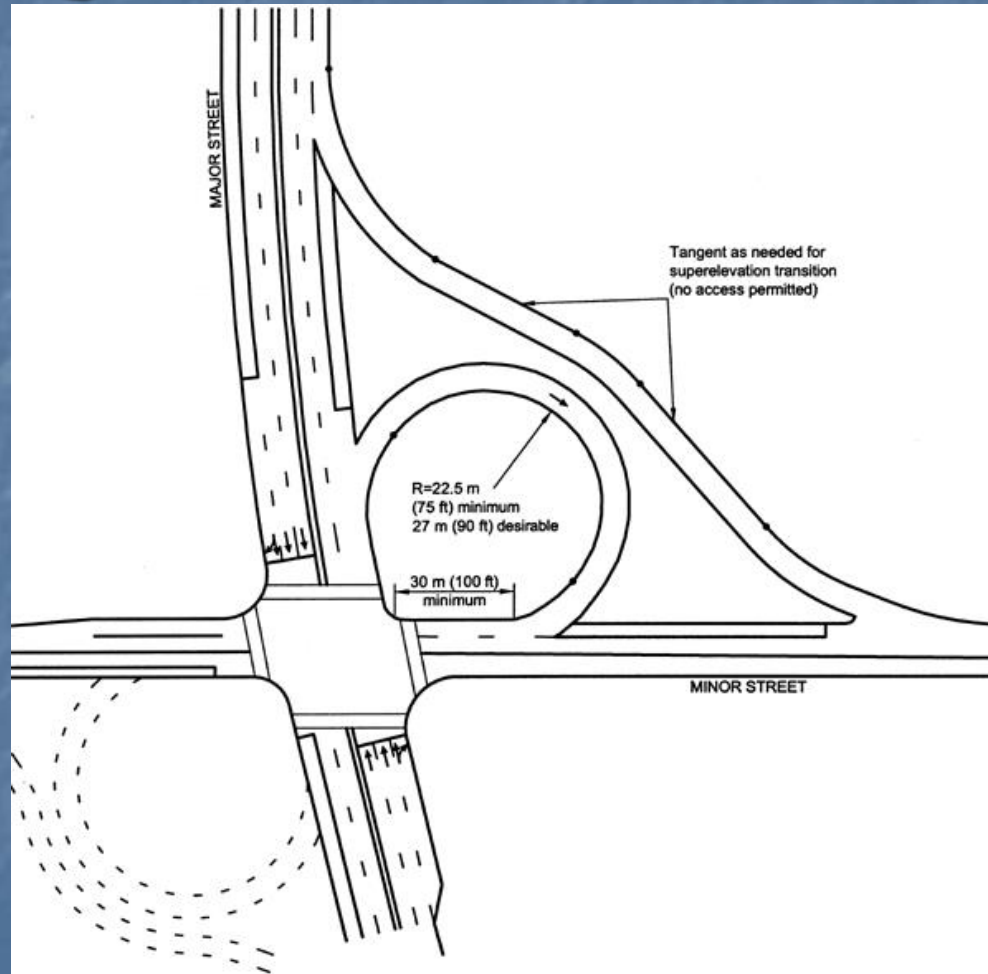
Jughandle Intersection



Design Layout of Near-side Jughandle

Source: FHWA

Jughandle Intersection

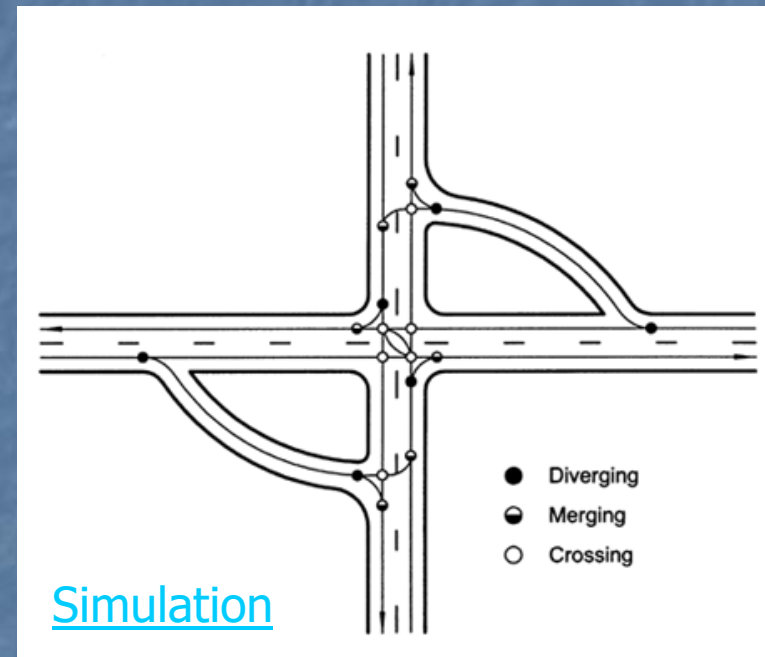


Design Layout of Far-side Jughandle

Source: FHWA

Jughandle Intersection

Conflict type	Four-Leg Signalized Intersection	Four-Leg Signalized Intersection with Two Jughandles
Merging/diverging	16	16
Crossing (left turn)	12	6
Crossing (angle)	4	4
Total	32	26



Jughandle Intersection

Summary of Issues Regarding Jughandle Intersection

Characteristic	Potential benefits	Potential Liabilities
Safety	Potential reduction in left-turn collisions.	None identified.
Operations	Potential reduction in overall travel time and stops.	Longer travel time and more stops for left-turning vehicles using the <u>jughandle</u> .
Multimodal	Pedestrian crossing distance may be less due to lack of left-turn lanes on the major street. Pedestrian delay may be reduced due to potentially shorter cycle lengths.	Increased exposure for pedestrians crossing the ramp terminal. Ramp diverges may create higher speed conflicts between bicyclists and motor vehicles. Transit stops may need to be relocated outside the influence area of the intersection.
Physical	None identified.	Additional right-of-way may be required.
Socioeconomic	None identified.	None identified.
Enforcement, Education, and maintenance	None identified.	Education may be needed unless good visual cues are provided.

Source: FHWA

Jughandle Intersections

■ **When to Consider Implementation**

- High through volumes and moderate to low left turn volumes
- Enough space for ramps

