WORKSHOP
ROADSAFETY,
A CONTINUOUS CHALLENGE

EFFECTIVENESS OF ROAD SAFETY MEASURES

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Infrastructure safety improvement schemes

- Key component of road safety strategies
- Specific programmes since the 1980´s
- Two categories of schemes
  - Spot locations: Black spots, accident concentration sections
  - Extended: High improvement potential sections, forgiving roadsides
- Require specific analysis and design techniques to address the safety problems related to user behaviour and site features
- Require structured management procedures to ensure effectiveness

International best practice references

- Europe: CEDR →
  - Best practice for Cost-Effective Road Safety Infrastructure Investments (2008)
- USA: AASHTO/NHTSA →
  - Highway safety manual (2010)
- Australia&New Zelland: Austroads →
  - Effectiveness of measures to reduce road fatality rates (2010)
- World road association: AIPCR →
  - Effective road safety measures (Road Safety Technical Committee, 2007)
  - Road safety manual (2003, 2015)

Main intervention areas to improve infrastructure safety *

- Road functionality
- Alignment
- Cross section
- Signing and marking
- Roadsides
- Intersections
- Vulnerable users
- Public and private services

** Effective road safety measures (Road Safety Technical Committee, 2007)*

Road functionality

- Network hierarchization
  - Long distance mobility
  - Distribution
  - Access
- Linear settlements
- Traffic calming
  - Signing
  - Physical obstructions
  - Pavement
  - Larger schemes

Road hierarchy and functional design

- **Long distance mobility**

  80-130 km/h

- **Distribution**

  50-80 km/h

- **Access**

  50-15 km/h

1. Function

1.01 LINEAR SETTLEMENTS

Problem: Linear settlements with a mixture of through and local slow traffic and non motorized road users. This is a major road safety problem especially in developing countries.

Treatment Types & Costs

T1: Access control **$**

Low cost solution with reasonable expectation of accident savings but strong legal enforcement

T2: Separation of the shoulder by barriers **$$**

Medium cost solution with good expectation of accident savings

T3: Separate system of Motorways and Express roads completely access controlled **$$$**

High cost solution with excellent potential for accident savings.

Crash Types

- Mainly severe accidents with pedestrians and cyclists
- Side collisions
- Head on collisions where crash barriers are missing

Affected Users

- All users but especially pedestrian, cyclists and motorcyclists

Treatments & Their Benefits, Road functions and categories

General Principles

Road design is determined by the desired travelling and transport time and transport capacity. Similar to a body's blood system road networks are organized in a hierarchy of:

Main arteries for high capacity and fast movement of blood.

- Distributors to spread the blood to organs and muscles
- And arterioles and capillaries to access the single cells in the muscles and organs.

Transforming this model to our road network we can see that we have different types of roads for different functions:

- Express roads for high capacity transport to shorten the travelling time for long **distance transport** or between strategically important economic centres like airports, ports and cities
- Various classifications of secondary roads for **distribution** of passengers and goods, and
- **Access** roads to reach private and public properties and for local communication

This model has shown over millions of years of evolution to be the most successful way of transporting blood around the body and we may derive from this the following general design principles for our road networks:

1) Make a clear distinction and separation between Interurban Roads for high speeds and Urban Roads for low speeds but smooth transport.
2) Design hierarchies of both function and different legal speeds within these two categories.
3) Take the legal speed limit as a consistent design speed.
4) Design each category and function specifically to facilitate safe movement. The safest roads are single functional roads.
5) Avoid mixed functions along Interurban Roads and, as far as possible, on Urban roads.
6) To improve road safety it is obviously necessary to limit the number of properties along inter urban roads and especially to rigorously control the access to these properties from the main carriageway. Separate local distributor roads or agricultural ways along or separate from highways are the only sustainable solution.

T1: Access control

Unconstrained access to roads allows an unsustainable mix of fast-moving, heavy and dangerous traffic together withy slower, vulnerable users, pedestrians, old people, cyclists etc. It is crucial to strictly control access to roads ensure that these incompatible mixes do not occur.

T2: Separation of the shoulder by barriers

A vehicle barrier separating the moving traffic from vulnerable users gives protection and facilitates efficient throughput of traffic.

T3: Separate system of Motorways and Express roads completely access controlled

The safest solution of all is to completely separate the different classes of road users and to rigidly control access to these roads.

1.04 TRAFFIC CALMING (T4) – Larger schemes


Problem: On many roads, the speed and also the volume of traffic is sufficiently high that the safety of all road users – pedestrians, cyclists, motorcyclists and even those in larger vehicles in the main traffic flow – is threatened.

