

The unconventional intersections design impact on the capacity performance in the cities

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Introduction

What does an unconventional intersection means?

- Modification or relocation of selected critical turning movements outside the main intersection node.
- Cost-effective and space-efficient solutions for key-junctions with the limited space layout
- Developed in the US, increasingly adopted in Asian countries.
- Minimal occurrence in Europe.
- Only briefly mention in the Czech road standards, missing of any complex guidelines.



Research

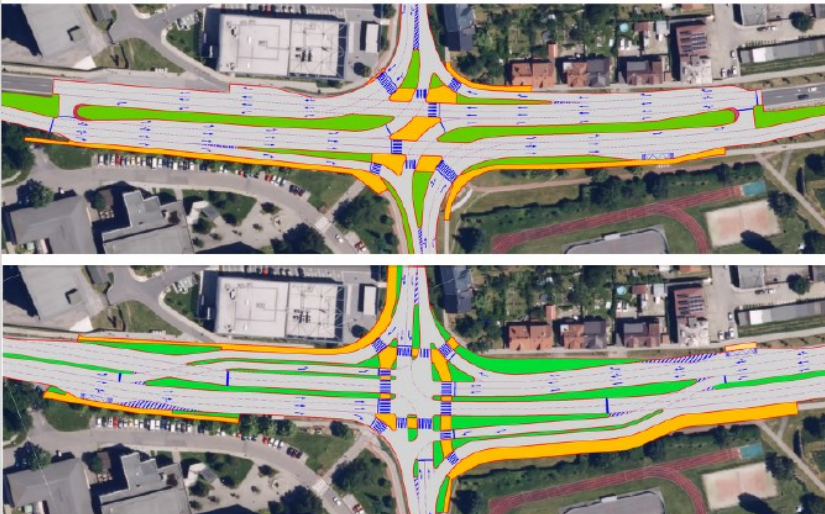
- Development of **methodology** and a **supplement** to the Czech road standard, with a focus on Czech conditions named **„Methodology for the Design of Unconventional Intersections,,** (Czech language)
- Defining the suitability of specific types based on traffic volumes and space limitation.
- Tool for increasing capacity in problematic urban locations across Czech cities with acceptable costs

Centrum dopravního výzkumu, v. v. i.

METODIKA

pro navrhování nekonvenčních křižovatek

NmetS – Metodiky schválené příslušným
orgánem státní správy



s levými odbočeními z vedlejších ramen B/D +
ý se zkrácením zelené pro vysazené levé odbočení

očení:

dlejších ramen, zelený signál společně s přímým
oplňkové šipky.

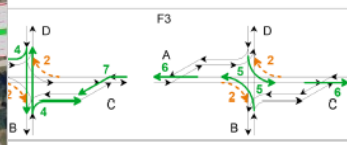
pravé odbočení z ramen A/C řídit pomocí blikající
ení z protilehlých ramen).

o z ramen A/C,

(2) vpravo z ramen A/C (pouze varianta 2),
ající žlutá.

V/C.

ek 15 a Obrázek 16. Pro částečné varianty CF1-2R
pro tvorbu signálního plánu jako v případě úplné



CF-2R – varianta 1. Zdroj: autor.



Obrázek 16: Vzorový signální plán CF-2R – varianta 1. Zdroj: autor.



CENTRUM
DOPRAVNÍHO
VÝZKUMU

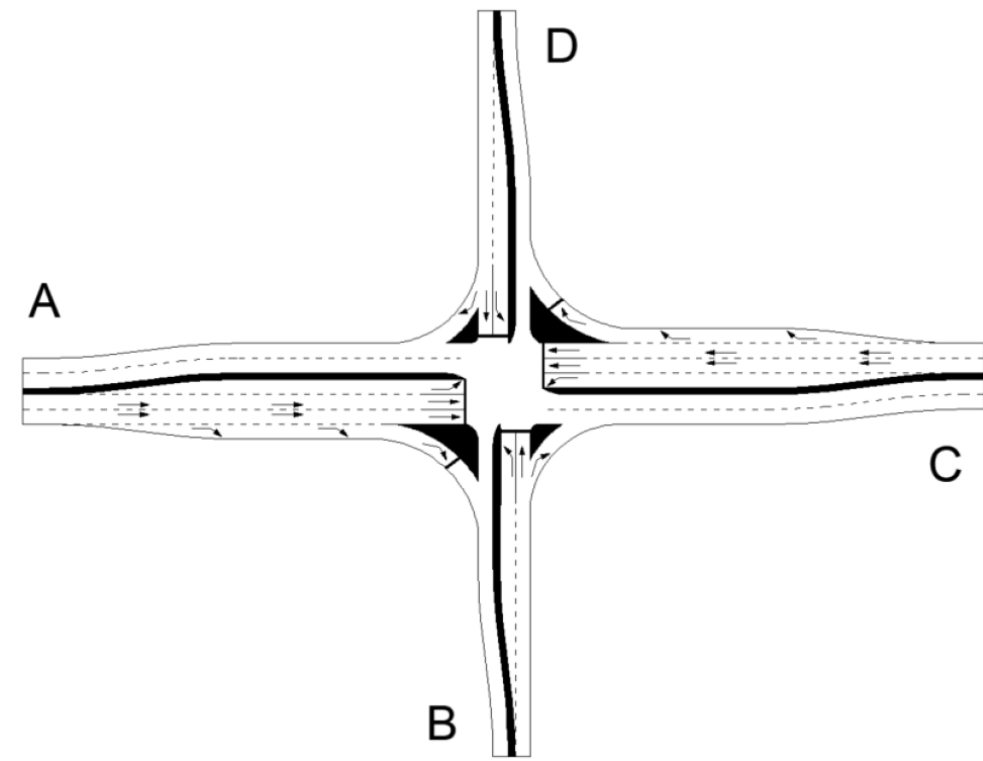
Overview

- Research on 7 types of unconventional intersection
 - 5 types of level intersections (three concepts)
 - 2 type of grade-separated interchange
- **Displaced Left-Turn intersections** – Continuous Flow, Parallel Flow
- **U-turn based intersections** – Superstreet/RCUT, Median U-turn
- **Indirect Left-Turn Intersections** – Bowtie, Jughandle
- **Diamond interchange** – Diverging Diamond Interchange, Median Urban Diamond Interchange



Methodological guidelines

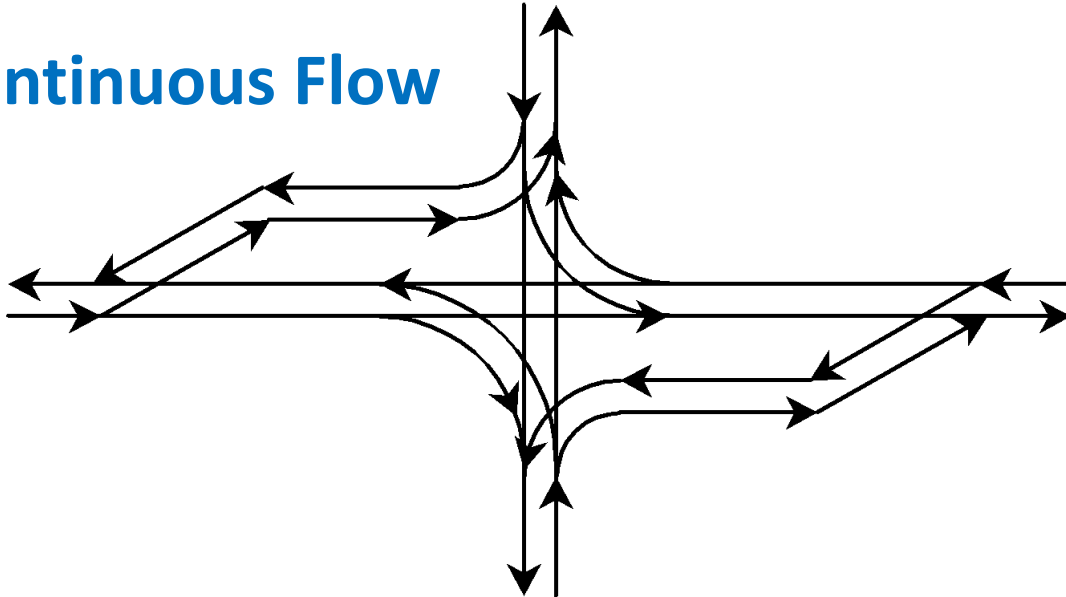
- Default standard four-leg intersection
- Basic layout and dimensions of elements
- Recommended designs of traffic signal control
- Load scenarios based on proportions of left-turning movements.
- Maximum peak hour capacity tested by microsimulation in PTV Vissim.
- Model-based case study in the Czech Republic.



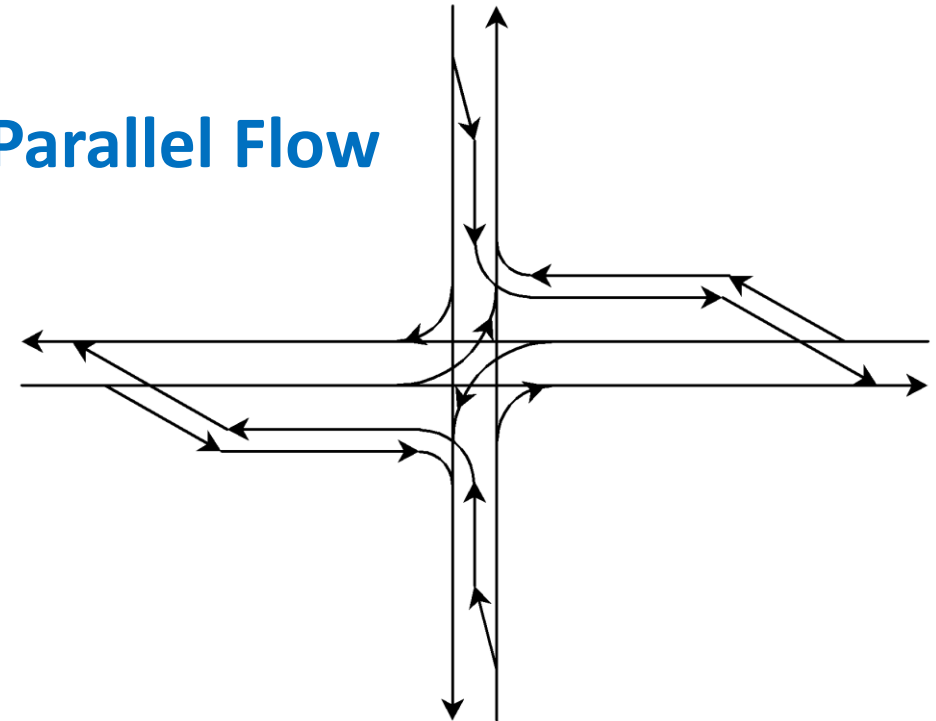
Intersections with Displaced left turn (DLT)

- Displacing left turn behind the oncoming traffic lane
- **Continuous Flow (CF)** – **crossover before the main junction** in the secondary node
- **Parallel Flow (PF)** – **crossover behind the main junction** in the secondary node
- **Higher capacity** – left turns run without conflicting with through traffic
- Most suitable for **high left-turn demand** from major resp. minor road

