B.Sc - Road & Railway Design I. *Lecture 7.*

ROAD TRAFFIC ACCIDENTS

Dr. András Timár Professor Emeritus

University of Pécs – Faculty of Engineering and Information Technology - Department of Civil Engineering

Pécs, 2019

DEFINITIONS

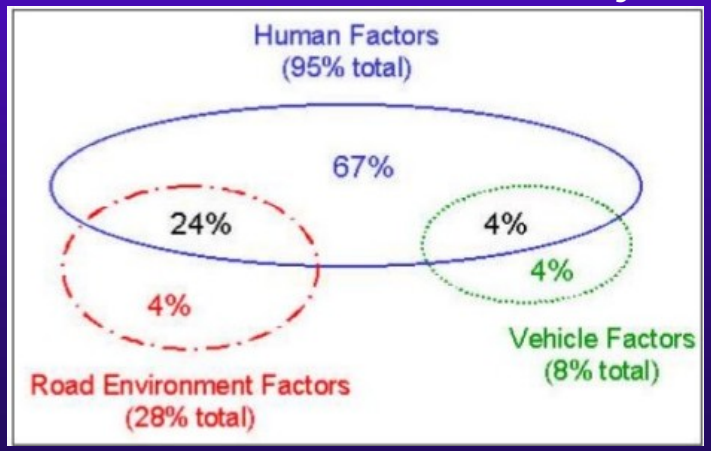
- An *accident* is defined as an unplanned event resulting in personal injury or property damage
- A *near miss* is defined as an incident in which there was no injury or property damage but where the potential for serious consequences existed
- A *dangerous occurrence* or *conflict* is an incident with a high potential to cause death or serious injury, but which happen relatively infrequently
- All accidents are incidents, however, the definition of an *incident* is wider in that it includes both dangerous occurrences (conflicts) and near misses as well

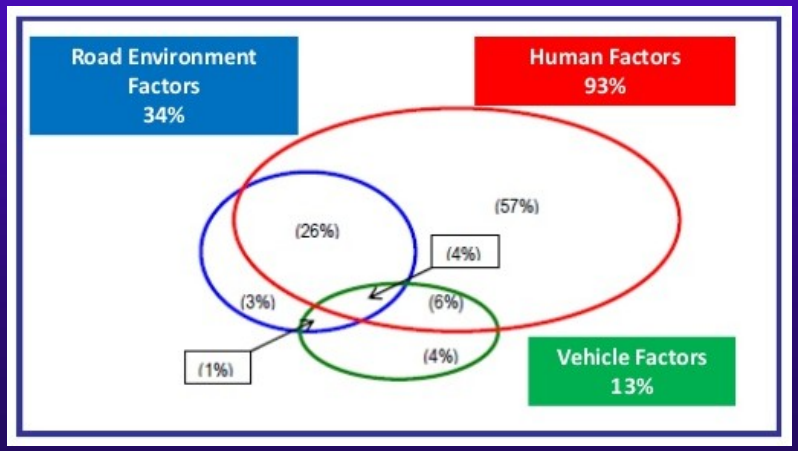
ROAD TRAFFIC ACCIDENT

- A road traffic accident (RTA) occurs when a vehicle that is moving along a roadway collides with another vehicle or object
- About 1.24 million people die each year as a result of road traffic crashes (8th leading cause of death worldwide)
- Road accident non-fatal injuries (20-50 million per year) are the leading cause of death among young people, aged 15–29 years
- In addition to the grief and suffering, RTAs result in considerable economic losses to victims & nations as a whole (1-2% of GNP)

CAUSES OF ROAD TRAFFIC ACCIDENTS

- A study using British and American crash reports as data, suggested in 1985, that
  - 57% of crashes were due solely to driver factors,
  - 27% to combined *roadway* and driver factors,
  - 6% to combined vehicle and driver factors,
  - 3% solely to *roadway* factors,
  - 3% to combined *roadway*, driver, and vehicle factors,
  - 2% solely to vehicle factors, and
  - 1% to combined *roadway* and vehicle factors



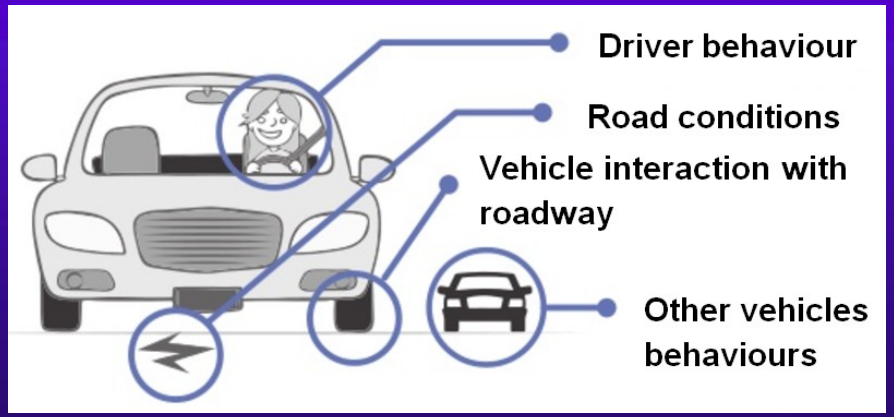


THE ROADWAY FACTOR

- The road or environmental factor is either noted, or not, makes a significant contribution to the circum-stances of the crash, or don't allow room to recover
- It is frequently the driver who is blamed rather than the road; those reporting the accident have a tendency to overlook the human factors involved, such as the subtleties of design and maintenance that a driver could fail to observe or inadequately compensate for
- Research has shown that careful design and maintenance, with well designed intersections, road surfaces, visibility and traffic control devices, can result in significant improvements in accident rates

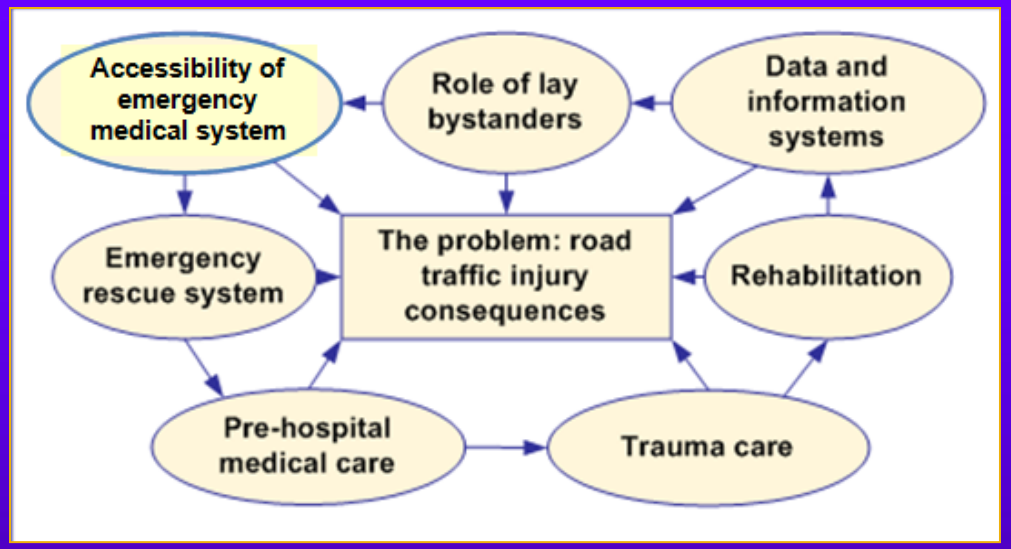
ACCIDENT PREVENTION & MITIGATION

- Reducing the severity of injury in crashes is more important than reducing incidence, and ranking incidence by too broad categories of causes is misleading regarding severe injury reduction
- Vehicle and road modifications are generally more effective than behavioural change efforts



