INTERSECTIONS

AT GRADE INTERSECTIONS

INTERSECTIONS

INTERSECTIONS = INTERRUPTED FACILITIES

Definitions and key elements

An ***intersection*** is defined as an area where two or more roadways join or cross.

Each roadway extending from the intersection is referred to as a ***leg****. The intersection of two* roadways has usually four legs (or three if there one of the roadway is ended). The leg used by traffic approaching the intersection is the ***approach leg****, and that used by traffic leaving is the* ***departure leg****.*

The ***major street*** *is typically the intersecting street with greater traffic* volume, larger cross-section, and higher functional class.

The ***minor street*** *is the intersecting street likely to have less traffic volume,* smaller cross-section and lower functional classification than the major street.

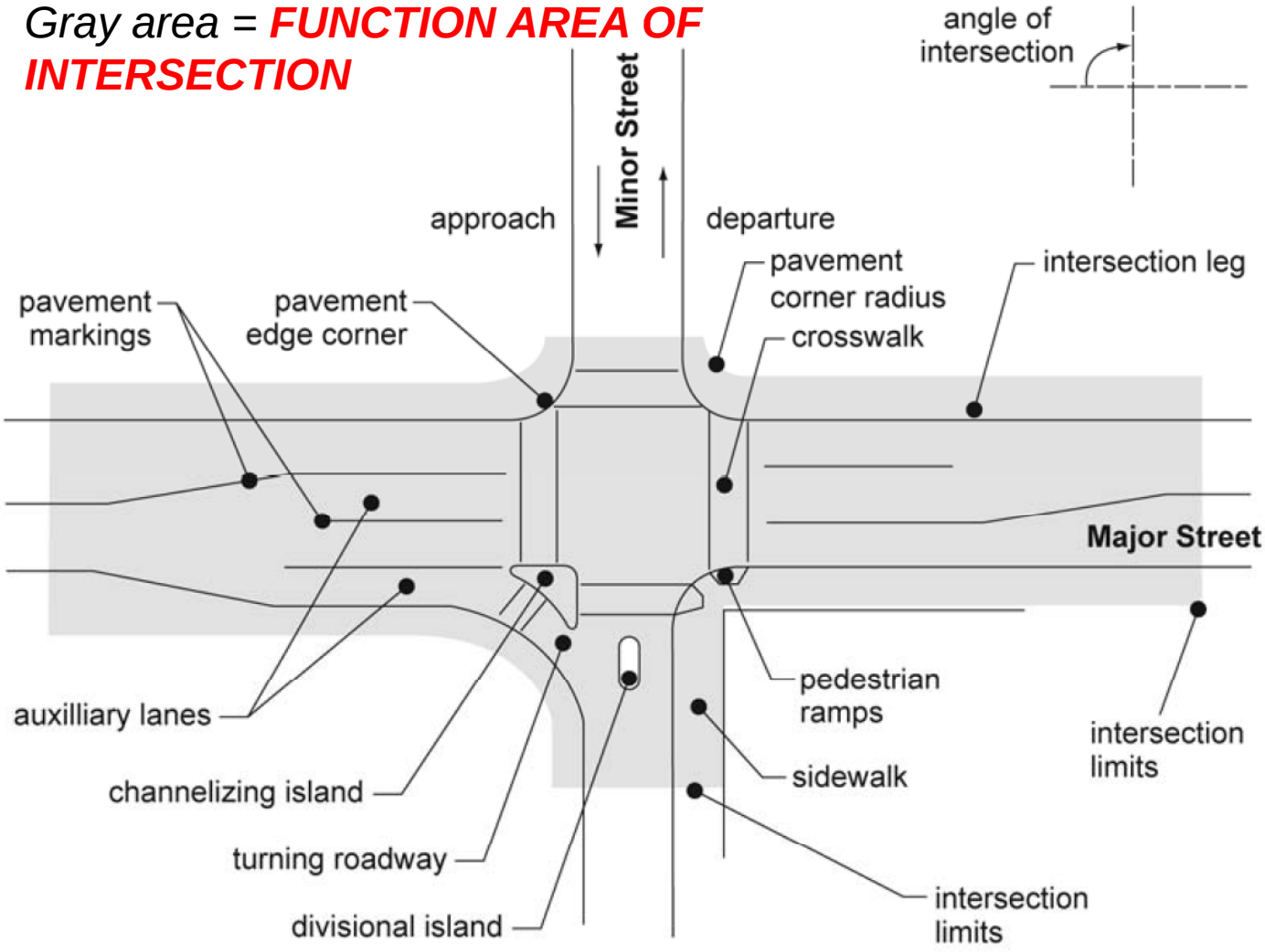
Channelization is the separation or regulation of conflicting traffic movements into definite paths of travel by traffic islands or pavement markings (regulation of traffic).

INTERSECTIONS

Definitions and key elements

Intersection Terminology

Gray area = ***FUNCTION AREA OF INTERSECTION***

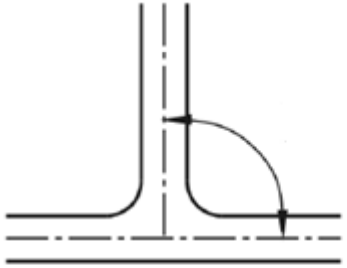


Sidewalks, crosswalks and pedestrian curb cut ramps *are considered to* be within the intersection.

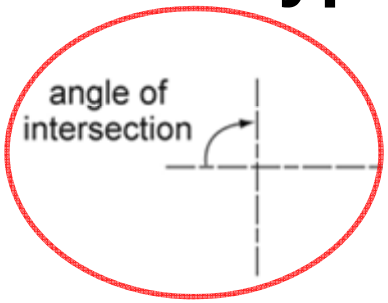
The ***pavement edge corner is the curve*** connecting the edges of pavement of the intersecting streets.

INTERSECTIONS

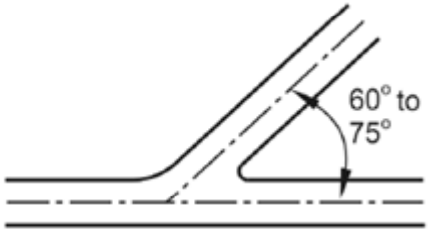
Basic types of intersections



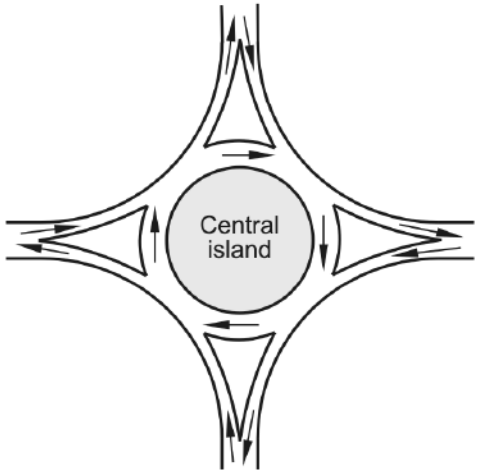
T-intersection

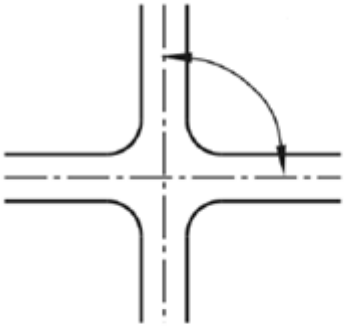


Three-legged intersections



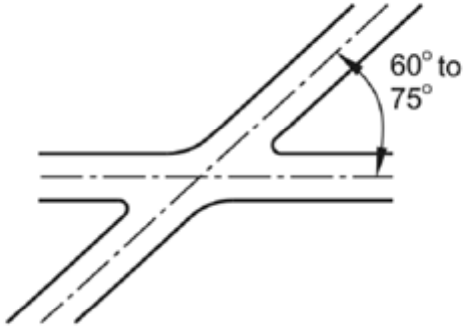
Y-intersection





Right-angled

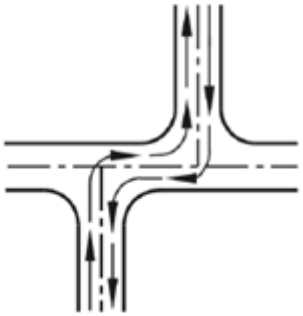
or cross intersection



Oblique

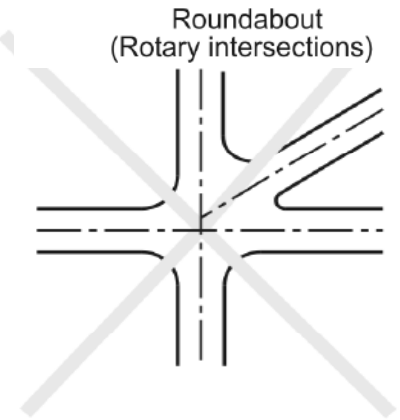
Four-legged intersections

(or scissor)



Offset

or stagerred intersection



Not recommended

Multi-legged intersection

The ***angle of intersection*** is formed by the intersecting streets centerlines (best angle is between 75 and 105 degrees).

