Introduction

The alternate design described in this document is presented for consideration as a value engineering proposal for the ODOT LUC-475-8.03 PID #88252 project.

The alternate design involves modifying the existing I-475/US-23/US-20 par-clo AB2 service interchange near Toledo, Ohio as a parallel flow par-clo interchange (PFPCI) by converting the existing ramp intersections to 2-phase parallel flow intersections (PFI) (see page 2, Concept Plan). The proposed PFPCI design is expected to operate at a higher level of service than the current design at significantly less cost.

The PFI has greater capacity than traditional intersections by reducing the number of signal phases per cycle. For this project, the PFI achieves higher capacity than the existing 3-phase operation of the T-type ramp intersection signals *and* proposed 3-phase SPUI signalized intersection.

Relatively minor work is required to convert the existing intersections to the PFI. Most of the activity is on the outsides of the existing roadway making for a safer work zone and much shorter duration than the proposed SPUI construction.

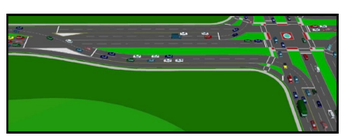
The majority of PFI conversion work includes:

- Pavement widening on ramps
- Adding channelizing islands
- New pavement markings
- New standard signage
- Adjusting existing signals at ramps on US-20 to 2-phase operation
- New signal added at each ramp bypass junction

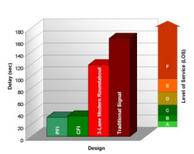
U-turns at existing US-20 intersections and Plainview Drive can be supported if desired.

About the Parallel Flow Intersection

The PFI was invented in 2004 by Greg Parsons who received the patent in 2006. The PFI is an innovative high-capacity signalized traffic intersection that can operate in two or three phases per signal cycle.



The PFI (shown right) accomplishes high efficiency by removing left turn movements from the main junction. Left turning drivers are directed onto a bypass road using channelizing islands, markings and standard signage. The left turn and cross road through movements are simultaneous.



Dramatic delay reduction can be achieved with the PFI over a traditional multi-phase signal (see right). The PFI is expected to closely match the performance of a continuous flow intersection (CFI) but with 50% shorter approaches.

For more information, visit the PFI information page on the web at http://www.gfparsons.com/pfi.

Satisfies Project Purpose and Need

From the *Interchange Modification Study August 2012* (IMS), the purpose of the proposed project is to:

- *Reduce existing and projected future mainline congestion and safety problems to provide a traffic level of service (LOS) D or better along the mainline through the year 2035.*
- *Reduce existing and projected future interchange congestion and safety problems to provide a traffic level of service D or better at the US-20 interchange through the year 2035.*
- *Reduce existing and future safety problems by eliminating existing geometric design deficiencies on the mainline and US-20 interchange wherever practical and cost effective.*

The PFPCI alternate design satisfies the project purpose and need conditions.

The PFPCI is compatible with planned improvements to the I-475/US-23 mainline. If necessary, a single ramp lane for the I-475/US-23 southbound exit ramp can be investigated for constructing under the existing bridge end-span by replacing a portion of slope protection with vertical retaining wall.

Minimal Construction Cost

The estimated construction cost for the PFPCI is expected to be less than $1 million (as shown in the Concept Plan) not including ramp construction under the existing US-20 bridge over I-475/US-23 if necessary.

The Ohio Transportation Review Advisory Council (TRAC) funding for construction of the SPUI as of September 2013 is $44 million which includes the new ~34,000 sq. ft bridge over I-475/US-23 and vertical wall abutments. The resulting life-cycle cost of the SPUI alternative can be expected to be very high relative to the PFPCI.

High Level of Service

All PFPCI ramp intersections are expected to operate at level of service B and C through the year 2035. The IMS SPUI intersection is 3-phase and predicted to operate at LOS D by 2035 in the PM peak period. See page 3, Traffic Analysis.

No Right-of-Way

The proposed PFPCI work is expected to fit entirely within existing right-of-way not requiring any new permanent or temporary right-of-way. The IMS SPUI plan is estimated to require various strip acquisitions and possibly involve relocating the BP gas station in the southwest quadrant on US-20. The TRAC has programmed $11 million for new right-of-way acquisition.

Environmental Impacts

None expected.

