Traffic Performance Comparison of New Jersey Jughandle Intersections (NJJI) and Conventional Intersections

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BMI-SG
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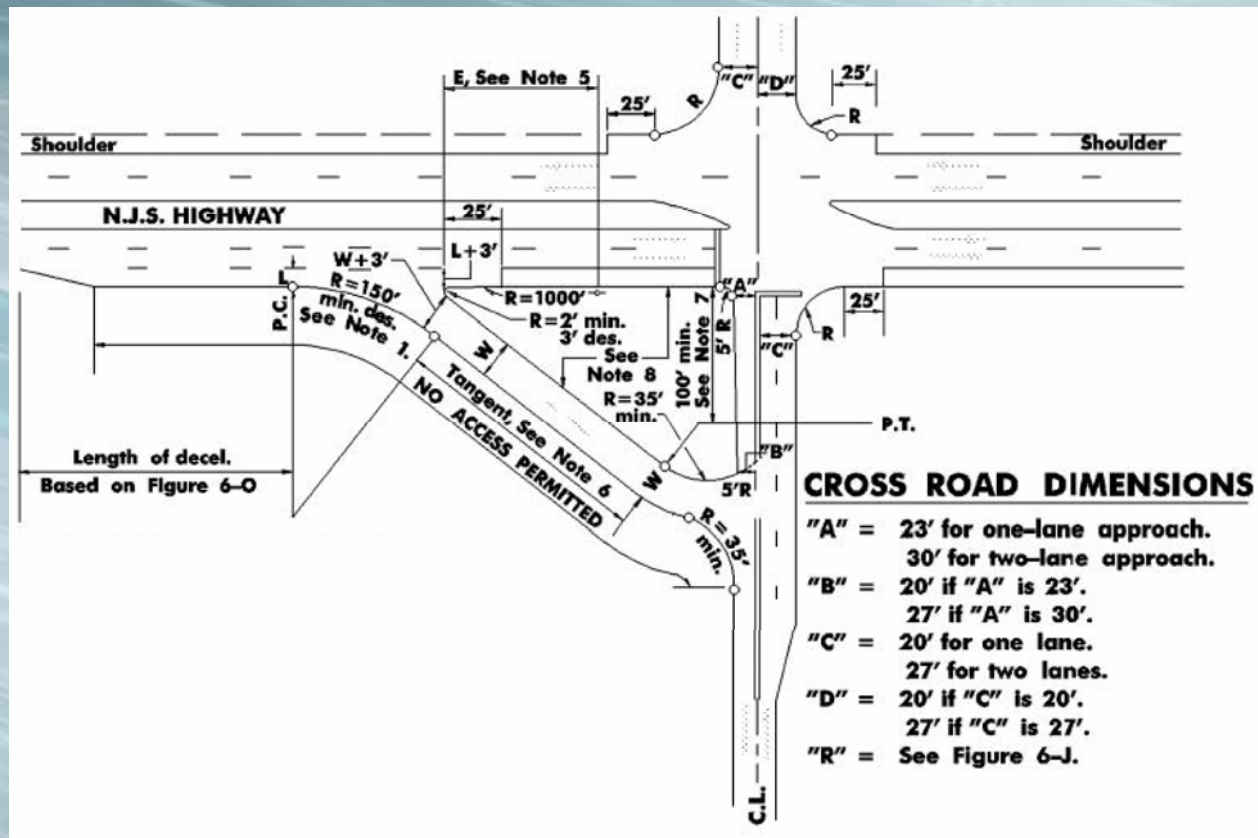
STUDY OBJECTIVE

To analyze the differences and similarities
in the traffic performance of
NJJIs vs. Conventional intersections
for a variety of traffic flows
and signal settings

BACKGROUND

- NJJIs have been around for the past few decades
- NJJIs are expected to improve traffic operations by eliminating the left-turn phase on the major road
- Reid and Hummer (2001) suggested that jughandles never performed better than conventional intersections in terms of average travel time for the seven “non-traditional” intersections that they modeled under varying traffic conditions.