INTERSECTIONS

Basic types of manoeuvres within intersections

Typical manoeuvres are:

- **Crossing**
- **Merging**
- **Diverging**
- **Weaving**

INTERSECTIONS

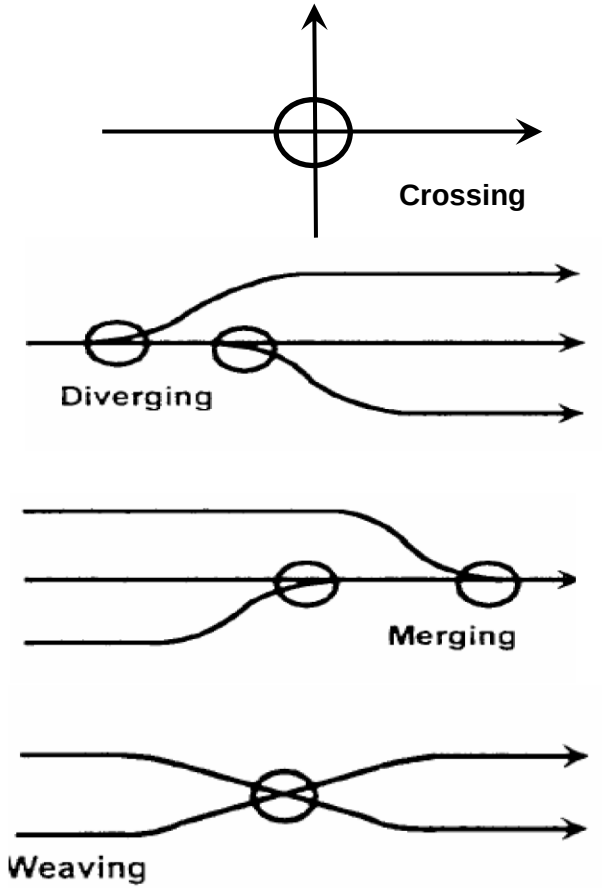
Basic types of manoeuvres within intersections

Crossings may be direct, if the angle of skew is between 75 and 105 degrees, ***or oblique*** if the angle is in the range of below 75 or above 105 degrees. (Oblique skews should be voided if at all possible).

Diverging is a traffic operation when the vehicles moving in one direction is separated into different streams according to their destinations.

Merging is the opposite of diverging. Merging is referred to as the process of joining the traffic coming from different approaches and going to a common destination into a single stream.

Weaving is the combined movement of both merging and diverging movements in the same direction.



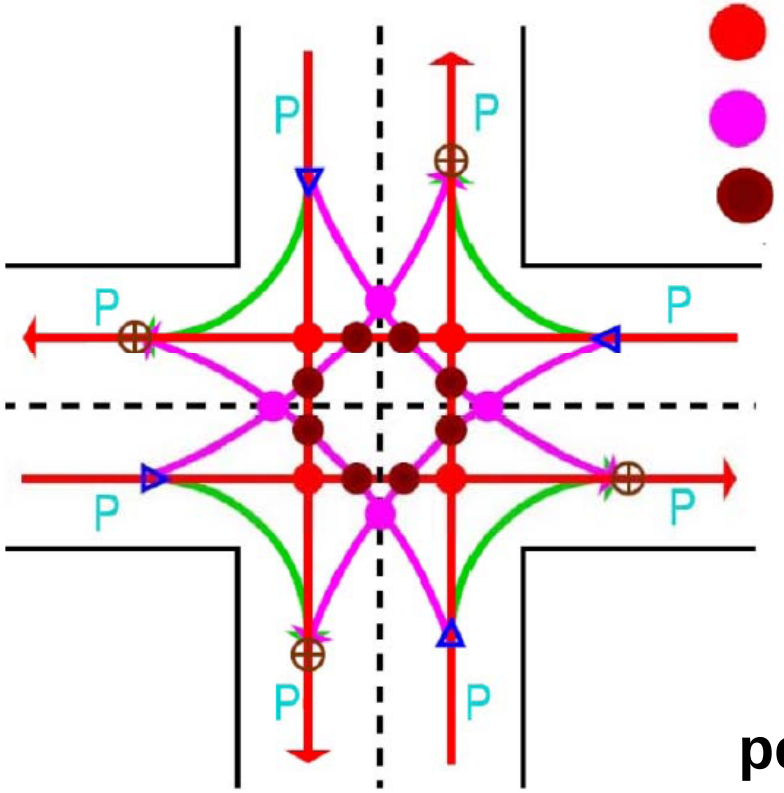
All manoeuvres within intersection result in conflits

INTERSECTIONS

Basic types of conflict points within intersections

Typical conflict points are:

- **Crossing conflicts (through traffic, left turns with through traffic)**
- **Merging conflicts**
- **Diverging conflicts**



4 through traffic
4 left turns
8 left turns – through traffic

8 merging
8 diverging
8 possible pedestrians

Total = 32 Conflicts

pedestrians not included

INTERSECTIONS

Basic types of conflict points within intersections

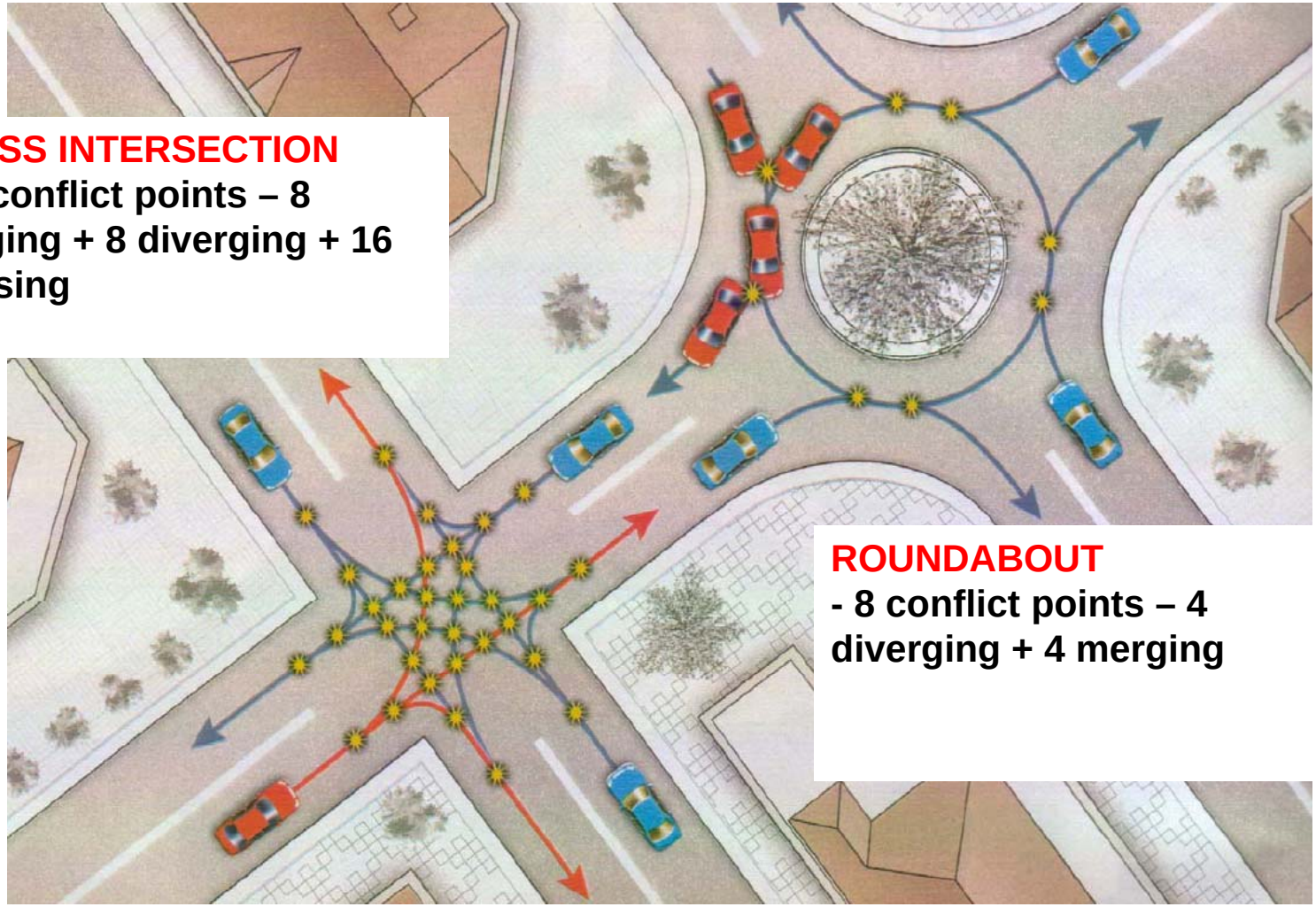
Typical conflict points are:

- Crossing conflicts (through traffic, left turns with through traffic)
- Merging conflicts
- Diverging conflicts

Number of intersection legs	Number of conflicts
3	**9**
4	**32**
5	**80**
6	**168**

INTERSECTIONS

Basic types of conflict points within intersections



CROSS INTERSECTION

- 32 conflict points – 8 merging + 8 diverging + 16 crossing

ROUNDABOUT

- 8 conflict points – 4 diverging + 4 merging

INTERSECTIONS

Intersections in traffic engineering

REMEMBER THAT:

1. Intersections are more **complicated** areas for drivers than uninterrupted facilities.

Drivers have to make split second decisions within intersections by considering their routes, intersection geometry, speeds and directions of other vehicles etc.

A small error in judgment can cause accidents.

Understanding this is central to intersection designs and to determine capacity.

2. Main function of intersections is to provide **change of direction**.

Direction changes within intersections define conflict points.

3. Interesections are sources of congestion in urban areas.

Manoeuvres within intersections cause delays.

INTERSECTIONS

BASIC DESIGN PRINCPLES

BASIC DESIGN PRINCPLES

This principles are independent on national standards.