Jughandle Intersection



Example of a Jughandle Intersection

Source: FHWA

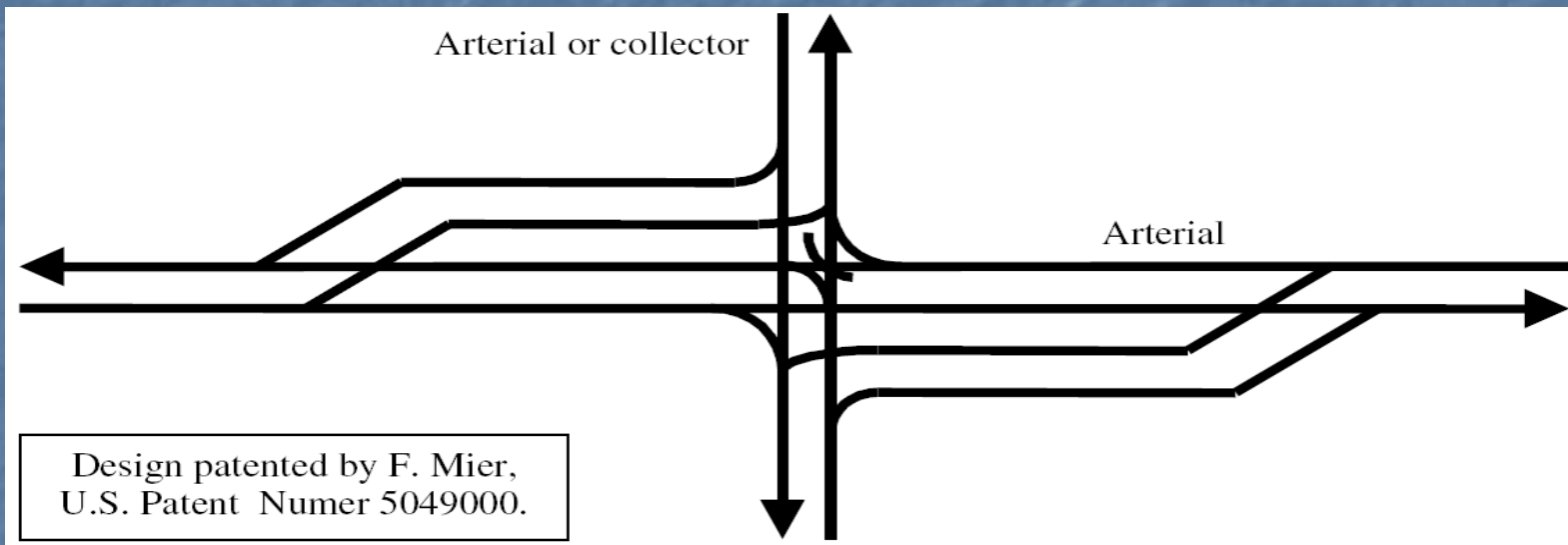
Jughandle Intersection



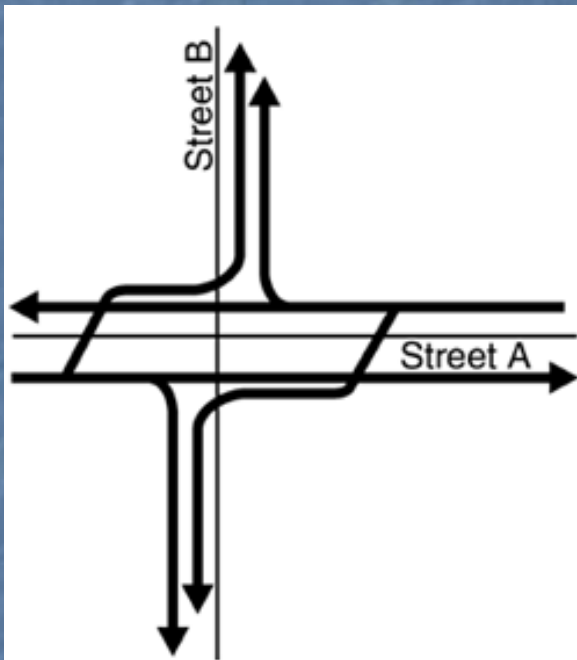
Example of a Jughandle Intersection

Source: FHWA

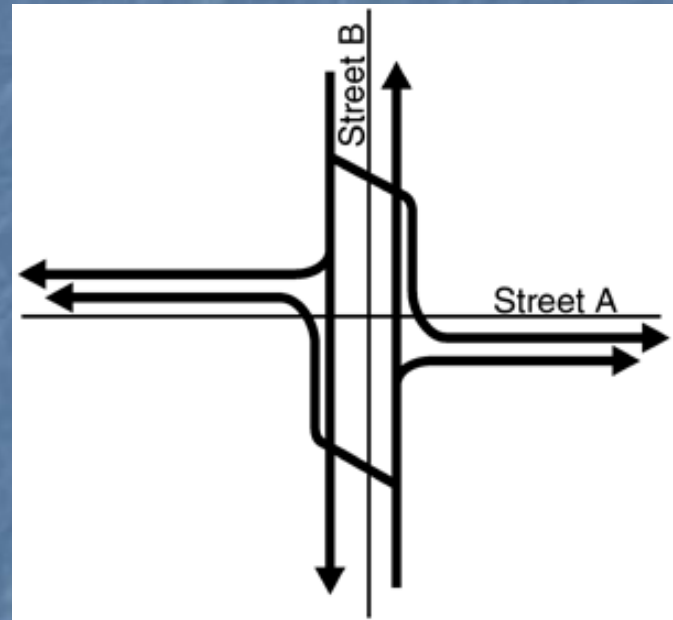
Continuous Flow Intersection



