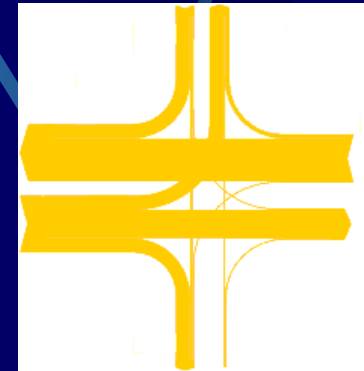
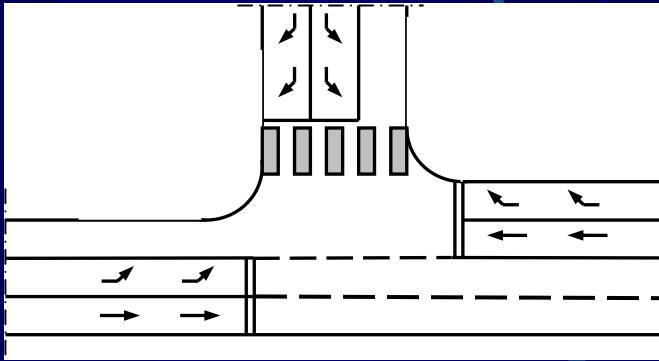


# Junctions, intersections



**Urban Transport 10.**  
**András Gulyás PhD habil**  
**associate professor**

# Content

- **Principles concerning intersections**
- **Urban multi-level interchanges**
- **Types of surface junctions**
- **Traffic conditions of intersections**
- **Traffic planning of signed junctions**
- **Traffic engineering solutions of intersections**
- **Example of re-design of a junction**

# Principles concerning intersections

**Traffic volume and safety demand together determine the type of the junction.**

**In the design of a junction equally must be ensured for vehicles, bicycles and pedestrians:**

- **recognisability,**
- **transparency,**
- **perceptibility,**
- **viability (i.e. widening of curves),**
- **reduction of the number of stops, decelerations and accelerations.**

# Urban multi-level interchanges

## Main reasons for constructing interchanges:

- the road category (high speed road),
- the traffic safety,
- the capacity,
- circumstances (i.e. multi-level crossing of a railway line).

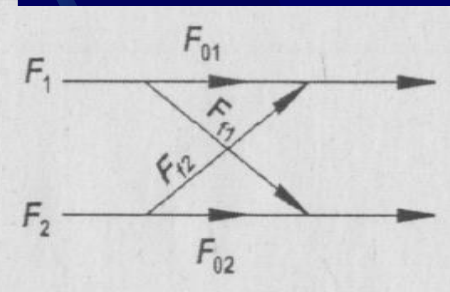
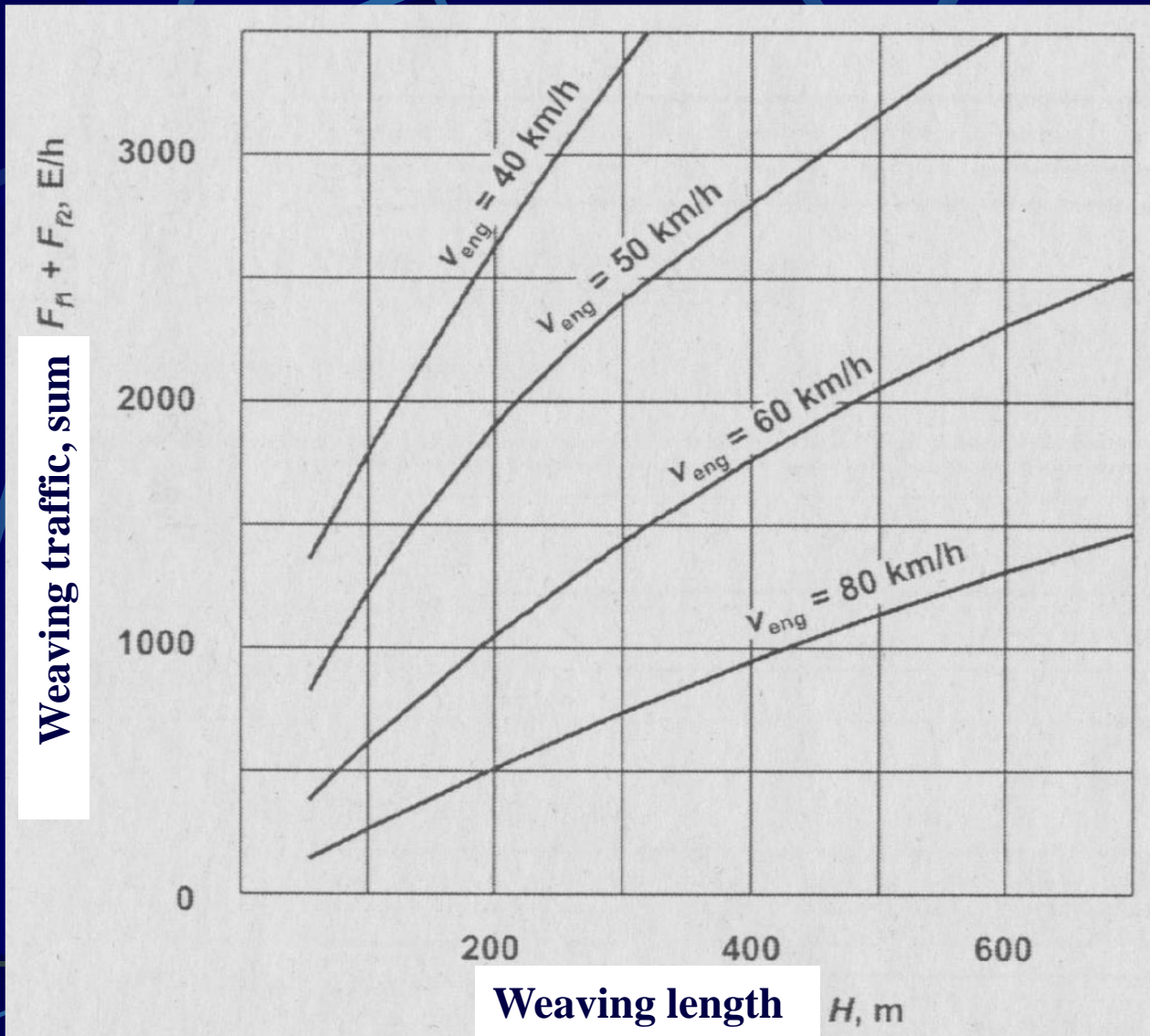
A multi-level interchange may contain surface junction elements, characteristically on not high speed roads.

# Urban multi-level interchanges

## Specialities of urban multi-level interchanges:

- Usually the direction with the largest traffic volume is elevated with some surface junction parts but there are solutions without surface junctions as well.
- Surface junction parts are usually signalised.
- In case of certain local conditions the height of clearance can be reduced but this solution increases the safety risk.
- Weaving sections must be considered with care because of their potential safety problem.