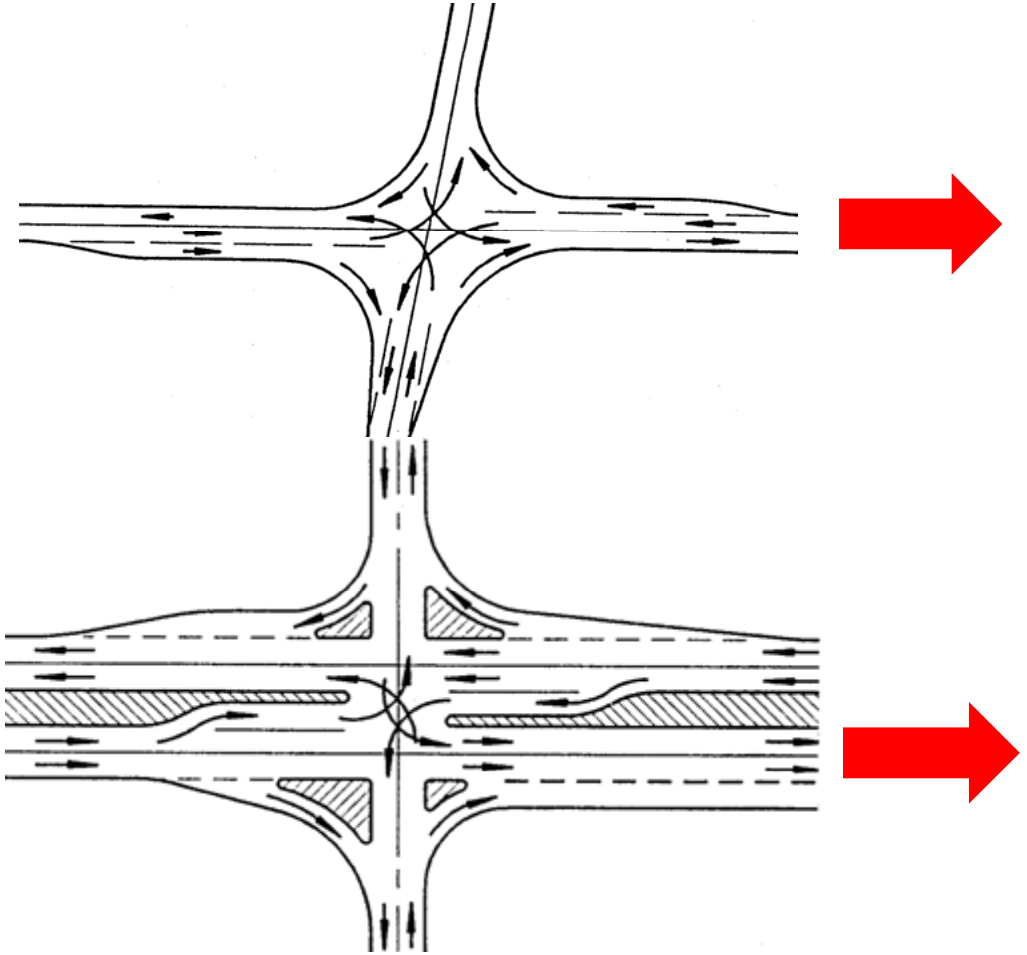
If one of them is not ensure than there could be problems within intersection – with speed, traffic, manoeuvres or safety of peds or bicyclists.

1. MINIMISE THE CARRIAGEWAY AREA WHERE CONFLICT CAN OCCUR
2. SEPARATE (REDUCE) POINTS OF CONFLICTS
3. TRAFFIC STREAMS SHOULD MERGE/DIVERGE AT FLAT ANGLES AND CROSS AT RIGHT ANGLES
4. REDUCE SPEEDS ON THE APPROACHES TO INTERSECTIONS
5. DECELERATING OR STOPPING VEHICLES SHOULDBE REMOVED FROM THE THROUGH TRAFFIC STREAM, HIGH PRIORITY TRAFFIC MOVEMENTS SHOULD BE FAVOUR
6. DISCOURAGE UNDESIRABLE TRAFFIC MOVEMENTS
7. PROVIDE REFUGES FOR VULNERABLE ROAD USERS
8. PROVIDE REFERENCE MARKERS FOR ROAD USERS
9. PROVIDE ADVANCE WARNING OF CHANGE AND GOOD SAFE LOCATIONS FOR THE INSTALLATION OF TRAFFIC CONTROL DEVICES
10. CONTROL ACCES IN THE VICINITY OF AN INTERSECTION
11. PROVIDE SAFETY STOPPING SIGHT DISTANCES AND KEEP THE SIGHT TRIANGLE WITHOUT ANY OBSTRUCTIONS

1. MINIMISE THE CARRIAGEWAY AREA WHERE CONFLICT CAN OCCUR

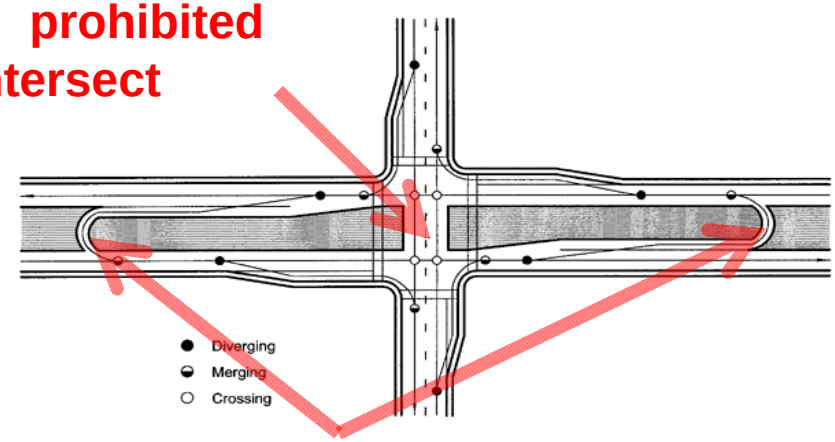
Large uncontrolled carriageway areas within intersection provide greater opportunities for collisions resulting from unexpected vehicle manoeuvres.

To prevent this – traffic island channelisation can be used.



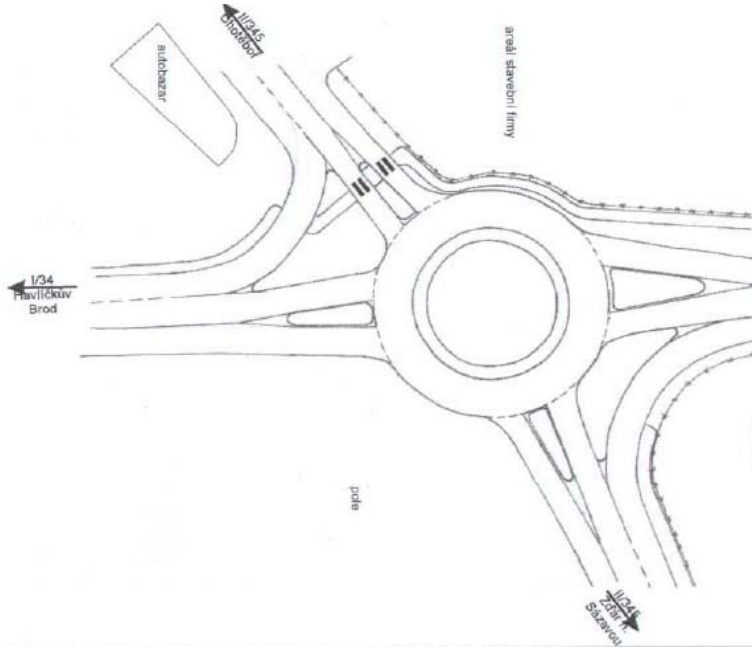
2. SEPARATE (REDUCE) POINTS OF CONFLICTS

