

NORTH CAROLINA

Department of Transportation



An Update to the “Selecting Optimum Intersection or Interchange Alternative” Guidance Document

Joe Hummer, PhD, PE, State Traffic Management Engineer

For NCDOT, February 1, 2024

Acknowledgements

- Congestion Management Section approved and posted the document
- Co-authors of the interchange directory were NCDOT interns Hayden Edwards and Breyer Roberts
- Thanks to NCDOT management for giving us the space and time to create

The Guidance Document

- Originally intended as a chapter of the Roadway Design Manual
 - But then got too big and too different
- Approved by Congestion Management
- First posted 2022
- 2024 edition just posted
 - https://connect.ncdot.gov/resources/safety/TEPPL/TEPPL%20All%20Documents%20Library/C62_Guidance.pdf

The Guidance Document

Help for project teams and consultants

- Need for alternatives
- Basic principles
- Tools to aid in the selection of an alternative
 - Safest feasible intersection charts
- Intersection alternatives
 - Grade separated intersections
- Interchange alternatives
- References

2024 Edition

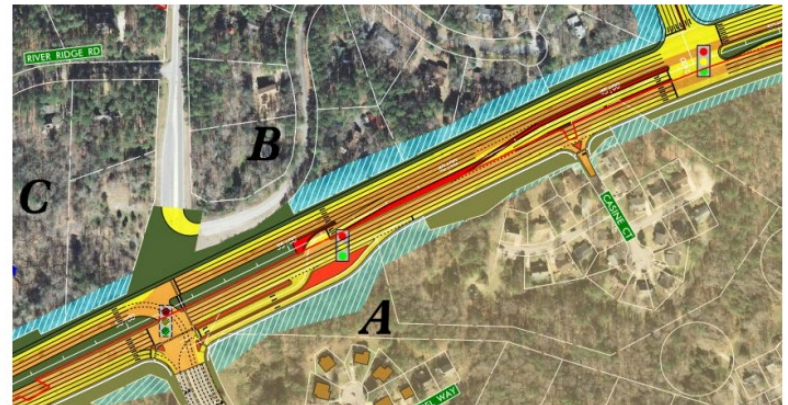
- Added about 20 pages
- New research published
- New designs opened
- Filled previous gaps

Selecting Optimum Intersection or Interchange Alternatives

Guidance for the staff and consultants of the
Congestion Management Section
Mobility and Safety Division
North Carolina Department of Transportation

By Joseph E. Hummer, PhD, PE
State Traffic Management Engineer

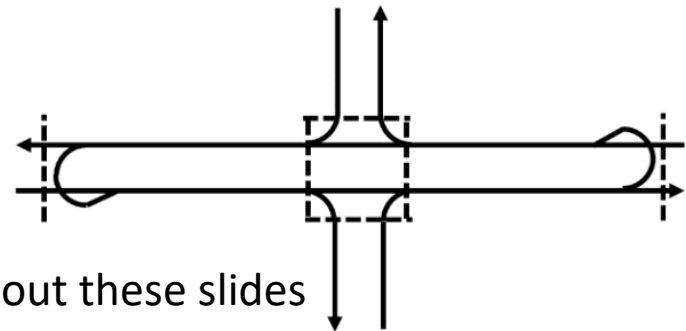
Updated **January 2024**



New Material on Intersections

Indirect Left and Cross (ILAC)

- An RCI without the left turn crossovers
 - US-15/501 at Erwin Road in Chapel Hill
- Promising for low-demand sites
- Can push the u-turn crossovers toward the main intersection
- New crash modification factor (CMF)
 - From Michigan
 - 0.69 for injury crashes



Dashed lines are walkways in sketches throughout these slides

Three-Legged Intersection

- Three-legged int. has nine conflict points while four-legged has 32
 - Should be much safer
 - Contrast with planning literature
- We have CMFs for continuous green T (0.96) and three-legged continuous flow int. (CFI, 0.86)
- Do not have CMFs for other popular three-legged int. concepts

Peanut and Oval Roundabouts

- Could help at 5-leg or 6-leg junctions
- Could help at int. with small offset
- We do not have a CMF
 - Research to begin soon
- Do you prefer oval or peanut?



Turbo Roundabout

- A version of a 2x1 roundabout with:
 - Separators between the lanes in the circle
 - Radial (90-degree) entry into the circle
 - Many more traffic control devices
- Used mostly in Europe
 - Two open in US

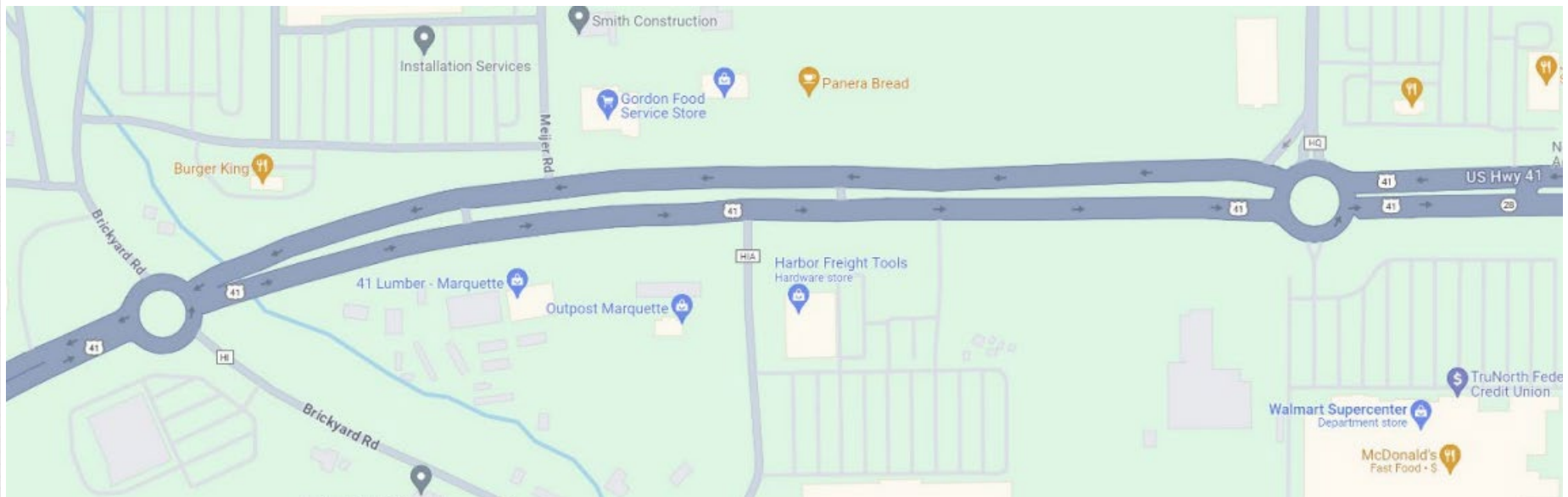


Turbo Roundabout

- May be safer than standard
 - We do not have a high-quality CMF
- May have higher capacity than standard
 - No US capacity data yet
- Likely costs more than standard
 - Larger radius so trucks stay in lane
- Change the name?