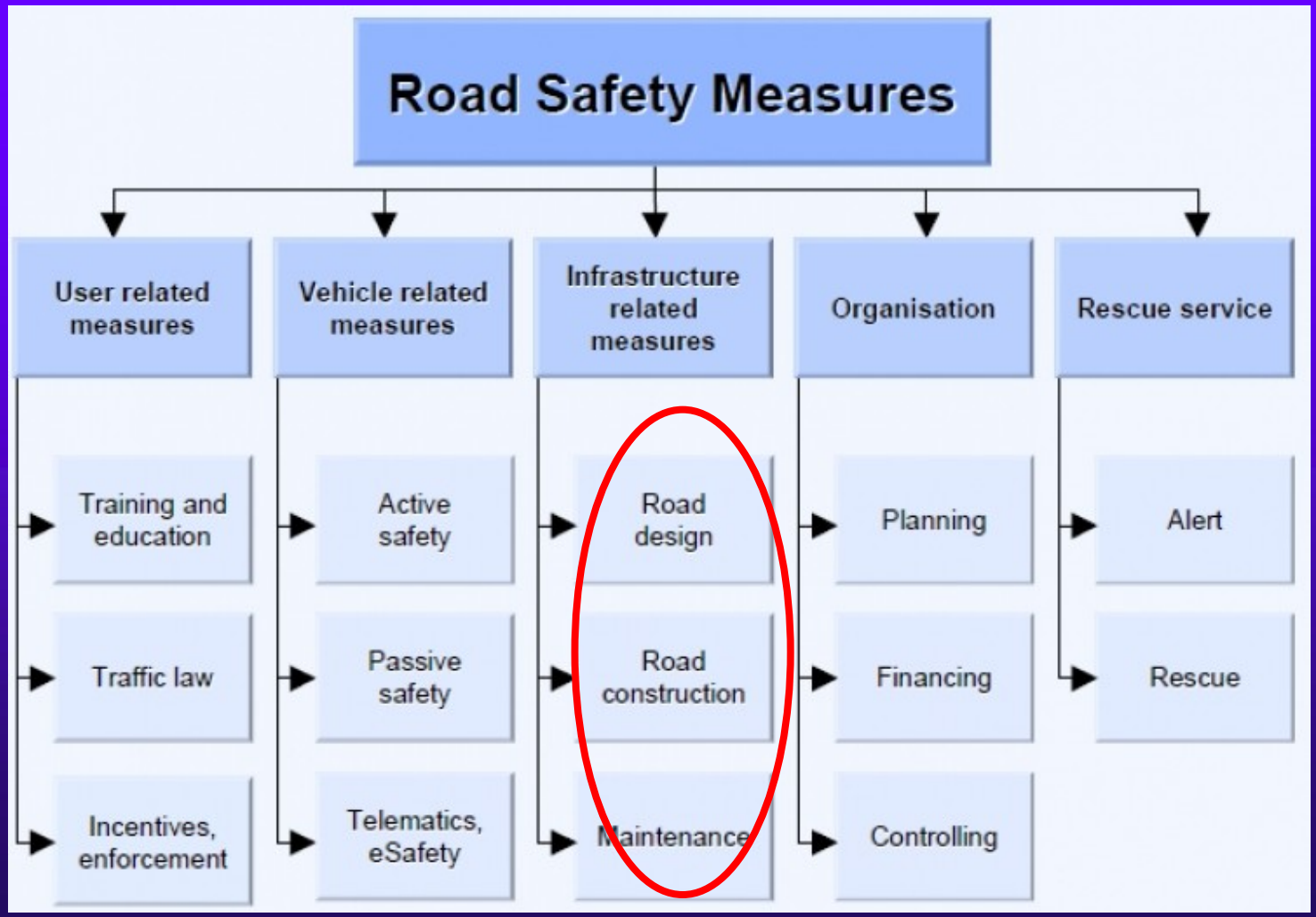
It would be necessary to know, what happened just before the accident, but crash reports prepared by the police are seldom cover all important data

POST-IMPACT CARE



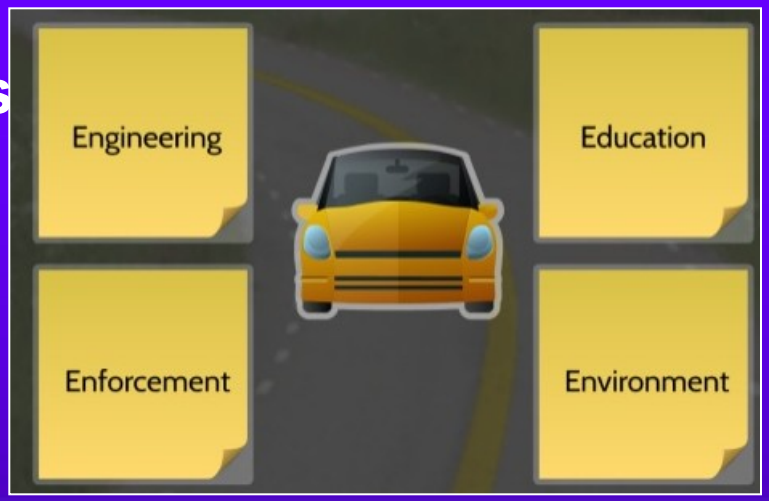
Post-impact care is a strategy which aims to reduce the severity of injury consequences once a road traffic accident has occurred. Minor injury patients will often need the help of a general practitioner and optimal medical and psychological follow up care is important to alleviate pain and distress. For major injuries, clinical experts define the post-impact care needed as the chain of help starting with action taken by the victims themselves or more commonly by lay bystanders at the scene of the crash, emergency rescue, access to the pre-hospital medical care system, and trauma care helping road crash victims (who have suffered debilitating injury), re-integrate into work and family life.