# Urban multi-level interchanges





# Urban multi-level interchanges

**Budapest**

**„BAH”**

**Budaörsi út –**

**Alkotás u. –**

**Hegyalja út**

**one elevated  
direction**





# Urban multi-level interchanges

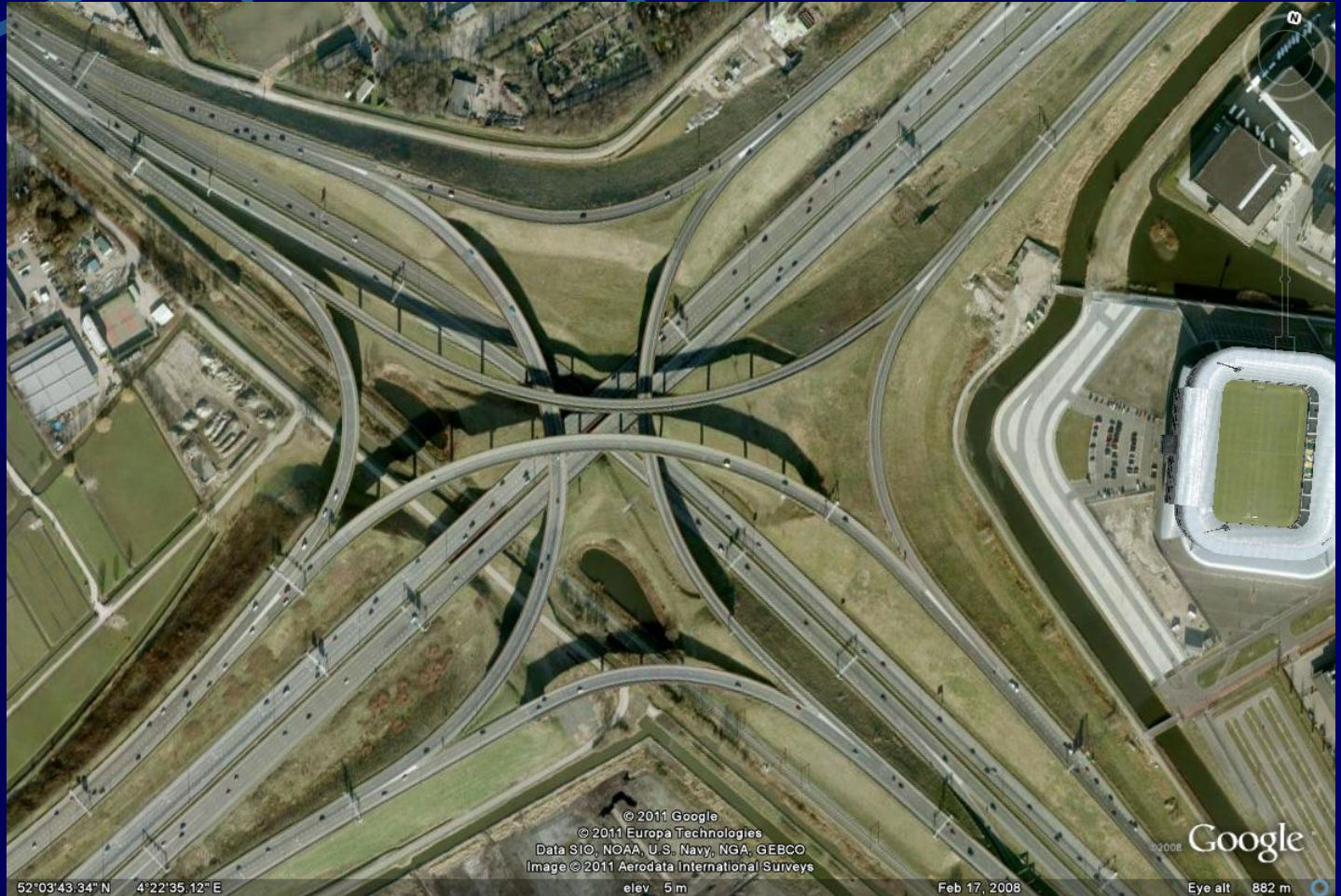
Budapest  
M3 –  
Hungária  
krt.





# Urban multi-level interchanges

The Hague  
4 levels  
„star” type



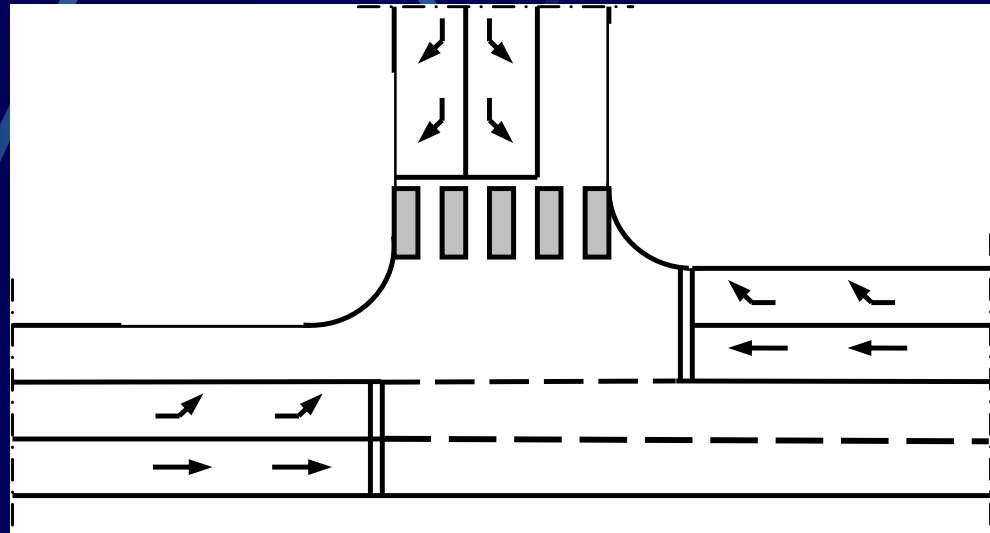
# Types of surface junctions

On a given road section the same type of junctions are recommended.

Priority road (direction) is called „main” while subordinate road (direction) is called „secondary”.

In case of bigger traffic volumes there is a need for a left turning lane on the main road.

In special cases there is need for a right turning lane as well.