Continuous Flow



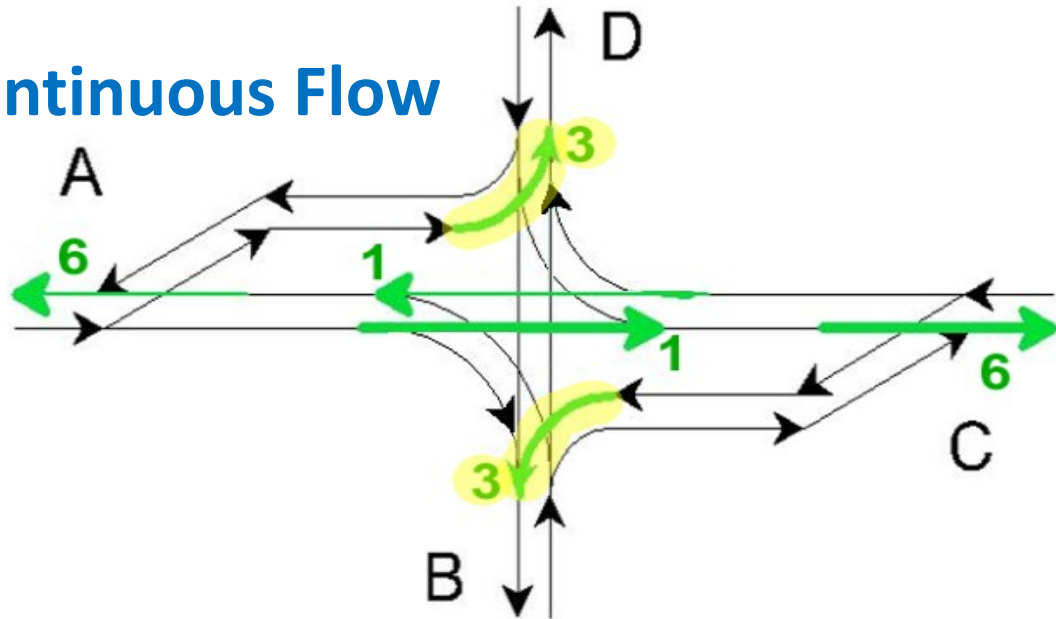
Parallel Flow



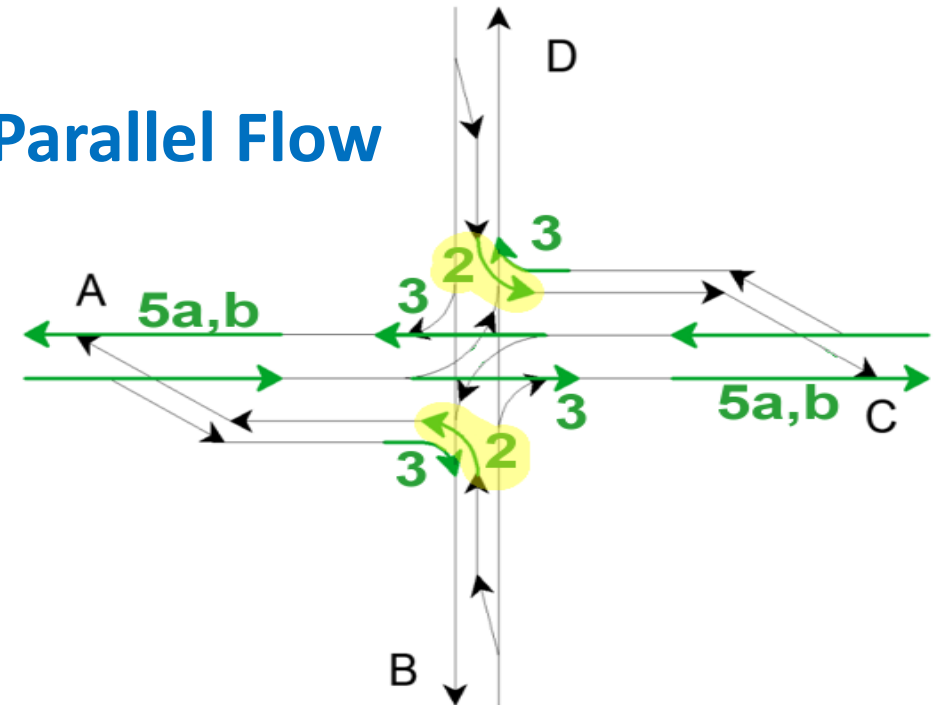
Intersections with Displaced left turn (DLT)

- Displacing left turn behind the oncoming traffic lane
- **Continuous Flow (CF)** – crossover before the main junction in the secondary node
- **Parallel Flow (PF)** – crossover behind the main junction in the secondary node
- **Higher capacity** – left turns run without conflicting with through traffic
- Most suitable for **high left-turn demand** from major resp. minor road

Continuous Flow

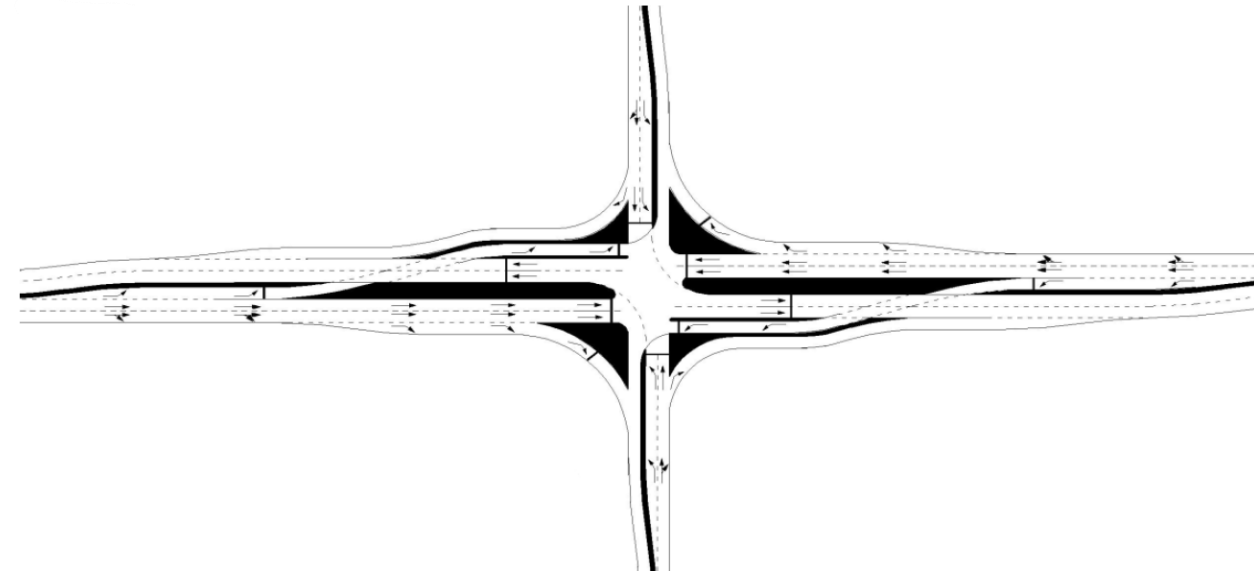


Parallel Flow

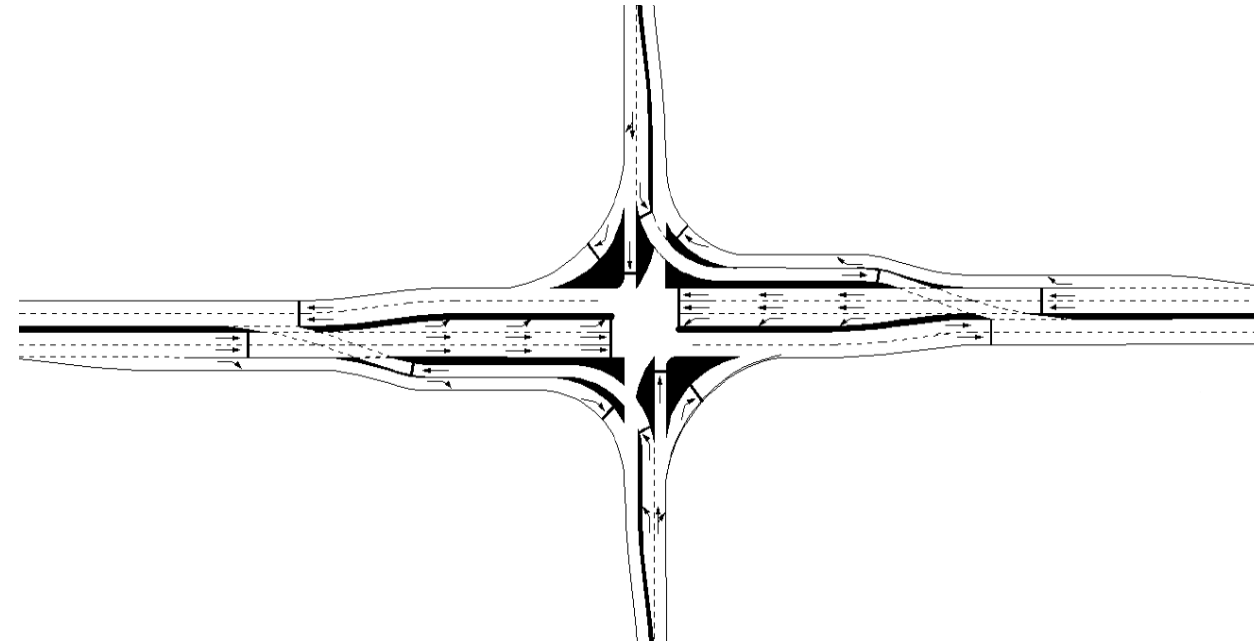


Intersections with Displaced left turn (DLT)