Minor Maintenance of Traffic

Construction of the PFPCI is minor with most work occurring on the outside of existing pavement. Temporary traffic control is needed for the construction of channelizing islands, installing loop detectors and other relatively incidental tasks.

The I-475/US-23 NB exit ramp is proposed to extend the existing two lane section about 400-ft. The PFPCI requires no work on I-475/US-23 mainline or US-20 bridge.

The IMS SPUI plan appears to require extensive construction phasing or complete closure of the interchange to build and will result in short duration closures of I-475/US-23 to erect steel for the new bridge and demolition of existing bridge.

Comparison Matrix

	SPUI Design		PFI Design	
Estimated Cost[1]	$55 Million[2]		$1 Million[3]	
Purpose and Need	Satisfies		Satisfies	
Level of Service[4]	C (30.9s)	D (41.5s)	C (25.4s)	C (30.3s)
Right-of-Way Impacts	Moderate[5]		None Estimated	
Environmental Impacts	Minor		None Estimated	
Maintenance of Traffic	Major[6]		Minor	

1. Includes construction and right-of-way
2. Source: *FINAL 2014-2017 Major New Program List* September 2013
3. Only work shown in PFPCI Concept Plan (does not include mainline I-475/US-23 work or potential ramp construction under existing US-20 bridge end-span)
4. Design year 2035 AM/PM peak periods using IMS certified traffic with SPUI intersection LOS from IMS and PFI LOS from VISSIM results for all four PFI junctions combined
5. Potential relocation of BP gas station on west side in addition to various strip acquisitions
6. Not considered in IMS document but estimated by GFParsons

YouTube See the parallel flow par-clo interchange on YouTube here.

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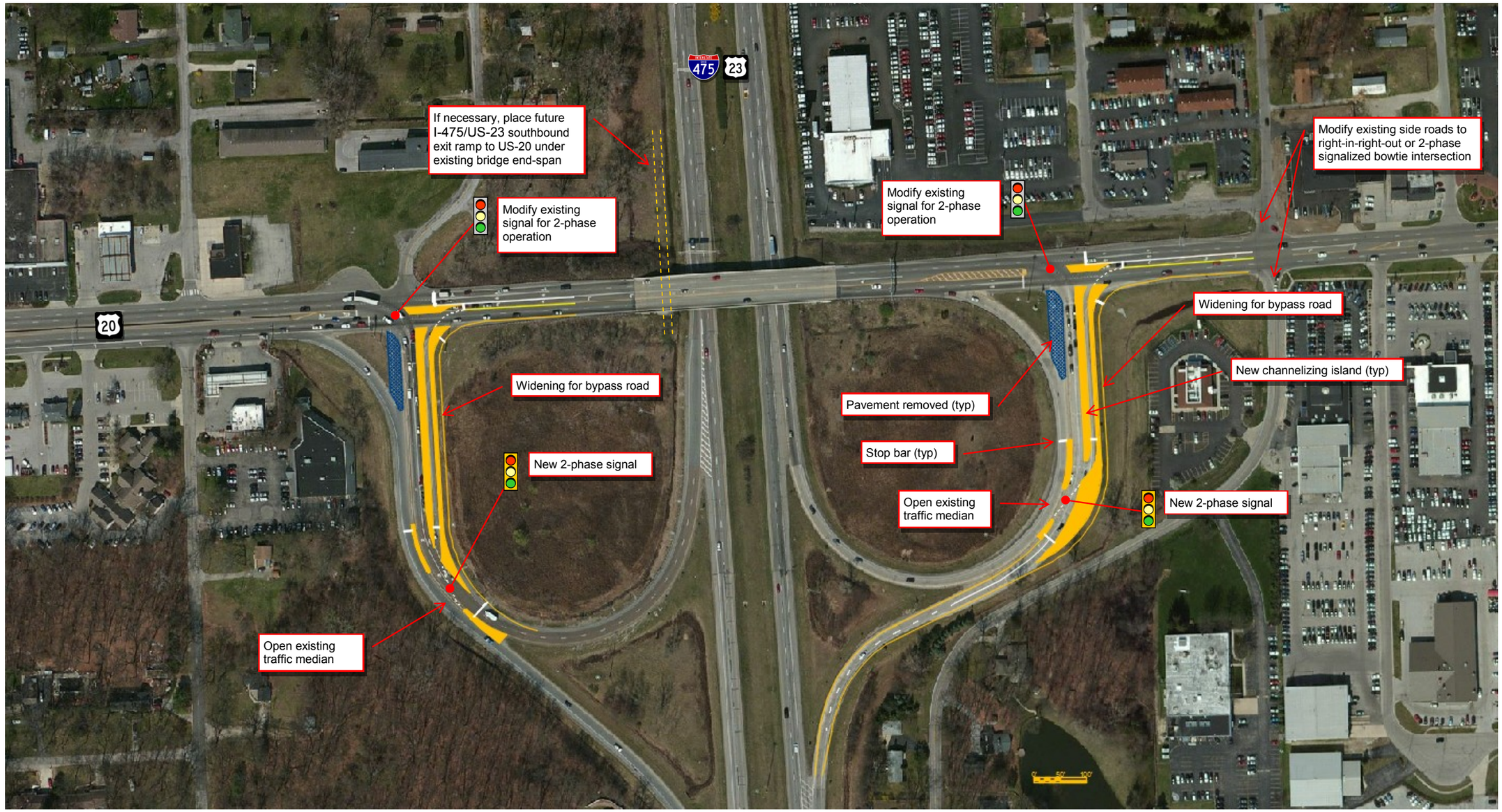