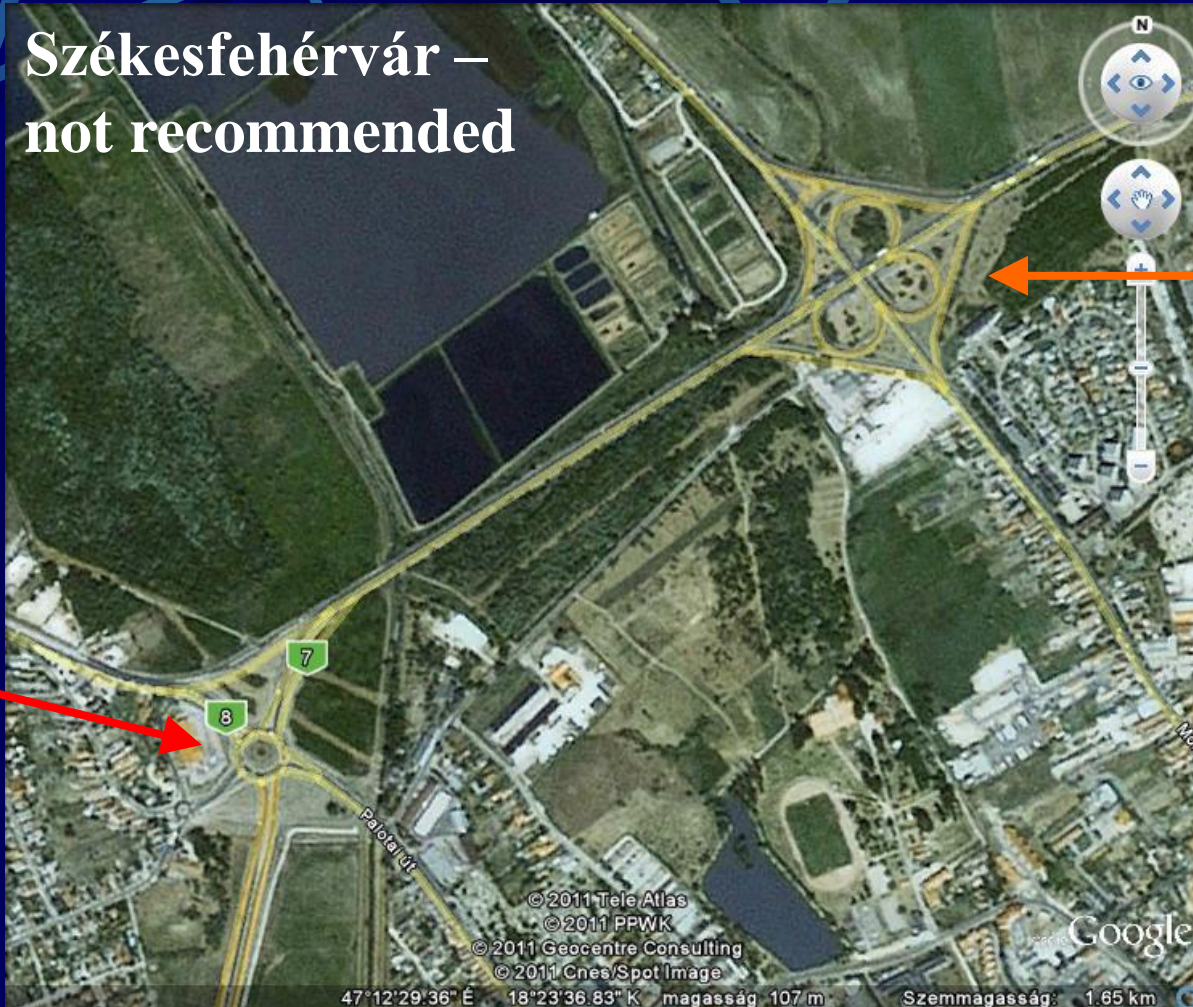




# Types of surface junctions

Székesfehérvár –  
not recommended

Multi-level,  
lower  
volumes



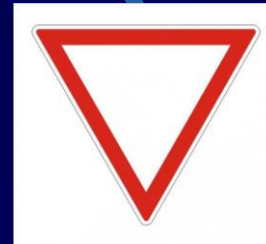
Roundabout,  
higher  
volumes,  
congestion



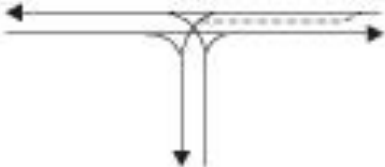
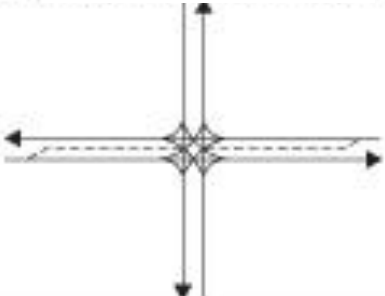
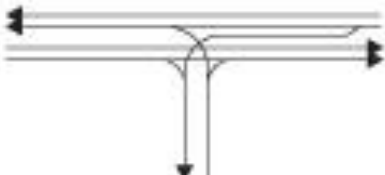
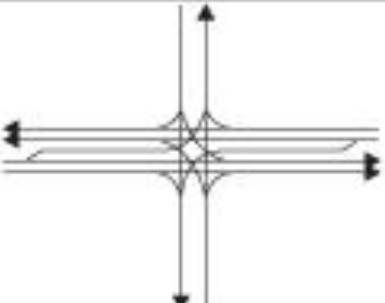
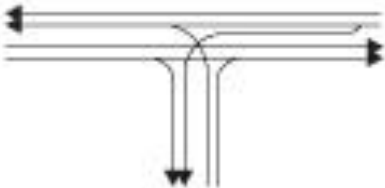
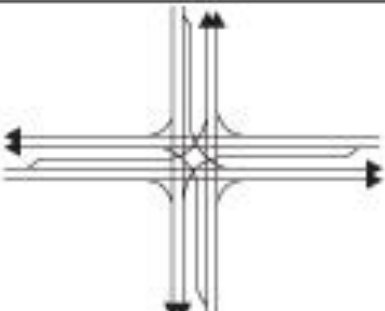
# Types of surface junctions

## Traffic priority solutions at one level junctions:

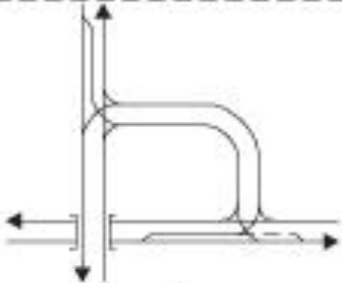

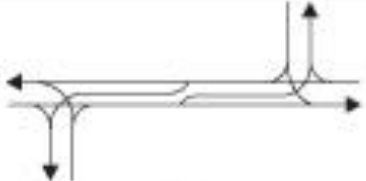
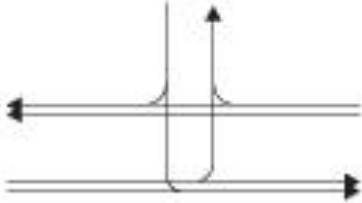
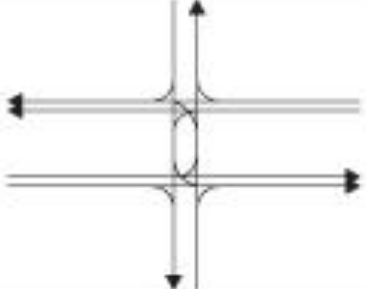
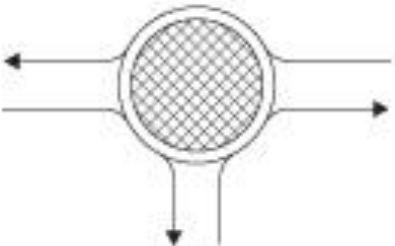
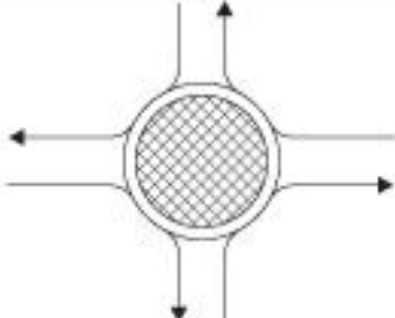
- right hand rule,
- priority yield signs  
(triangle or „STOP”),
- signalised,
- roundabout,
- signalised multi-lanes circle-like geometry.