TYPES OF NJJI RAMPS



"FORWARD" JUGHANDLE RAMP

TYPES OF NJJI RAMPS

“FORWARD” JUGHANDLE RAMP

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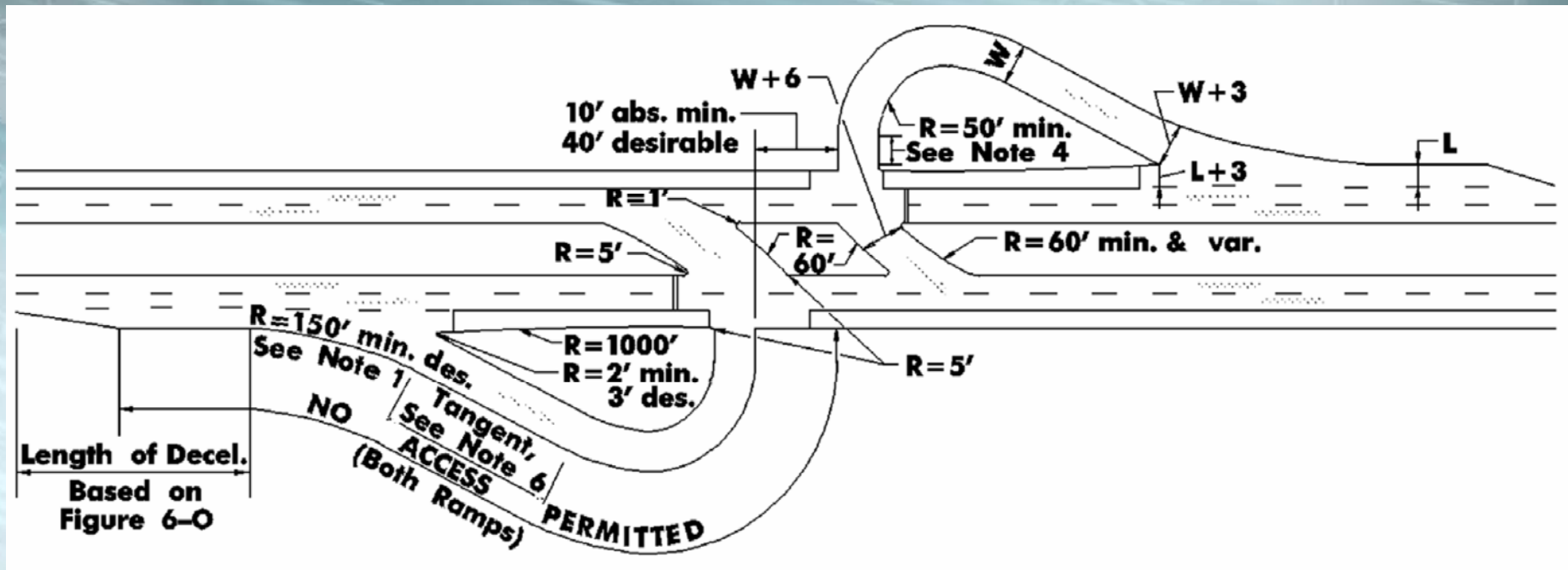
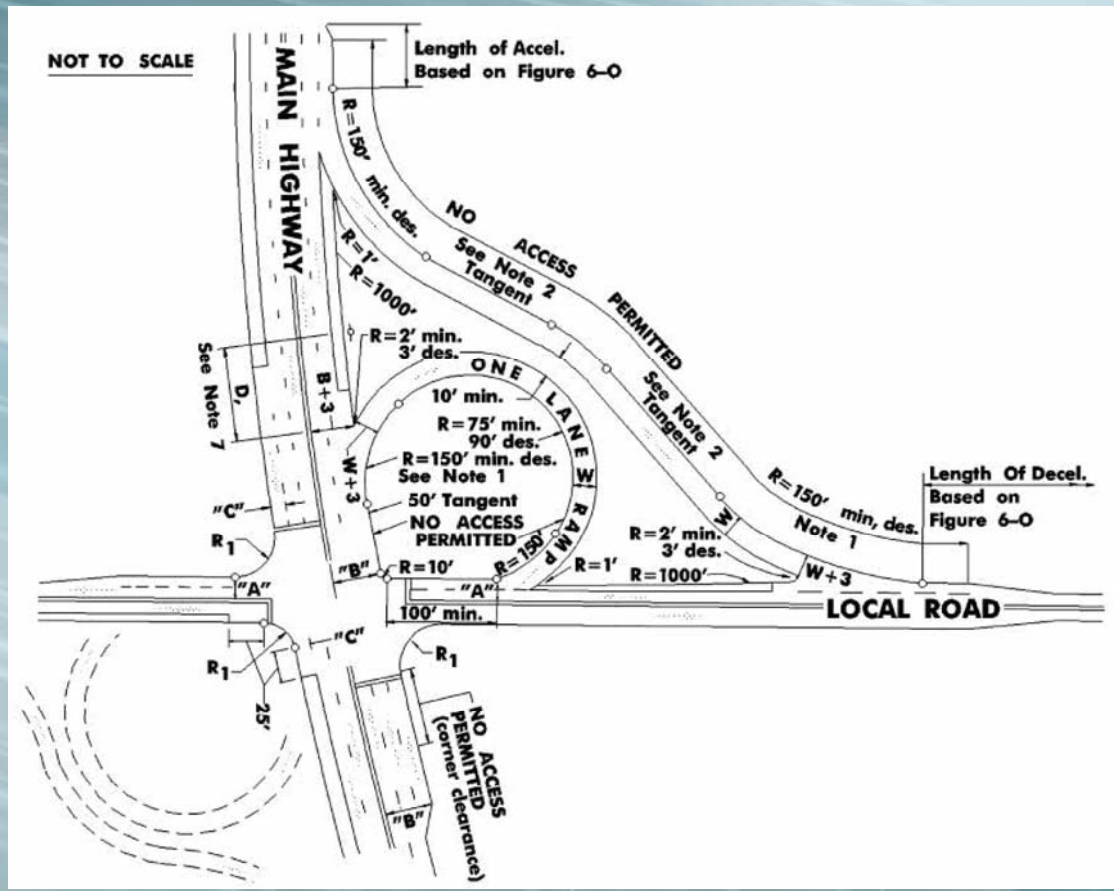
TYPES OF NJJI RAMPS