Roundabout Corridor

- Roundabouts at major intersections
- RIRO or RCI between major intersections
 - Roundabouts handle the u-turn demand



Roundabout Corridor

- Likely to be very safe
 - Minimize conflict points, control speeds, great pedestrian crossings
- In the right place, likely to reduce travel time
 - Need good roundabout spacing
- Cost and impacts likely lower than conventional
 - Need ROW for roundabouts, but corridor can be narrow

Offset RCI

- Usual “Z” crossing perceived to be unfriendly to pedestrians
- Instead, create a short 90-degree crosswalk by offsetting the two minor street legs
 - Motorists will never notice the extra 50 feet of driving distance



Parallel Flow Intersection

- Patented design published in 2007
- Variation of CFI
- Secondary intersections have full signals
- Advantage is left turns occur at usual place



Thru-Cut

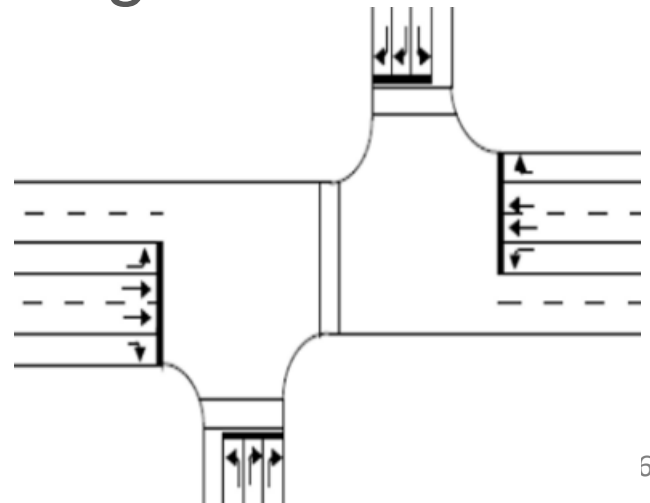
- Now three open in NC
 - Many more coming soon
- Redirects minor street through movements
 - Often do not need u-turn crossovers
- Great for capacity and progression



Thru-Cut

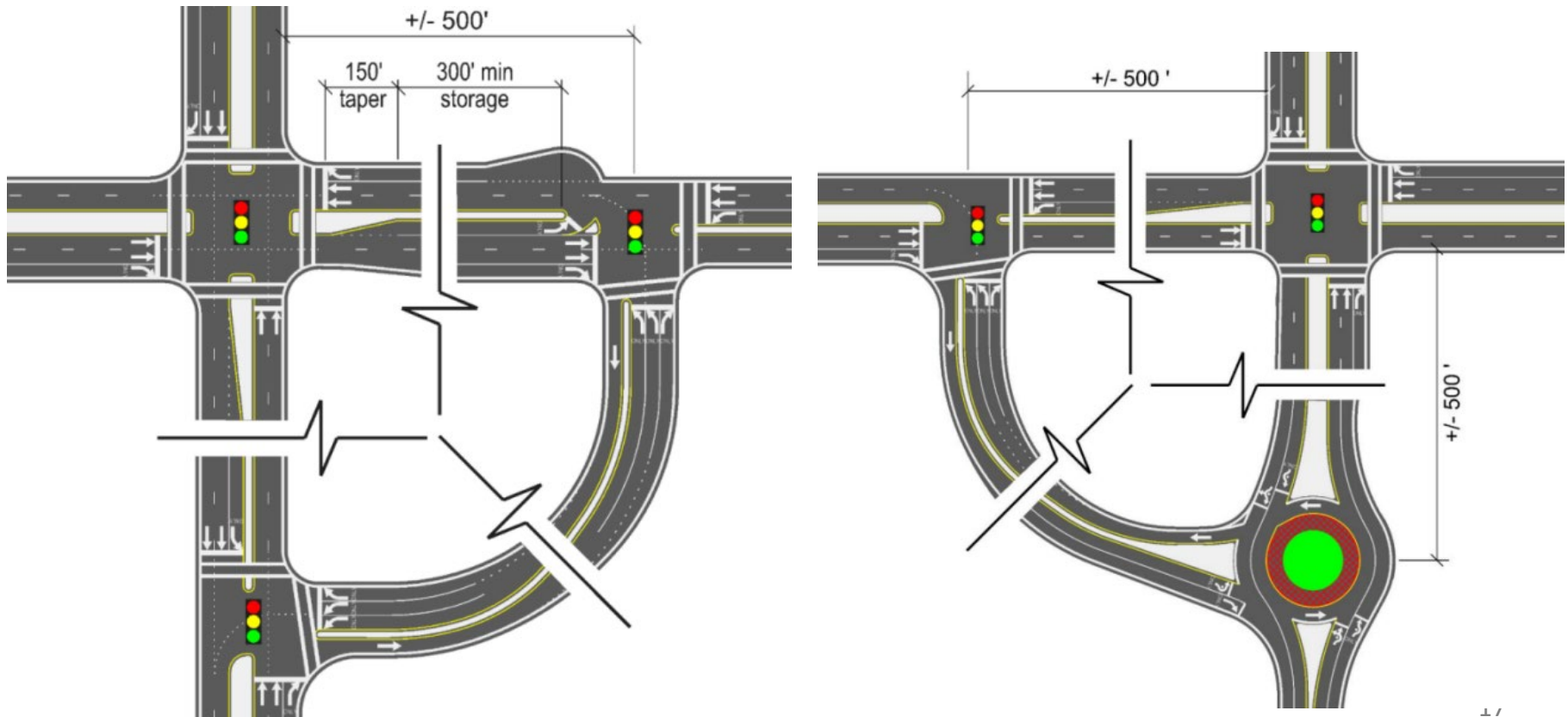
- New crash data from Holly Springs shows terrific safety performance
 - Over 60 percent crash reduction
- Not great for crossing pedestrian
 - Diagonal or two-stage crossing