Lucas County, Ohio

Longitude: 83°41'38"W Latitude: 41°40'32"N

0' 200'

Scale: 1" = 200'

N W E S

August 8, 2014

I-475/US-23 @ US-20 (Central Avenue)
ODOT LUC-475-8.03 PID #88252
Parallel Flow Par-Clo Interchange AB2
Alternate Design Proposal

Concept Plan

2

5

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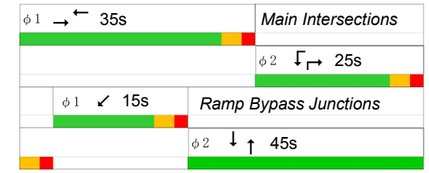
Vehicle Delay (secs)

	Seed	Delay All	Stopped	Stops	#Veh	Delay All	Stopped	Stops	#Veh	Delay All	Stopped	Stops	#Veh	Delay All	Stopped	Stops	#Veh	Delay All	Stopped	Stops	#Veh	Delay All	Stopped	Stops	#Veh	Delay All	Stopped	Stops	#Veh
		Total Network All Entering Vehicles				US-20 WB All Entering Vehicles				US-20 EB All Entering Vehicles				I-475 SB Ramp All Entering Vehicles				I-475 NB Ramp All Entering Vehicles				West PFI Junctions				East PFI Junctions			
AM	27	25.5	10.4	0.91	4781	29.8	13.5	1.21	1043	27	10	0.87	2104	23.3	11.2	0.83	792	18.5	6.6	0.7	842	15.5	6.1	0.54	4244	15.5	6.4	0.55	3512
	53	25.4	10.1	0.91	4794	28.5	12.9	1.19	1046	27.7	10.1	0.88	2103	22.3	10.5	0.86	799	18.9	6.3	0.68	846	14.8	5.7	0.53	4266	16	6.6	0.57	3524
	76	25.3	10.2	0.91	4825	29.1	13.2	1.21	1050	26.8	9.6	0.84	2169	23.2	11.3	0.88	756	18.5	6.7	0.71	850	14.8	5.7	0.52	4306	15.9	6.6	0.57	3543
		C				C				C				C				B				B				B			
Average		25.40	10.23	0.91	4800.00	29.13	13.20	1.20	1046.33	27.17	9.90	0.86	2125.33	22.93	11.00	0.86	782.33	18.63	6.53	0.70	846.00	15.03	5.83	0.53	4272.00	15.80	6.53	0.56	3526.33
PM	27	31.9	12.2	1.03	5808	39.9	15.4	1.31	1652	27.4	9.7	0.86	2201	28.6	13.6	0.93	995	32	11.1	1.01	960	21.5	7.9	0.65	5322	17.8	6.6	0.57	4158
	53	29.9	11.7	1	5829	37.5	15.2	1.28	1692	26.5	9.6	0.84	2193	26.4	12.7	0.93	1002	27.7	9.5	0.91	942	19.1	7.2	0.61	5373	16.9	6.8	0.57	4229
	76	29	11.5	0.95	5828	35.2	14.8	1.21	1652	27.2	9.7	0.84	2267	26.2	12.8	0.92	953	25.3	8.8	0.79	956	17.9	6.8	0.57	5352	17	7	0.57	4218
		C				D				C				C				C				B				B			
Average		30.27	11.80	0.99	5821.67	37.53	15.13	1.27	1665.33	27.03	9.67	0.85	2220.33	27.07	13.03	0.93	983.33	28.33	9.80	0.90	952.67	19.50	7.30	0.61	5349.00	17.23	6.80	0.57	4201.67