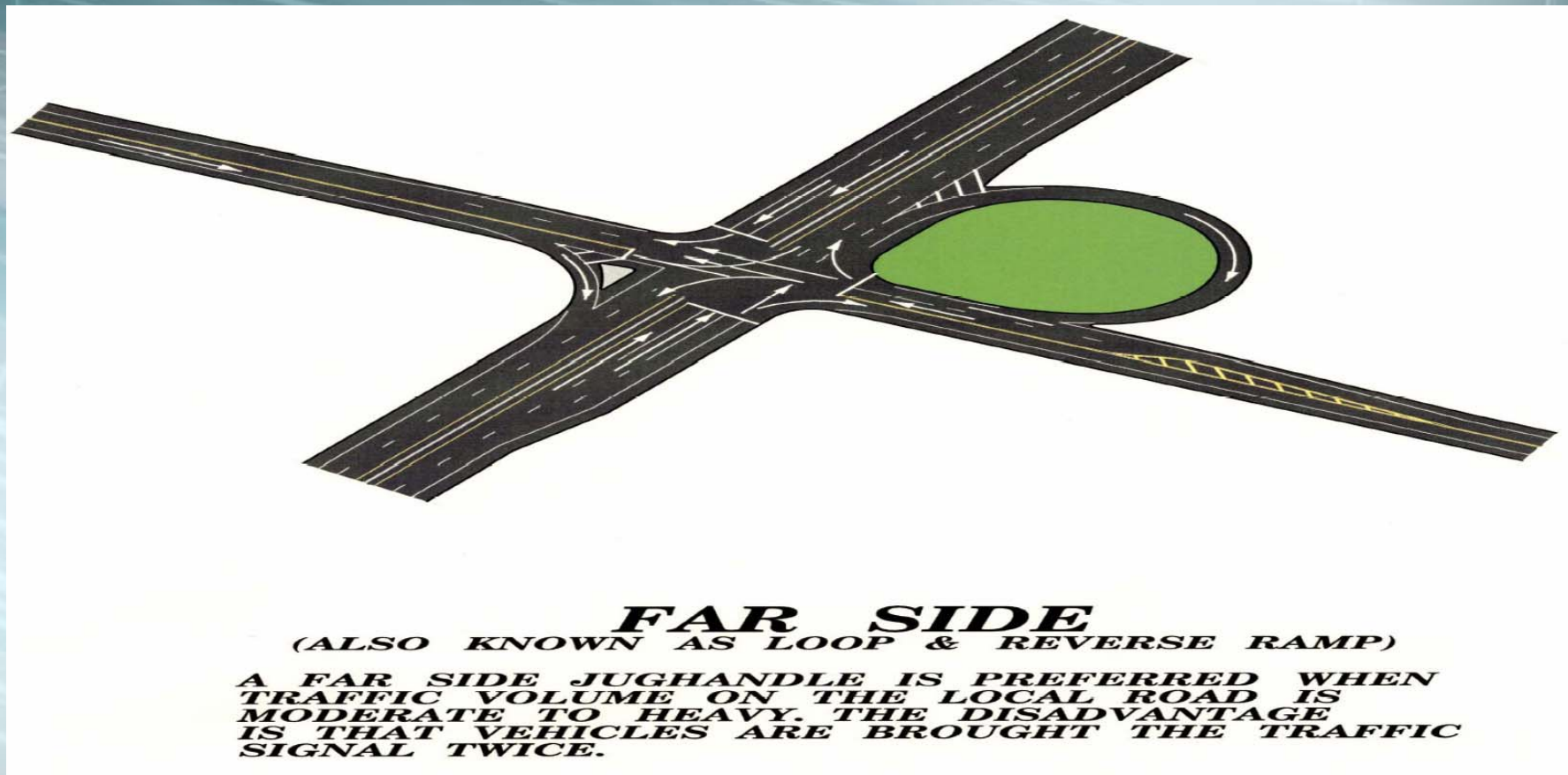
“U-TURN” JUGHANDLE RAMP

TYPES OF NJJI RAMPS



"REVERSE" JUGHANDLE RAMP

TYPES OF NJJI RAMPS



“REVERSE” JUGHANDLE RAMP

FACTORS INFLUENCING LEFT-TURN CAPACITY AT NJJIs

- Terminus location of the NJJI ramp on the major and minor roads
- Relative proportions of thru and right-turning vehicles on the major road
- Minor road traffic volumes
- Lane geometry, sight distance and posted speed limits on minor road approaches to the NJJI