# Types of surface junctions

Geometry	„T” type	Crossing
I 2 lanes roads		
II 4 lanes main road vs. 2 lanes road		
III 4 lanes main road vs. 4 lanes main road		

# Types of surface junctions

IV	<b>partially multi-level</b>		
V	<b>shifted crossing</b>		
VI	<b>distributed conflict points</b>		
VII	<b>roundabout</b>		



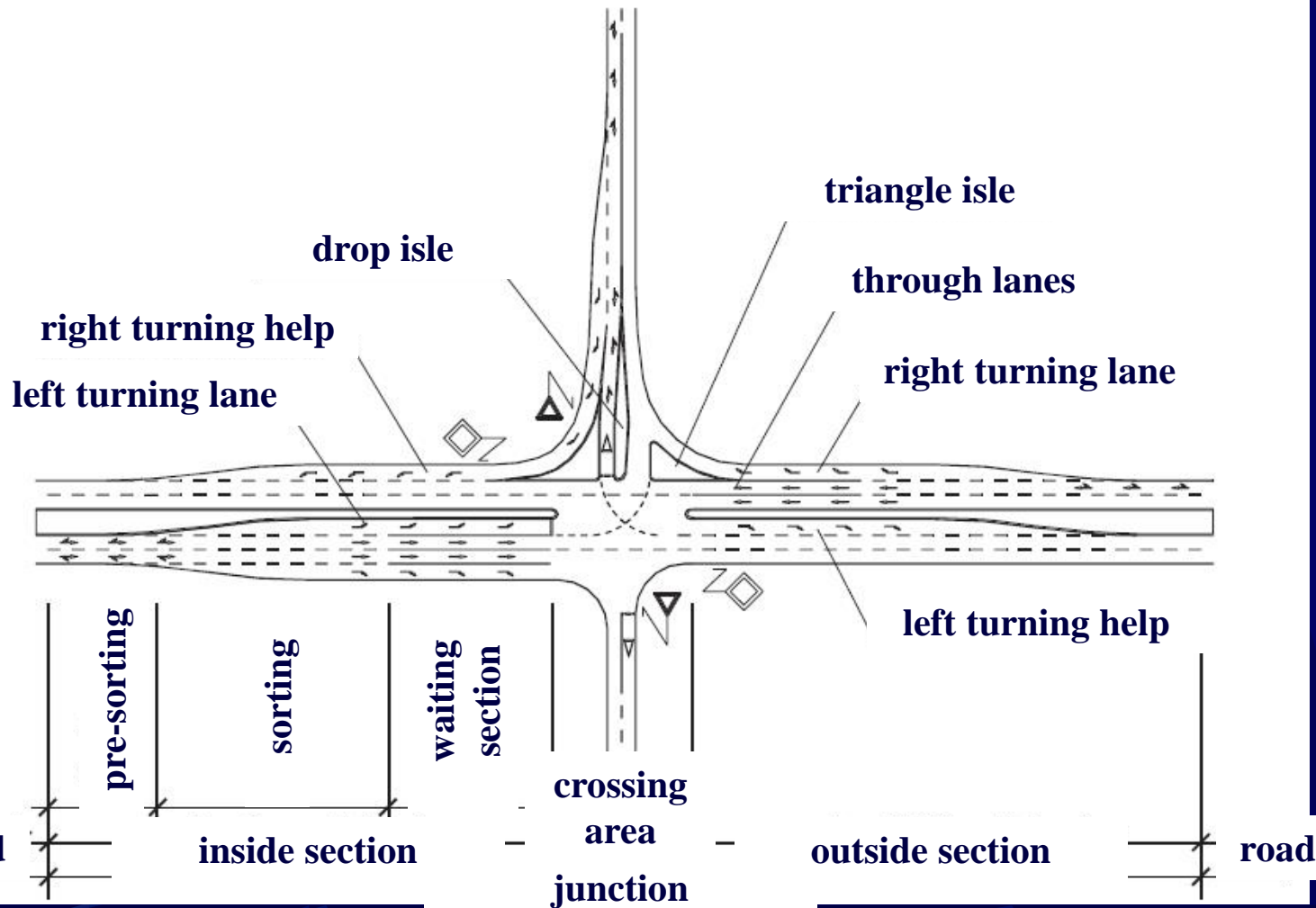
# Types of surface junctions

**Factors influencing the choice of the junction type:**

- **traffic safety situation,**
- **traffic volumes and peaks,**
- **environmental conditions,**
- **economy of construction and operation.**

**Junction distances prescribed in guidelines and standards usually are not complied in urban areas.**

# Types of surface junctions



# Traffic conditions of intersections

## Possible vehicle movements in a junction:

- sorting (choosing the proper lane),
- driving through along the main direction,
- turning right from the main direction,
- turning left from the main direction,
- crossing along the secondary direction,
- turning right from the secondary direction,
- turning left from the secondary direction,
- joining, separation, weaving.



# Traffic conditions of intersections

In case of a single junction the arrival of vehicles is probabilistic. In the simplest case the distribution of the vehicles arriving in a time unit is described by the Poisson distribution. Probability  $p$  of arrival of  $x$  vehicles in  $t$  time:

$$p(x) = \frac{(\lambda * t)^x * e^{-\lambda * t}}{x!}$$

where

$$\lambda = \frac{F(v/h)}{3600} \quad \text{traffic volume per second (v/s)}$$

# Traffic conditions of intersections

If the arrivals have Poisson distribution then the distribution of headways is exponential. Probability  $p$  of the headway  $X$  is less than  $x$ :

$$p(X \leq x) = 1 - e^{-\lambda * x}$$

where

$\lambda$  = traffic volume per second (v/s)

$1/\lambda$  = expected (average) headway time

If the distribution of headways would be equal, than above a certain traffic volume the crossing would be impossible

# Traffic conditions of intersections

For the crossing or turning of a vehicle arriving from the secondary direction must be a certain „gap” between vehicles moving in the main direction. The minimum headway time that is suitable for crossing or turning is the headway limit.

The longer the route of the movement of the higher the speeds in the main direction the bigger is the headway limit (depending from the drivers abilities as well).



# Traffic conditions of intersections

## Headway limits (s)

	Average speed in the main direction					
Type of movement	38	50	60	70	80	90
Left turn from main	4,5	5,2	5,8	6,5	7,1	7,8
Right turn from sec.	5,0	5,8	6,5	7,2	7,9	8,7
Crossing from secondary	5,1	5,8	6,5	7,3	8,0	8,7
Left turn from sec.	5,6	6,4	7,2	8,0	8,8	9,6

# Traffic planning of signed junctions

**Traffic planning of signed junctions (priority junctions) means comparing peak hour traffic volumes to capacity values based on standards.**

**The Hungarian guidelines are similar to the USA Highway Capacity Manual method determining 6 different service levels, based on the average time loss per vehicle in the junction analysed.**

**Besides traffic volumes and capacity ratios, the number of waiting vehicles and the necessary queue length must be calculated as well.**