ROAD SAFETY MEASURES



IMPROVING ROAD SAFETY

- Road related measures
- Vehicle related measures
- Road safety research
- Traffic laws, operations and management
- Capacity building



- Road user behaviour strategies, public awareness & education, driver's training
- Medical care & rehabilitation
- Other

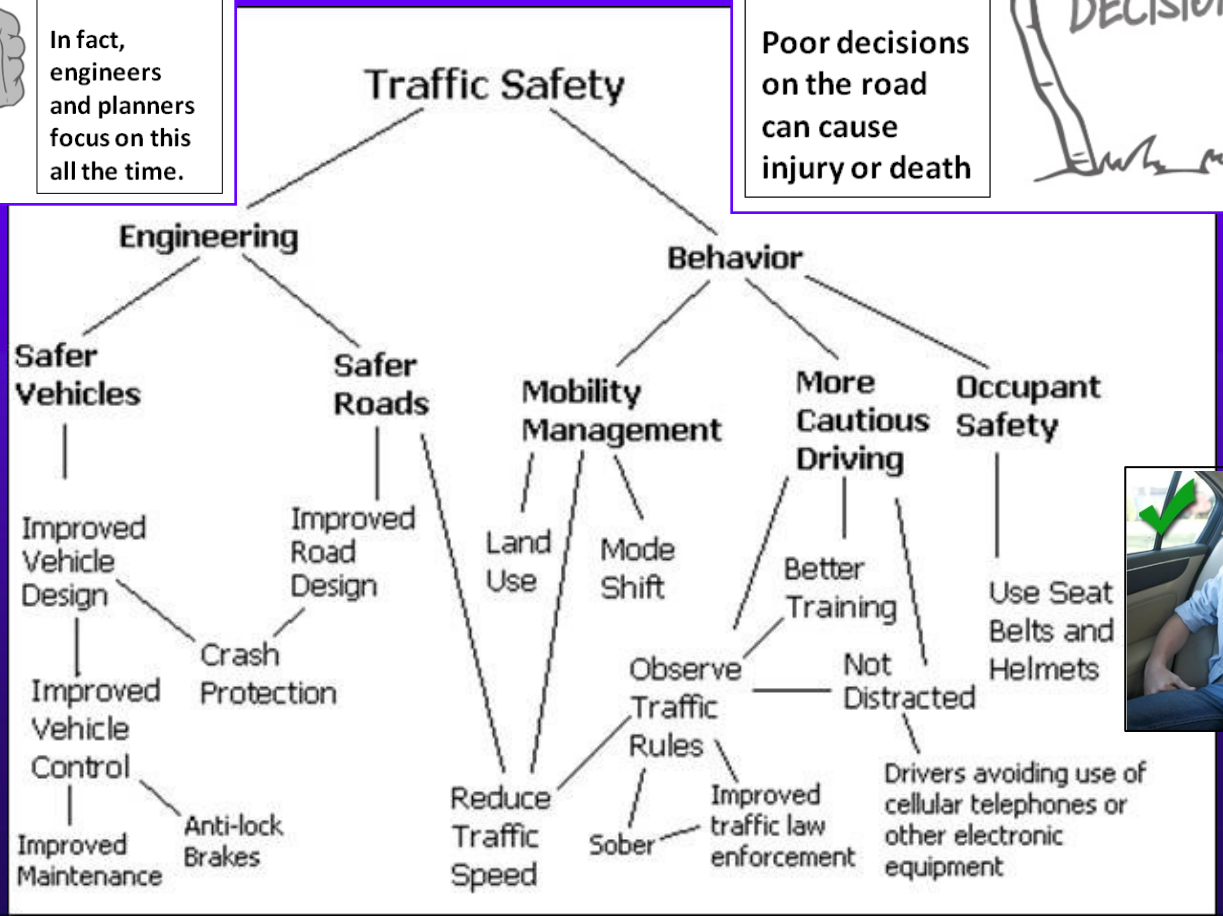
TRAFFIC SAFETY IMPROVEMENT STRATEGIES

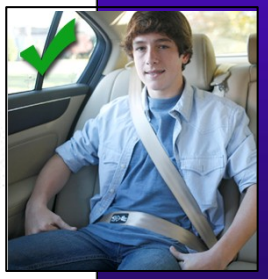
We know that road users deserve the safest system possible.

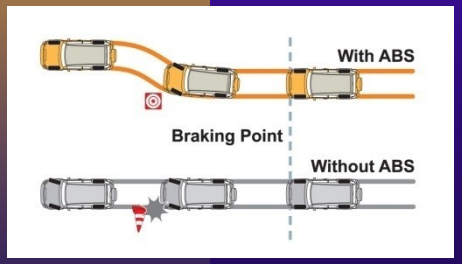
In fact, engineers and planners focus on this all the time.

Humans sometimes make wrong decisions.

Poor decisions on the road can cause injury or death







ROAD SAFETY IMPROVEMENT PROGRAM

Stage I: Development of Accident Recording System

↓

Stage II: Ranking of Safety Hazardous Locations

↓

Stage III: Identification of Remedial Safety Measures

↓

Stage IV: Prioritization of Remedial Safety Measures

↓

Output
(Road Safety Improvement Program)