- Relative proportion of right turning vehicles on the major road not using the ramp (forward NJJI ramp only)

ANALYSIS METHODOLOGY

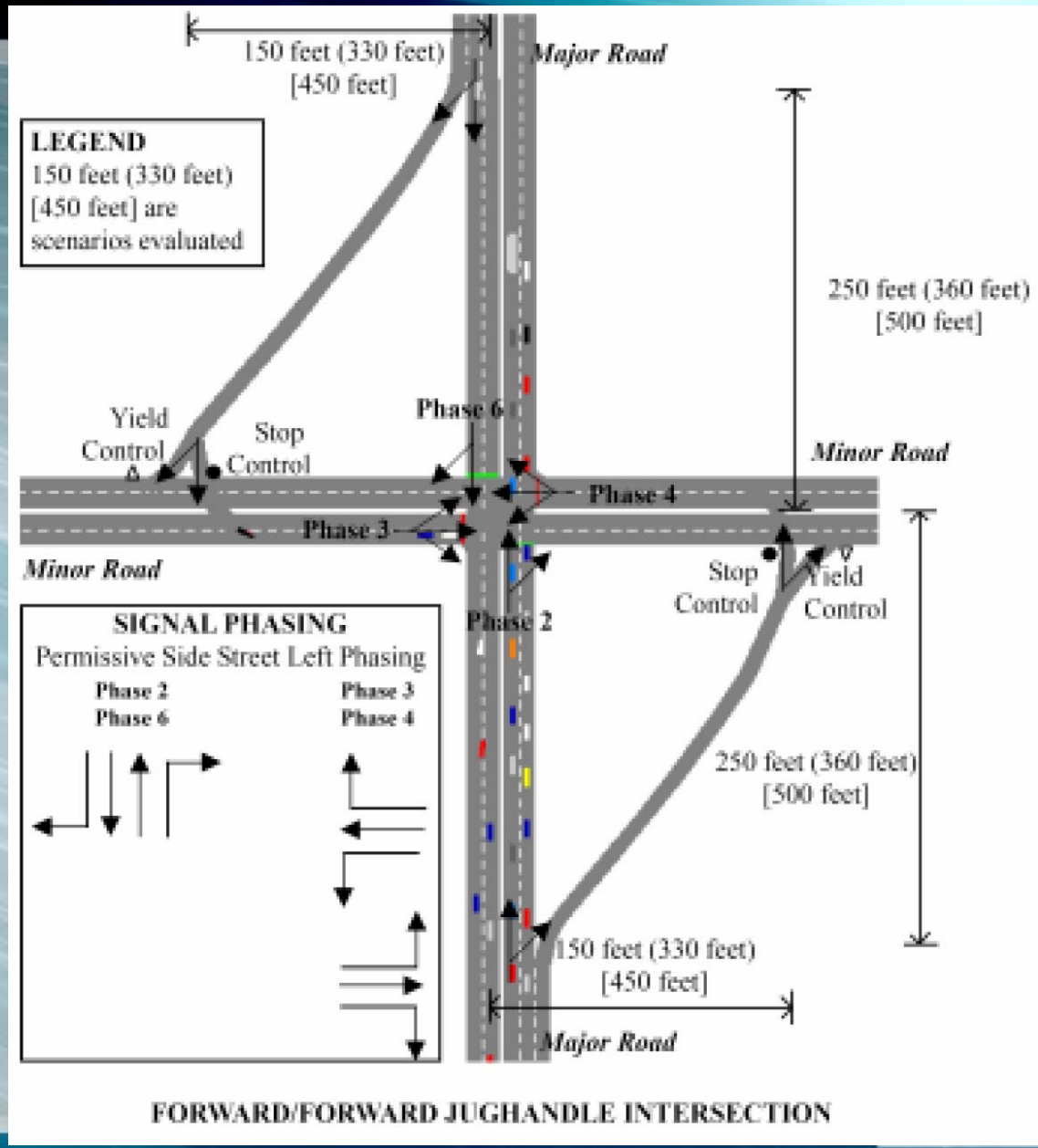
- VISSIM microscopic simulation software
- Three NJJI configurations (“F/F”, “F/R”, “R/R”)
- Three variations of jughandle ramp offsets on the major and minor roads
- Wide range of traffic flows distributions simulated
- Two alternative signalization strategies for the minor road (permissive lefts and protected/permissive lefts)