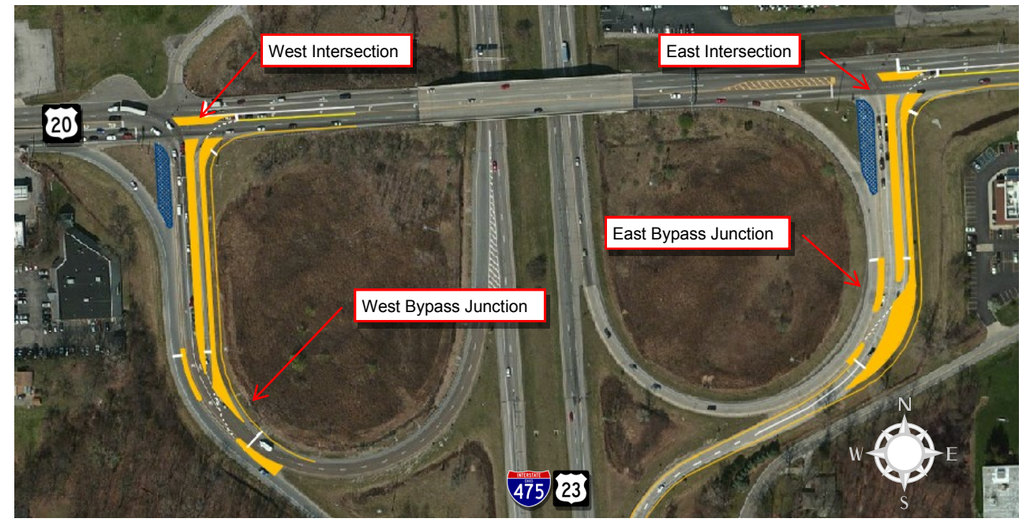
Signal Timing (60 sec cycle)

Vehicle Queues (ft)

	Seed	Aver	Max	Stops	Aver	Max	Stops	Aver	Max	Stops	Aver	Max	Stops	Aver	Max	Stops	Aver	Max	Stops
		West Int US-20 EB Thru			West Int US20 WB Thru			West Int US-20 WB Left			West Int Ramp Left			West Byp SB Thru			West Byp SB Left		
AM	27	62	509	1788	19	226	538	11	204	289	24	142	415	14	193	346	22	274	489
	53	54	411	1659	18	232	562	10	184	264	21	103	377	13	210	323	20	217	464
	76	52	342	1613	19	229	566	11	198	290	24	130	404	15	212	362	22	230	500
Average		56.00	420.67	1686.67	18.67	229.00	555.33	10.67	195.33	281.00	23.00	125.00	398.67	14.00	205.00	343.67	21.33	240.33	484.33
PM	27	59	435	1771	92	950	2032	12	255	316	39	239	654	19	352	426	29	247	641
	53	51	359	1639	78	663	1916	10	212	269	36	233	626	18	214	417	25	304	548
	76	53	363	1624	63	372	1679	10	253	264	37	238	627	18	250	420	30	263	632
Average		54.33	385.67	1678.00	77.67	661.67	1875.67	10.67	240.00	283.00	37.33	236.67	635.67	18.33	272.00	421.00	28.00	271.33	607.00