# Traffic planning of signed junctions

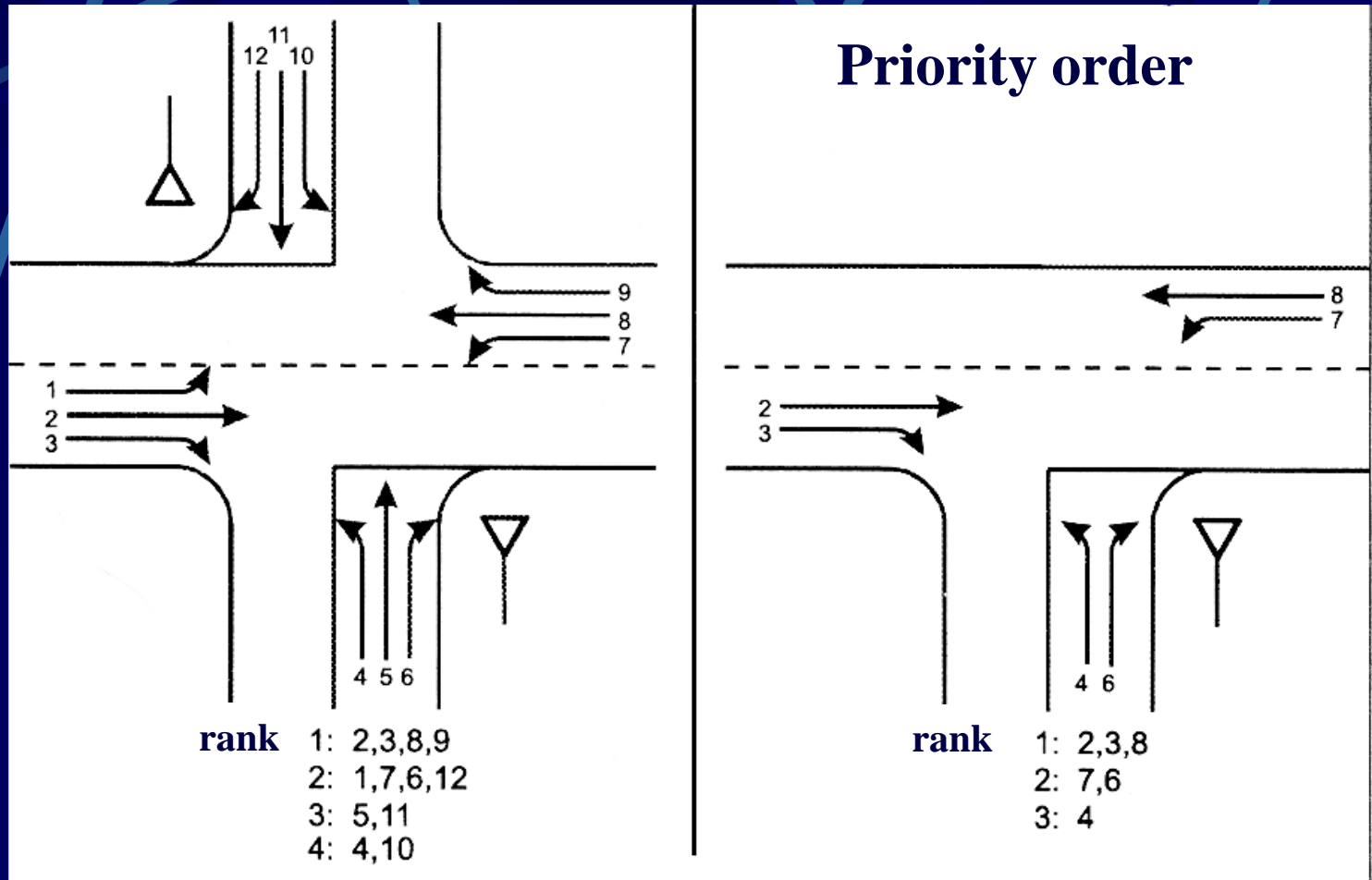
The traffic planning procedure of a signed junction in steps:

1. Calculate priority flow(s)  $V_p$
2. Calculate secondary flow(s) – its basic value  $V_b$  and corrected value  $V_{bc}$
3. Maximum number of vehicles moving through the junction  $V_{max}$  (capacity) and the capacity reserve  $V_{max} - V_{bc}$

Correction factors depend on the speed(s), the number of lanes, the yield type, the movement type, the sight distances and possible obstacles.

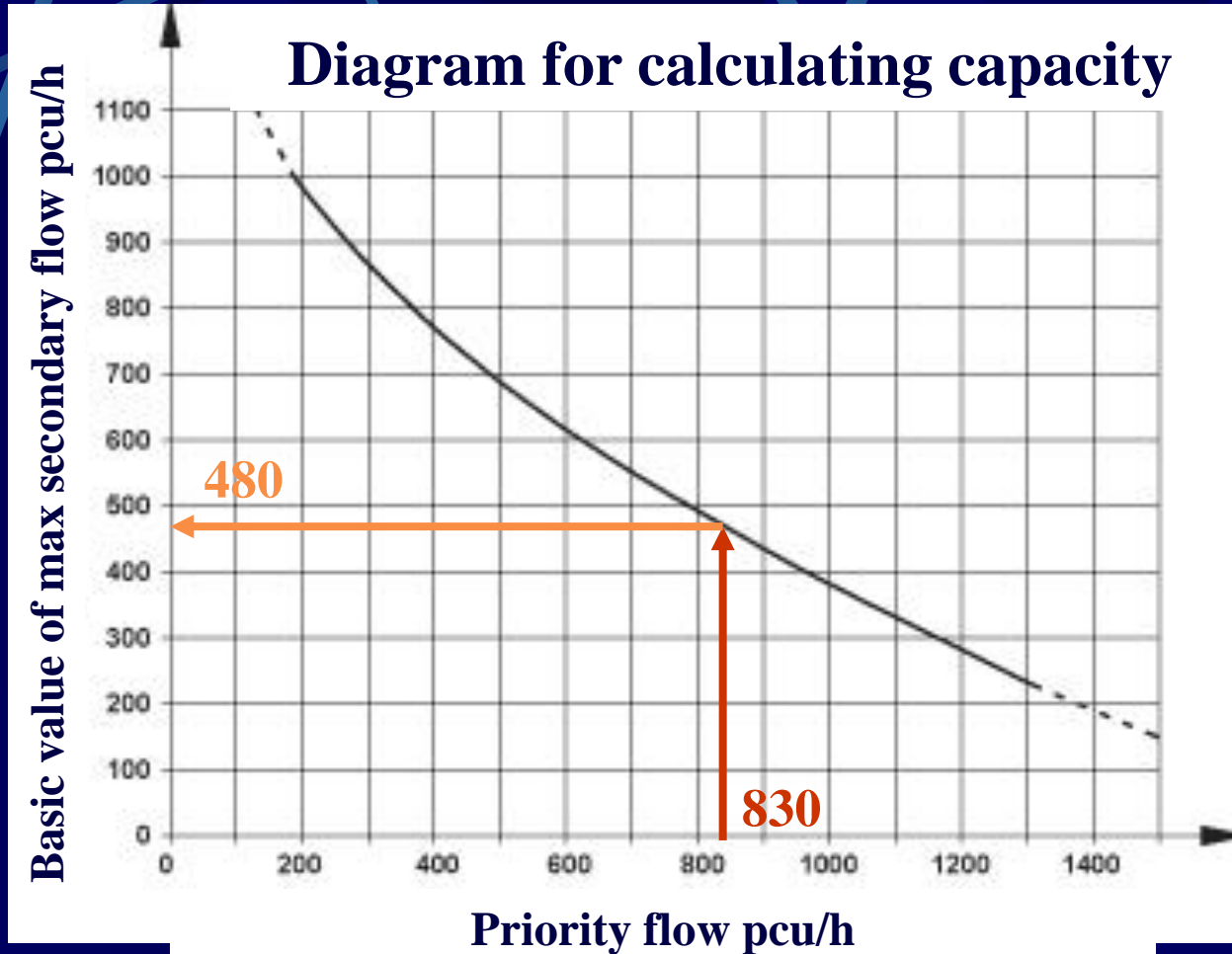
Dimension is personal car unit / hour (pcu/h).