CASES MODELED

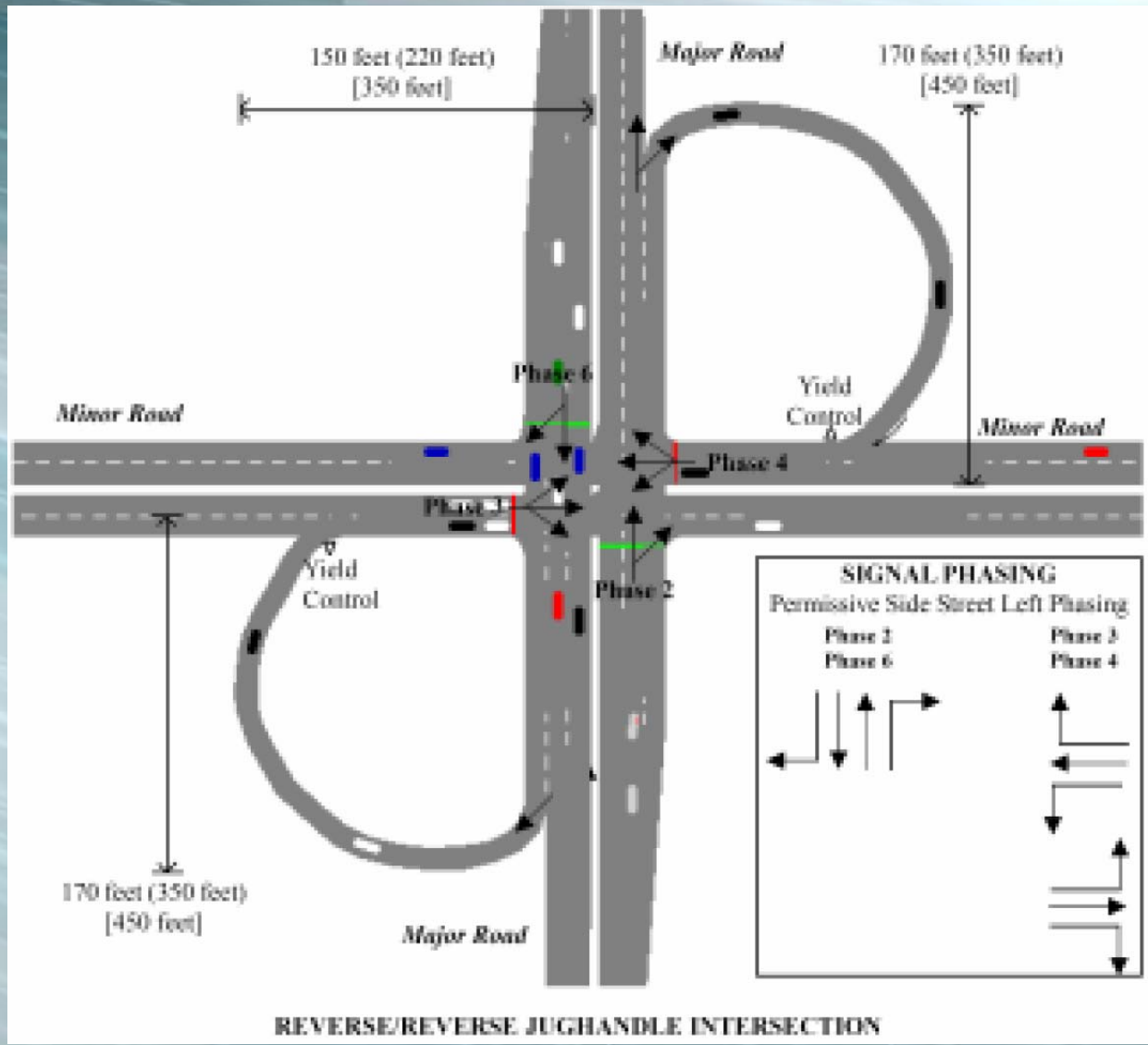
- Two cases of lane geometry and corresponding signal control strategy modeled
  - First case - 2 thru lanes on major road per direction, 1 shared thru+left and 1 shared thru+right lane on minor road per direction with non-directional split, permissive left turn phasing
  - Second case - 2 thru lanes on major road per direction and 1 left and 1 shared thru+right lane on minor road per direction with non-directional split, protected left turn phasing