Continuous Flow

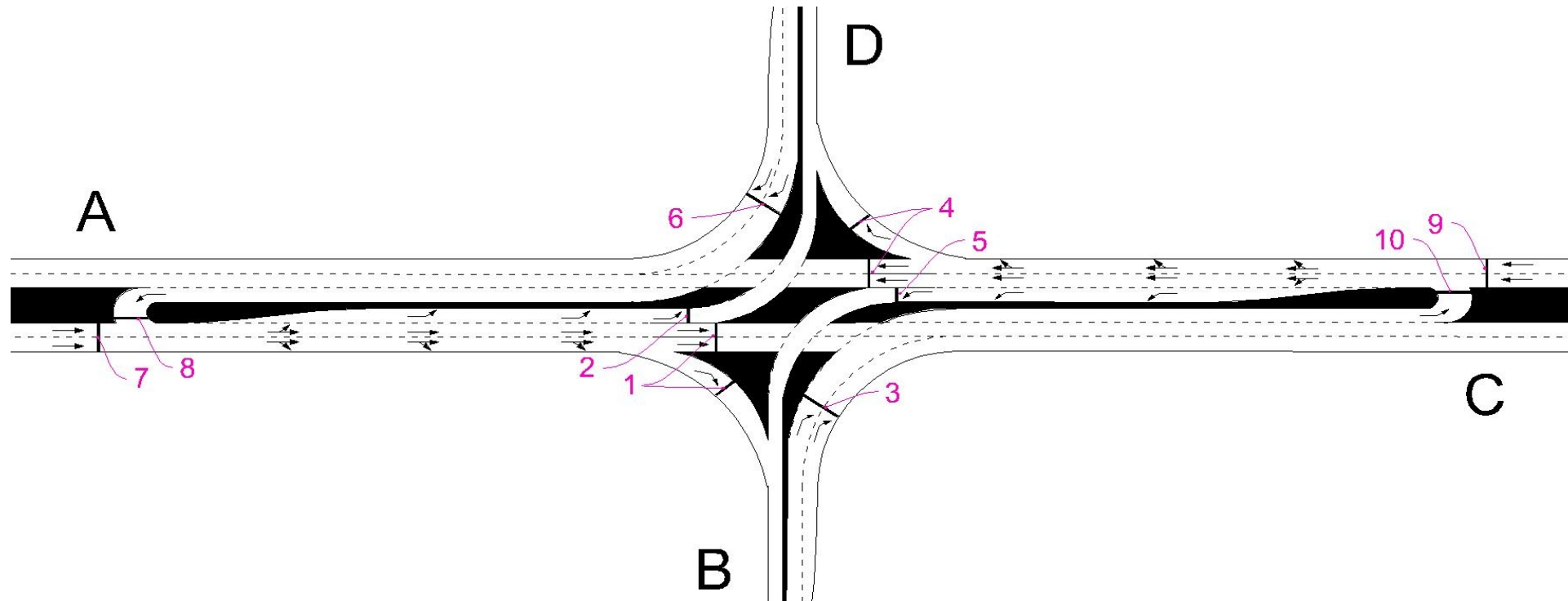


Parallel Flow



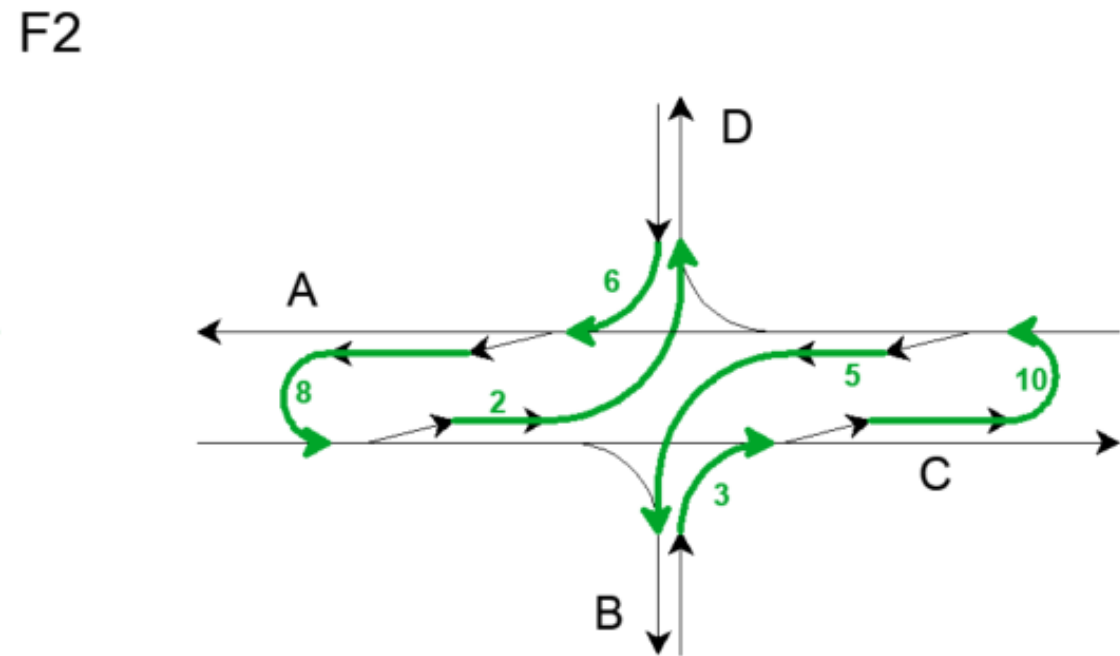
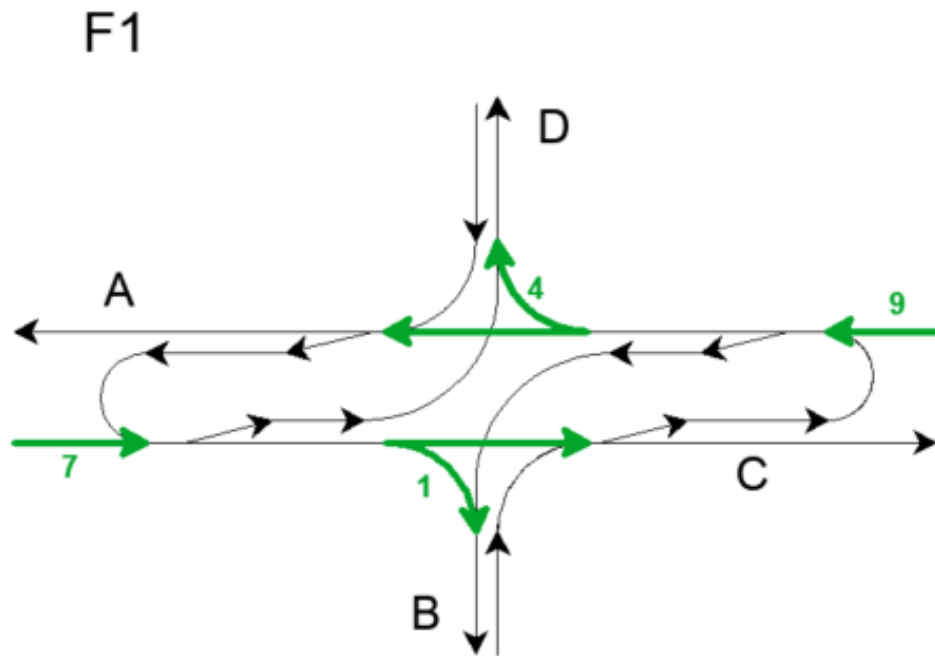
Superstreet intersection (SS) or restricted crossing U-turn (RCUT)

- **Elimination of through and left-turn movements** from the minor road replaced by a right turn followed by a signalized median U-turn
- Suitable for **high through and left-turn demand on the major road** and **lower demand from the minor road**



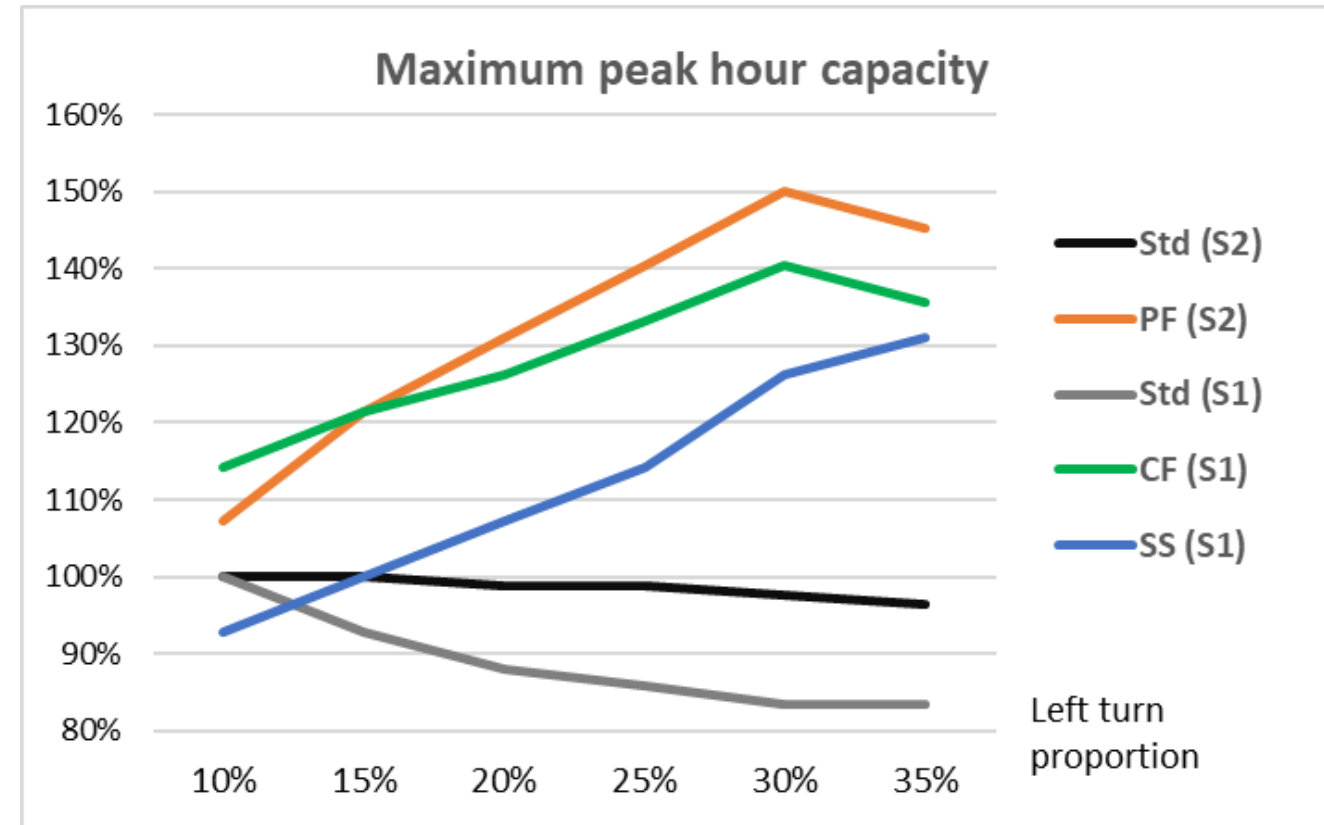
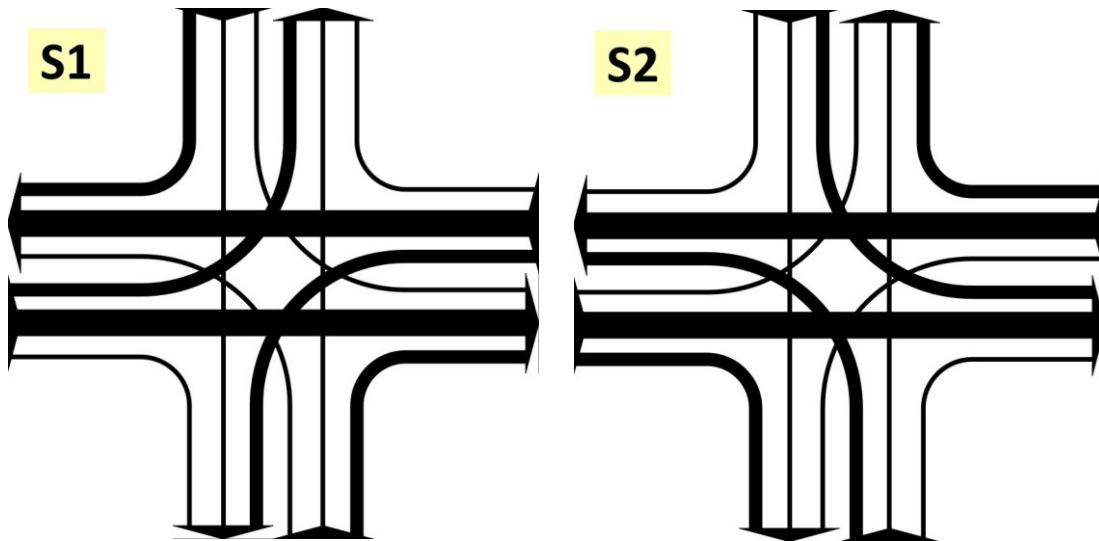
Superstreet intersection (SS) or restricted crossing U-turn (RCUT)

- Suitable for **high through and left-turn demand on the major road** and **lower demand from the minor road**
- **Higher capacity** – effective two signal phases