	Seed	Aver	Max	Stops	Aver	Max	Stops	Aver	Max	Stops	Aver	Max	Stops	Aver	Max	Stops	Aver	Max	Stops
		West Byp NB Thru			West Int Ramp Right			East Int US-20 EB Thru			East Int US-20 WB Thru			East Int US-20 WB Left			East Int Ramp Right		
AM	27	19	214	584	3	132	142	55	344	1428	25	189	791	12	162	221	10	214	474
	53	19	251	590	5	108	168	62	419	1575	21	193	692	13	129	210	12	230	435
	76	18	190	547	3	114	165	58	325	1507	22	223	713	13	171	229	10	220	424
Average		18.67	218.33	573.67	3.67	118.00	158.33	58.33	362.67	1503.33	22.67	201.67	732.00	12.67	154.00	220.00	10.67	221.33	444.33
PM	27	24	232	769	4	184	157	58	324	1521	48	341	1447	13	205	228	7	127	388
	53	24	263	760	4	112	165	64	323	1608	44	338	1354	14	142	246	7	130	343
	76	23	301	724	5	140	184	66	369	1628	47	377	1339	15	155	261	6	118	334
Average		23.67	265.33	751.00	4.33	145.33	168.67	62.67	338.67	1585.67	46.33	352.00	1380.00	14.00	167.33	245.00	6.67	125.00	355.00

	Seed	Aver	Max	Stops	Aver	Max	Stops	Aver	Max	Stops	Aver	Max	Stops
		East Int Ramp Left			East Byp SB Left			East Byp SB Thru			East Byp NB Thru		
AM	27	17	166	265	16	189	347	6	163	136	8	120	343
	53	18	127	285	16	182	344	7	308	129	8	121	344
	76	17	140	275	16	179	341	7	285	134	9	121	378
Average		17.33	144.33	275.00	16.00	183.33	344.00	6.67	252.00	133.00	8.33	120.67	355.00
PM	27	25	174	416	17	251	355	7	322	141	11	287	457
	53	23	170	388	18	194	367	3	105	80	13	163	507
	76	24	192	408	18	225	381	6	283	138	12	237	491
Average		24.00	178.67	404.00	17.67	223.33	367.67	5.33	236.67	119.67	12.00	229.00	485.00



Traffic analysis was performed using the certified traffic contained in IMS Appendix A for the design year 2035 AM and PM peak hour periods. Manual signal timing is employed with minimal optimization. AM and PM timing plans are the same and fixed.

The results tabulated left were generated by VISSIM v4.2 using the default settings. Three separate seeded runs were performed and average values computed. Delay is given for the entire network of four intersections, for each vehicle source by travel direction and for each intersection.

Queue lengths were also generated and tabulated for each stop condition at the four network intersections. Average and maximum queue lengths are included and averages of the seeded runs.