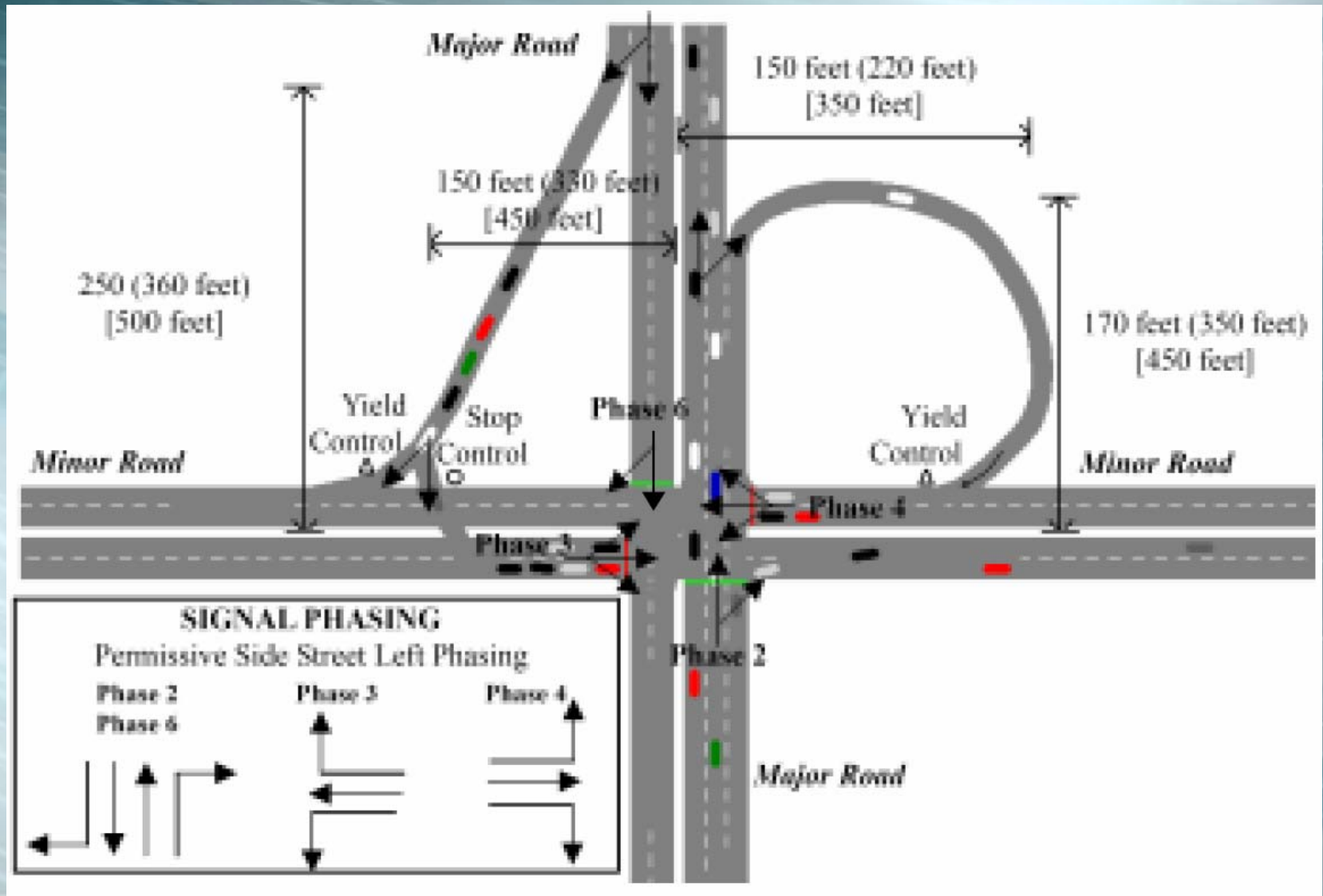
CASES MODELED (cont'd.)