Offset thru-cut could help pedestrian crossing



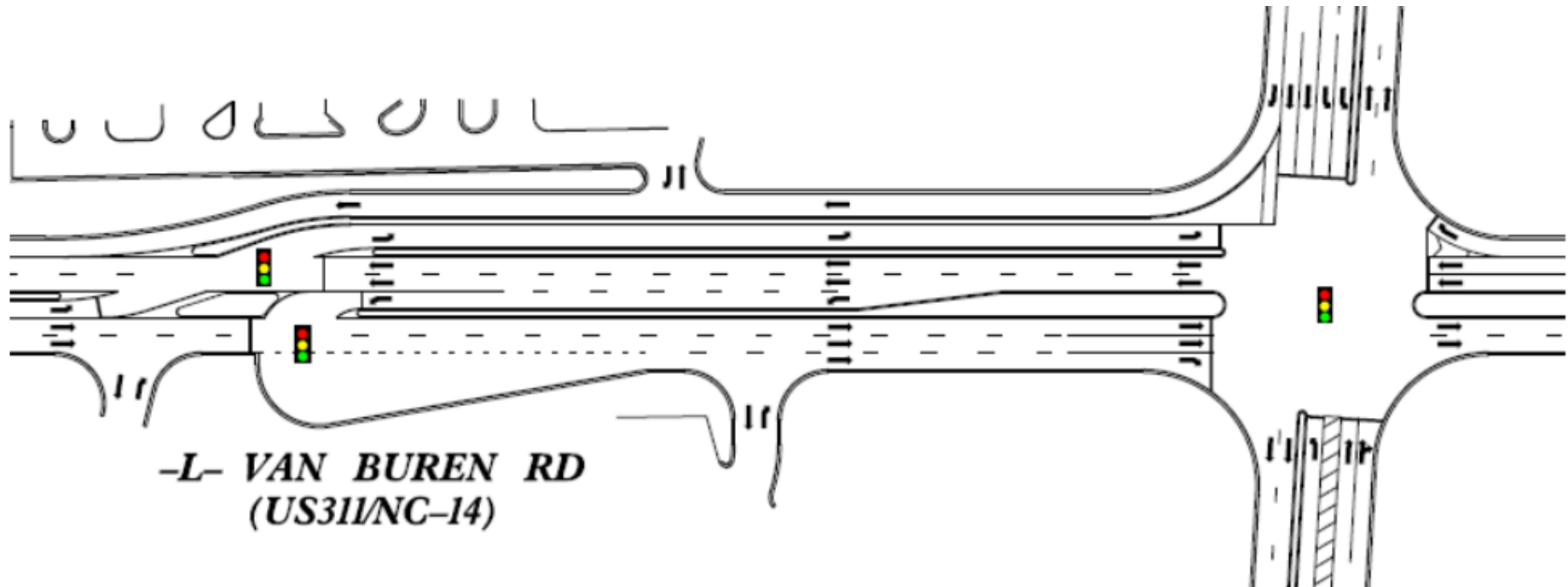
Partial and Hybrid Designs

- Some of these use roundabouts or u-turns



Partial and Hybrid Designs

- Two of these CFI and MUT combinations are moving ahead in NCDOT projects



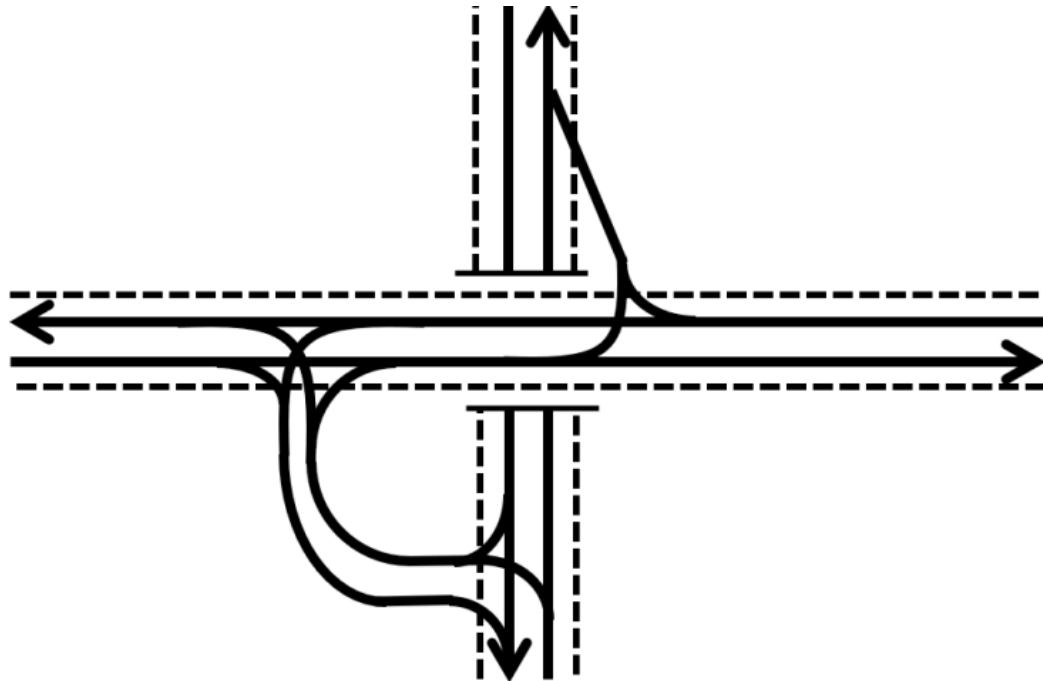
Dual Left Turn Lanes

- A popular option but..
- Will drivers use the second lane?
 - Use simple equations from NCHRP 707 to estimate lane usage
- Are they safe?
 - New CMF from Safety Unit shows CMF of 1.00 for total crashes and 0.98 for injury crashes

Grade-Separated Intersections

Non-Symmetric Designs

- Keep in mind that in these spots neither road is a freeway so teams can use signals
 - Control speeds, eliminate weaving, and reduce ROW



Interchanges

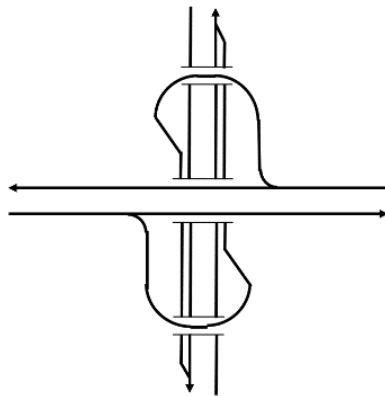
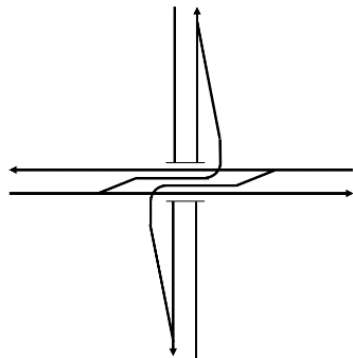
Large Menu of Service Intchgs.