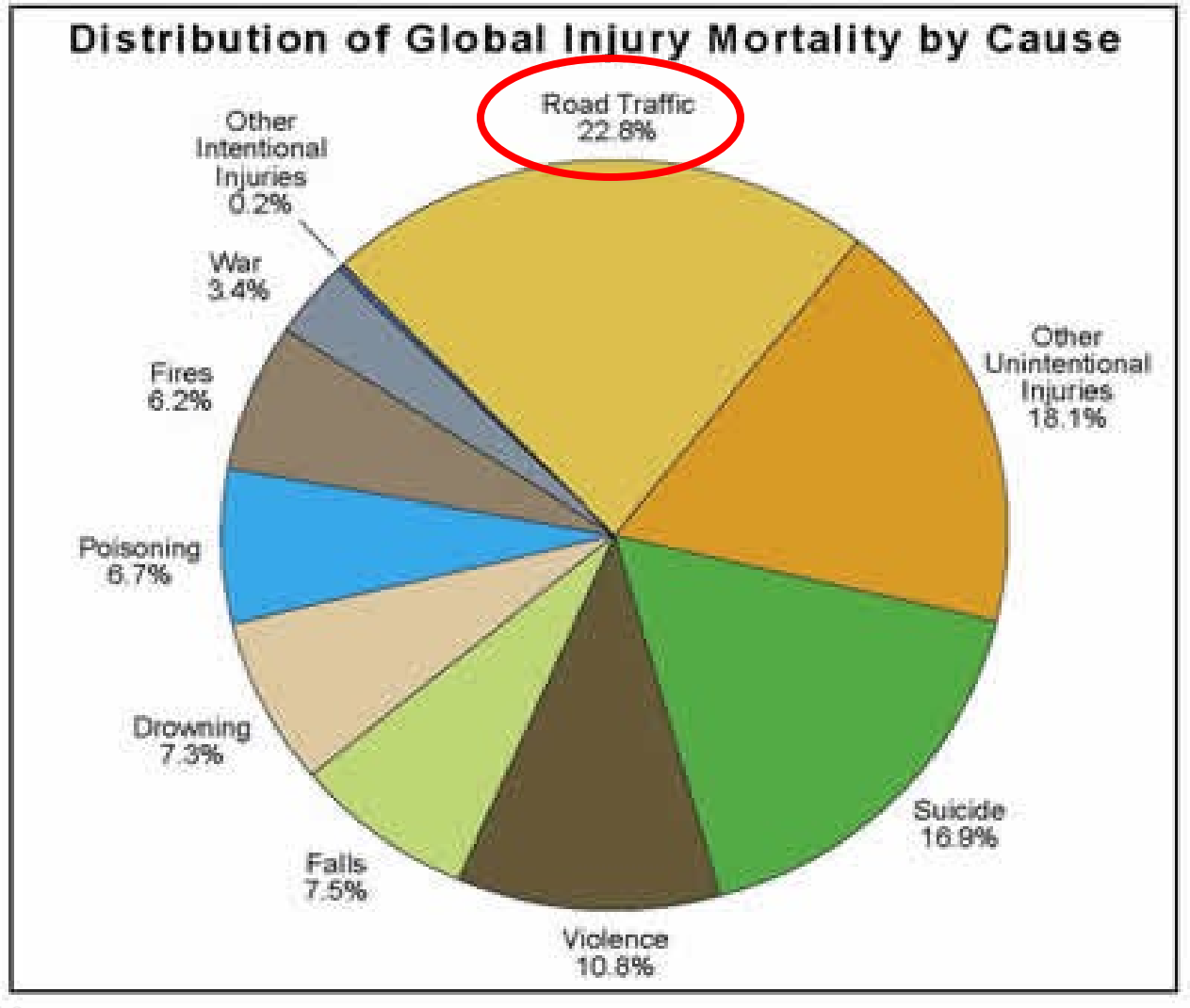
SAFETY IMPROVEMENT IMPACT PYRAMID

***Source*: Highway Safety Investment Program (HSIP), USA, 2010**

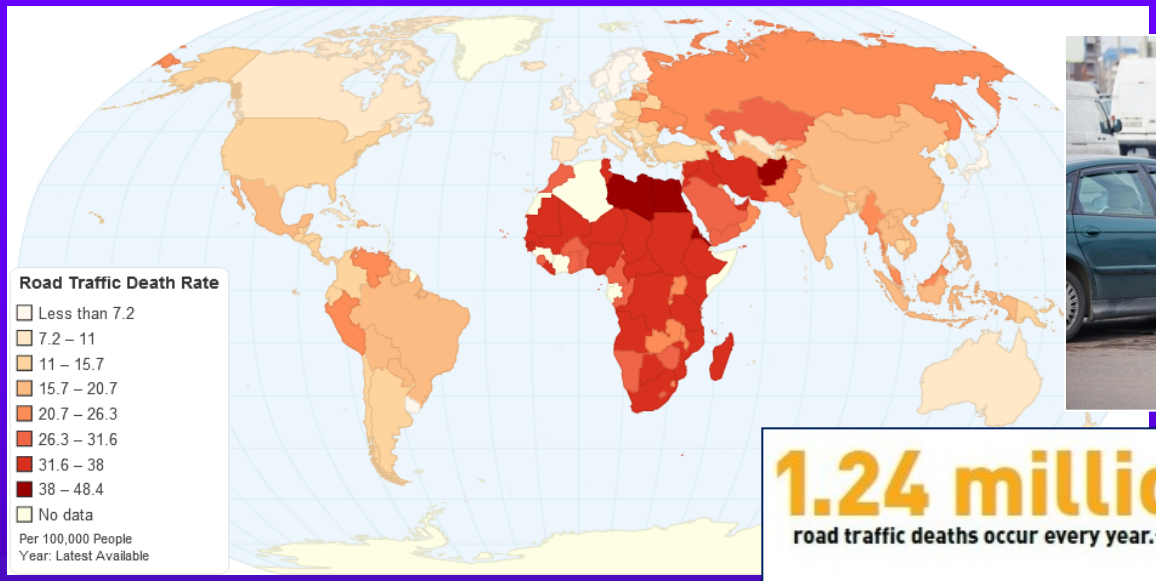
THE FIRST VICTIM OF A ROAD TRAFFIC ACCIDENT

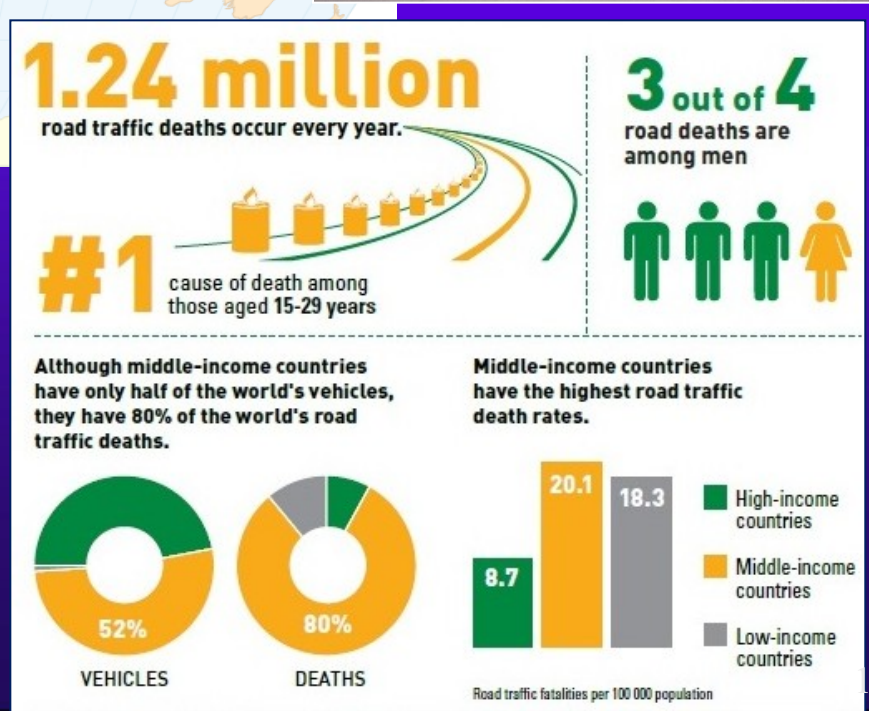
- ***Ms Bridget Driscoll*** **was the first pedestrian victim of an automobile collision in Great Britain at 17 August 1896. As she crossed Dolphin Terrace in the grounds of Crystal Palace in London, she was struck by an automobile that was used to give demonstration rides. One witness described the car as travelling at "*a reckless pace, in fact, like a fire engine!*„ Presumably it was around *12 km/h*.**
- **The jury returned a verdict of "accidental death" after an inquest during some six hours and no prosecution was made. The coroner said he hoped "*such a thing would never happen again*."**

CAUSES OF INJURY DEATHS WORLDWIDE (2012)