# Traffic planning of signed junctions

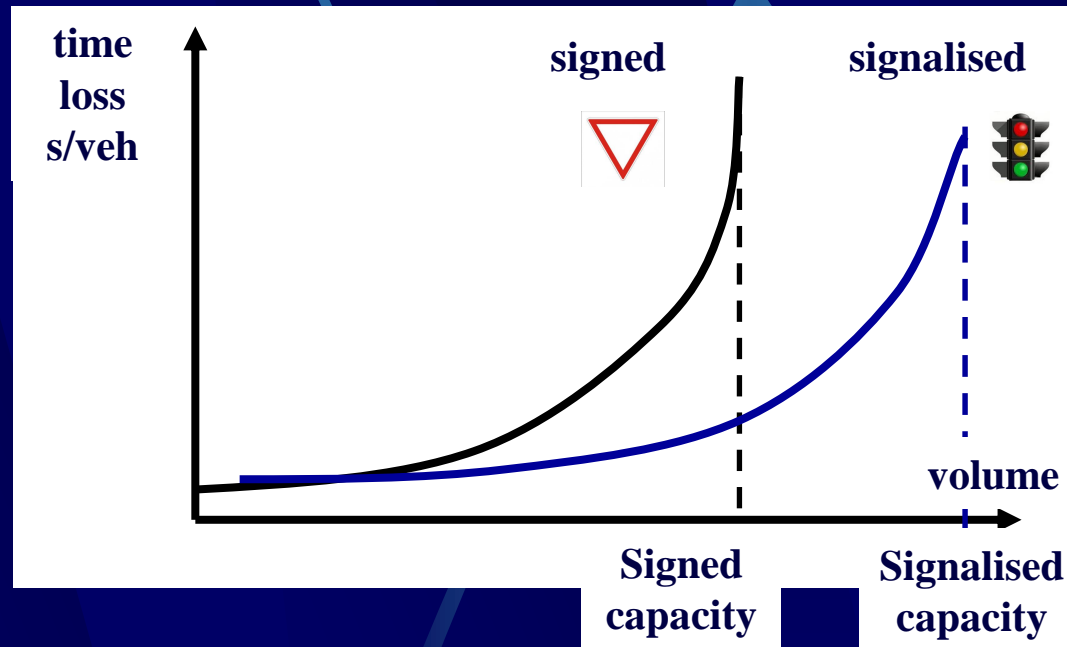




# Traffic planning of signed junctions



# Traffic planning of signed junctions



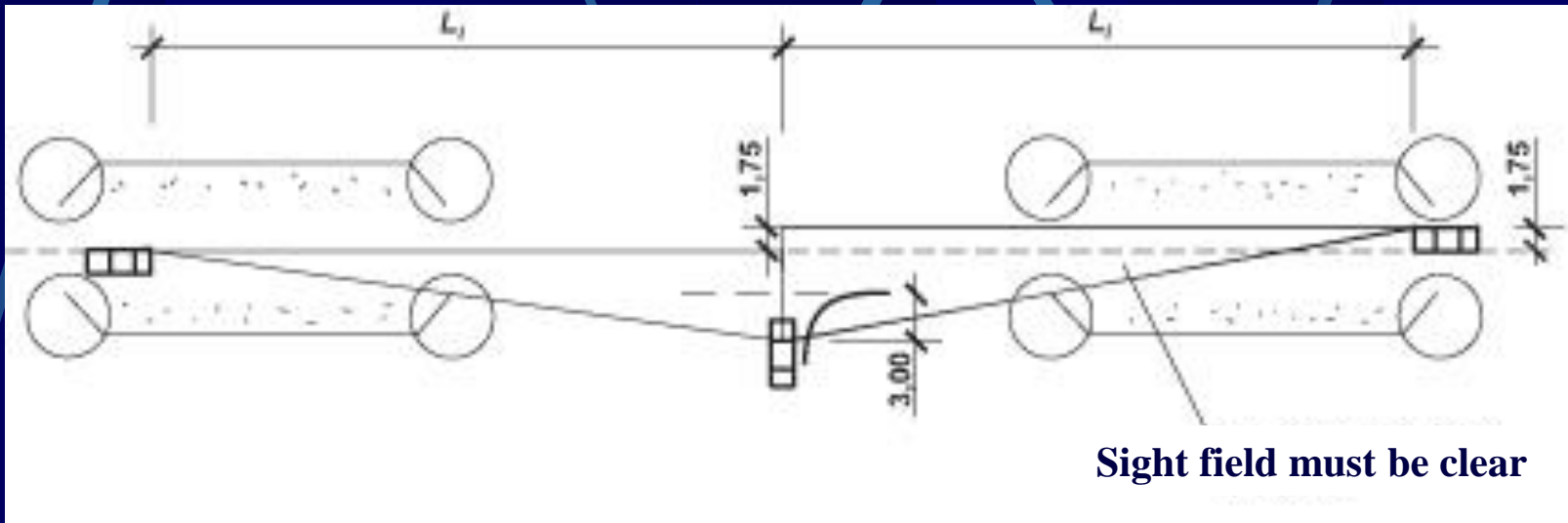
**Average time loss depending on traffic volume and junction type**

# Traffic engineering solutions of intersections

**Within the design process not only the demand of vehicles must be considered but:**

- **safe movement of cyclists,**
- **safe movement of pedestrians,**
- **proper placing of public transport stops and connections,**
- **clear sight fields for every participant,**
- **urban aesthetics and points of view.**