- Service interchanges are important
- Happily we get to do many improvement projects
- Most project teams choose one of only a handful of concepts
- But there are dozens of other rare and published designs
 - Plus many promising new designs

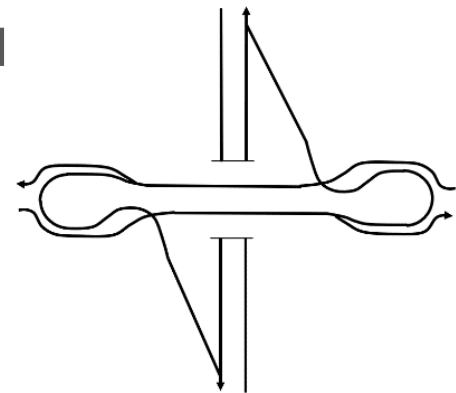
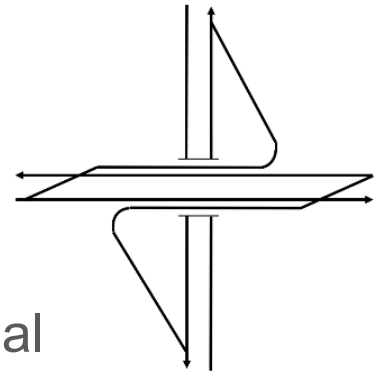
Finding New Designs

- 14 ways to make a left turn from the arterial to the freeway

- Single point
- Tight diamond
- Standard diamond
- Spread diamond
- Tight contraflow
- Standard contraflow
- Spread contraflow



- Displaced
- Loops
- U-turn on arterial
- U-turn over freeway
- U-turn over fwy with slip ramps
- Saint Augustine
- Split diamond



Tight = 200' spacing,
Standard = 600',
Spread = 1200'

Finding New Designs

- 13 ways to make a left turn from the freeway to the arterial
 - All of the above except split diamond
- Created 14x13 matrix
- Sketched all cells
- Eliminated the unrealistic ones
- Result was 8 common concepts, 18 rare or published concepts, and 44 new concepts with potential

Finding New Designs

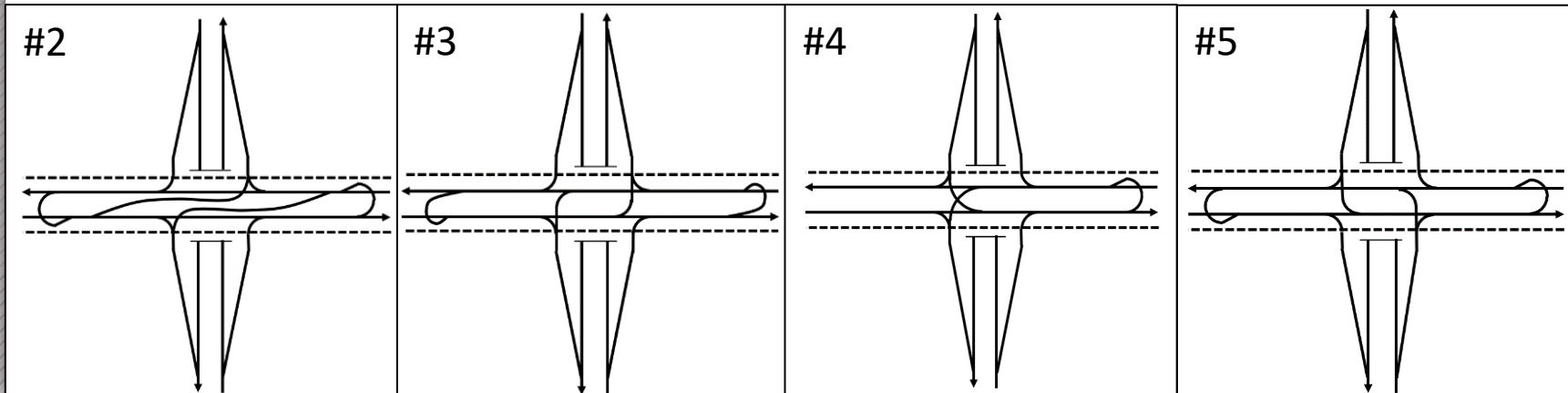
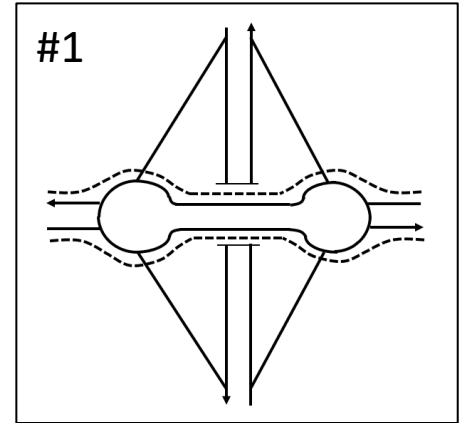
- Add in some non-symmetric (i.e., one-loop), some three-level, some roundabout, and some DDI concepts
- Current menu has 108 concepts
- Let me know if you know of more ways to make a left turn or more concepts
 - Intended to be a living document

Rating System

- To make sense of the large menu
- 11 categories
 - 3 travel efficiency, 4 safety, 4 cost/impact
- 0 to 5 points in each category (55 total)
 - 0 was poorest, 5 was best
 - Average 2-3
- Generic sketches, quantitative criteria
- Fair, consistent

Overall Best

1. Double roundabout
2. Synchronized
3. Tight diamond, u-turn on arterial
4. One u-turn Weaker in travel efficiency
5. U-turn on arterial, tight diamond