Left turning is prohibited within point of intersect

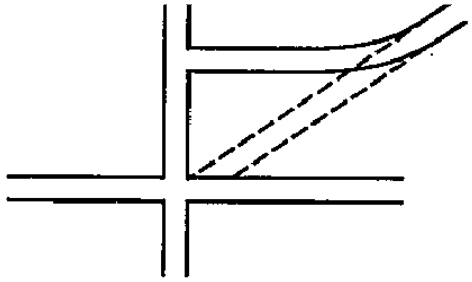


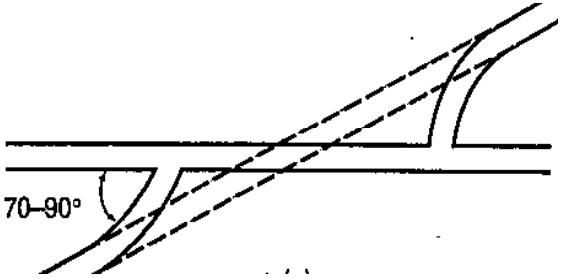
Left turning is allowed here

- by prohibiting certain traffic movements at an intersection



- by conversion conventional intersection to a roundabout



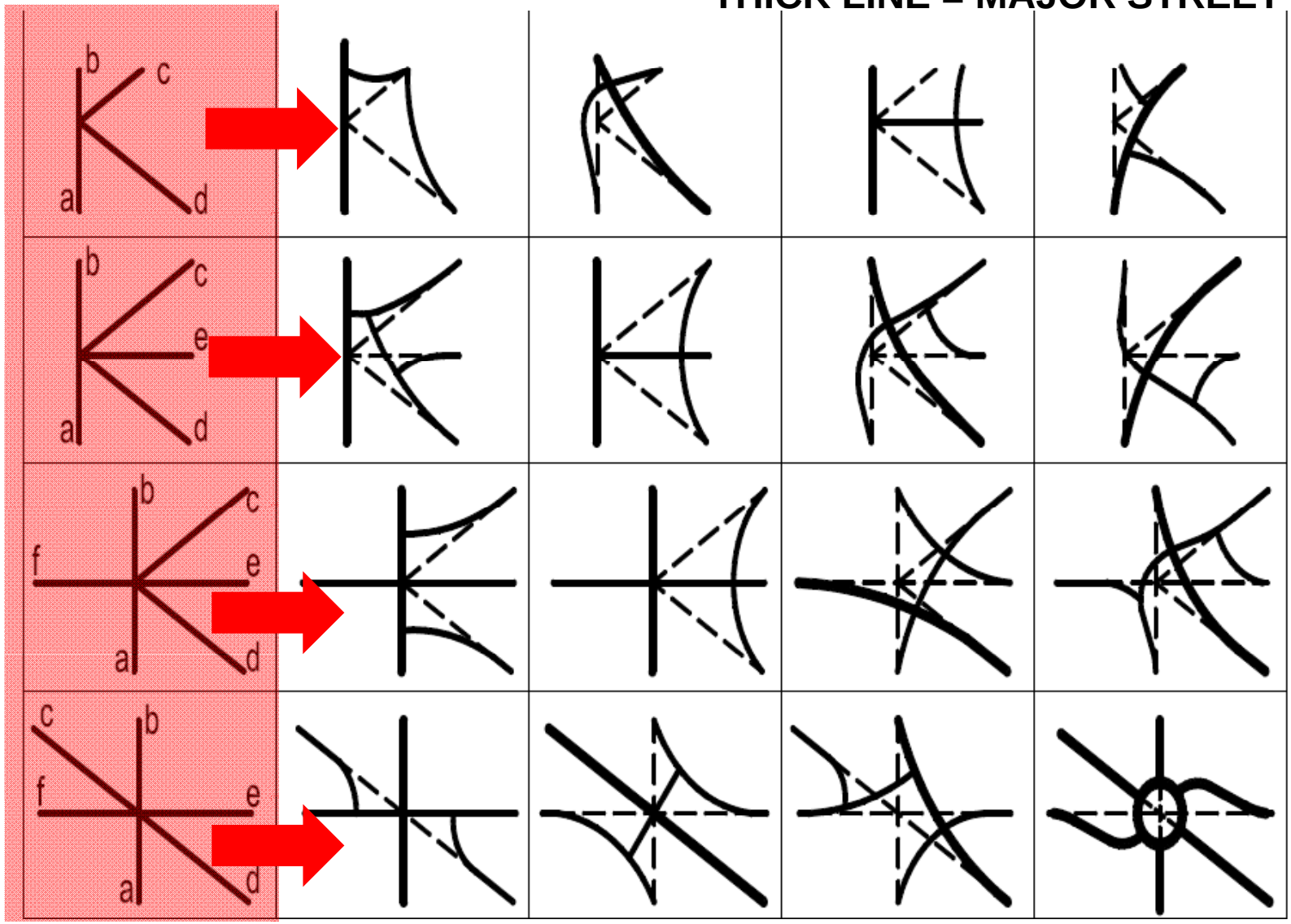


- by using two separated intersection instead of a single more complicated one

2. SEPARATE (REDUCE) POINTS OF CONFLICTS

POSSIBLE WAY TO REDESIGN INCORRECT INTERSECTION

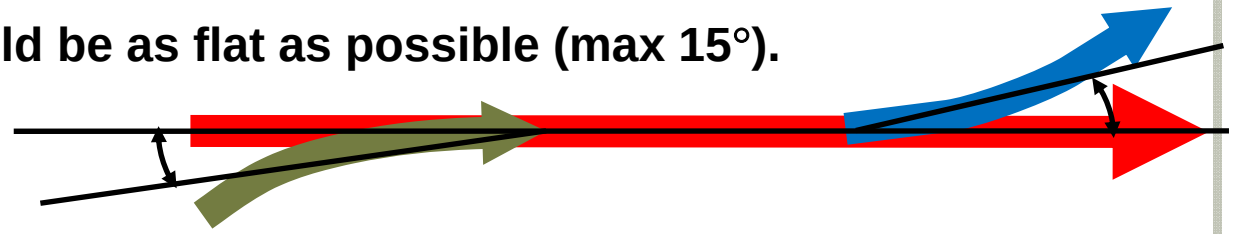
THICK LINE = MAJOR STREET



3. TRAFFIC STREAMS SHOULD MERGE/DIVERGE AT FLAT ANGLES AND CROSS AT RIGHT ANGLES

Merging / Diverging:

Merging / diverging should be as flat as possible (max 15°).

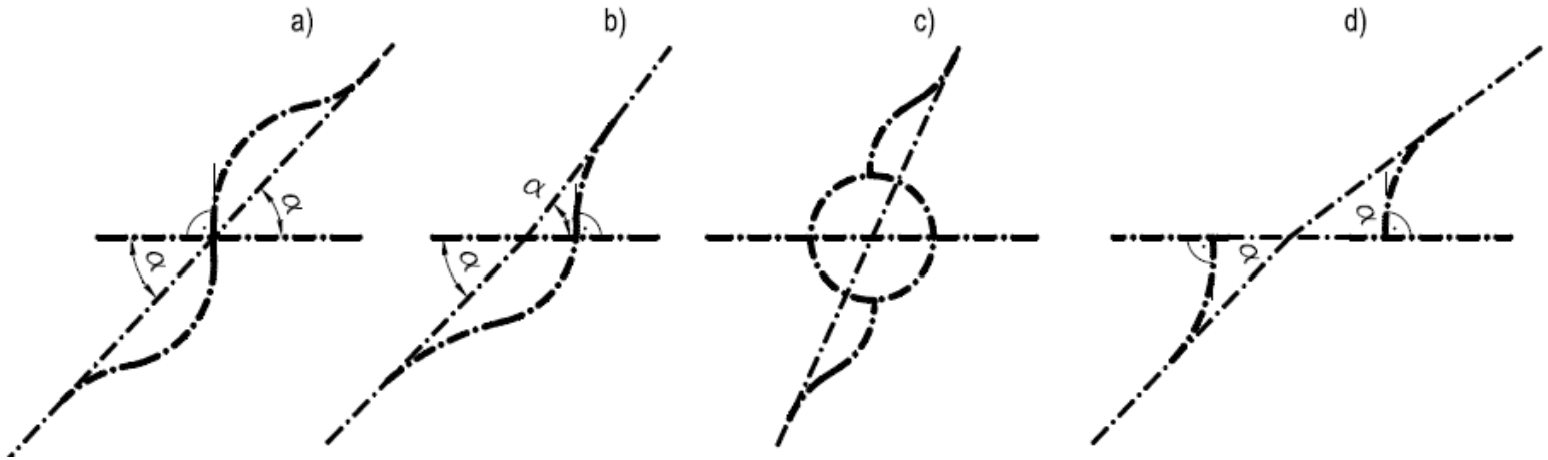


Crossing:

Crossings should be direct (90°).

The angle of skew range have to be between 75° and 105°.

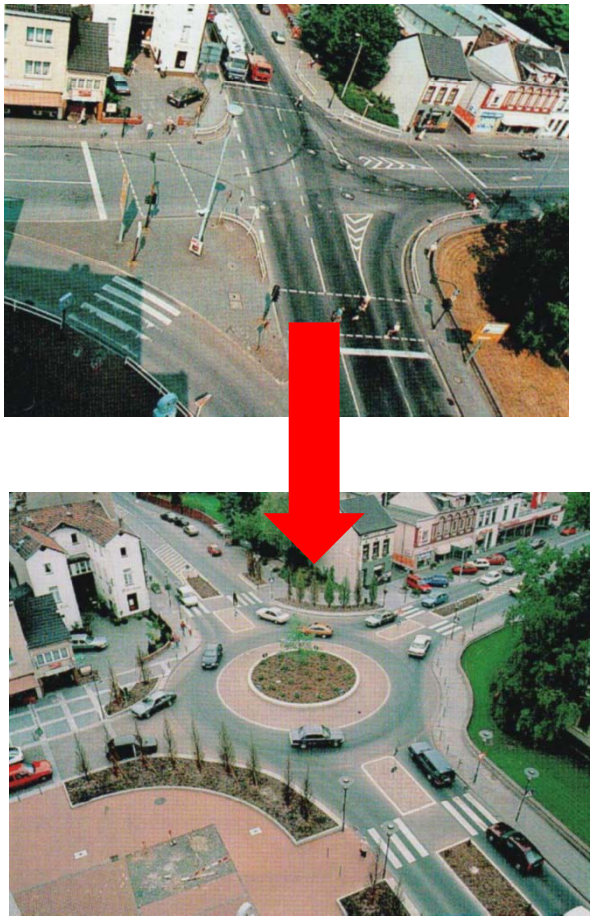
Oblique angles should be avoided if it is possible,
or redesign according to figures a – d:

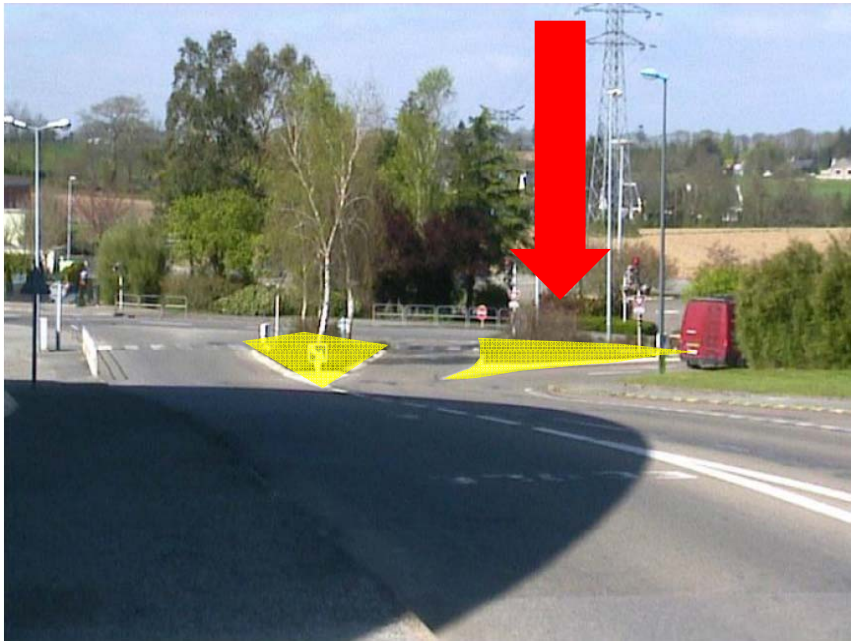


4. REDUCE SPEEDS ON THE APPROACHES TO INTERSECTIONS

Minor road vehicles should approach the intersection slowly. Than they can easily stop and give way to through traffic.

Figure illustrates how this effect can be achieved by the use of a roundabout (right side) or a traffic island (down) .