Treatment Types & Costs

Rather than installing barriers and other measures to protect vulnerable road users from fast moving vehicles, traffic calming measures specifically aim to reduce the speed of the vehicles so that all road users can mix more safely in the same space. In most cases, a reduction in speed also serves to reduce the number of vehicles using the road. Other outcomes of traffic calming include an improved quality of life and reduced pollution.

Traffic calming measures can be divided into four categories according to the nature of the measure and how it is constructed, Signs, physical obstruction, road surface and larger schemes. It is difficult to divide them in any other way, such as rural/urban or link/junction since most measures can be used in a variety of locations.

T1. Signs – 1.04(1)	$
T2. Physical obstruction – 1.04(2)	$$
T3. Road surface – 1.04(3)	$$
T4. Larger schemes – this page 1.04(4)	**$$$**

Each measure can have several variants and can be used either in combination with others or in isolation

Crash types

- The close proximity of fast moving vehicles to each other and to vulnerable road users can result in head-on, side impact and rear-end accidents.
- All crash types.

Affected Users

- All road users are at risk from fast moving vehicles.

Treatments & Their Benefits – T(4) Larger schemes

All the solutions on this page are more complex than single isolated measures. They are either larger schemes that require more substantial works to complete or solutions which enforce significant changes to the traffic flow pattern in an area.

T4.1 Width restrictors permit narrow vehicles, sometimes only bicycles and motorcycles, to pass

T4.2 Amended junctions change the permitted movements into and out of a junction

T4.3 Bus-only accesses permit buses (and emergency vehicles) to pass, but block other vehicles, using restriction signs or high cushions

T4.4 Gateways combine a variety of measures to indicate that the driver has entered an area where slower speeds are expected

T4.5 Roundabouts are a junction type which, when traffic flows are low or balanced, calm traffic in all directions

T4.6 Home zones use a wide variety of traffic calming and safety measures over an extensive residential area

T4.7 One-way streets change travel patterns by restricting movement along a road to a single direction

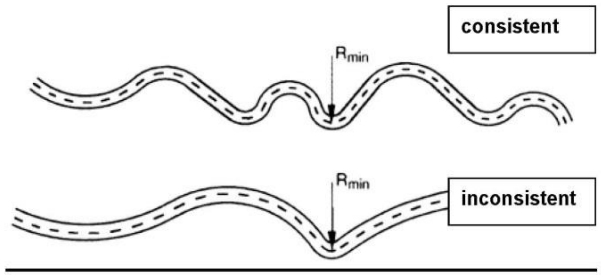
T4.8 Speed limit zones force vehicles to travel at or below a defined speed

T4.9 Closed roads have a great impact upon traffic patterns and can prevent residential roads being used as short cuts

Alignment

- Horizontal
- Vertical
- Alignment consistency
- Forward visibility
- Lack of superelevation
- Poor horizontal and vertical curvature

3.02 HORIZONTAL ALIGNMENT



Problem: An inconsistent alignment with a combination of large with small radius horizontal curves surprises the driver.

Treatment Types & Costs

T 1: Consistent design avoids treatment $

This can be expensive if the road has to be rebuilt later. ($$$$)

T 2: Traffic signing and markings $

Low cost solution with fairly good expectation of accident savings.

T3: Additional barriers $$

Medium cost solution with good expectation of accident savings.

T4: Reconstruction of curves $$$

High cost solution with excellent potential for accident savings.

Crash Types

- Head-on collisions
- Run off accidents

Affected Users

- Car, van, bus and truck occupants as well as motorcyclists

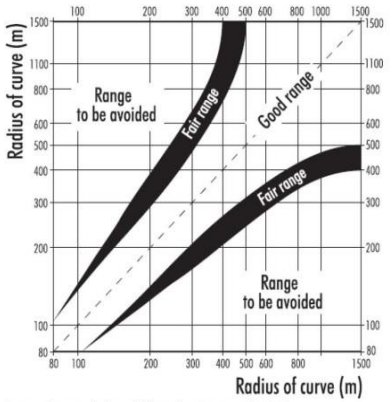
Treatments & Their Benefits, Horizontal alignment

T1: Consistent design
The differences of two radii in curve sequences should be in the good range. For example, first radius 400 m ▶following radius between 250 m and 800m.

Range of horizontal radii for :

Motorways: R>700 m with spiral curves A>240 m
Express roads: R≥ 500 m with spiral curves A≥ 150 m
Highways R = 300-900 m with spiral curves A ≥ 80 m
Regional roads: R = 250-600 m with spiral curves A ≥ 80 m
Small rural roads: R = 150-300 m, no transition curves

Figure HA-9 Tuning radii in curve sequences



Source : German design guidelines, from Lamm et al. (1999)

T2: Traffic signing and markings
In existing cases, speed reduction, chevrons and rumble strips ahead.