Overall Best

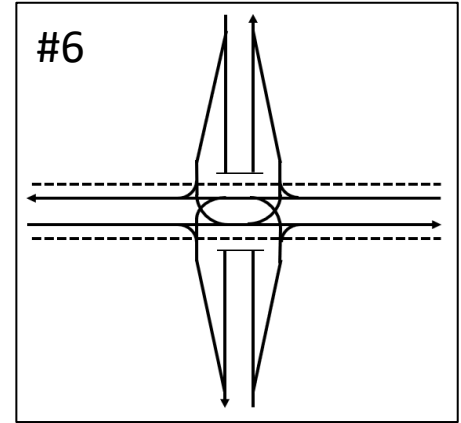
6. Tight diamond

7. Single roundabout

8. Superstreet

9. Signalized FRE

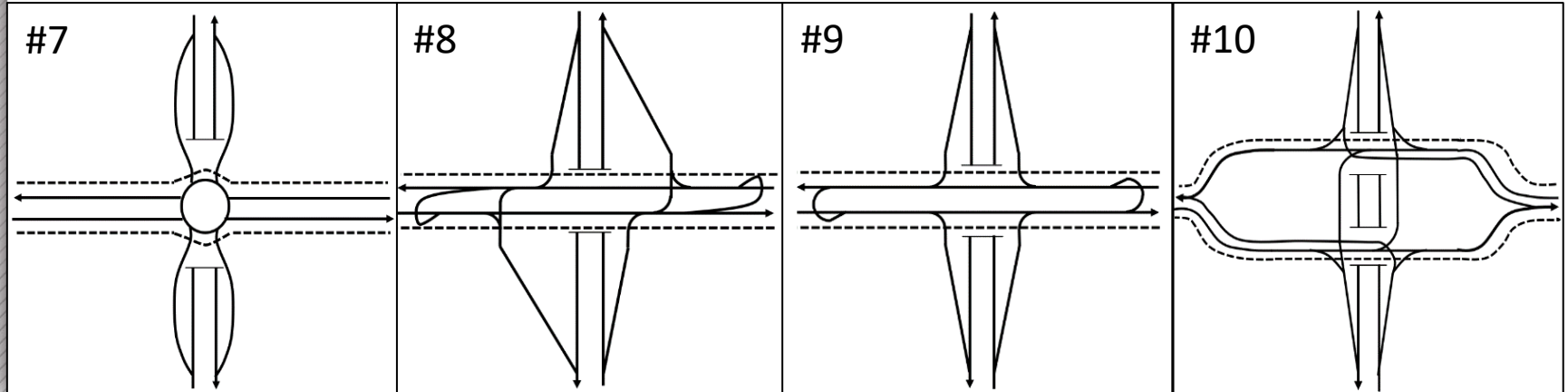
10. Split diamond, tight contraflow



Weaker in travel efficiency

More costly

Average safety scores

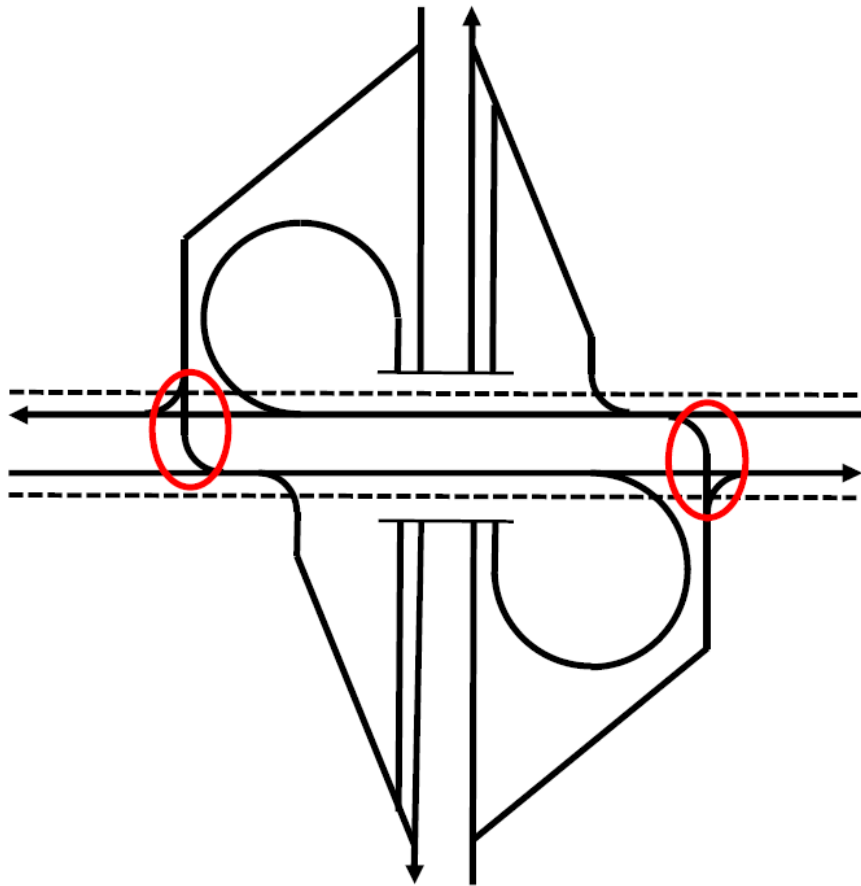


Common Concepts

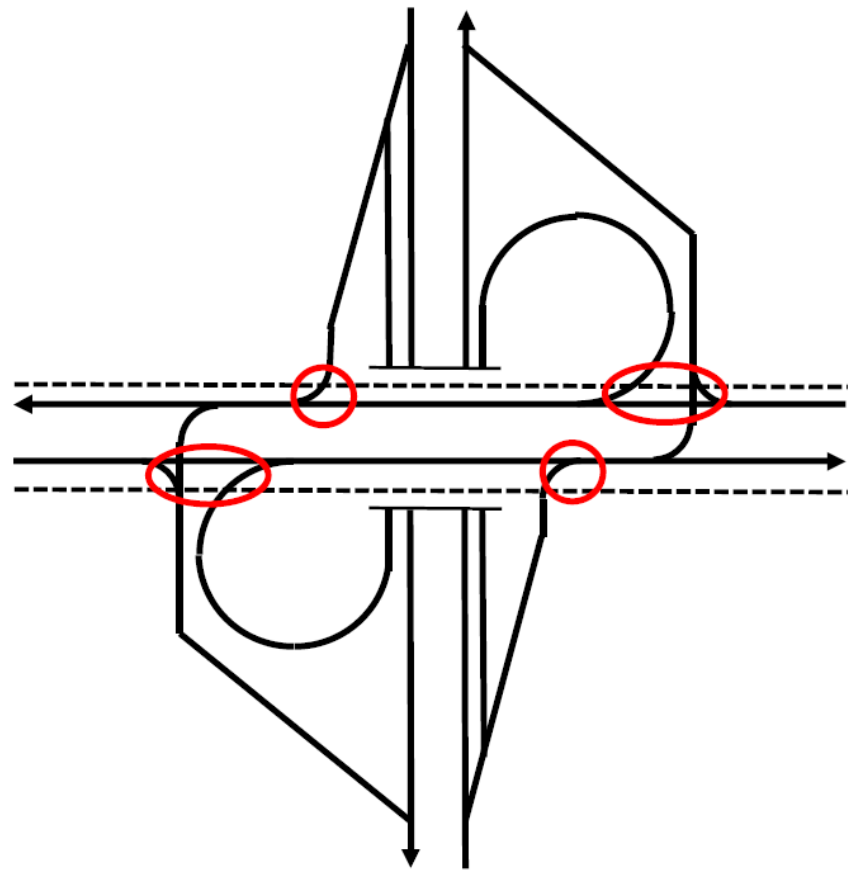
Interchange	Efficiency (of 15)	Safety (of 20)	Cost (of 20)	Total (of 55)	Rank (of 108)
Parclo B	10	15	11	36	21
Standard diamond	5	14	15	34	36
Diverging diamond	6	12*	16	34	37
Single point	11	7	15	33	47
Parclo A	6	13	11	30	77
Parclo AB	2	12	14	28	93
Spread diamond	3	14	10	27	99
Cloverleaf	9	10	6	25	105

Parclo A and Parclo B

Parclo A