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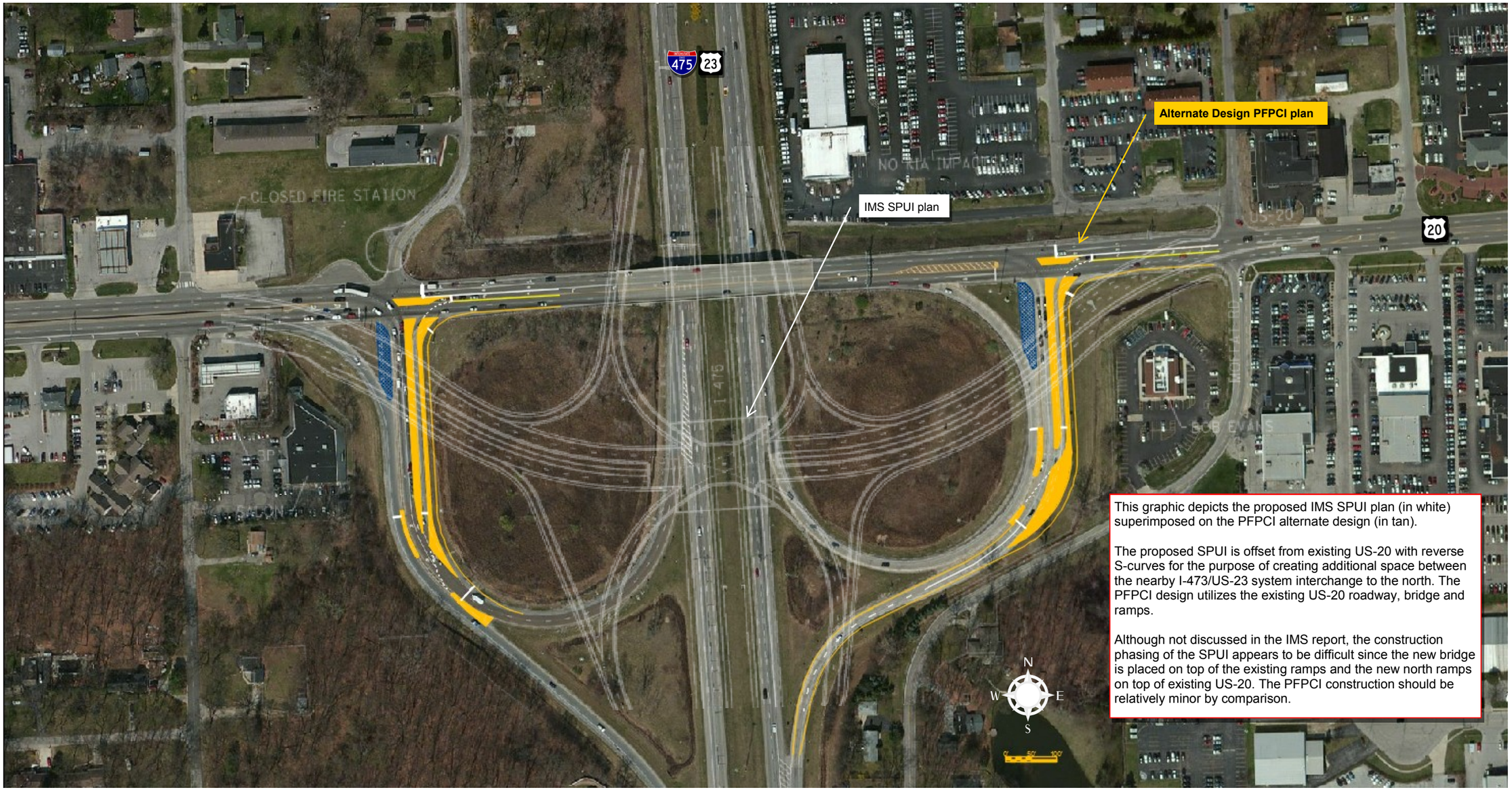

This graphic depicts the proposed IMS SPUI plan (in white) superimposed on the PFPCI alternate design (in tan).

The proposed SPUI is offset from existing US-20 with reverse S-curves for the purpose of creating additional space between the nearby I-473/US-23 system interchange to the north. The PFPCI design utilizes the existing US-20 roadway, bridge and ramps.

Although not discussed in the IMS report, the construction phasing of the SPUI appears to be difficult since the new bridge is placed on top of the existing ramps and the new north ramps on top of existing US-20. The PFPCI construction should be relatively minor by comparison.

August 8, 2014

I-475/US-23 @ US-20 (Central Avenue)
ODOT LUC-475-8.03 PID #88252
Parallel Flow Par-Clo Interchange AB2
Alternate Design Proposal
IMS SPUI Plan Overlay

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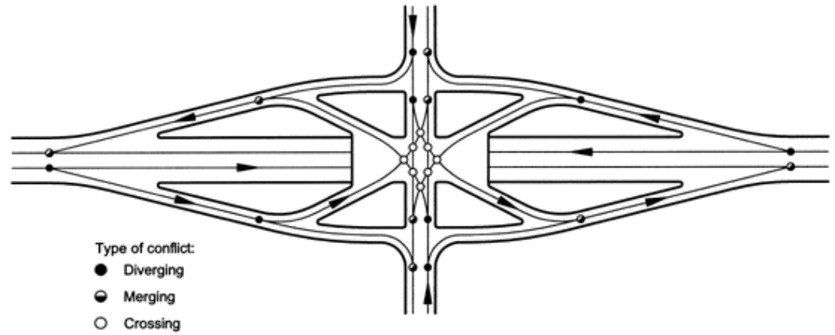
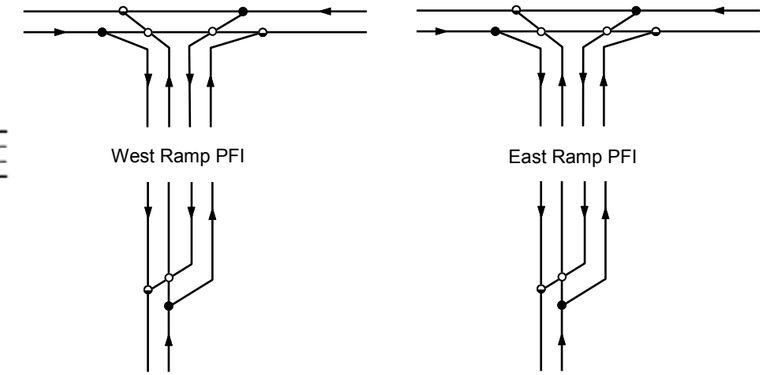
Vehicle Conflicts Comparison