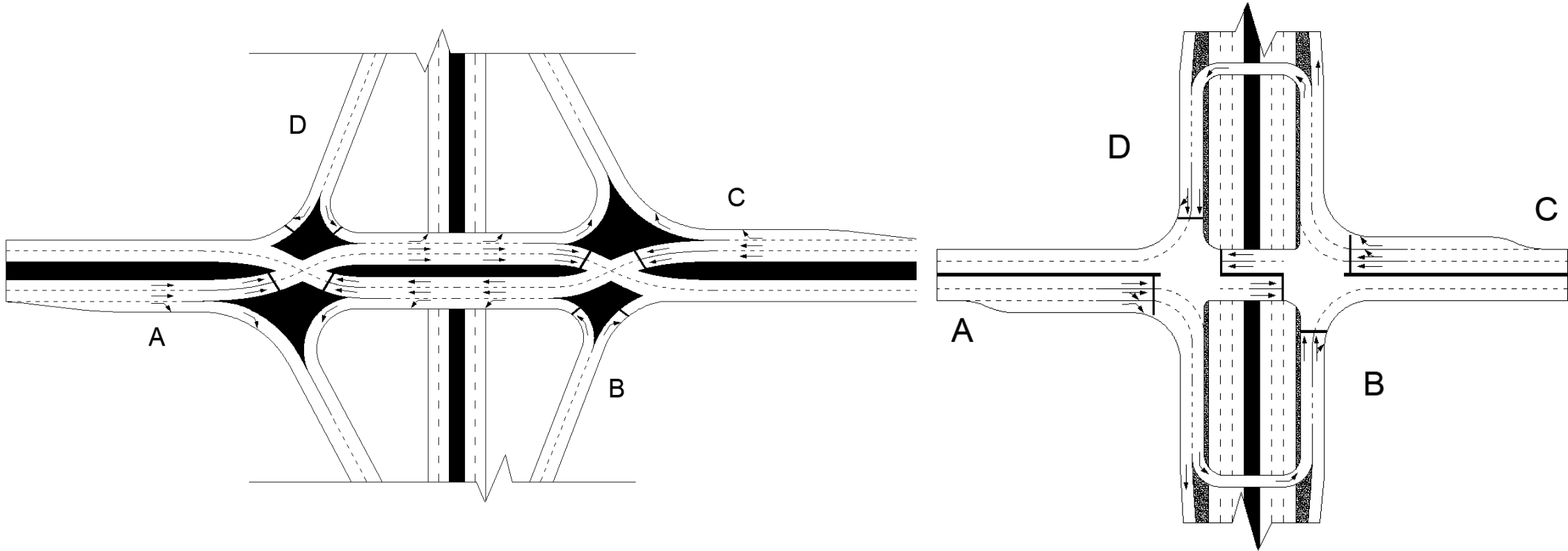
CF + PF + SS – Overall capacity

- Scenarios with an increasing share of left-turn traffic on the main road up to 35%
- (S1) Left turns from the major road – **Continuous Flow** and **Superstreet**
- (S2) Left turns from the minor to major road – **Parallel Flow**



Diamond grade-separated intersections – DDI + MUDI

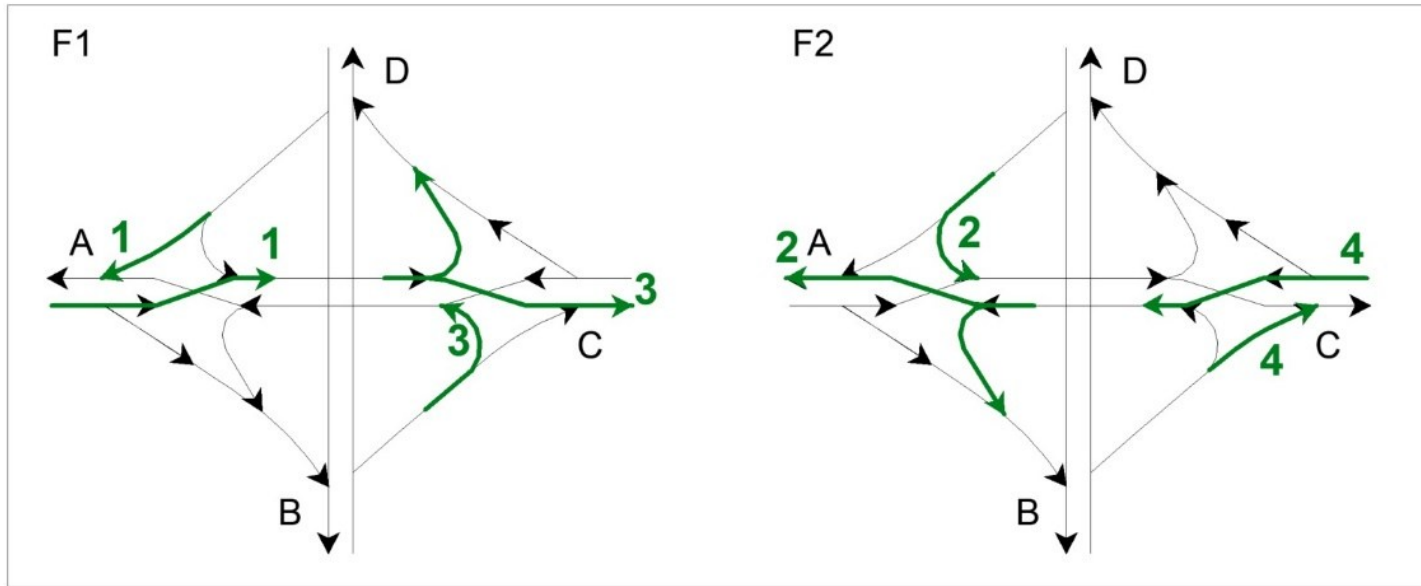
- Displacing left turn behind the oncoming traffic lane
- **Diverging Diamond Interchange (DDI)** – double crossover of through traffic
- **Median Urban Diamond Interchange (MUDI)** – Indirect left-turn movement



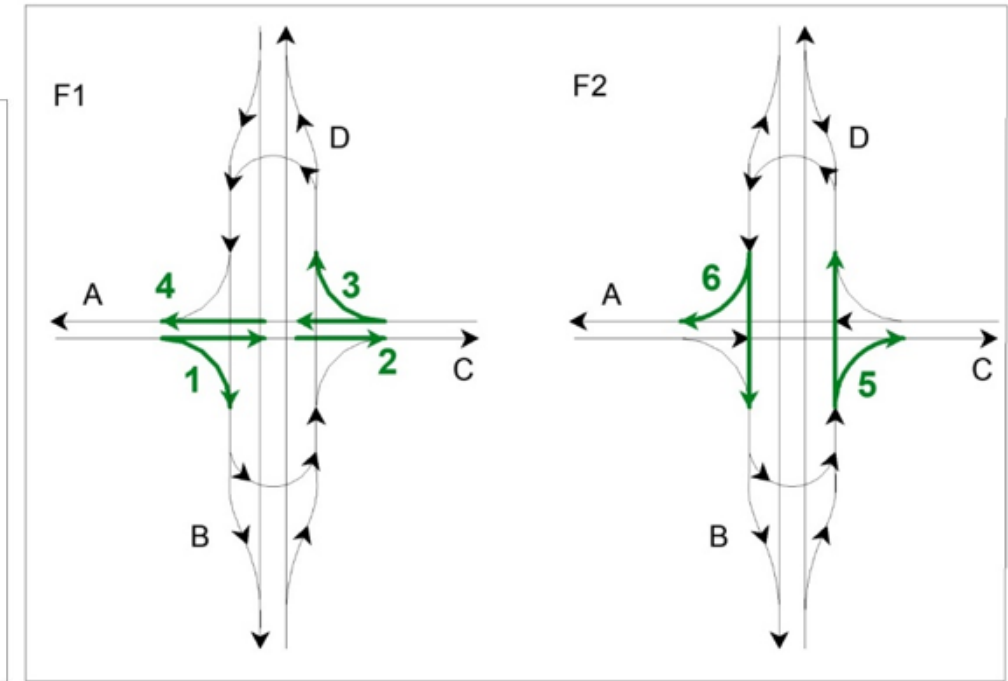
Diamond grade-separated intersections – DDI + MUDI

- Effective two signal phases
- DDI – suitable for high left-turn demand with lower through traffic
- MUDI – suitable for low left-turn demand with high through traffic

DDI

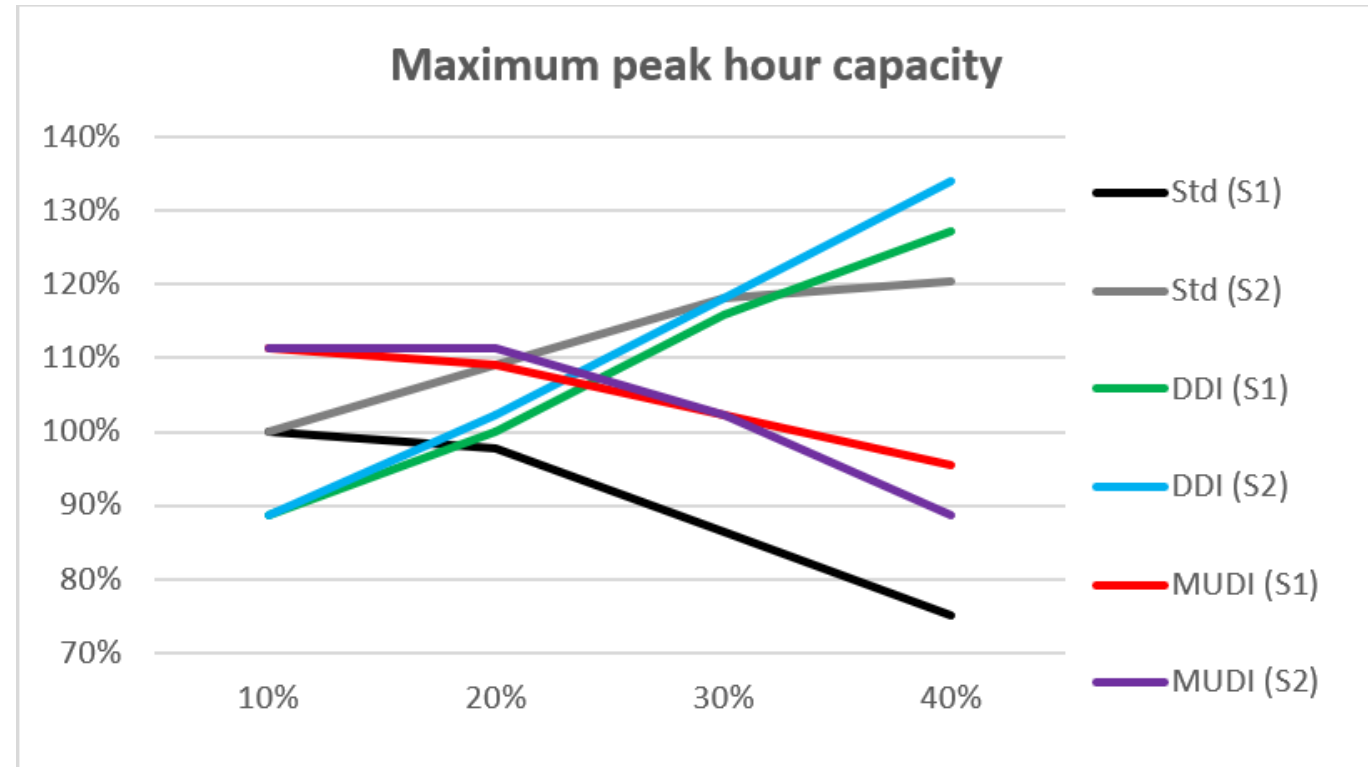
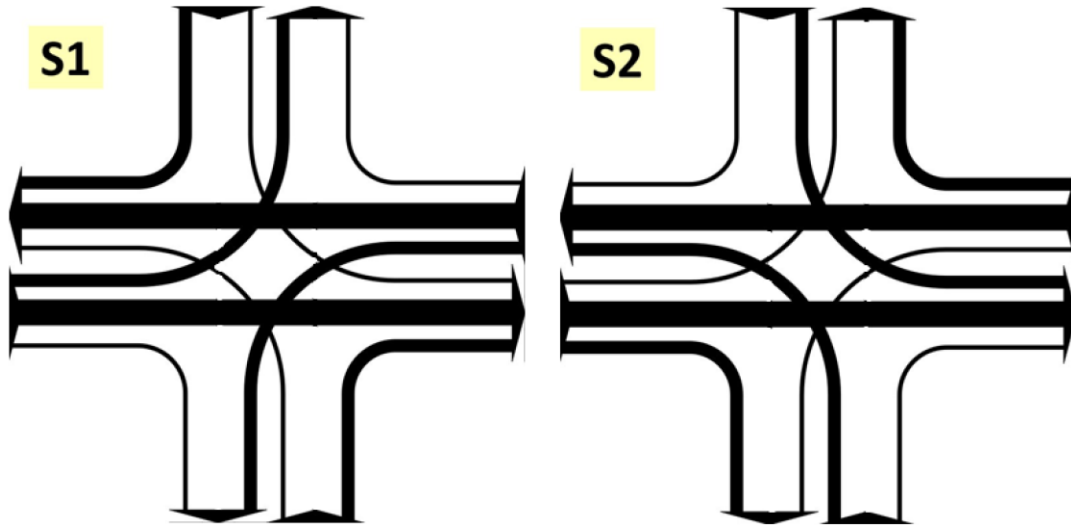