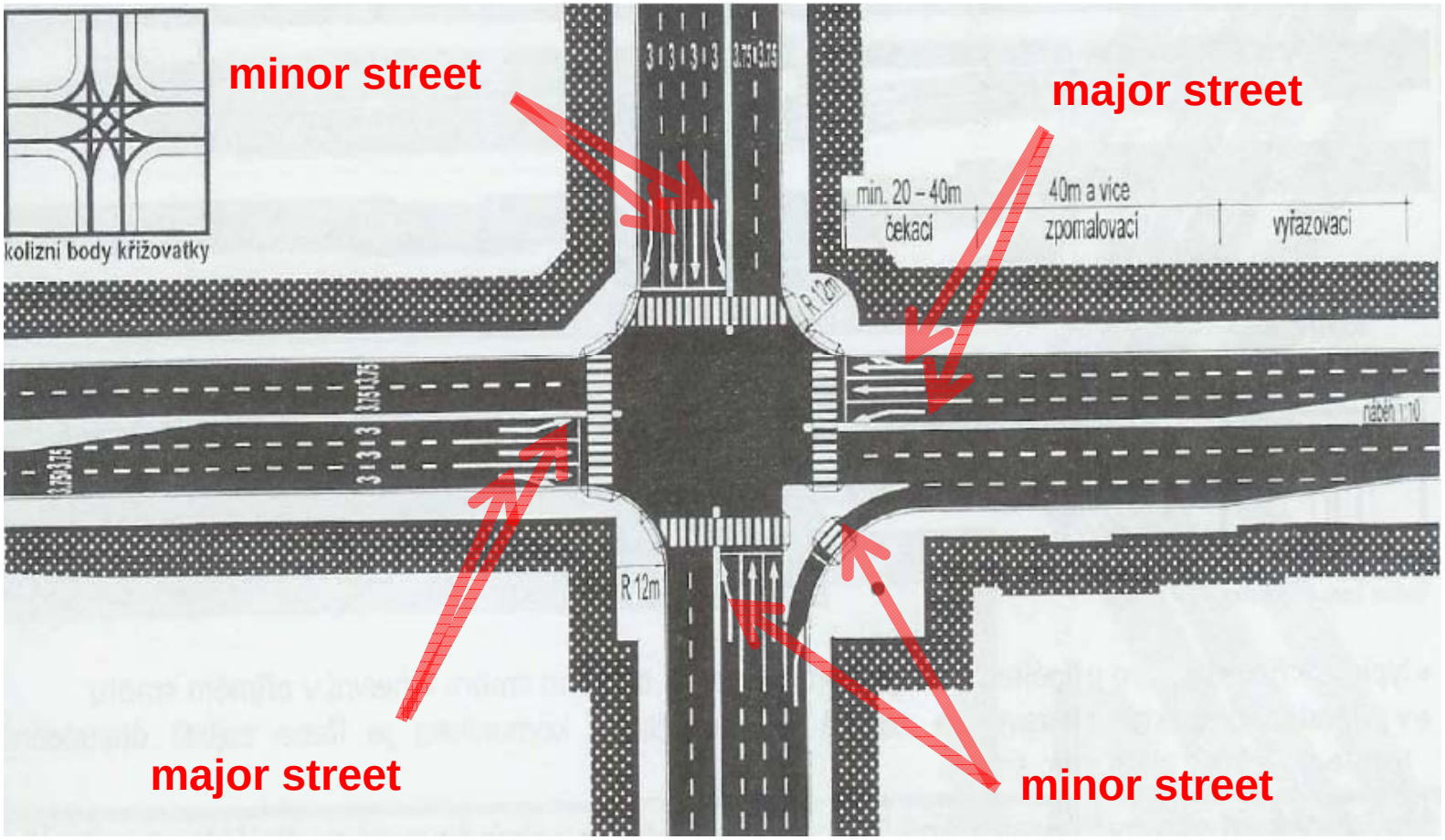




This method also has the advantage that it prevents overtaking in closer area of the intersection.

5. DECELERATING OR STOPPING VEHICLES SHOULD BE REMOVED FROM THE THROUGH TRAFFIC STREAM, HIGH PRIORITY TRAFFIC MOVEMENTS SHOULD BE FAVOUR

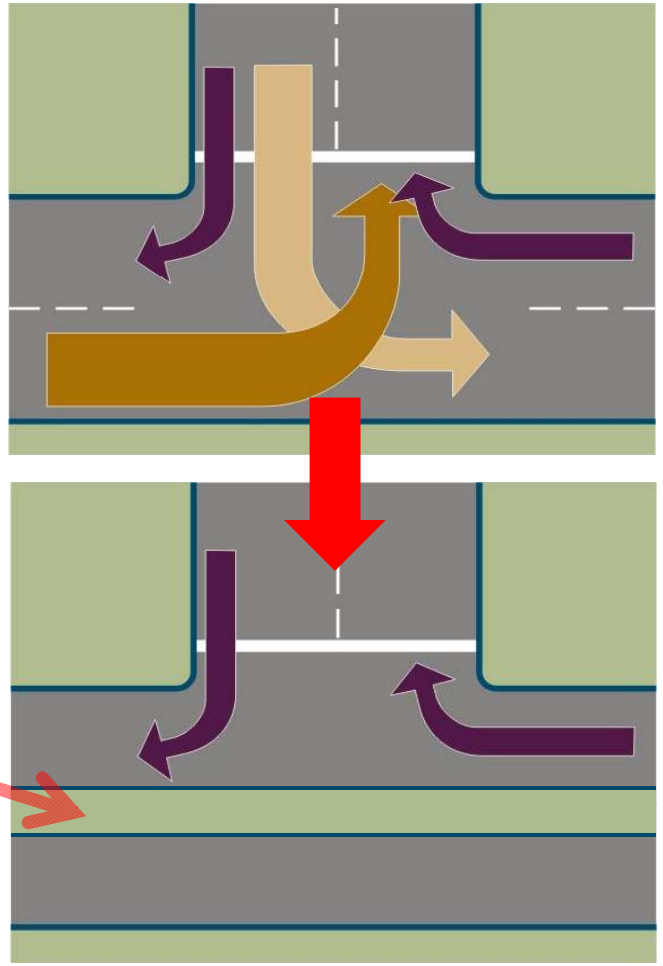
Separating the traffic streams into auxiliary lanes reduces the number and severity of rear – end crashes and increase capacity



6. DISCOURAGE UNDESIRABLE TRAFFIC MOVEMENTS

Traffic islands and corner radii can be used to discourage motorists from taking undesirable travel paths, and encourage them to take defined ones

Traffic island for
No Left Turn



7. PROVIDE REFUGES FOR VULNERABLE ROAD USERS

Pedestrians and also handicapped persons often need to cross a road in two separate manoeuvres.
Properly sited traffic islands have the added advantage that they can be used as refuges by these vulnerable road users, especially at intersections on wide roads

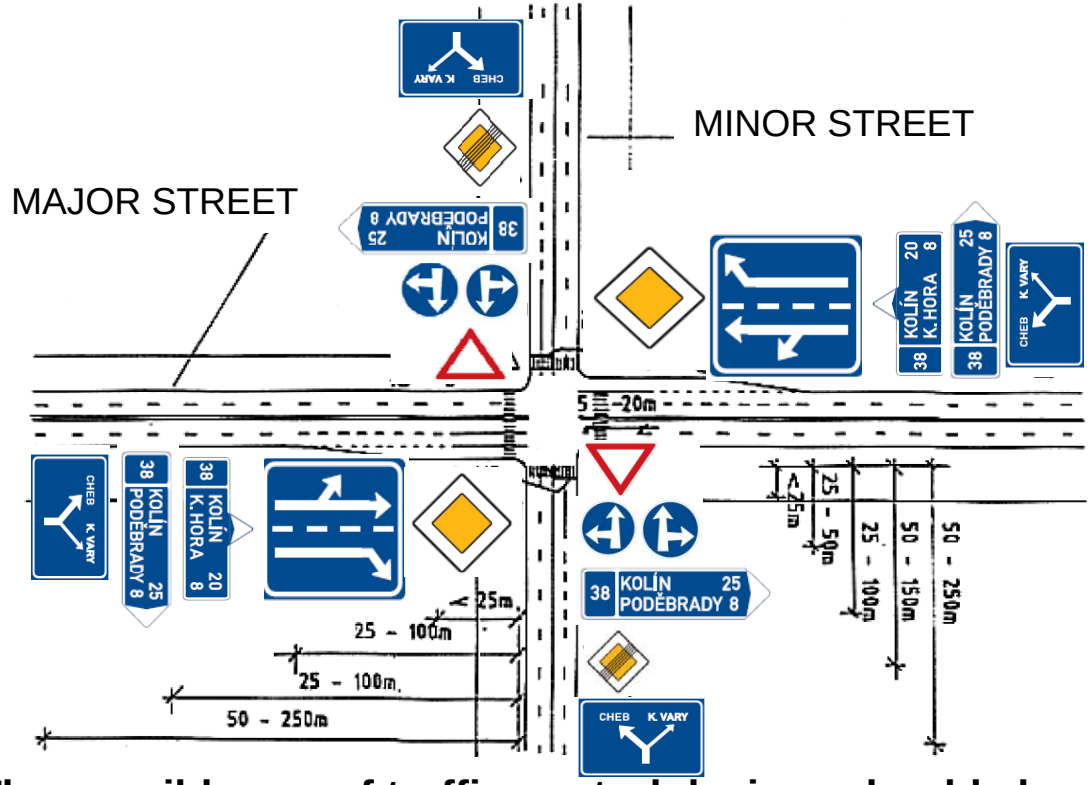
8. PROVIDE REFERENCE MARKERS FOR ROAD USERS

Drivers should be provided with appropriate references at intersections, f.e. Stop/Give Way lines which indicate where the lead vehicle in a minor road traffic stream should stop until a suitable entry gap appears in the main road stream.

REFERENCE MARKERS ALSO INCLUDE CROSSWALKS AND CYCLE TRACKS ON PAVEMENT

9. PROVIDE ADVANCE WARNING OF CHANGE AND GOOD SAFE LOCATIONS FOR THE INSTALLATION OF TRAFFIC CONTROL DEVICES

Drivers should never be suddenly faced with the unexpected.