Continuous Flow Intersection



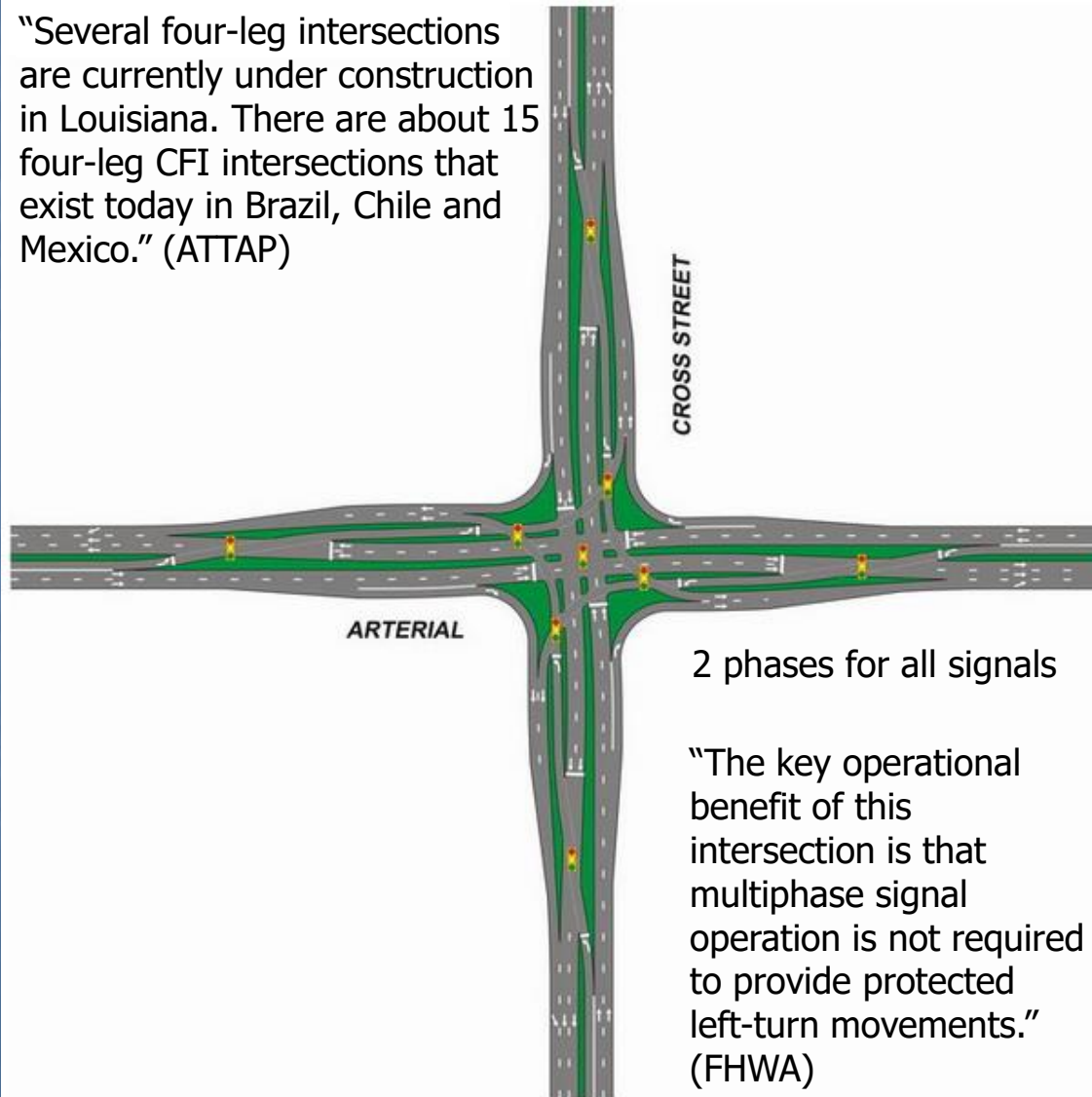
Major Street Movements



Minor Street Movements

Continuous Flow Intersection

"Several four-leg intersections are currently under construction in Louisiana. There are about 15 four-leg CFI intersections that exist today in Brazil, Chile and Mexico." (ATTAP)