MUDI



DDI + MUDI – Overall capacity

- Scenarios with an increasing share of left-turn traffic on the main road up to 40%
- (S1) Left turns from the major road + opposite right turns
- (S2) Left turns from the interchange ramp + opposite right turns



Model-based Case study

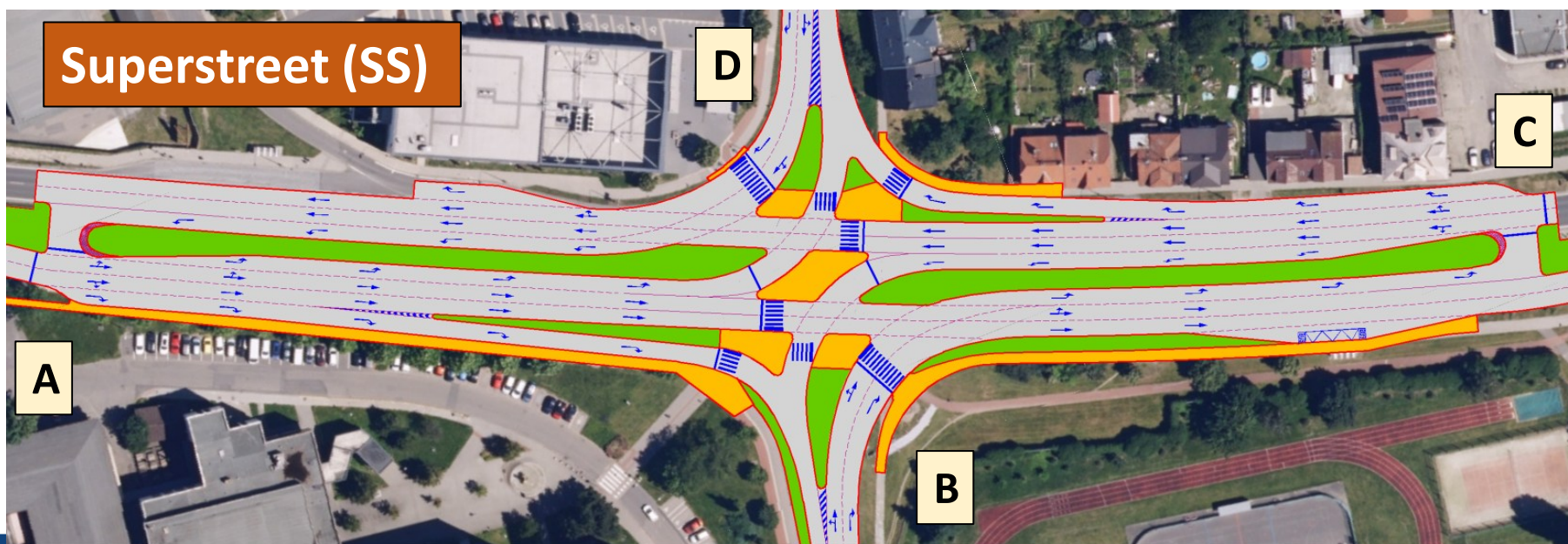
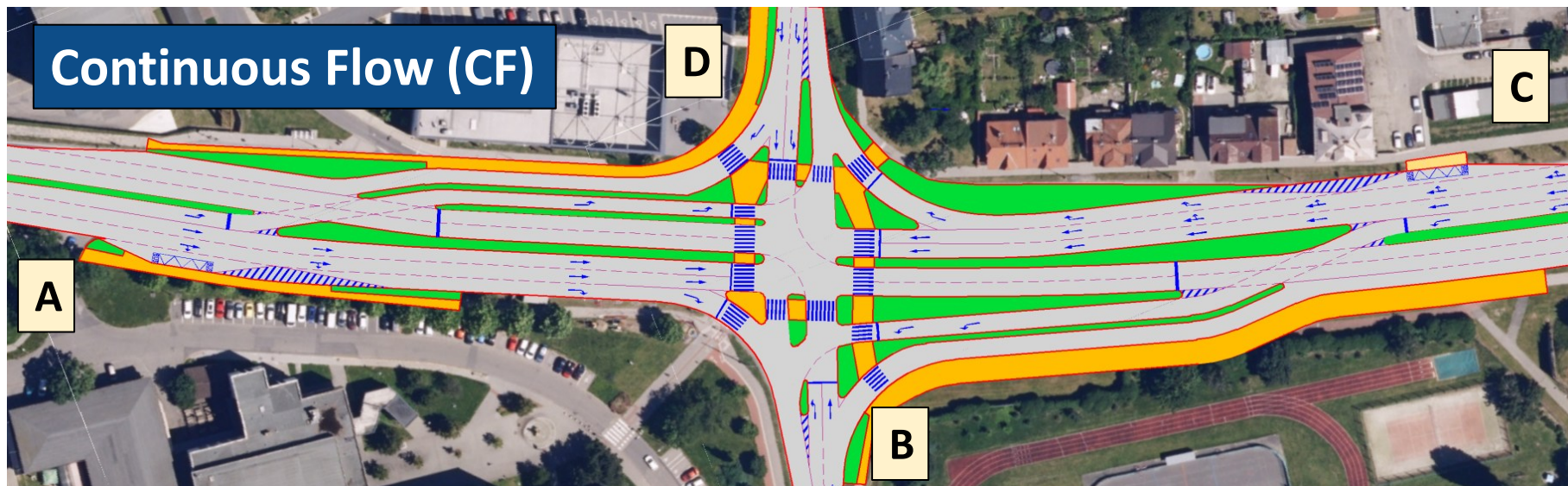
- Six studied intersections in urban areas
- Real data collections
- Proposed redesign within the existing layout
- Calibrated microsimulation in PTV Vissim + capacity assessment
 - Current state (CS)
 - Proposed unconventional modification
- Emission dispersion modeling – line and intersection sources

Case study – Olomouc

- **Current state** – congested signalized 4-leg intersection of national road with the local road



Case study – Olomouc

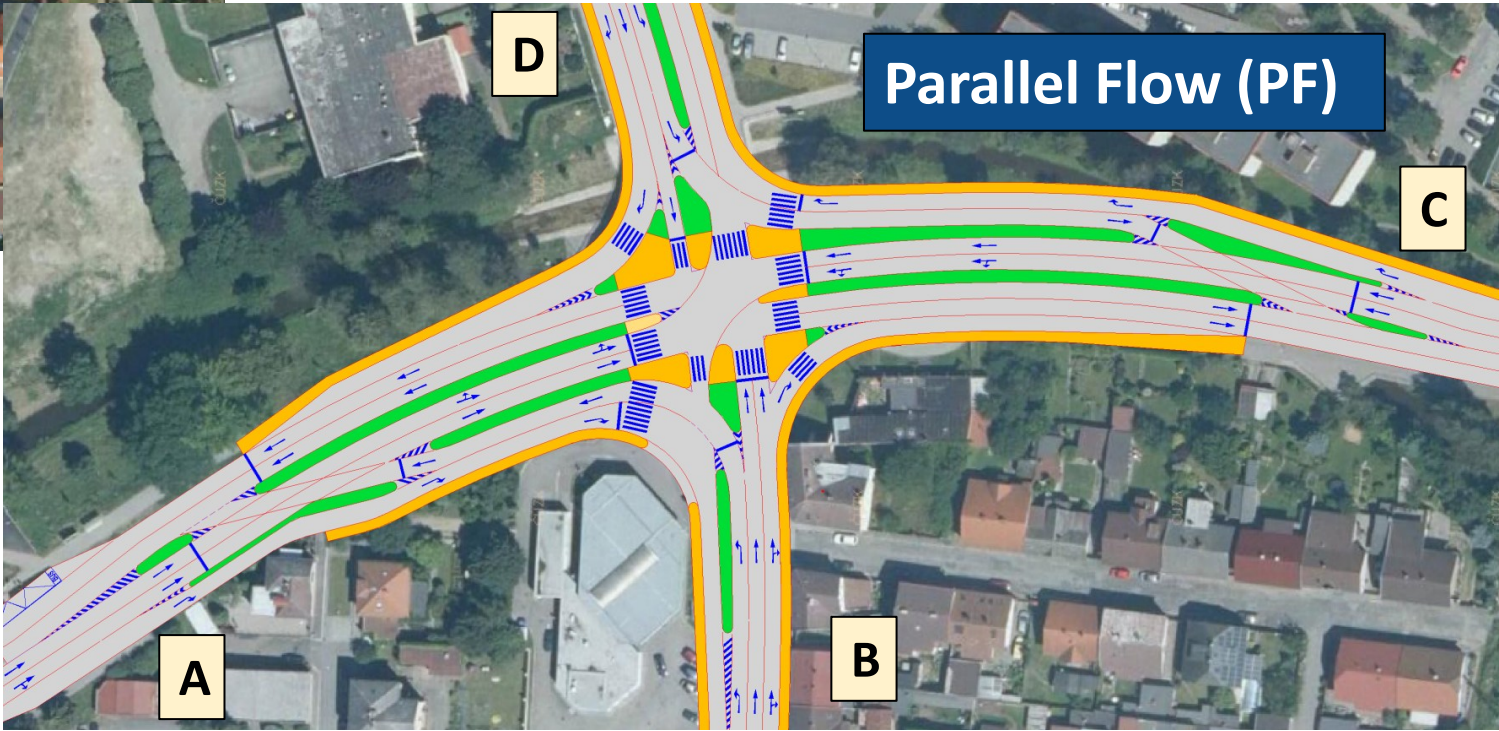
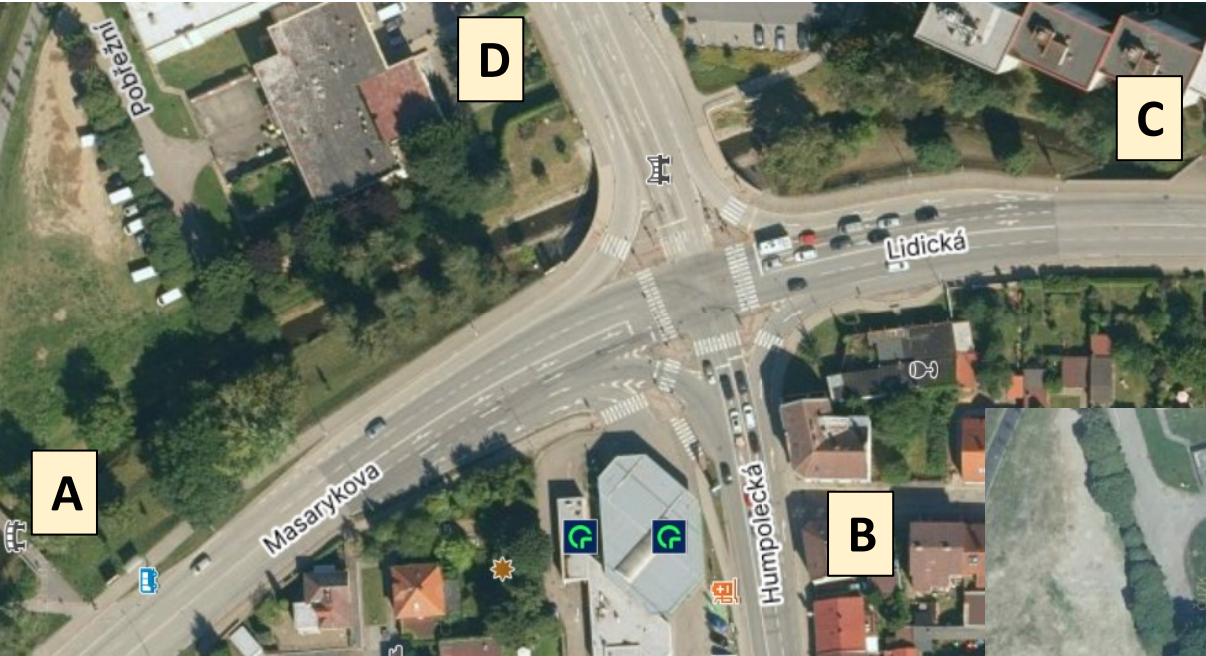