- Single lane forward NJJI ramp widens at the terminus to permit two lanes at the intersection with the minor road
- 1,300 sets of randomly computer-generated traffic flow sets simulated for each configuration
- The signal timings optimized using Synchro
- Comparable conventional intersections modeled for low, medium and high traffic flow inputs



FORWARD/FORWARD JUGHANDLE INTERSECTION


150 feet (220 feet)
[350 feet]
Major Road
170 feet (350 feet)
[450 feet]
Minor Road
Phase 6
Yield
Control
Minor Road
Phase 4
Phase 5
Yield
Control
Phase 2
SIGNAL PHASING
Permissive Side Street Left Phasing
Phase 2
Phase 6
Phase 3
Phase 4
170 feet (350 feet)
[450 feet]
Major Road
REVERSE/REVERSE JUGHANDLE INTERSECTION


Major Road
150 feet (220 feet)
[350 feet]
150 feet (330 feet)
[450 feet]
250 (360 feet)
[500 feet]
170 feet (350 feet)
[450 feet]
Yield
Control
Stop
Control
Phase 6
Yield
Control
Minor Road
Minor Road
Phase 4
Phase 3
SIGNAL PHASING
Permissive Side Street Left Phasing
Phase 2
Phase 6
Phase 3
Phase 4
Phase 2
Major Road

TRAFFIC SIMULATION RESULTS

- “F/F”, “F/R” and “R/R” NJJIs performed similar or slightly worse than conventional intersections for low and medium traffic volumes
- “F/F”, “F/R” and “R/R” NJJIs reported lower average intersection delays in the ranges of 15-35%, 20-40%, 25%-40% respectively in comparison to conventional intersections for higher traffic volumes
- Maximum intersection capacity of the “F/F”, “F/R” and “R/R” NJJIs were higher than comparable conventional intersections in the ranges of 10-15%, 15-20%, 15%-25% respectively

SIMULATION RESULTS (cont'd.)

- "F/F", "F/R" and "R/R" NJJIs had 10%-15% higher average intersection travel times when compared to conventional intersections for low and medium traffic volumes and lower travel times than conventional intersections for high traffic volumes
- "F/F", "F/R" and "R/R" NJJIs reported a higher number of stops/vehicle than conventional intersections except for high traffic volume conditions
- The "R/R" NJJI, "F/R' NJJI and the "F/F" NJJI have maximum intersection capacities of 5500 veh/hr, 5300 veh/hr and 5150 veh/hr respectively

SIMULATION RESULTS (cont'd.)