Advance signing that warns drivers ahead of intersections should be use.

This warning should be provided on minor roads leading to controlled intersections, on all roads where visibility is restricted prior to an intersection, and in high – speed roads.

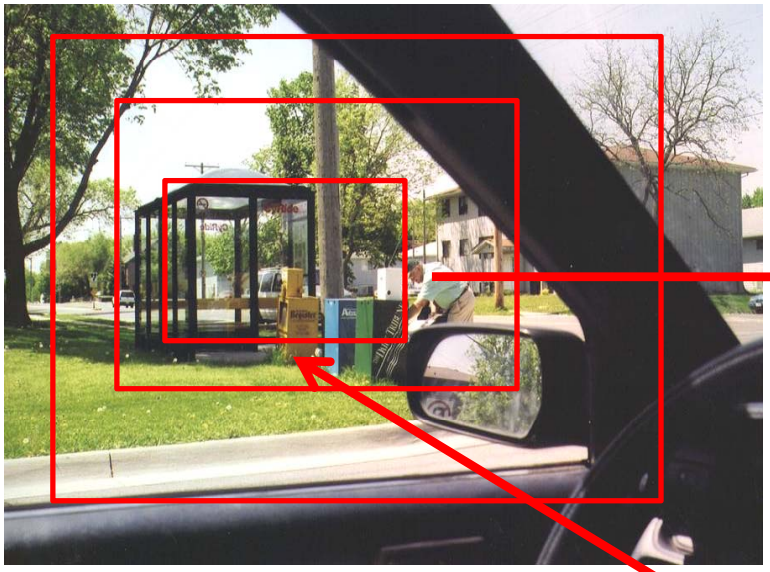
The possible use of traffic control devices should always be considered; for instance, the design of an intersection to be eventually controlled by signals may differ from one requiring channelistation and signs.

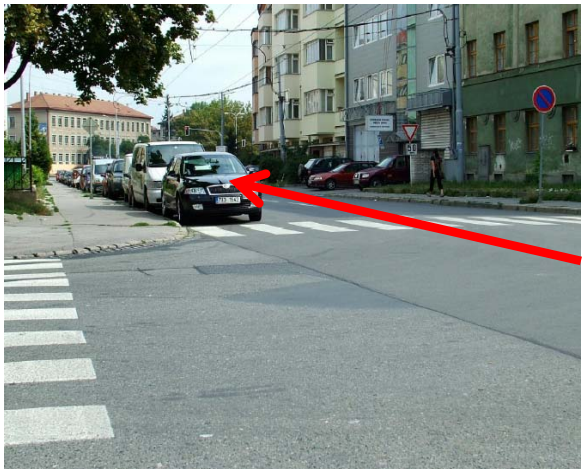
10. CONTROL ACCES IN THE VICINITY OF AN INTERSECTION

Driveways (i.e. approaches to estates, parking places) should not be designed within the function area of a newly designed intersection.

If such acces points already exists and closure is not possible for practical reasons, than channellisation techniques should be used to prevent entering vehicles from crossing the traffic flow, i.e. the vehicles entering the intersection from the driveway should always merge with the nearside traffic stream.

11. PROVIDE SAFETY STOPPING SIGHT DISTANCES AND KEEP THE SIGHT TRIANGLE WITHOUT ANY OBSTRUCTIONS





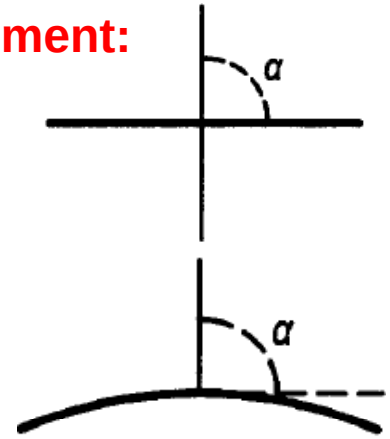
NO OBSTRUCTIONS SHOULD BE WITHIN SIGHT TRIANGLES

DESIGN OF SIGHT TRIANGLES DEPENDS ON NATIONAL METHODOLOGIES

11. PROVIDE SAFETY STOPPING SIGHT DISTANCES AND KEEP THE SIGHT TRIANGLE WITHOUT ANY OBSTRUCTIONS

Safe location of intersection in horizontal alignment:

in straight – best solution



in flat curve – possible solution

Safe location of intersection in horizontal alignment:

in sag curve – best solution

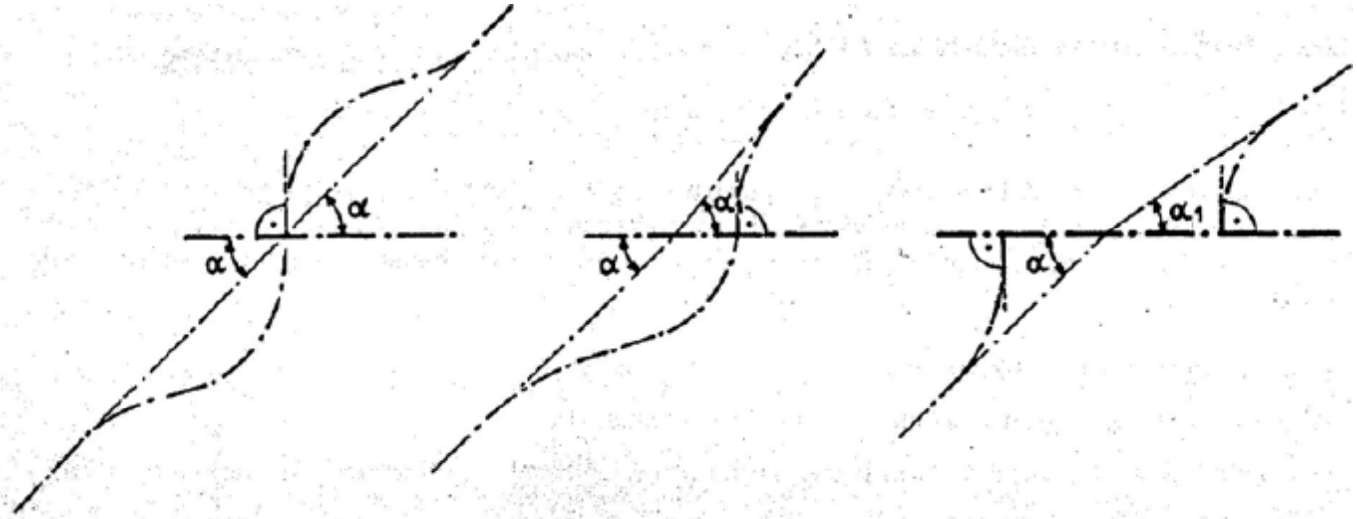
in straight between two curves (max 3 %) – possible solution

THIS LOCATIONS PROVIDE MOST COMFORT AND SAFETY SIGHT DISTANCES !!!

INTERSECTIONS

OTHER RULES

CROSSING ANGLE



α BETWEEN 75 AN 105 DEGREES

DISTANCE BETWEEN INTERSECTIONS

HIGHWAYS AND ROADS:

Design speed	Intersection distance in km on highways and roads			
	Highways and motorways – lane divided	Roads		
		Lane divided	Two lane roads (undivided)	
			I. class	II. a III. class
120	4,0	-	-	-
100	4,0	2,5	-	-
90	-	2,5	2,0	-
80	3,0	2,0	2,0	1,5
70	-	1,5	1,5	1,0
60	-	-	1,0	0,5
50	-	-	-	0,25

Distance is measured between auxiliary lanes startings and endings

DISTANCE BETWEEN INTERSECTIONS

URBAN ROADS AND MUNICIPAL COMMUNICATIONS:

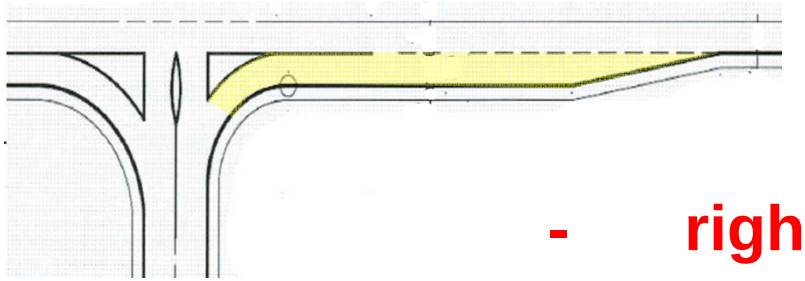
Functional group	Type of crossing	Lay – out of traffic lanes	Intersection distance in m
			minimum
A	Interchange only	Lane divided road	**1000**
		-	
B	Interchange, intersection	Lane divided road	**150 (70 - exception)**
		Undivided	
C	Intersection	Lane divided road	**50**
		Undivided	

Distance is measured between points of intersect

AUXILIARY TURNING LANES

Auxiliary lanes include:

- **left and right-turn deceleration lanes**



- **right turn acceleration lanes**

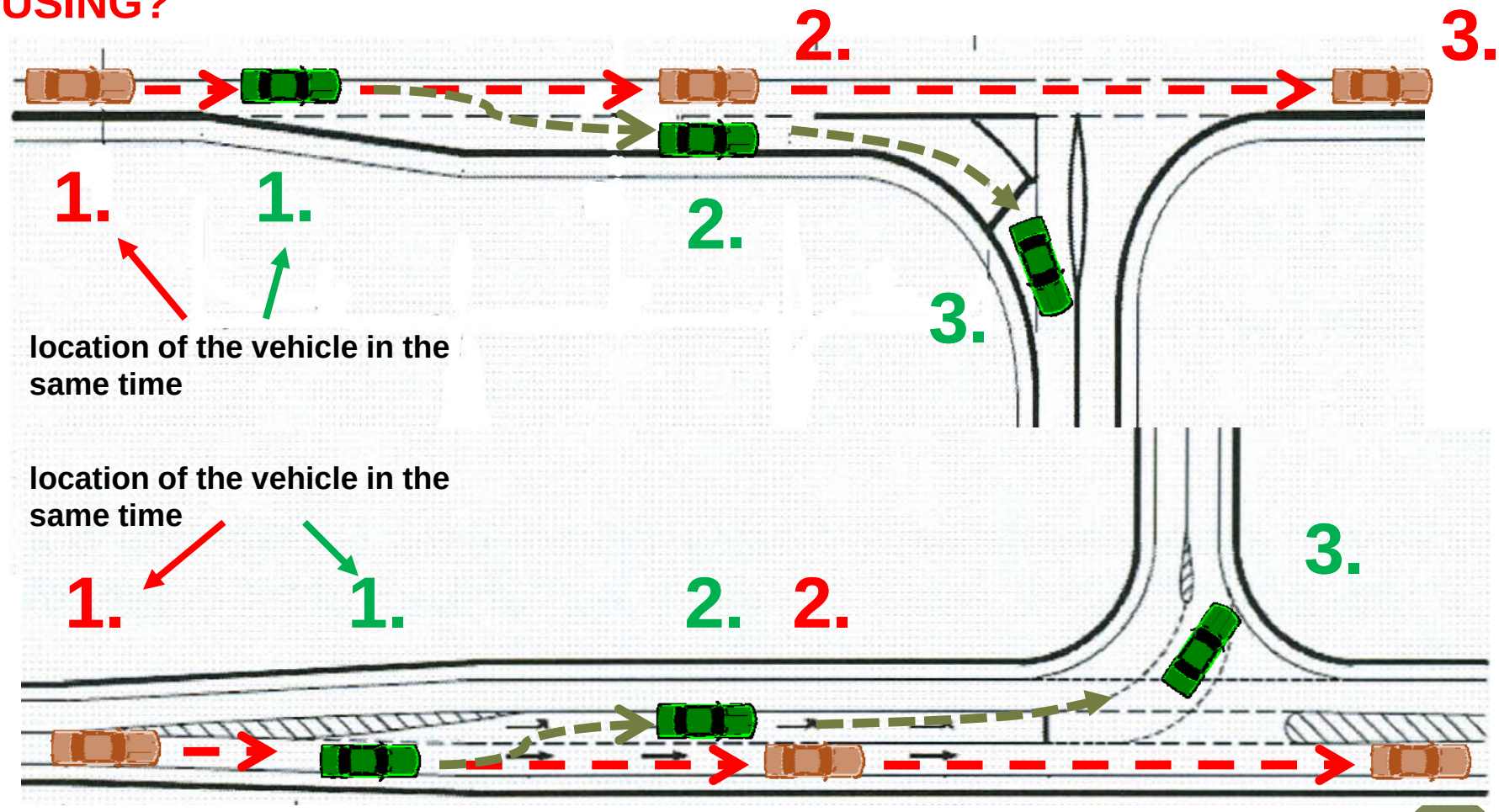
The length of auxiliary lanes depends on local conditions, traffic volumes, traffic mix, design speed, posted speed, selected level of service, longitudinal slope and operating speeds.

Auxiliary lanes should be from 3 – 3,5 m wide to minimize encroachment (zásah) of turning vehicles upon the adjacent travel way.

In restricted urban locations where space is limited and operating speeds are low, a minimum of 2,5 – 2,75 m plus the curb offset may be the only width attainable.

AUXILIARY TURNING LANES

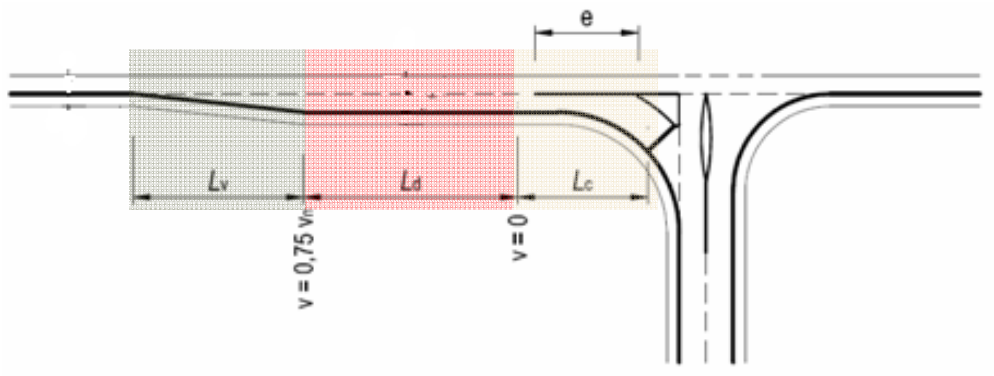
LEFT AND RIGHT-TURN DECELERATION LANES – WHY THEY ARE USING?



(improvement of traffic continuousness – decelerating and stopping vehicles are removed from through traffic stream)

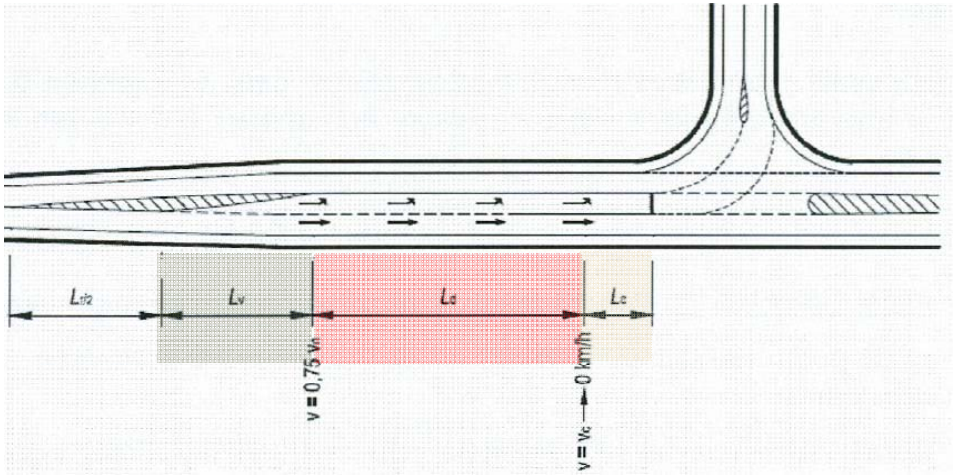
AUXILIARY TURNING LANES

LEFT AND RIGHT-TURN DECELERATION LANES – DESIGN PRINCIPLES



Lv – Taper lenght
Ld – Deceleration lenght
Lc – Storage lenght

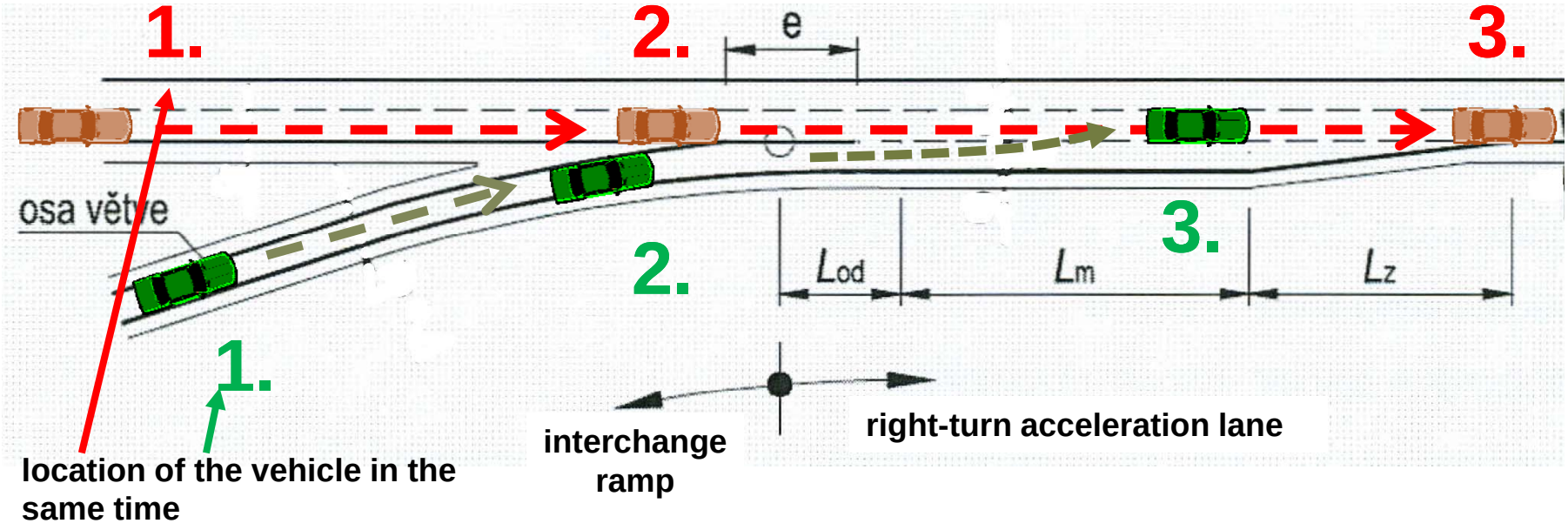
„v“ original speed;