# Traffic engineering solutions of intersections

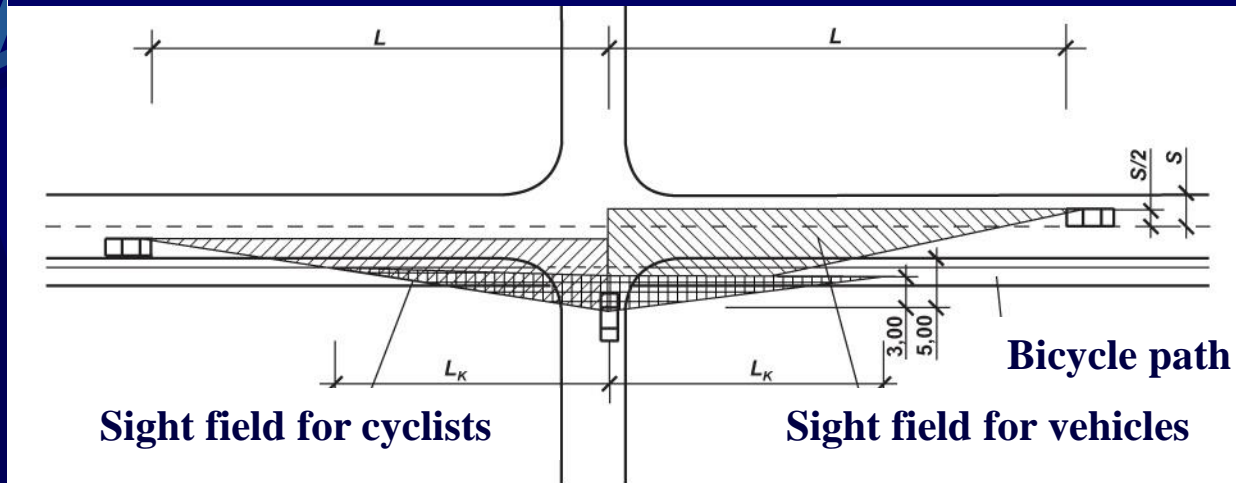


**Sight field for joining from stopped position**

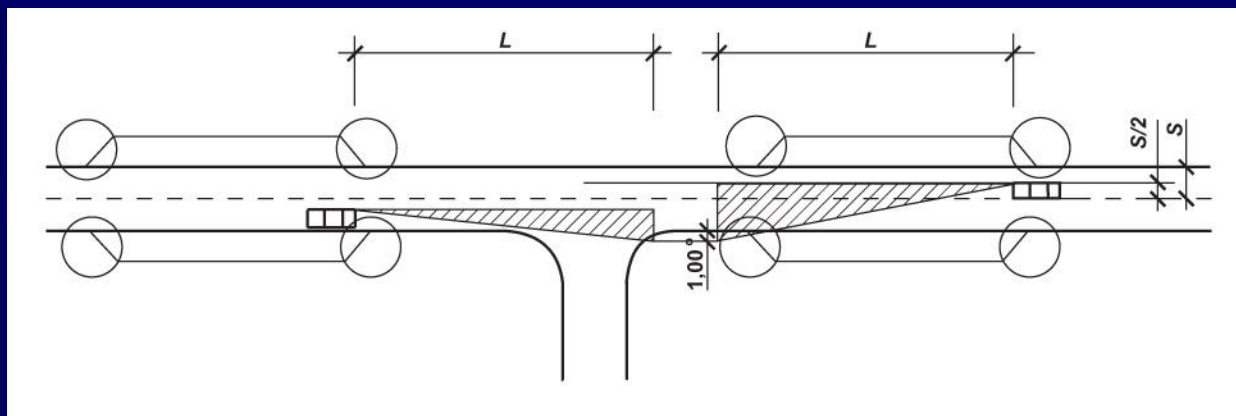


# Traffic engineering solutions of intersections

## Sight fields in case of cyclists with priority



## Sight fields in case of pedestrian crossing



# Traffic engineering solutions of intersections

**Detailed design of junctions include the next elements (among others):**

- **moving of traffic lanes and widenings,**
- **curve radiuses for turning vehicles**
- **waiting sections for left turning,**
- **dividing drop-like and triangle islands,**
- **traffic signs and prisms on the pavement,**
- **traffic signs at roadside,**
- **public lighting.**

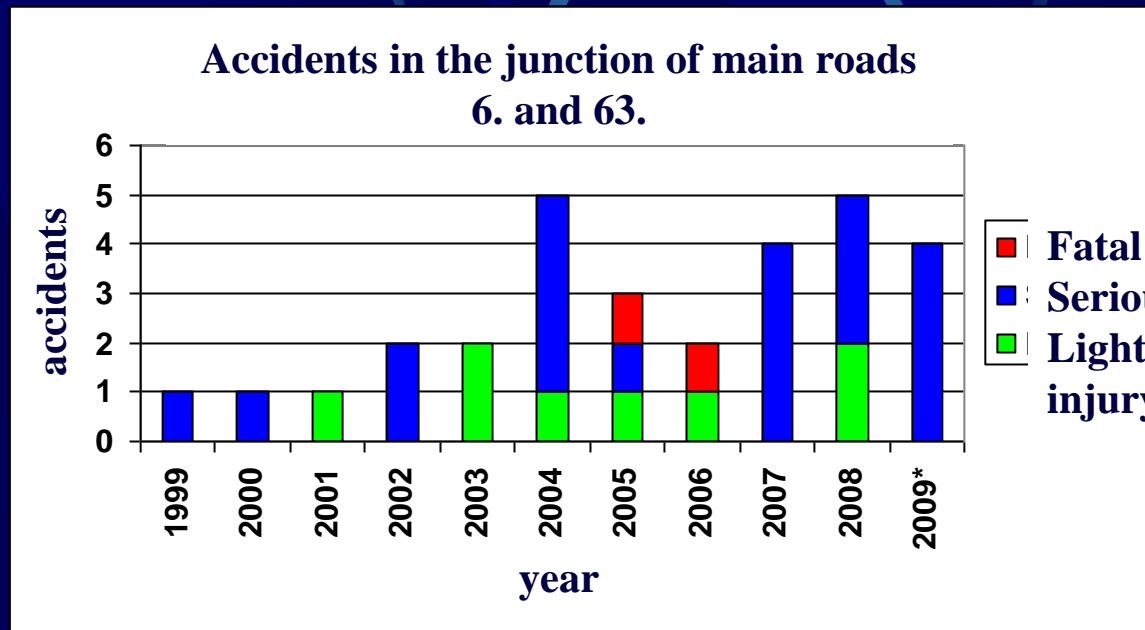
# Example of re-design of a junction

Example of re-design of a junction in order to improve traffic safety with low cost intervention. Szekszárd main roads 6. and 63. Krea-TURA Ltd. 2010.



# Example of re-design of a junction

In the junction of main road 6. at 137+300 km with main road 63. the traffic volume decreased in 2010 after opening of the nearby M6 motorway. Before that time there was a serious safety problem.



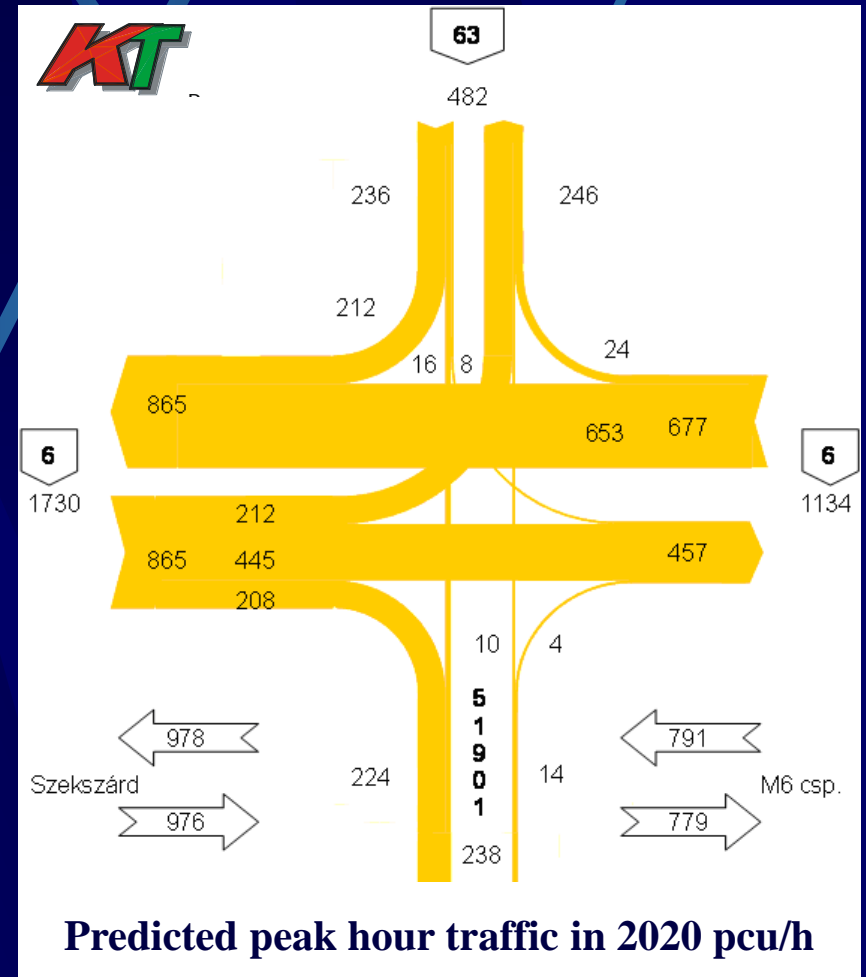
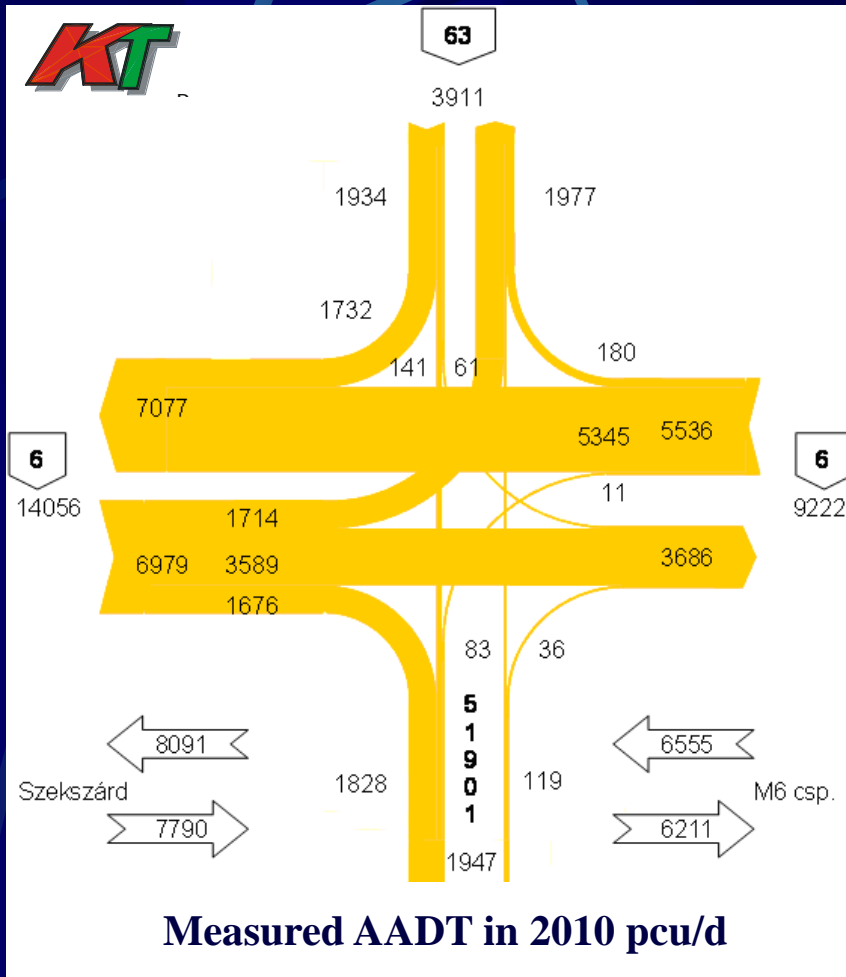
# Example of re-design of a junction