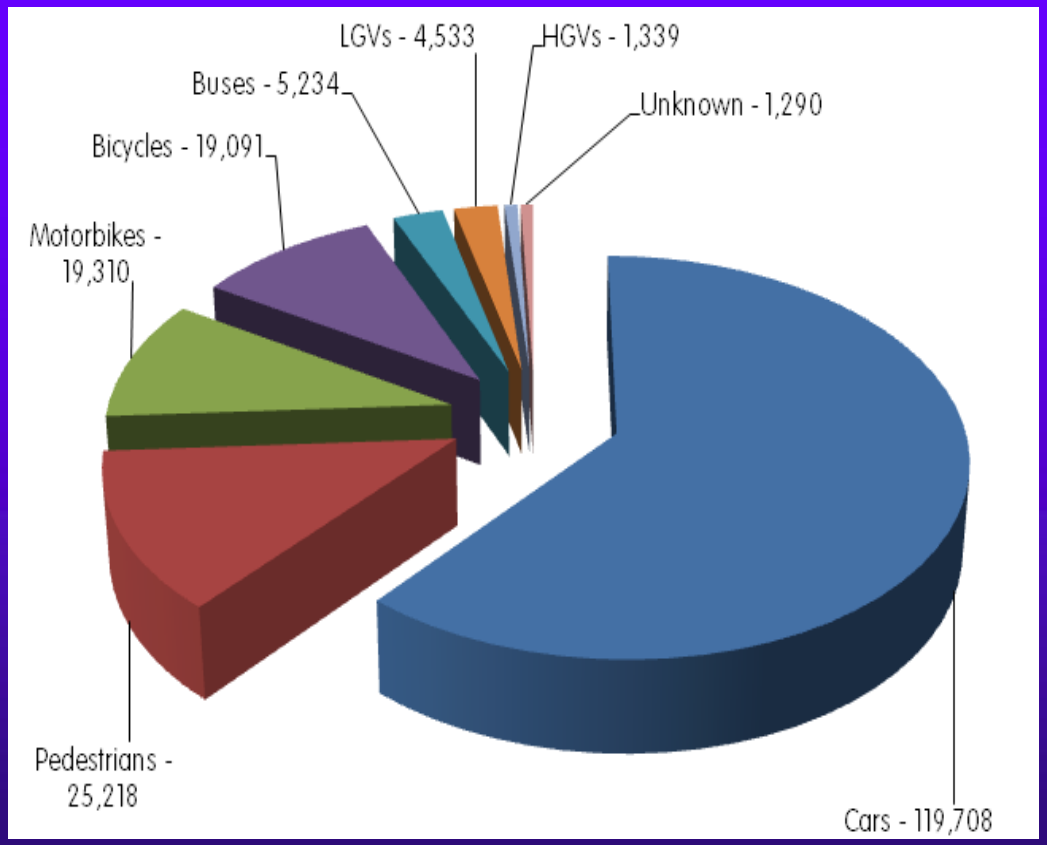


DISTRIBUTION OF ROAD TRAFFIC DEATH RATE (2012)





BREAKDOWN OF ROAD TRAFFIC INJURIES



Number of people injured in road traffic accidents in 2012 (by vehicle type) in the UK

Half of the world's road traffic deaths occur among motor-cyclists (*23%*), pedestrians (*22%*) and cyclists (*5%*) – i.e. "vulnerable road users" – with *31%* of deaths among car occupants and the remaining *19%* among unspecified road users (*Source*: WHO; 2013)

DEFINITIONS AGAIN

- **For the purposes of the road accident statistics:**
  - ***a fatal injury*** **is one which causes death less than 30 days after the accident**
  - ***a fatal accident*** **is one in which at least one person is fatally injured**
  - ***a serious injury*** **is one which does not cause death less than 30 days after the accident, and which is in one (or more) of the following categories**

    (a) an injury for which a person is detained in hospital as an in-patient ,or

    (b) any of the following injuries (whether or not the person is detained in hospital): fractures, concussion, internal injuries, crushings, severe cuts and lacerations, severe general shock requiring treatment, or

    (c) any injury causing death 30 or more days after the accident
  - ***a serious accident*** **is one in which at least one person is seriously injured, but no-one suffers a fatal injury**
  - ***a slight injury*** **is any injury which is neither fatal nor serious - for example, a sprain, bruise or cut which is not judged to be severe, or slight shock requiring roadside attention**
  - ***a slight accident*** **is one in which at least one person suffers slight injuries, but no-one is seriously injured, or fatally injured**
  - **a *damage only* or *no-injury accident* is one which causes only material damage, no personal injuries**

SMEED'S LAW

- In 1949 R.J. Smeed found an inverse (or negative) relationship between the traffic risk (fatality per motor vehicle) and the level of motorisation (number of vehicles per inhabitant)
- Smeed concluded that fatalities (D) in any country in a given year are related to the number of registered vehicles (n) and population (p) of that country by the following equation:

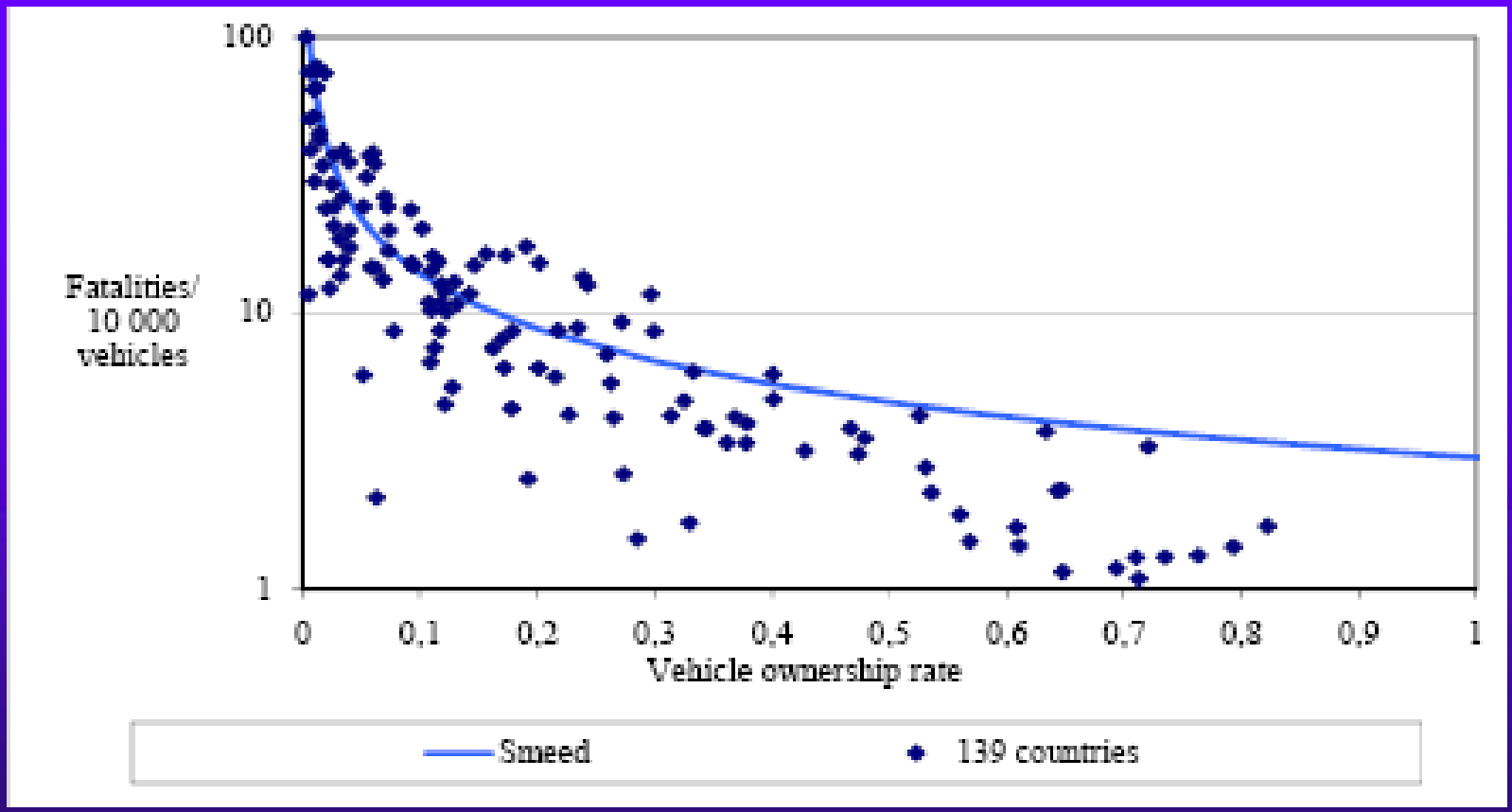
$$D = 0.0003(np^2)^{1/3}$$

where D = number of fatalities in road accidents in the country

n = number of vehicles in the country

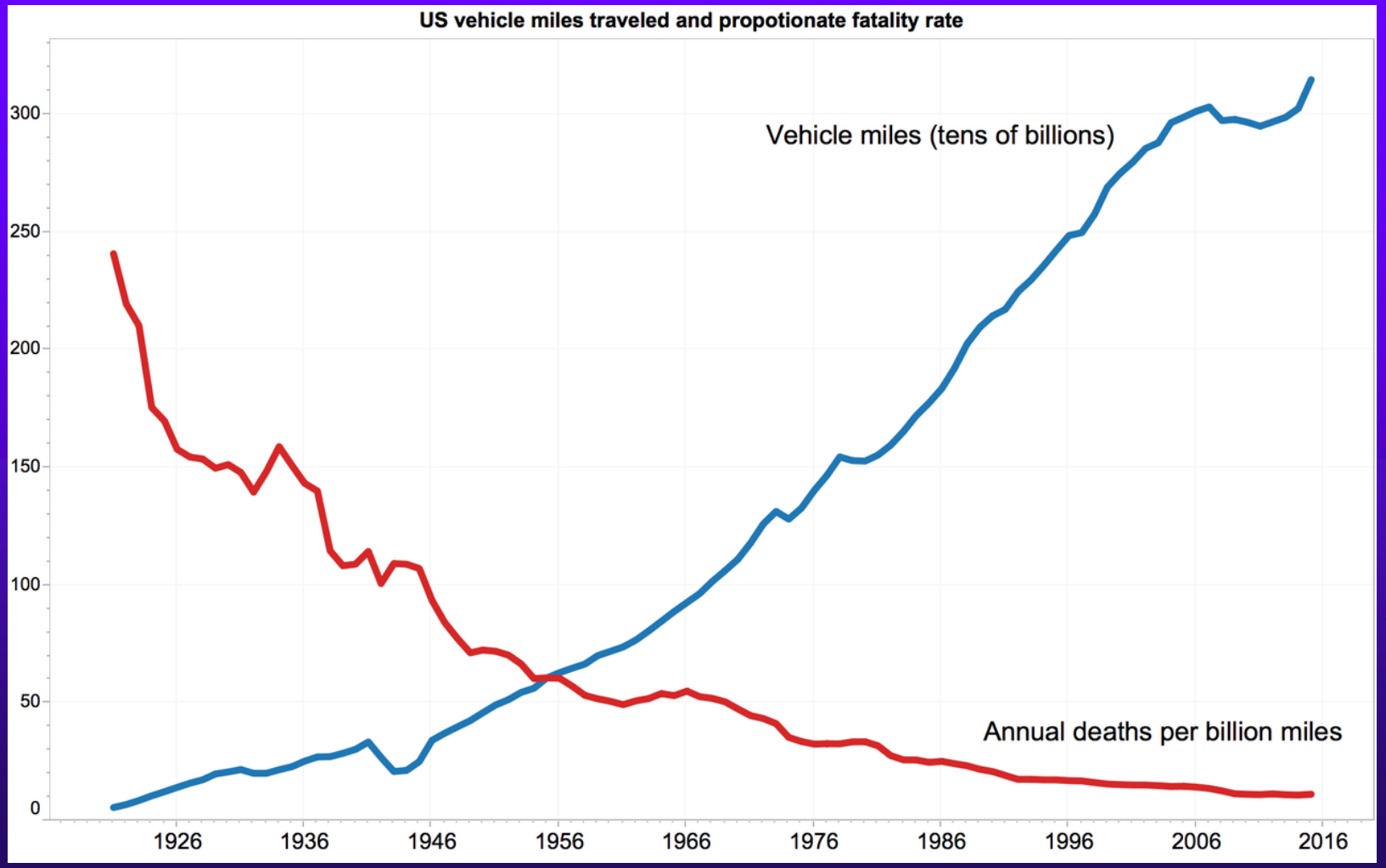
p = population

VALIDITY OF SMEED'S LAW



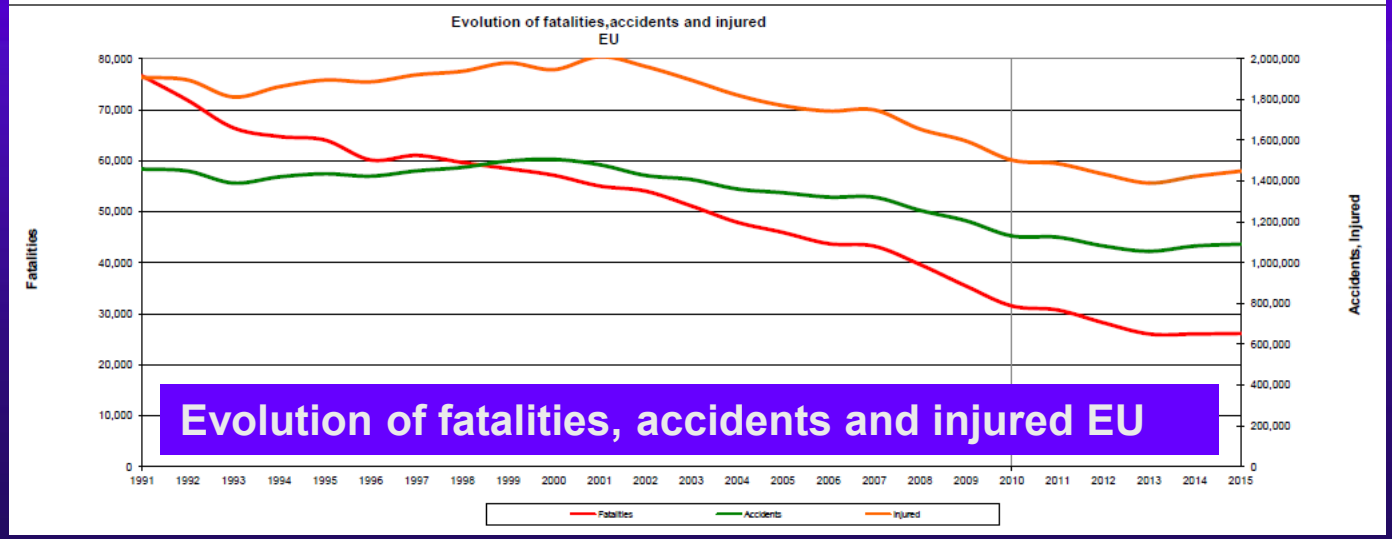
Smeed's formula is describing reasonably well the changes (increase) in road fatalities up to the 0.2-0.3 vehicles/person ownership level, whereas above this level the formula is too pessimistic, the fatalities are fortunately tending to decrease in reality (*Source*: Cs. Koren - A. Borsos; 2007).

EVOLUTION OF ROAD SAFETY IN THE USA



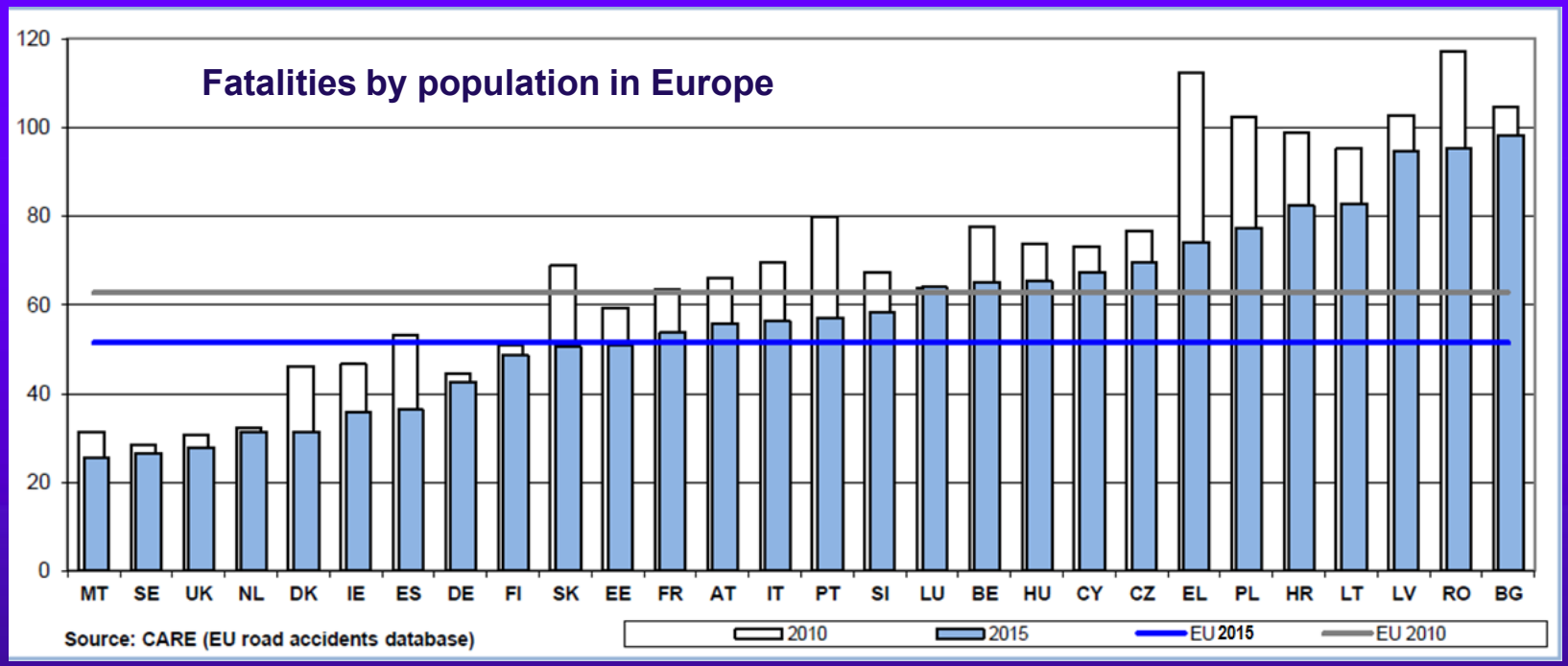
EVOLUTION OF ROAD SAFETY IN THE EU

EU fatalities and targets 2010 - 2020



Evolution of fatalities, accidents and injured EU

FATAL ACCIDENTS RATE IN EUROPE



For every death on Europe's roads there are an estimated (*i*) 4 permanently disabling injuries such as damage to the brain or spinal cord; (*ii*) 8 serious injuries and (*iii*) 50 minor injuries

TRADITIONAL, OR STATISTICAL ANALYSIS 1

- A location can be identified as hazardous by the occurrence of an abnormal number, rate, or severity of accidents over a period of time
- To compare the accident experience of several locations fairly, the period of time over which accidents are counted & the length of road section should ideally be the same at each location
- If not, an accident rate may be compared between locations, expressed for a common unit of exposure (accidents per million vehicle-km, or accidents per million entering vehicles)