Case study – Olomouc

Comparison of emission	Line source [g/h]			Intersection source [g/h]			Total [g/h]			Comparison [%]	
Intersection modification	CS	CF	SS	CS	CF	SS	CS	CF	SS	CS→ CF	CS→ SS
NOx	1640,8	1267,1	1480,7	1066,7	415,0	434,3	2707,4	1682,0	1915,0	-38%	-29%
NO2	252,8	188,7	223,4	99,2	38,5	40,4	352,0	227,2	263,8	-35%	-25%
CO	3114,5	2075,8	2439,4	2037,6	741,8	589,5	5152,1	2817,6	3028,9	-45%	-41%
Benzene	29,3	19,2	23,3	10,7	4,2	4,0	40,0	23,4	27,3	-42%	-32%
B(a)P	0,017	0,015	0,018	0,001	0,001	0,001	0,019	0,016	0,018	-15%	-3%
PM10	181,8	148,2	171,2	14,2	5,7	5,5	196,0	153,9	176,7	-21%	-10%
PM2.5	127,4	102,6	117,8	11,9	4,7	4,6	139,3	107,4	122,5	-23%	-12%

Capacity assesment		Average Queue Length [m]			Average Delay [s]			LOS		
Approach		CS	CF	SS	CS	CF	SS	CS	CF	SS
A	Left	77	7	6	78	43	31	E	C	B
	Through	97	21	41	34	16	40	B	A	C
	Right	51	12	7	18	26	35	A	B	B
B	Left	22	23	20	51	53	44	D	D	C
	Through	24	22	20	45	31	39	C	B	C
	Right	24	1	20	26	10	21	B	A	B
C	Left	259	7	4	118	45	49	E	C	C
	Through	266	97	11	82	32	42	E	B	C
	Right	1	21	2	19	35	37	A	B	C
D	Left	73	5	12	95	28	49	E	B	C
	Through	98	9	12	103	23	48	E	B	C
	Right	96	1	12	97	8	26	E	A	B

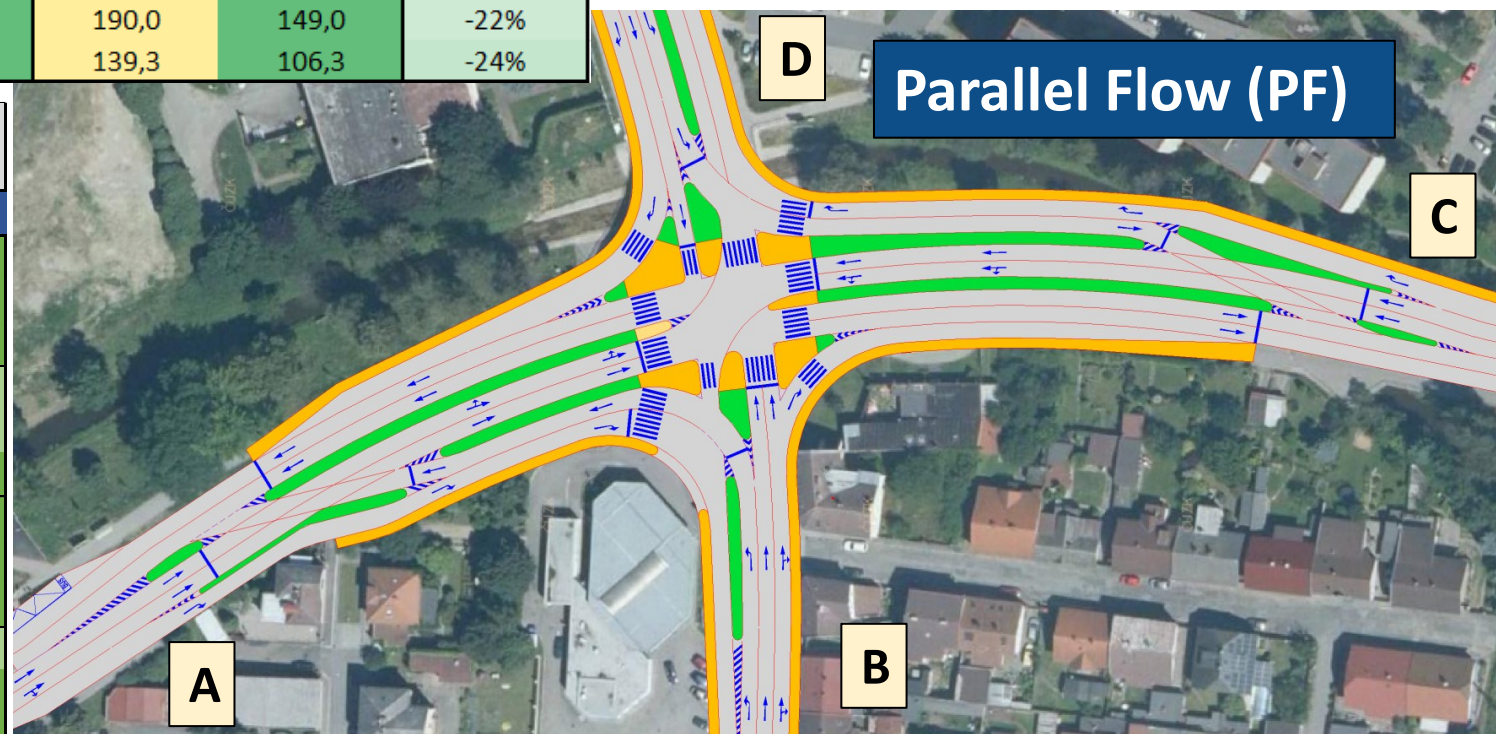
Case study – Havlickuv Brod



Case study – Havlickuv Brod

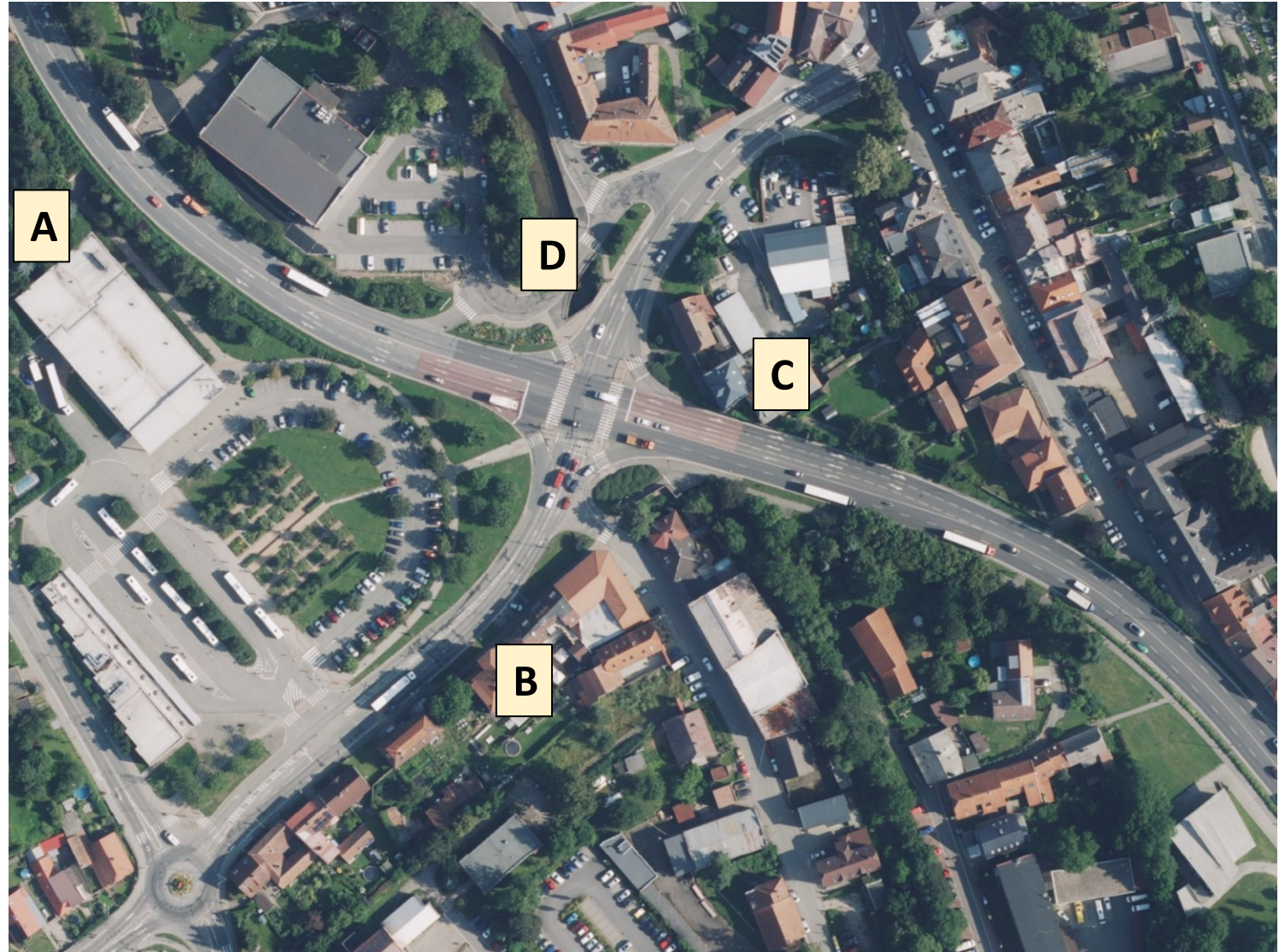
Comparison of emission	Line source [g/h]		Intersection source [g/h]		Total [g/h]		Comparison [%]
Intersection modification	CS	PF	CS	PF	CS	PF	CS → PF
NOx	1378,9	1096,7	1022,2	233,3	2401,1	1330,0	-45%
NO2	211,8	160,7	98,0	22,3	309,8	183,0	-41%
CO	2366,6	1714,2	779,2	204,3	3145,8	1918,5	-39%
Benzen	17,5	13,0	2,9	1,0	20,5	14,0	-32%
B(a)P	0,013	0,013	0,001	0,000	0,015	0,013	-11%
PM10	175,7	145,9	14,3	3,1	190,0	149,0	-22%
PM2.5	127,3	103,7	12,0	2,6	139,3	106,3	-24%