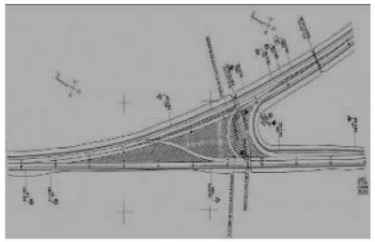
T3: Additional crash barriers
Crash barriers on the outside of bends can drastically reduce the severity of accidents.

T4: Reconstruction of the curve
Reconstructing the bend with a more sympathetic radius and/or better super-elevation can drastically reduce the severity of accidents.

Intersections

- **Junctions**
  - Poor design
  - Visibility at T-junctions
  - Visibility at cross roads
  - Acceleration and deceleration lanes
  - Dangerous turning manoeuvres
  - Y-Type intersections
- **Roundabouts**
  - Insufficient deflection
  - Faults at small roundabouts

4.07 Y-TYPE INTERSECTIONS



Problem: Intersections of the Y-Type don't give a clear explanation on the right of way, have dangerous conflict points and give poor safety conditions for pedestrians and other vulnerable users.

Treatment Types & Costs

T1: A perpendicular junction (T-Type)
Relatively cheap and safe solution. It has a reasonable expectation of accident savings. Signalization may be necessary. **$$**

T2: Round about
Relatively cheap and safe solution savings if traffic volume is lower than 15,000 vehicles per day. **$$**

T3: General solutions
General recommendations of the PIARC Road Safety manual. For example, junction realignment. **$$$**

Crash Types

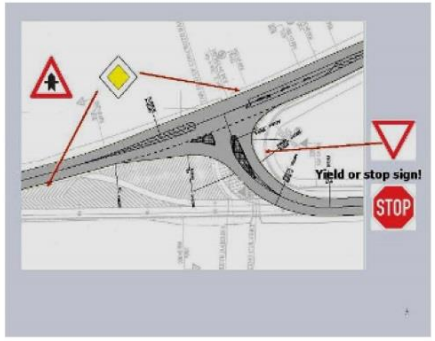
- Mainly severe accidents with pedestrians and cyclists
- Side collisions
- Head-on collisions

Affected Users

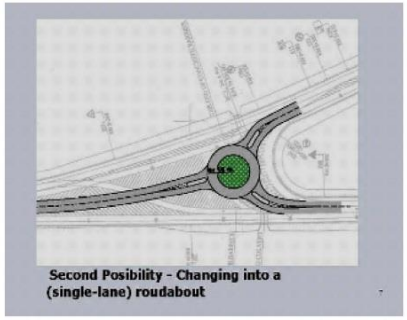
- All road users

Treatments & Their Benefits

T1: Redesign to a perpendicular junction (T-Type) with signalization, if necessary.

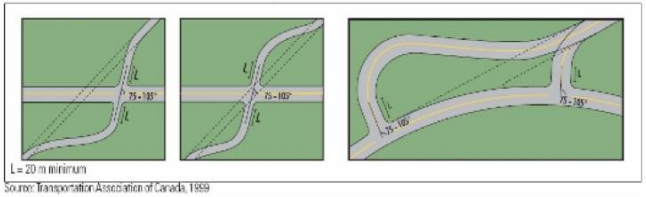


T2: Redesign to a roundabout if necessary with pedestrian crossings.



T3: General solutions

Figure I-5 Examples – Intersection re-alignments



Roadsides

- Unprotected non-traversable obstacles
- Unprotected embankment edge
- Deep side drain close to the road
- Inadequate shoulders
- Inadequate barriers
- Exposed bridge abutments
- Traffic barrier spearing
- Guidance on curves
- Un-forgiving roadsides
- Snow measures

8.02 (2) THE DRAINAGE SYSTEM



Problem:
Deep ditches and headwalls of culverts close to the carriageway are very dangerous road side obstacles causing serious accidents. Driving mistakes or manoeuvres to avoid other accidents will not be forgiven.

Treatment Types & Costs

T1: Signing and marking $
Fairly useless

T2: Rumble strips $
Good results like every where

T3: Steel barriers $$
Excellent results and removal of black spots

T4: Soakaways
An inexpensive and safe solution. $

T5: Shallow green ditches
Much cheaper and safer solution than concrete ditches.
Excellent results and removal of hazards. $

T6: Piped drainage $$
Cheaper and safer solution than concrete ditches,
Excellent results and removals of hazards.

T7: Avoid headwalls on culverts $
Inexpensive and safe solution.
Excellent results and removals of hazards.

Crash Types

- Single vehicle loss of control
- Vulnerable road users might fall into the ditches
- Vulnerable road users might come into conflicts with motorized traffic when using the carriageway avoiding the obstacles

Affected Users

- Trucks, buses, passenger cars and motorcyclists
- Vulnerable road users

Design/Treatment & Its Benefits:

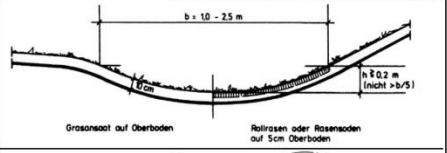
T1: Signing and marking
As the pictures show signing and marking are not sufficient and should not be regarded as a complete solution.