Results of junction O-D traffic count 2010. pcu/d

ÁNF 2010		6 S	63	6 N	51901	Sum
	Left		1714			6979
6 S	Straight			3589		
	Right				1676	
	Left			61		1934
63	Straight				141	
	Right	1732				
	Left				11	5536
6 N	Straight	5345				
	Right		180			
51901	Straight		83			119
	Right			36		
Sum		7077	1977	3686	1828	14568



# Example of re-design of a junction



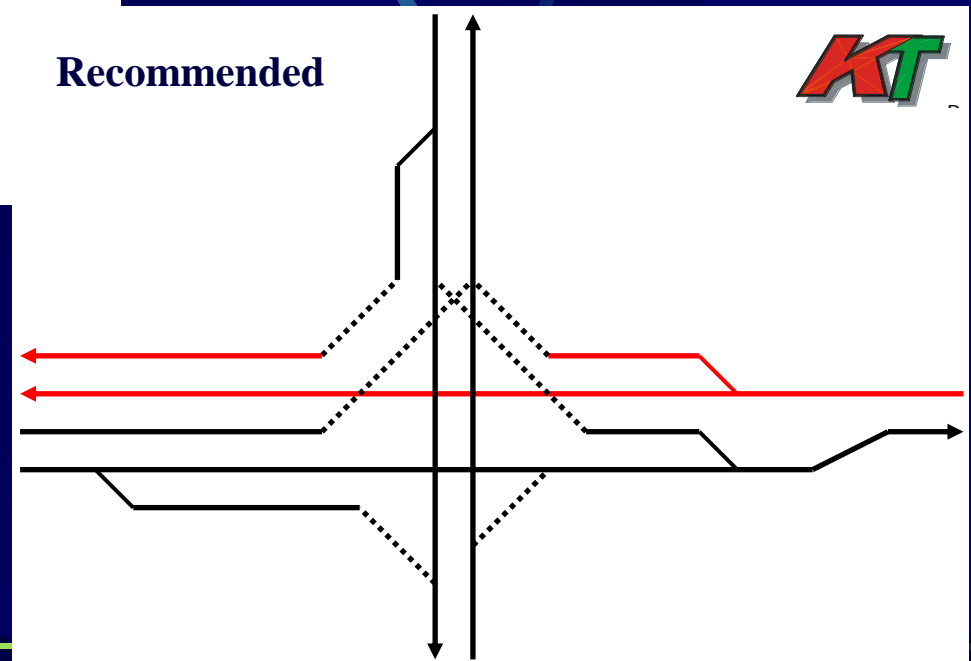
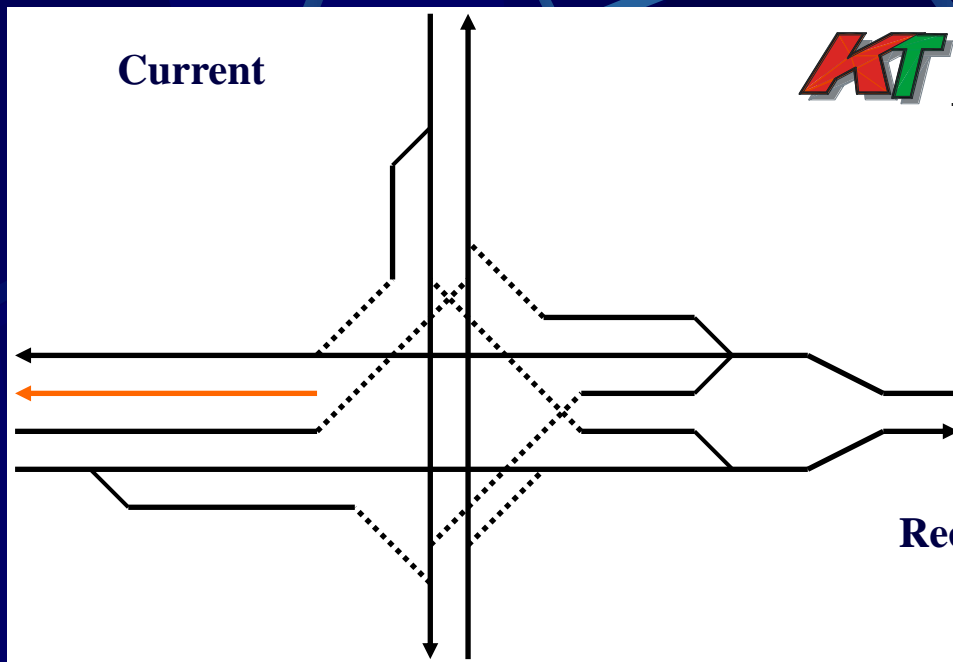
## Example of re-design of a junction

The recommended solution drives the through traffic lane from the north part of main road 6. to the inner lane of the 2x2 lanes section. This means to cancel left turning from north but there is very small traffic in that direction.

Right turning traffic from main road 63 therefore may join the 2x2 lanes section in the outer lane without obstacles.

The cancelled direction can be provided in the nearby interchange system of the M6 motorway.

# Example of re-design of a junction



# Summary

**Traffic volume and safety demand together determine the type of the junction.**

**On a given road section the same type of junctions are recommended.**

**Traffic planning of signed junctions (priority junctions) means comparing peak hour traffic volumes to capacity values based on standards.**

**Within the design process the safe movement of cyclists and pedestrians as well as requirements of public transport must be considered.**



Thank you for your attention!

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