Parclo B



Why Parclo B is Better Than A

Aspect	Parclo A	Parclo B
Progression	Two full signals at 1200-foot spacing = no chance for two-way progression	All signals only affect one direction = perfect two-way progression
Lane utilization	All turning traffic stacked in right lane	Left turn traffic in left lane, right turn traffic in right lane
Unusual maneuvers	Left turn traffic has to turn right	Left turn traffic stays left, right turn traffic stays right
Pedestrians	Each pedestrian must cross two free-flowing ramps	All ramp crossings are signal-controlled

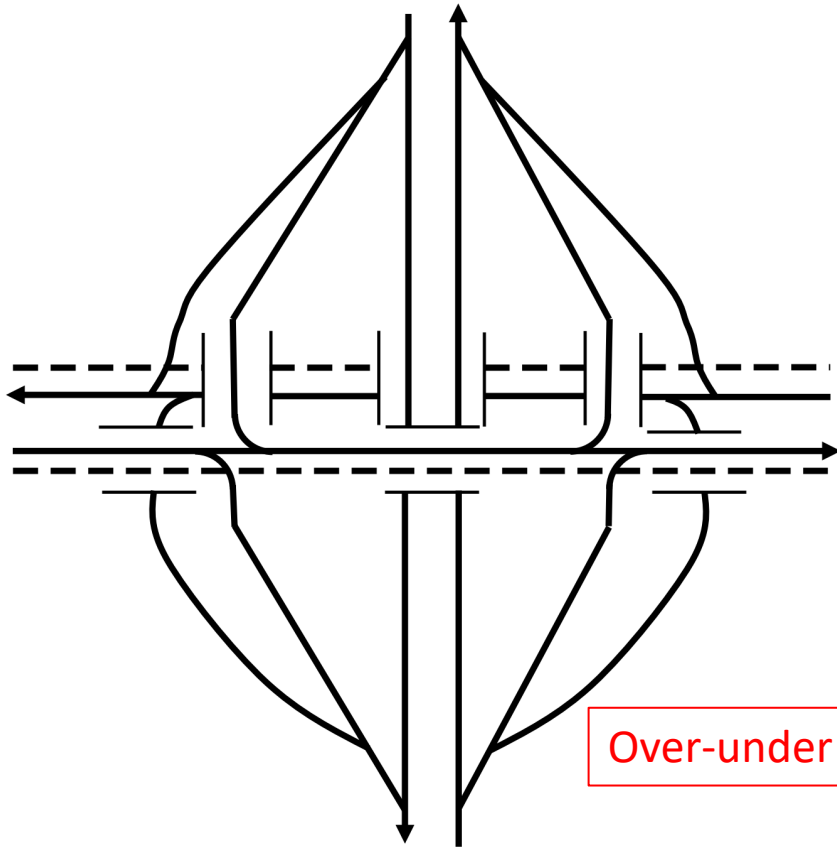
Parclo AB

- The least efficient of all 108 concepts!
 - Low capacity, poor progression, long driving distances