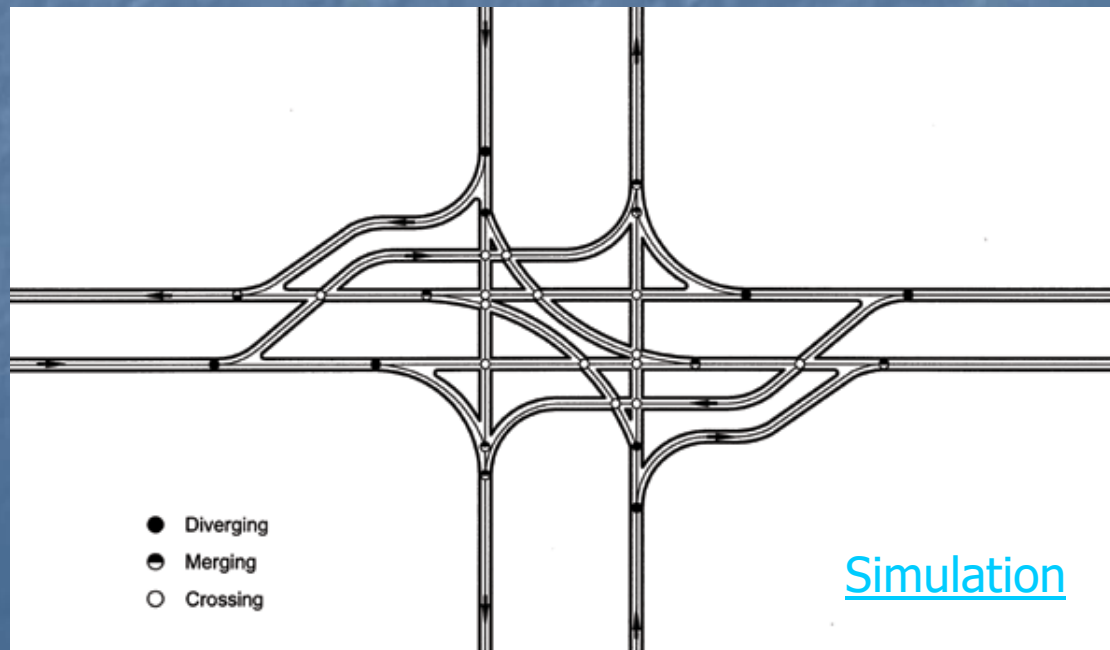


2 phases for all signals

"The key operational benefit of this intersection is that multiphase signal operation is not required to provide protected left-turn movements." (FHWA)

Continuous Flow Intersection

Conflict type	Four-Leg Signalized Intersection	Continuous Flow Intersection
Merging/diverging	16	14
Crossing (left turn)	12	6
Crossing (angle)	4	10
Total	32	30



Continuous Flow Intersections

Summary of Issues Regarding Continuous Flow Intersections

Characteristics	Potential benefits	Potential Liabilities
Safety	Left turns removed from main intersection.	None identified.
Operations	More green for through.	More stops and delay for left turns.
Multimodal	No conflicts during pedestrian crossing.	Two-stage pedestrian crossing. Layout may not be immediately apparent, especially for visually impaired pedestrians.
Physical	Smaller footprint than interchange alternative.	Right-of-way needed. Larger footprint than conventional intersection. Access management.
Socioeconomic	Air quality.	Construction cost. Access management.
Enforcement, Education, and maintenance	None identified.	Public information campaign may be needed.

Source: FHWA

Cost of patent rights

Continuous Flow Intersection

■ **When to Consider Implementation**

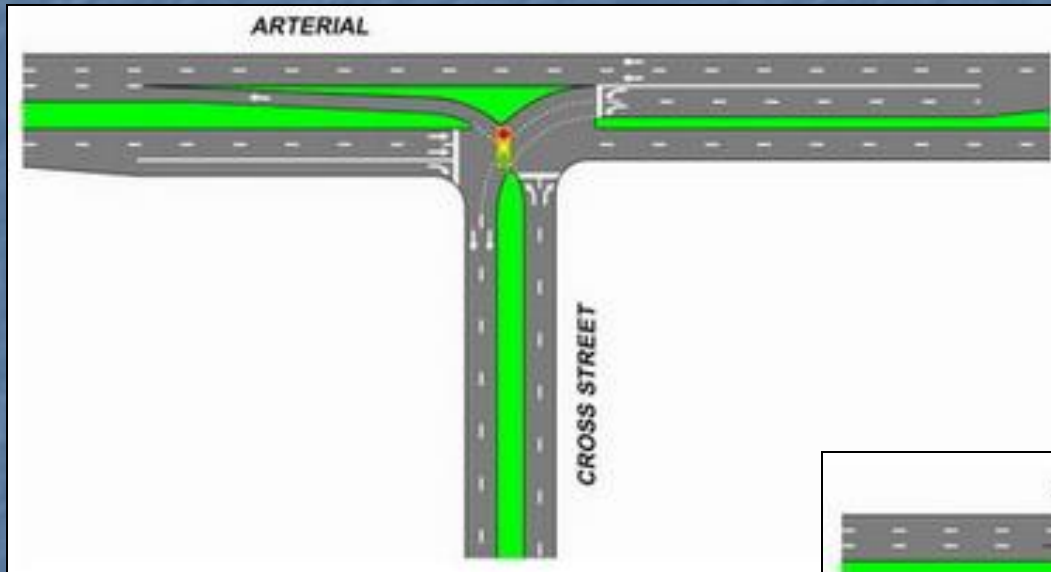
- Arterials with high through and left-turn volumes and little demand for U-turns
- Available ROW along arterial near intersection
- Ability to restrict arterial access for parcels near the intersection