Capacity assesment		Average Queue Length [m]		Average Delay [s]		LOS	
Approach		CS	PF	CS	PF	CS	PF
A	Left	39	1	66	17	D	A
	Through	39	1	66	12	D	A
	Right	10	0	29	0	B	A
B	Left	38	1	77	31	E	B
	Through	55	6	94	19	E	B
	Right	0	0	6	8	A	A
C	Left	41	2	48	15	C	A
	Through	41	2	47	13	C	A
	Right	24	0	17	2	A	A
D	Left	45	2	76	34	E	B
	Through	45	4	77	18	E	A
	Right	0	2	14	8	A	A

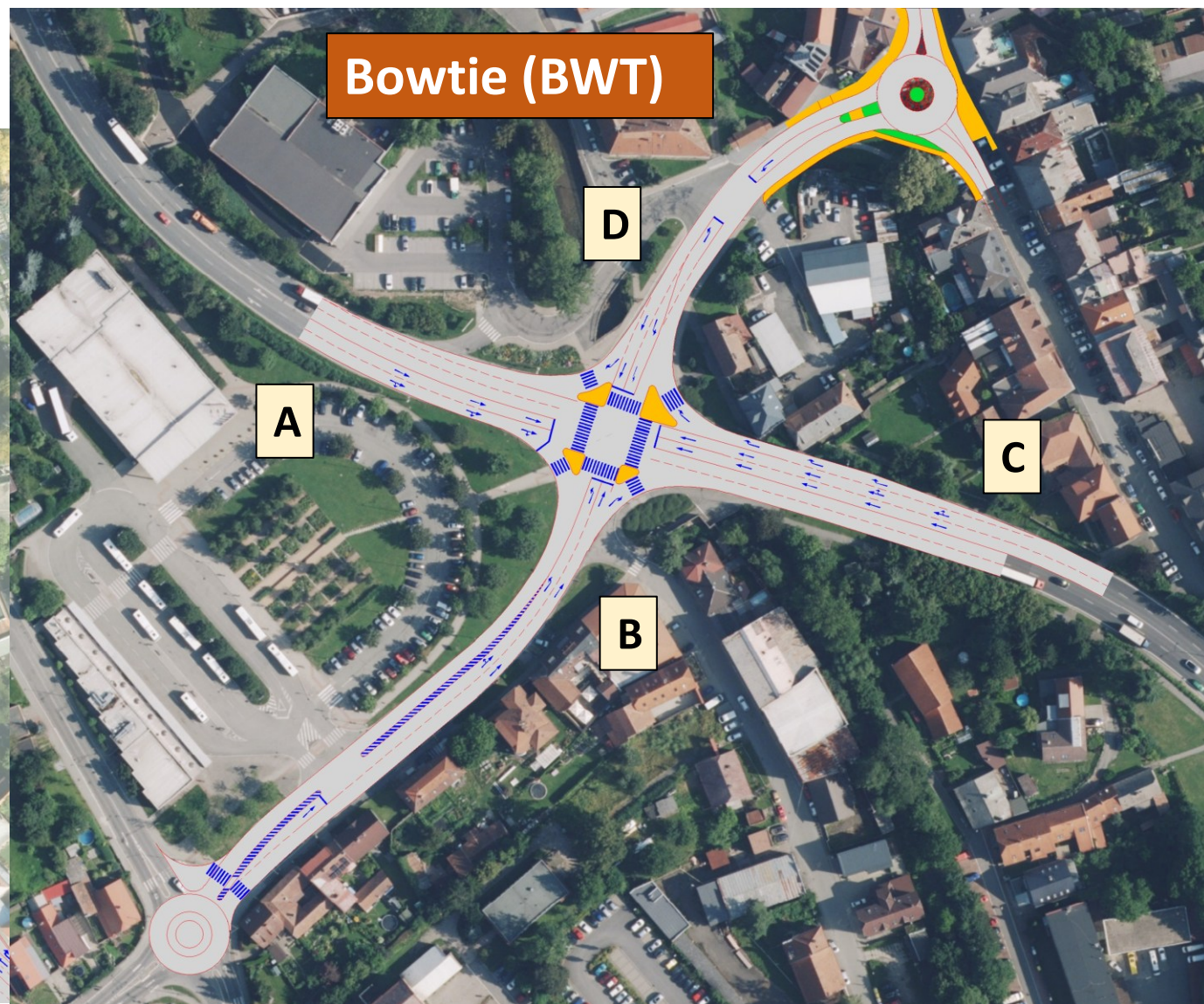
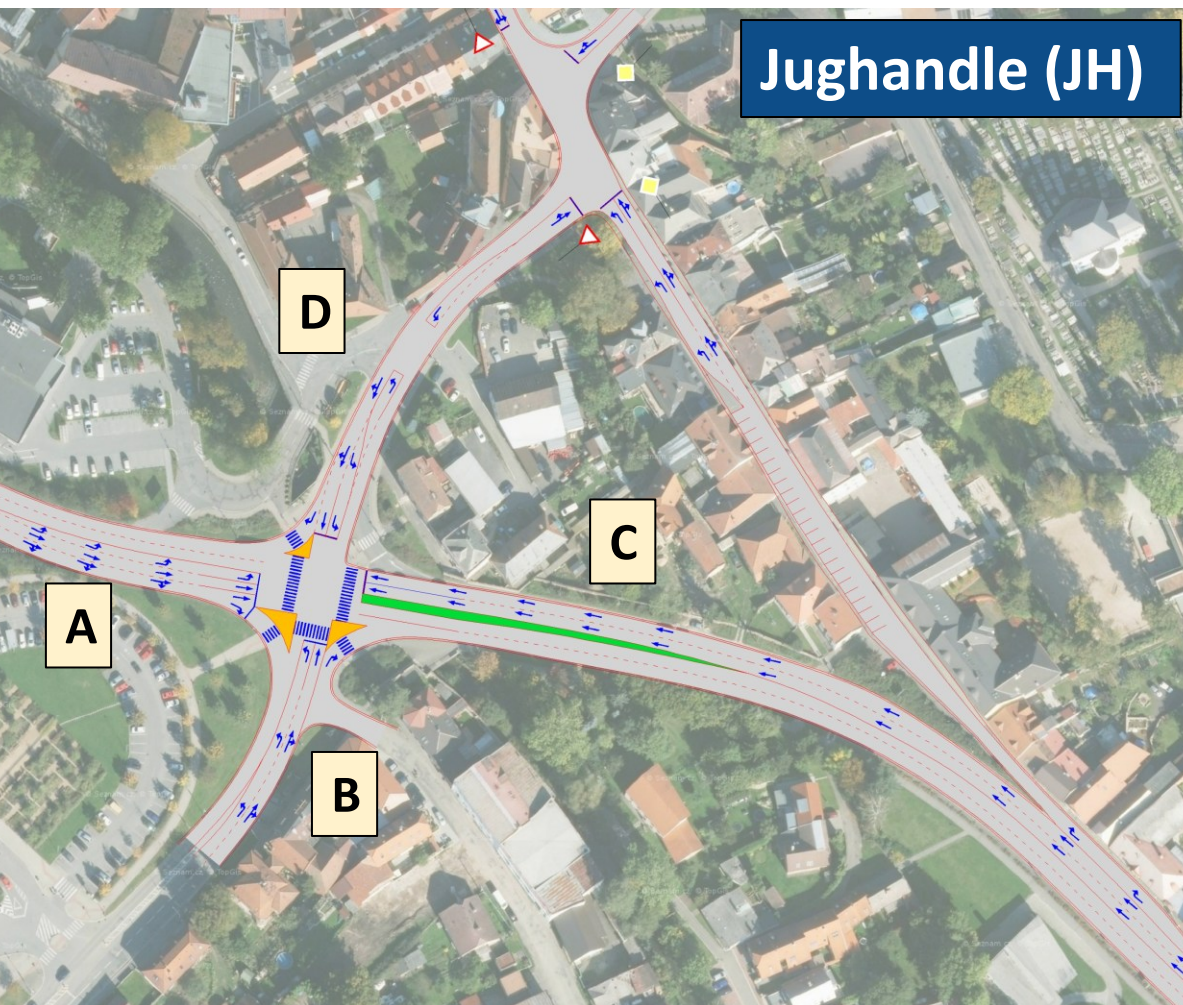


Case study – Litomyšl

- **Current state** – congested signalized 4-leg intersection of national road with the local road