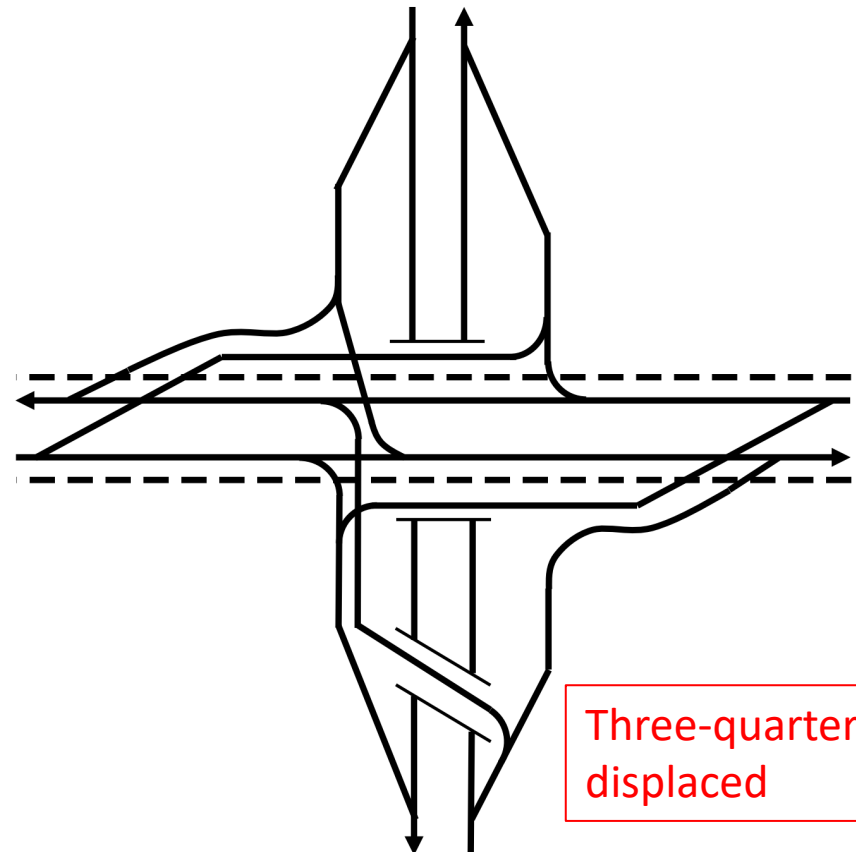


Scored Well for Travel Efficiency

Three-level concepts

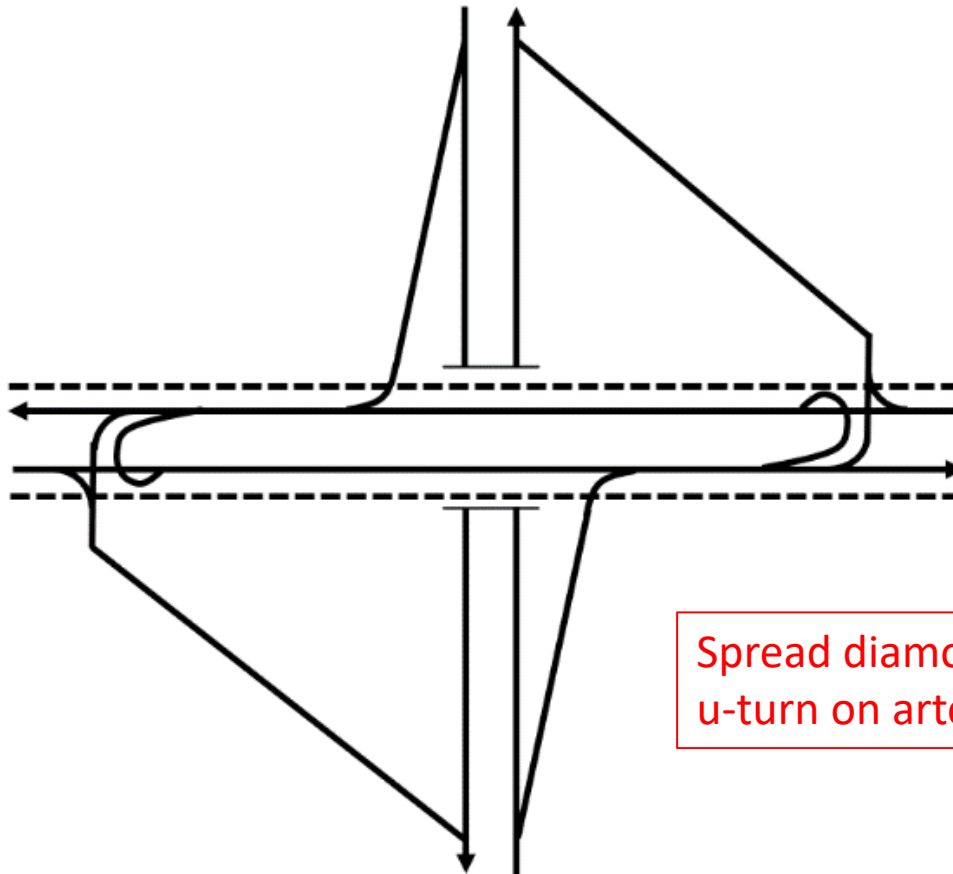


Displaced concepts



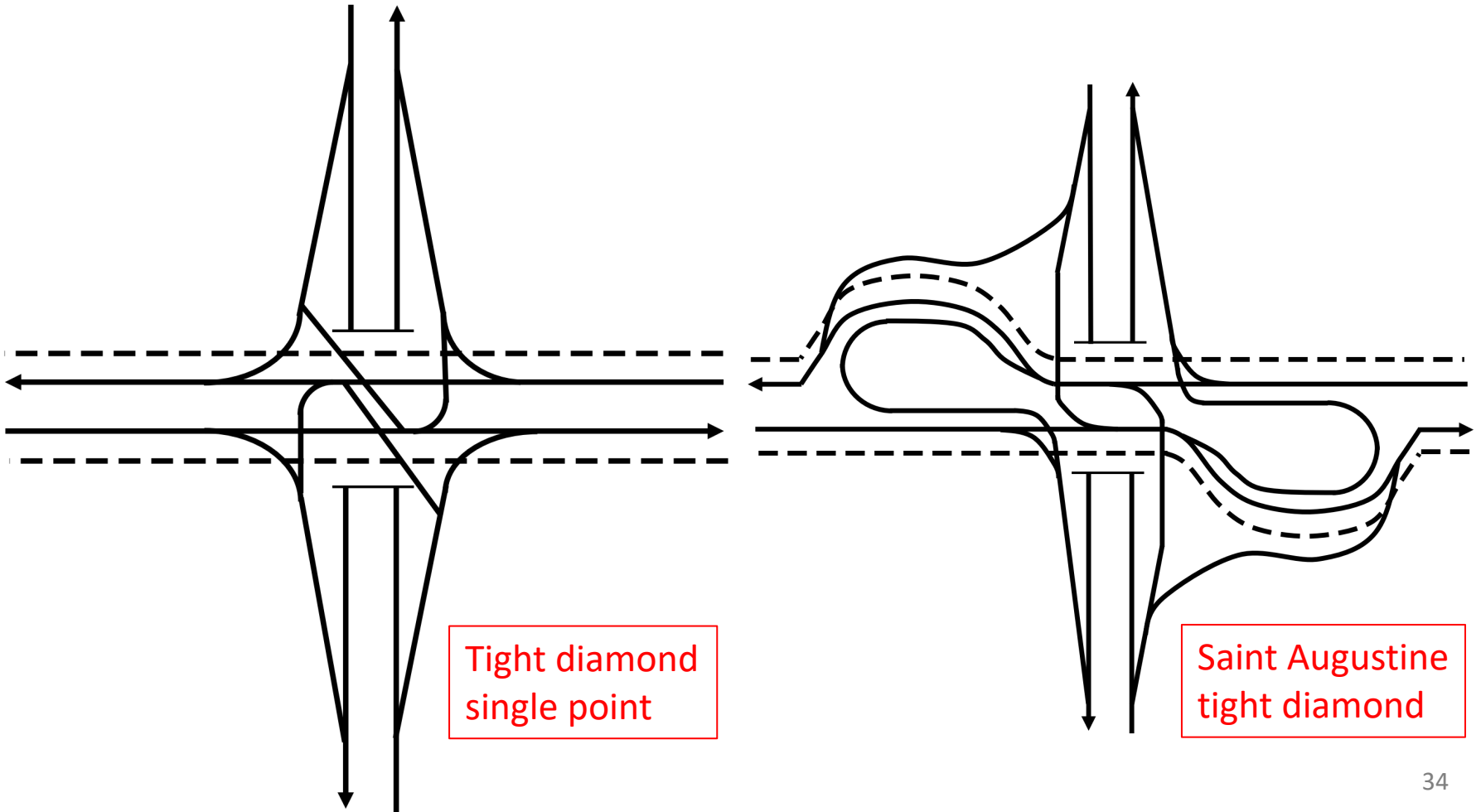
Scored Well for Safety

Concepts with U-turns on the arterial



Scored Well for Cost

Tight diamond concepts



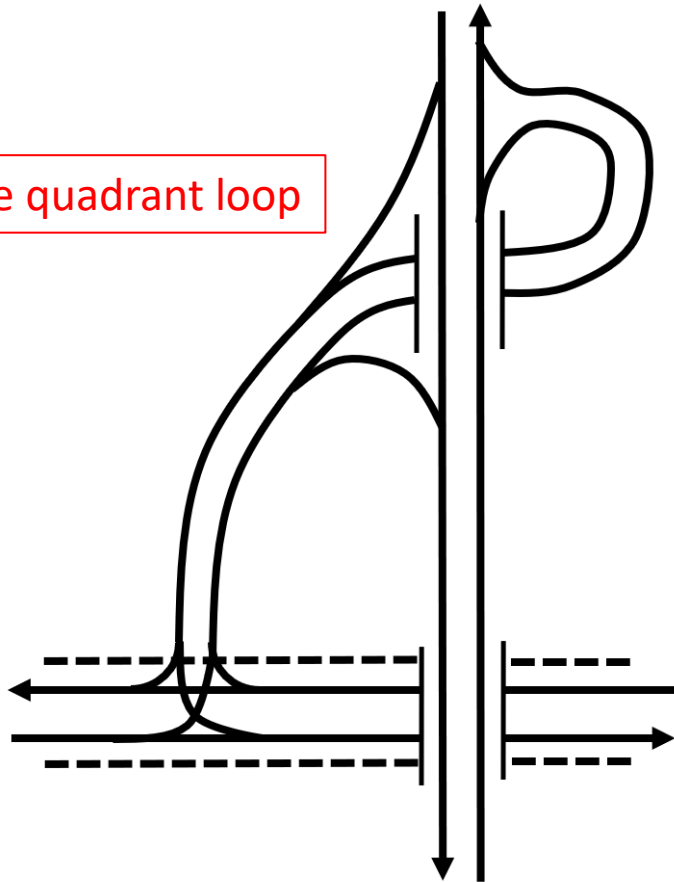
Tight diamond
single point

Saint Augustine
tight diamond

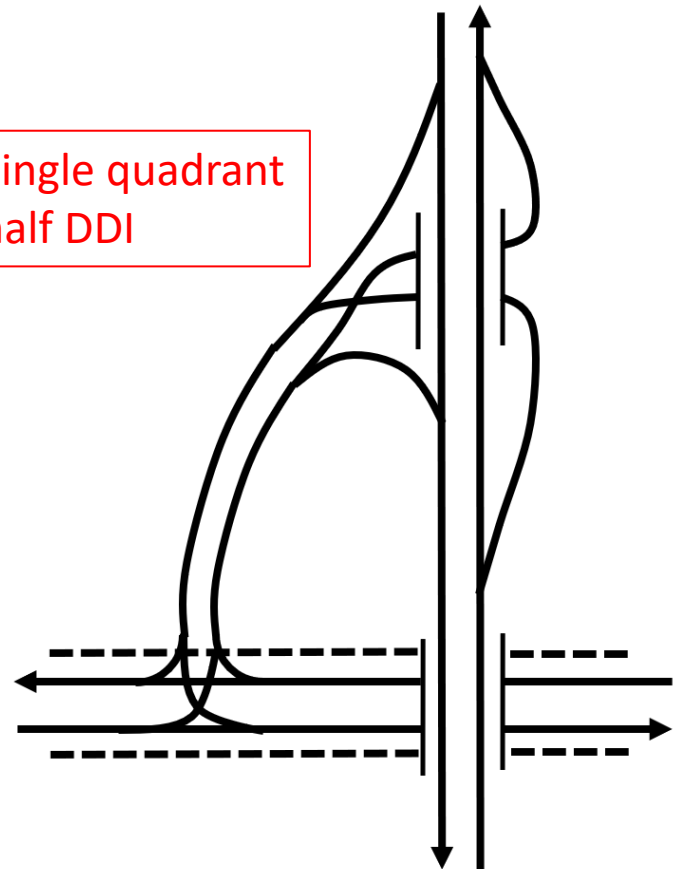
Best for Pedestrians

Single quadrant concepts

Single quadrant loop



Single quadrant half DDI



Interchange Summary

- There is a huge service interchange menu
 - 10 common concepts
 - Several dozen rare or published concepts
 - At least 50 promising new concepts
- Now sketched and scored
 - A Directory and spreadsheet with scores at <https://connect.ncdot.gov/resources/safety/Pages/Congestion-Management.aspx>
- No concept is perfect
 - But some are much better than others

Overall Wrap-Up

- Guidance document available at
 - https://connect.ncdot.gov/resources/safety/TEPPL/TEPPL%20All%20Documents%20Library/C62_Guidance.pdf
- How to select
 - Includes safest feasible intersection charts
- Alternatives
 - Intersections, grade-separated intersections, and interchanges

Thank You!

- Let's talk intersections, interchanges, or AVs
- Joe Hummer
 - 919-814-5040, jehummer@ncdot.gov