- Changing of the left-turn gap acceptance maneuver (i.e. forward jughandle ramp) to a right-turn merge maneuver (i.e. reverse jughandle ramp) yields a 5%-15% increase in intersection capacity based on the distribution of turning movement
- Simulation cases with three thru lanes per approach on the major road and proportional increases in entering volumes for NJJIs and conventional intersections resulted in very similar traffic performance as in cases with two lanes per approach on the major road.

DEVELOPMENT OF TRAFFIC PERFORMANCE PREDICTION MODELS

- Statistical models were developed to estimate three variables of interest (average control delay (CD) in seconds/vehicle, average number of stops (ST) in stops/vehicle and maximum queue (MQ)) commonly used by practitioners in assessing intersection traffic performance.
- The models were developed using the non-linear regression technique readily available in the SAS software (Proc NLIN) to express an exponential form.
- All variables are significant beyond the 95% confidence level. Goodness-of-fit measures (in terms of the conventional R-squared) are strong for all models.

DEVELOPMENT OF PREDICTION MODELS (cont'd.)

CD = EXPO [a0 + (a1*XL1C1/10000 + a2*XL2C2/10000 + a3*XMNVOL/10000 + a4*XFWDREV + a5*XREV + a6*XSIG + a7*XOFFTYPE)]

ST = EXPO [b0 + (b1*XL1C1/10000 + b2*XL2C2/10000 + b3*XMNVOL/10000 + b4*XFWDREV + b5*XREV + b6*XOFFTYPE)]

MQ = EXPO [c0 + (c1*XL1C1/10000 + c2*XL2C2/10000 + c3*XMNVOL/10000 + c4*XSIG + c5*XOFFTYPE)]

DEVELOPMENT OF PREDICTION MODELS (cont'd.)

- a, band c are regression coefficients
- XL1C1 = cross product of major left turn flow from the southern approach with the total minor flow on the eastern approach(vph),
- XL2C2 = cross product of major left turn flow from the northern approach with the total minor flow on the western approach(vph),
- XMNVOL = sum of the minor road flows on the eastern and western approaches(vph),
- XFWDREV = 1 if fwd/reverse type jughandle, else 0,
- XREV = 1 if reverse/reverse type jughandle, else 0,
- XOFFTYPE = 1 if minor road ramp offset less than 275ft , else 0), EXPO (exponential) = e = 2.716828

Variable	CD coeff.	ST coeff.	MQ coeff.
	#standard error#	#standard error#	#standard error#
Intercept	2.3315	0.2074	4.7193
	#0.0236#	#0.0203#	#0.0195#
XL1C1	0.0178	0.00301	0.00948
	#0.000369#	#0.000382#	#0.000355#
XL2C2	0.0174	0.00318	0.00917
	#0.000492#	#0.000501#	#0.000483#
XMNVOL	-7.369	-1.7601	-5.0494
	#0.5075#	#0.4701#	#0.4676#
XFWDREV	0.1718	-0.0294	
	#0.0144#	#0.0128#	
XREV	0.1843	-0.055	
	#0.0115#	#0.00975#	
XSIG	-0.0897		-0.022
	#0.00919#		#0.008844#
XOFFTYPE	0.2099	0.0344	0.1416
	#0.0117#	#0.0106#	#0.00999#
R^2	0.92	0.94	0.93
F-Value	6035.49	8417.15	9566.18

CONCLUSIONS

- “F/F”, “F/R” and “R/R” NJJIs have lower average intersection delays than conventional intersections for saturated traffic conditions in the ranges of 15-35%, 20-40%, 25%-40% respectively; and similar or slightly worse traffic performance for under-saturated traffic conditions.
- “F/F”, “F/R” and “R/R” NJJIs have higher intersection capacities than conventional intersections for saturated traffic conditions in the ranges of 10-15%, 15-20%, 15%-25% respectively.

CONCLUSIONS (cont'd.)

- "R/R" NJJIs have the highest intersection capacity followed by "F/R" and "F/F" NJIIs
- Travel times and number of stops/vehicle for NJJIs are lower than conventional intersections only for saturated traffic conditions.
- Vehicular capacity of left-turn volumes on the major road of the NJJIs decreases as the ramp offsets decrease, such that, reduction in the minor road offsets and major road offsets from 450 feet to 230 feet reduces the left-turn volumes on the major road approach by approximately 30%

QUESTIONS ?

COMMENTS !