each segment must be designed separately

AUXILIARY TURNING LANES

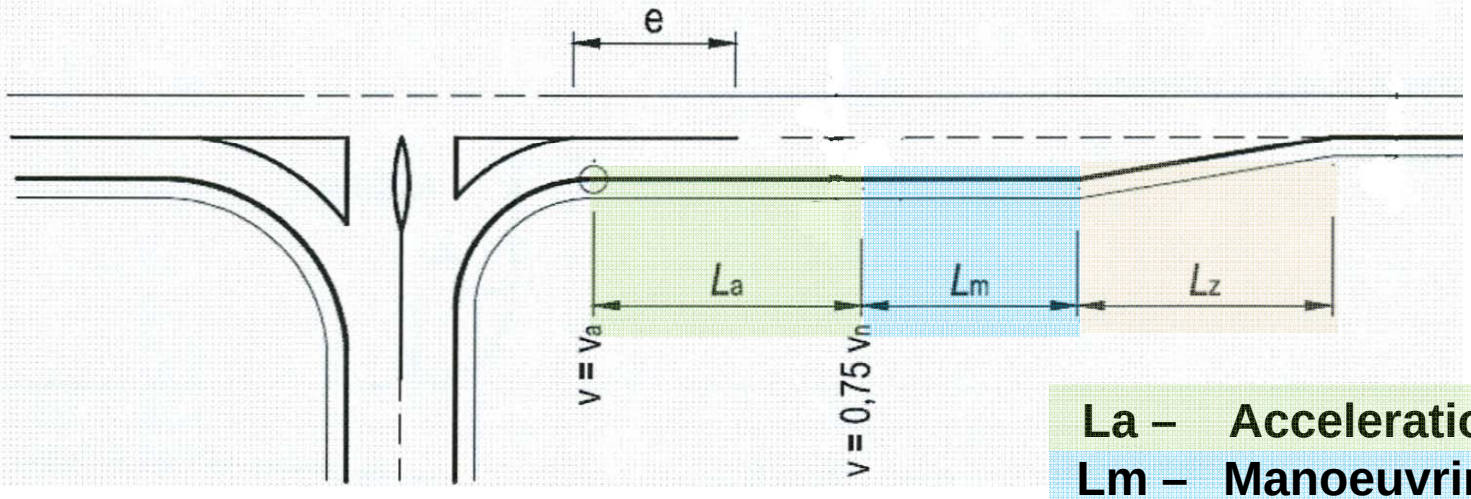
RIGHT-TURN ACCELERATION LANES – WHY THEY ARE USING?



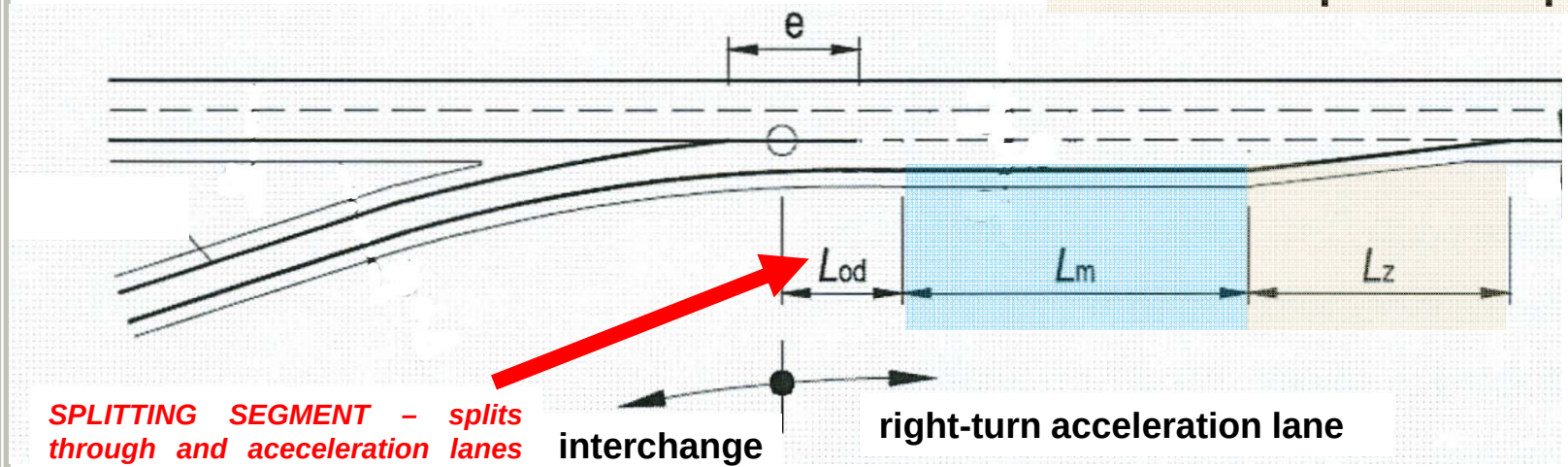
(improvement of traffic continuousness – accelerating vehicles are removed from fast through traffic stream)

AUXILIARY TURNING LANES

RIGHT-TURN ACCELERATION LANES – DESIGN PRINCIPLES



La – Acceleration lenght
Lm – Manoeuvring lenght
Lz – Departure Taper



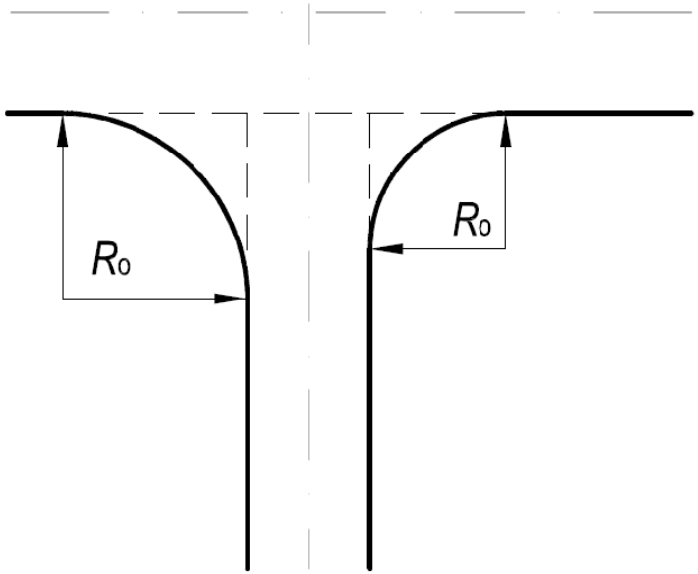
SPLITTING SEGMENT – splits through and acceceleration lanes (separation line can not exceed to manoeuvring segment)

interchange ramp

right-turn acceleration lane

„e“ is separation line (horizontal traffic marking);

CURB RADIUS



Minimal R_0 in m		vehicle
allowed	recommended	
5,00	**6,00**	personal motor car, van
7,00	**8,00**	small and middle cargo truck, bus
9,00	**10,00**	cargo truck, transit bus, semi – trailer
12,00	**15,00**	long city bus, trailer, long vehicle

INTERSECTIONS

INTERSECTION CONTROL

INTERSECTION CONTROL

Passive control (LEVEL I)

When the volume of traffic is less, no explicit control is required. Here the road users are required to obey the basic rules of the road. Passive control like guide traffic signs, road markings etc. are used to complement the intersection control. Some of the intersection control that are classified under passive control are as follows:

No control

If the traffic coming to an intersection is very low, then is sufficient applying the basic rules of the road (**right hand rule**).

Informatory traffic signs

Informatory traffic signs only waken (warn) the drivers, i.e. locality with right hand rule etc. This signs don´t provide any additional intersection control.

Informatory traffic signs plus marking

Some of the examples include recommended stop line marking, recommended yield lines, arrow marking etc. This signs also don´t provide any additional intersection control.

INTERSECTION CONTROL

Semi control (LEVEL II)

In semi control or partial control, the drivers are gently guided to avoid conflicts. Traffic signs, channelization and traffic rotaries are three examples of this:

Traffic signs

With the help of warning signs, it is able to provide some level of control at an intersection. Give way control, two-way stop control, and all-way stop control are some examples.

The **GIVE WAY (YIELD) control** requires the driver in the minor road to slow down to a minimum speed and allow the vehicle on the major road to proceed.

Two way stop control requires the vehicle drivers on the minor streets should see that the conflicts are avoided.

Finally an **all-way stop control** is usually used when it is difficult to differentiate between the major and minor roads in an intersection. In such a case, STOP sign is placed on all the approaches to the intersection and the driver on all the approaches are required to stop the vehicle. The vehicle at the right side will get priority over the left approach. The traffic control at 'at-grade' intersection may be uncontrolled in cases of low traffic. Here the road users are required to obey the basic rules of the road. Passive control like traffic signs, road markings etc. are used to complement the intersection control.

Channelization techniques

The traffic is separated to flow through definite paths by using traffic islands supplemented by road markings. The conflicts in traffic movements are reduced to a great extent in such a case. In channelized intersections, as the name suggests, the traffic is directed to flow through different channels and this physical separation is made possible with the help of some barriers in the road like traffic islands, road markings etc.

Traffic rotaries / roundabouts

It is a form of intersection control in which the traffic is made to flow along one direction around a traffic island. The essential principle of this control is to convert all the crossing conflicts into milder conflicts like merging, weaving and diverging. Free-left turn and through movements are permitted – **all of traffic movements are forced to move around the central island in a clock-wise direction**. Merging, weaving and diverging operations reduces the conflicting movements at the rotary.

INTERSECTION CONTROL

Active control (LEVEL III)

Active control implies that the road user will be forced to follow the path suggested by the traffic control agencies. He cannot maneuver according to his wish. Traffic signals and grade separated intersections come under this classification:

Traffic signals

Control using traffic signal is based on time sharing approach. At a given time, certain traffic movements are restricted where as certain other movements are permitted to pass through the intersection. Two or more phases may be provided depending upon the traffic conditions of the intersection.

The signals can operate in several modes. Most common are fixed time signals and vehicle actuated signals. In fixed time signals, the cycle time, phases and interval of each signal is fixed. Each cycle of the signal will be exactly like another. But they cannot cater to the needs of the fluctuating traffic. On the other hand, vehicle actuated signals can respond to dynamic traffic situations. Vehicle detectors will be placed on the streets approaching the intersection and the detector will sense the presence of the vehicle and pass the information to a controller. The controller then sets the cycle time and adjusts the phase lengths according to the prevailing traffic conditions.

Grade separated intersections / interchanges

Grade separated intersections allows the traffic to cross at different vertical levels. Grade separated intersections are usually constructed on high speed facilities like expressways, freeways etc. These type of intersection increases the road capacity because vehicles can flow with high speed and accident potential is also reduced due to vertical separation of traffic.