Conflict Type	SPUI	PFPCI
Diverging	8	6
Merging	8	6
Crossing*	8	6
Total	24	18

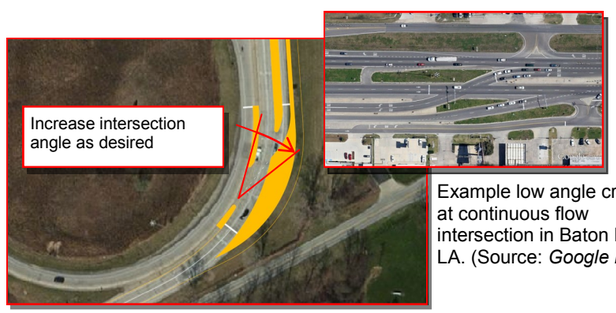
* Crossing conflicts are severest type



Single Point Urban Interchange (SPUI)
Vehicle Conflicts (Source: FHWA)



Parallel Flow Par-Clo Interchange (PFPCI) Type AB2
Vehicle Conflicts



Example low angle crossing at continuous flow intersection in Baton Rouge, LA. (Source: *Google Earth*)

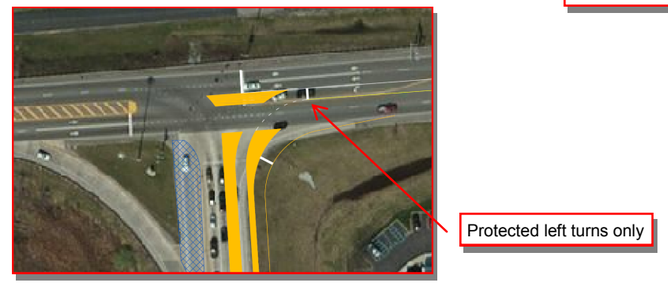
Increase Bypass Intersection Angle as Needed

The bypass junction includes a crossover maneuver from the bypass road to the entrance ramp. Similar crossing arrangements are found with both the diverging diamond interchange (DDI) and continuous flow intersection (CFI) which also involve contra-flow lanes.

The PFI bypass junction crossing has the advantage over the DDI and CFI by being low-speed. Both DDI and CFI allow for high-speed crossing maneuvers increasing wrong-way risk.

Channelizing islands and pavement markings provide drivers with visual cues to guide them onto the entrance ramp.

And unlike the DDI and CFI, the intersection angle of the PFI bypass road can be increased to as much as 90-degrees if desired and space permitting.

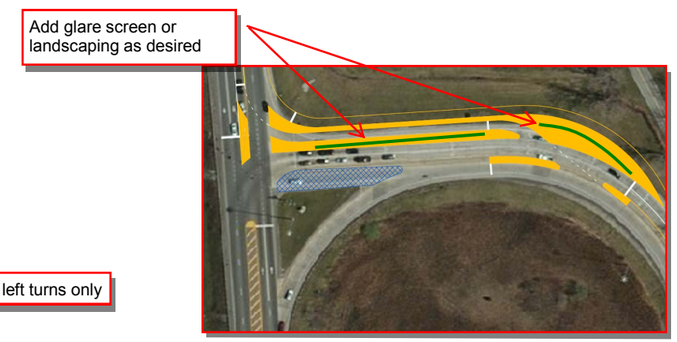


Extensive Channelizing and No Permitted Left Turns

The drivers making the main junction left turn are guided by channelizing islands and pavement markings. Wrong-way turns are extremely unlikely here since the ramp right and left turn lanes are protected by the islands.

All left turns are protected. There are no permitted left turns at the PFI.

Channelizing islands can also be used as pedestrian refuges for safer crossings.



Reduce Headlight Glare If Desired

Glare from headlights can be expected to be low if interchange lighting is present. Additional measures of adding glare screens and or landscaping in channelizing islands can also be considered.

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