Case study – Litomyšl



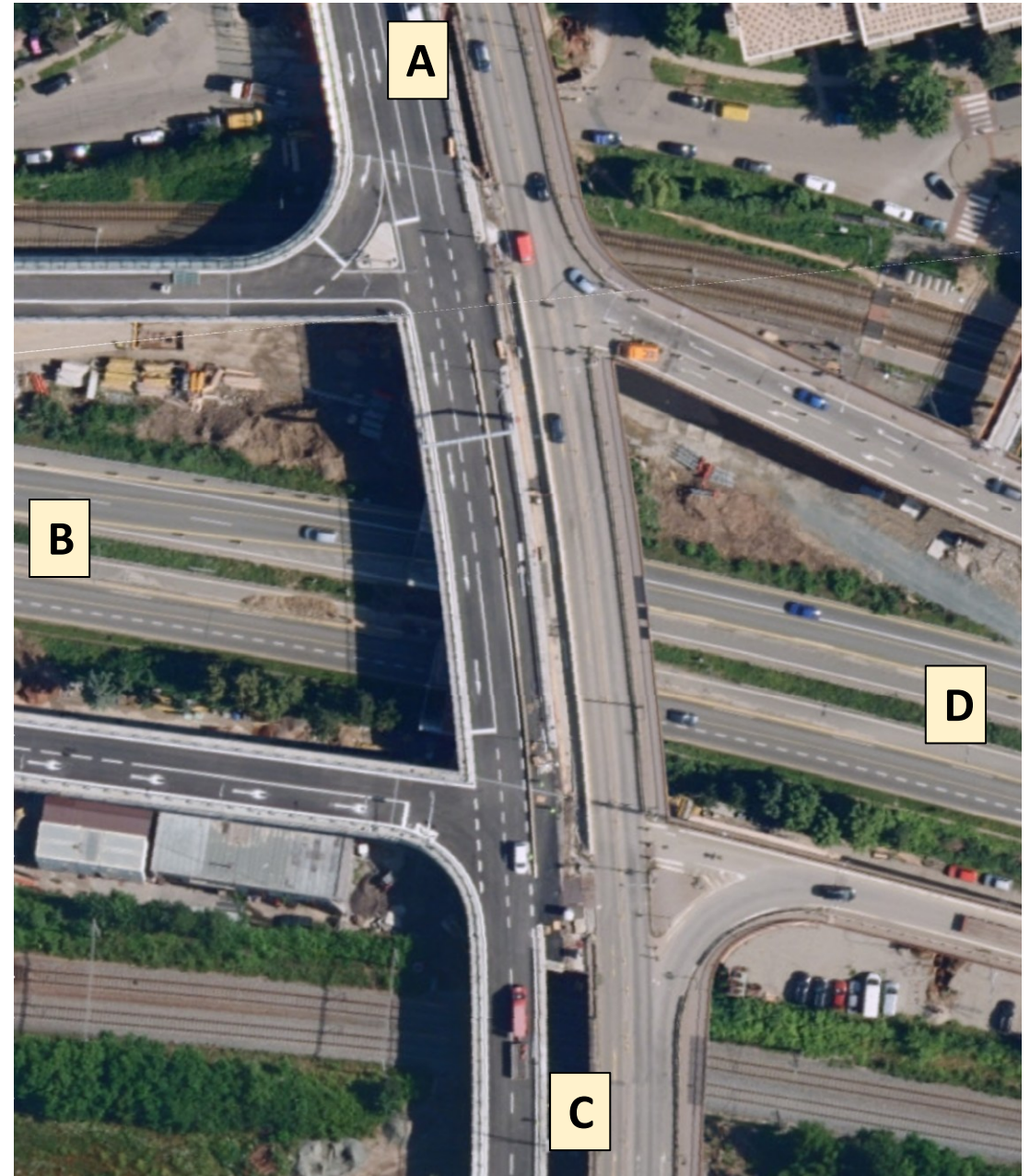
Case study – Litomyšl

Comparison of emission	Line source [g/h]			Intersection source [g/h]			Total [g/h]			Comparison [%]	
Intersection modification	CS	JH	BWT	CS	JH	BWT	CS	JH	BWT	CS→ JH	CS→ BWT
NO _x	2105,5	1929,4	1984,0	728,9	564,4	510,1	2834,4	2493,8	2494,1	-12%	-12%
NO ₂	280,9	257,8	264,8	68,6	53,1	48,0	349,6	310,9	312,8	-11%	-11%
CO	3330,5	3026,1	3150,6	701,3	524,2	507,5	4031,8	3550,2	3658,1	-12%	-9%
Benzene	23,9	21,9	22,4	2,8	2,3	2,2	26,7	24,2	24,6	-9%	-8%
B(a)P	0,021	0,019	0,019	0,001	0,001	0,001	0,022	0,020	0,020	-8%	-8%
PM ₁₀	262,2	240,0	248,2	11,1	8,7	7,8	273,3	248,7	256,1	-9%	-6%
PM _{2.5}	190,0	173,5	180,0	11,4	7,3	6,6	201,4	180,8	186,6	-10%	-7%

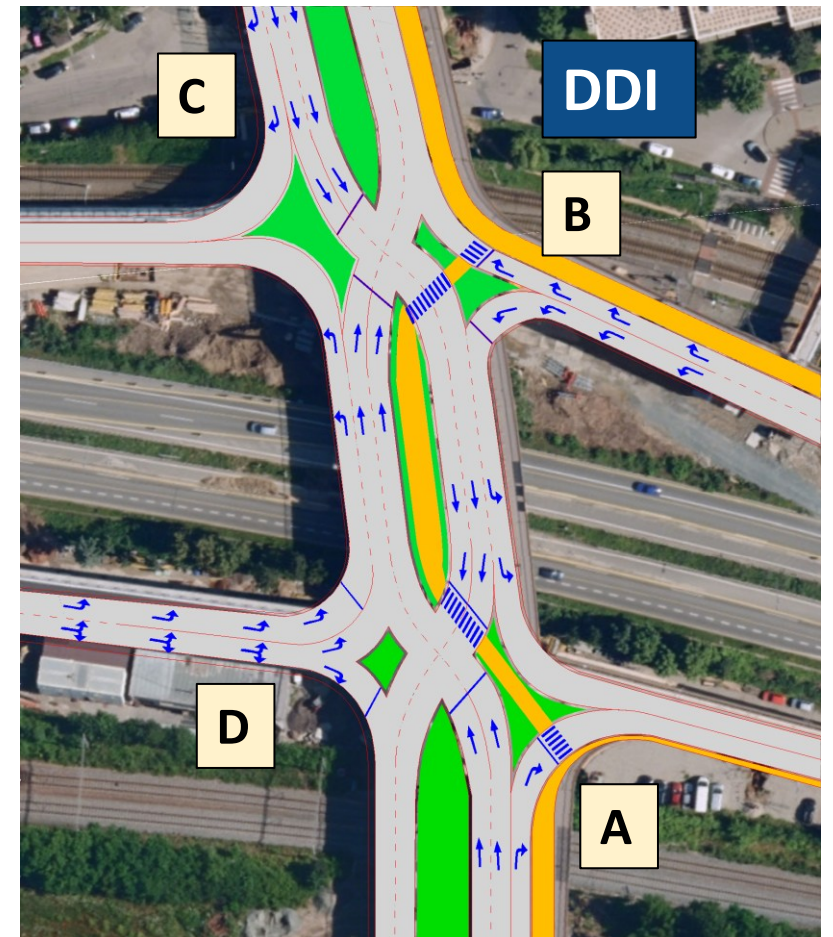
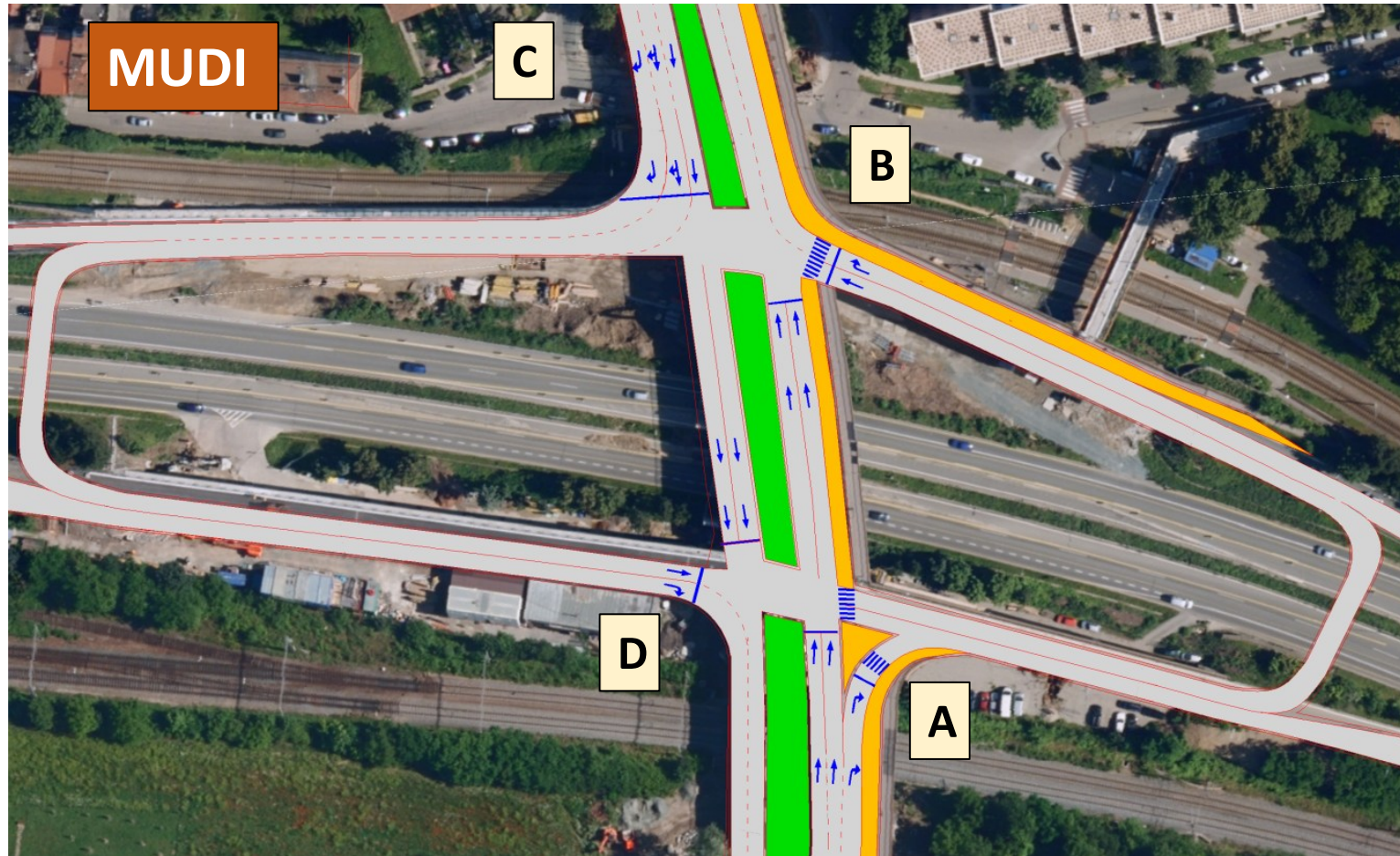
Capacity assesment		Average Queue Length [m]			Average Delay [s]			LOS		
Approach		CS	JH	BWT	CS	JH	BWT	CS	JH	BWT
A	Left	8	6	-	38	49	-	C	C	-
	Through	31	31	29	30	30	28	B	B	B
	Right	30	31	13	31	24	29	B	B	B
B	Left	19	20	15	39	46	27	C	C	B
	Through	20	20	15	30	27	19	B	B	A
	Right	11	13	13	29	28	19	B	B	A
C	Left	60	8	-	108	47	-	E	C	-
	Through	66	25	27	40	29	25	C	B	B
	Right	51	8	25	38	19	30	C	A	B
D	Left	6	5	8	27	26	30	B	B	B
	Through	12	26	18	18	18	23	A	A	B
	Right	11	18	13	17	19	20	A	A	A

Case study – Brno

- **Current state** – congested diamond signalized grade-separated intersection



Case study – Brno



Case study – Brno

Comparison of emission	Line source [g/h]			Intersection source [g/h]			Total [g/h]			Comparison [%]	
Intersection modification	CS	DDI	MUDI	CS	DDI	MUDI	CS	DDI	MUDI	CS→ DDI	CS→ MUDI
NOx	4621,1	3471,5	4625,5	942,2	518,9	400,2	5563,3	3990,4	5025,7	-28%	-10%
NO2	677,1	491,9	670,3	86,8	47,5	36,6	763,9	539,4	706,9	-29%	-7%
CO	7431,1	4841,5	6664,4	1482,6	974,4	740,4	8913,7	5815,9	7404,8	-35%	-17%
Benzen	61,2	40,0	56,8	7,7	4,9	4,1	68,8	44,9	60,9	-35%	-12%
B(a)P	0,046	0,039	0,052	0,002	0,001	0,001	0,048	0,041	0,053	-15%	11%
PM10	551,5	406,7	562,7	17,6	9,4	7,3	569,1	416,1	569,9	-27%	0%
PM2.5	402,1	296,8	402,8	11,4	7,9	6,1	413,6	304,7	408,9	-26%	-1%

Capacity assesment		Average Queue Length [m]			Average Delay [s]			LOS		
Approach		CS	DDI	MUDI	CS	DDI	MUDI	CS	DDI	MUDI
A	Left	91	34	8	115	41	23	E	C	B
	Through	91	34	13	115	44	16	E	C	A
	Right	85	23	8	71	3	13	E	A	A
B	Left	19	1	21	17	7	42	A	A	C
	Right	19	15	21	15	14	22	A	A	B
C	Left	115	89	25	96	49	41	E	C	C
	Through	115	89	59	96	33	15	E	B	A
	Right	114	61	59	6	12	33	A	A	B
D	Left	17	24	6	27	32	47	B	B	C
	Right	19	17	6	28	13	16	B	A	A

Thank you

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