Continuous Flow Intersection

Somewhere in Mexico

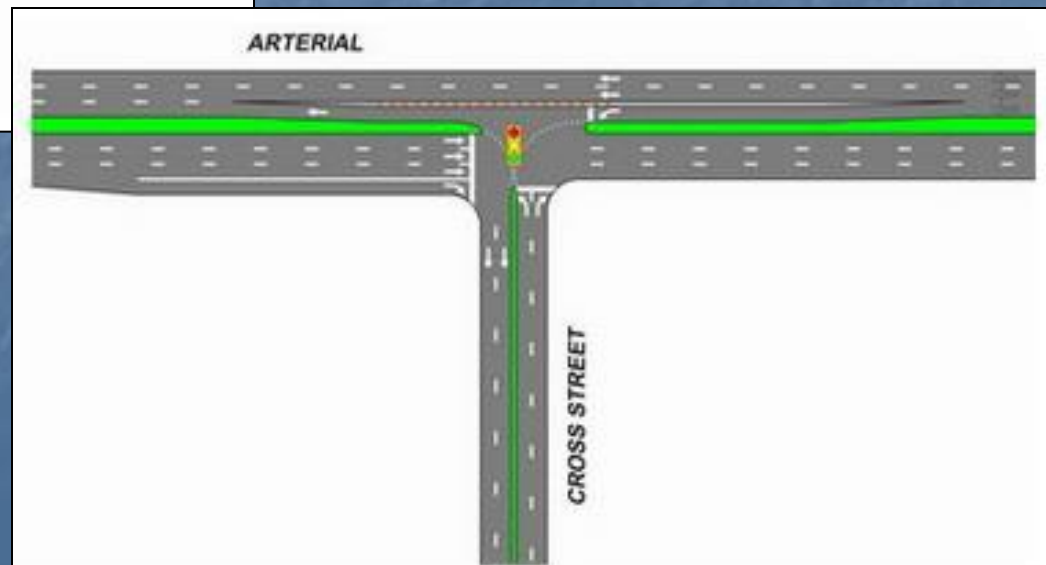


Continuous Green T-Intersection



- Continuous green in only 1 direction
- 3 signal phases
- Implemented in FL mostly

[Simulation](#)



Comparison Summary

Alternative	Applicable traffic volume			Extra right of way needed
	Left turns from arterial	Left turns from minor street	Minor street through	
Median U-Turn	Low-Medium	Low-Medium	Any	30' wide along arterial
Bowtie	Low-Medium	Low-Medium	Low-Medium	2 circles up to 300' diameter on minor st.
Superstreet	Any	Low-Medium	Low-Medium	30' wide along arterial
Jughandle	Low-Medium	Low-Medium	Any	Two 400' by 300' triangles at int.
Continuous Flow	Any	Any	Any	Two 40' by 300' rectangles at int.

Conclusion

- Unconventional arterial intersections, “under certain circumstances, move traffic more efficiently than conventional arterials with fewer negative impacts than widening, bypasses, or interchanges.” (A15)
- “Although there may be some level of excessive left-turn travel time that would cause many violations, the evidence suggests that with good traffic control devices, enforcement, and more than a few isolated applications, the unconventional alternatives should not cause those violations.” (B160)
- “Clear signing is a necessity for indirect left-turn designs, especially if there are not similar treatments at other intersections in an area.” (C10.2)
- “Valid collision reduction factors or collision models will have to wait until agencies build more unconventional alternatives.” (A16)

Questions?

Additional Information:

Maryland - An Applied Technology and Analysis Program (ATTAP)

<http://attap.umd.edu/UAID.php>

FHWA – Turner-Fairbank Highway Research Center (TFHRC)

<http://www.tfhrc.gov/safety/pubs/04091/10.htm>