T2: Rumble strips along the deep ditches and in front of the headwalls can sometimes reduce the frequency of such accidents in cases of sleepiness and poor concentration of the drivers

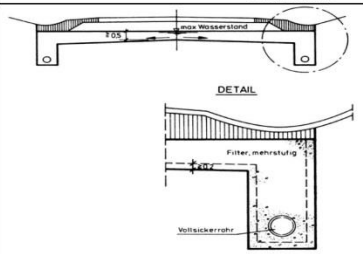
T3: Steel barriers along the ditches and above the culverts are a good medium term solution.

T4: Soakaways. Let the water seep into the ground at the roadside where ever it is possible.
This is also a sensible ecological measure. It has been discovered that most of the critical pollutions of the water from the road, such as oil and petrol will be destroyed by soil bacteria.

T5: Shallow green ditches. These collect the water in low green ditches from where most of it will seep into the ground



T6: Piped drainage. Choose a subsurface piped solution if water permeability of the soil is low



T7: Avoid headwalls on culverts.

Vulnerable road users

- Protection of pedestrians/cyclists at intersections
- Pedestrians/cyclists paths
- Kerb ramps
- Refuge islands
- Conflicts at urban intersections
- Conflicts in rural areas
- Obstructions for pedestrians
- Parking near intersections
- Pedestrian crosswalks – signing / signals
- Work zones

6.02 PROTECTION OF PEDESTRIANS AT INTERSECTIONS

Problem: Pedestrian conflicts with motorised traffic at intersections often result in fatalities. Provision for pedestrians at intersections should be given sufficient attention to ensure their safety without significantly affecting the journey time of the motorised traffic.

Treatment Types & Costs

T1: The installation of pedestrian guard rails, central refugees and pedestrian.	**$**
T2: A minor road central refuge at an unmarked crossing place.	**$**
T3: Zebra crossing, with or without a central refuge	**$**
T4: Traffic signals to control the movements at the intersection	**$$**

Crash Types

- Pedestrian-motor vehicle collisions
- Pedestrian-cyclist collisions

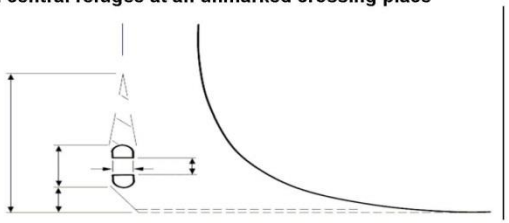
Affected Users

- All road users

Treatments & Their Benefits

T1: Pedestrian guard rails, central refugees and crossings to guide pedestrians and encourage them to cross the street in 2 steps.

T2: Minor road central refugee at an unmarked crossing place



T3: Zebra crossing

T4: Traffic signals that cater for pedestrians

Public and private services

- Rest areas
- Parking facilities
- Public transport stops
- Driving in the wrong direction

5.07 PUBLIC TRANSPORT STOPS (1)

Problem: For many people, public transport is their only option for getting to and from work, to shop or to visit friends. Buses and trams form major elements of the public transport system and, generally, use the road network. They need to offer frequent services along major connector roads with reasonably regular stops. At those stops, conflict can exist between the bus or tram, other vehicles and vulnerable road users such as pedestrians and cyclists.

Treatment types & costs

T1 Signage	**$**
T2 Improved stops	**$**

Crash types

- Rear shunts
- Side impact

Affected users

- All road users

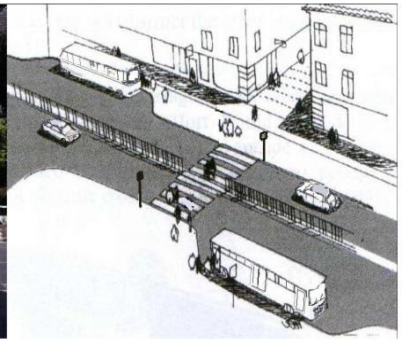
Treatments & Their Benefits

T1 Signage

This includes advance warning signs, clearer signs at the stop and attachments to the bus or tram. An example is shown opposite of a STOP sign that emerges when the doors are opened on a tram. The example below shows signage at a tram stop indicating priority for pedestrians – note there is also traffic calming at this stop.

T2 Improved stops

In some countries efforts have been made to ensure the stop is well defined, well lit and obvious to the motorist. In some countries bus bays are indented to get the bus out of the main traffic stream. Pedestrian crossings can also be added to provide further safety for people using public transport.



Thank you for your attention!