TRADITIONAL, OR STATISTICAL ANALYSIS 2

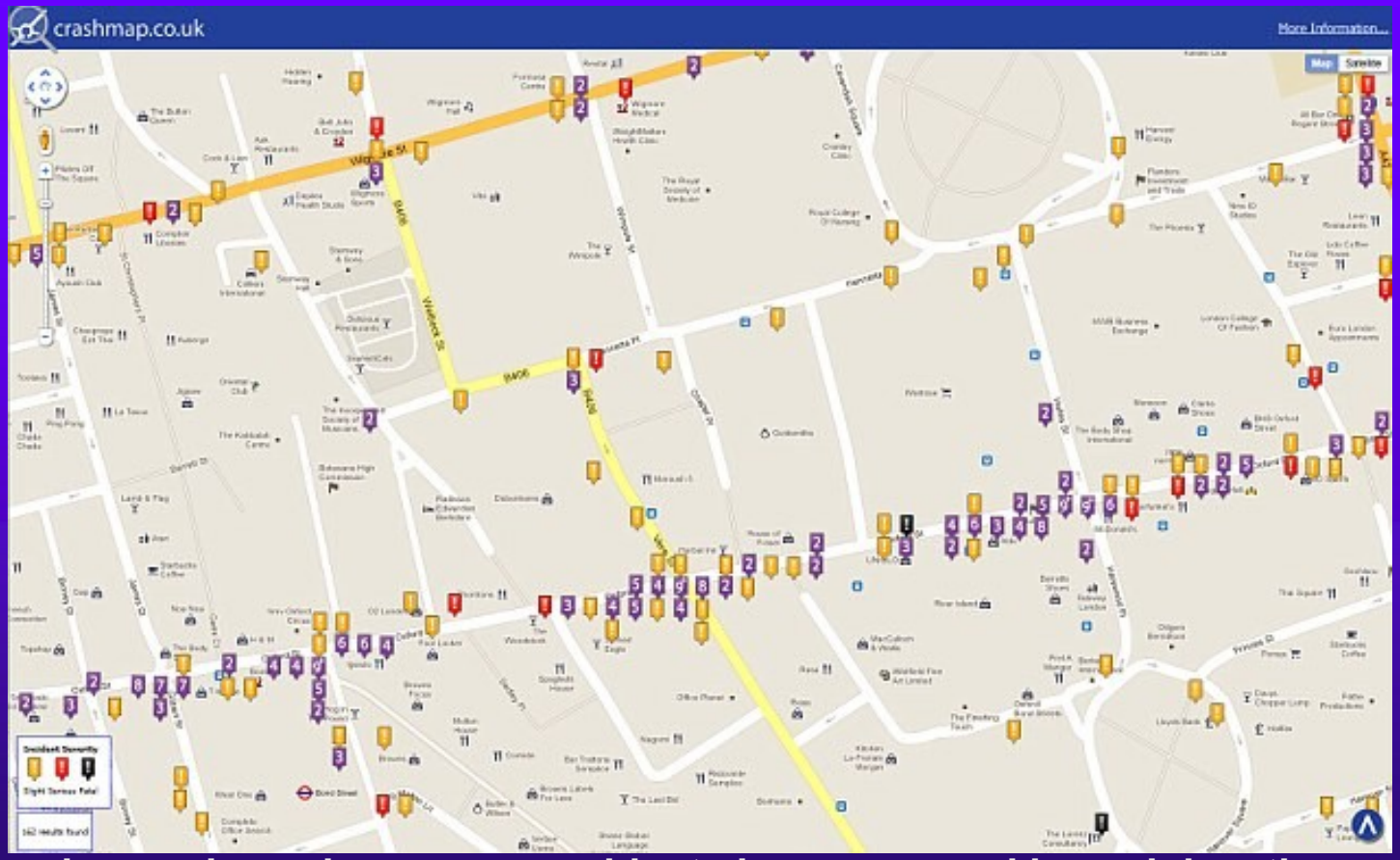
- Accident data for the most recent 1 to 3 year period are used, which is generally sufficient
- Accident data should only be used when there are no major changes in facility characteristics or land use
- Methods for analyzing the hazardousness of locations include the following:
  - *Spot map* method
  - *Accident frequency* method
  - *Accident rate* method

SPOT MAP METHOD

- The simplest method for identifying hazardous locations is to examine an accident spot map showing the spots or segments having the greatest numbers of accidents
- An accident *blackspot* is a place where road traffic accidents have historically been concentrated (i. e. occurred *frequently*)
- The objective of the traditional RTA analysis is to discover and eliminate the assumed causes of accidents and their concentration at these blackspots, starting with the most hazardous locations

BLACK SPOTS ON THE MAP

(London, 2011)



Crashmap shows how many accidents have occurred in each location - with colour indicating how serious each accident is, as on this map of central London (black is a fatal accident, red is a serious injury accident)

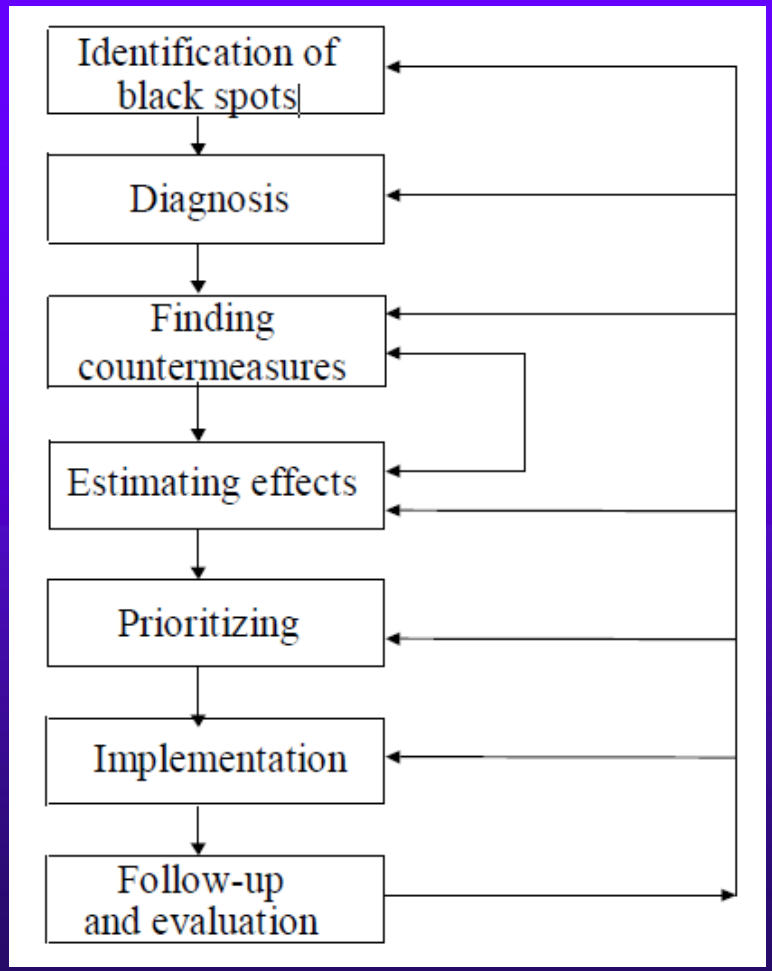
BLACK SPOTS ON THE MAP

(Budapest, 2003)

Legend:

blue **– light injury**
red **– serious injury**
black **– fatal accident**

IDENTIFICATION OF BLACK SPOTS



- ***Rate – Quality – Control*** **method consists of calculating three different parameters for each road section:**
  - **accident rate**
  - **accident frequency**
  - **severity index**
- **Each of these values is compared with a critical *reference value***
- **If a certain road section shows higher values than the critical ones for *all these three parameters*, the section is considered to be a *black spot***

BLACK SPOT ANALYSIS

- Identification of black spots is the procedure to locate those spots in the road network that are particularly dangerous,
- Diagnosis is the process to study what are the problems, the accident contributing factors and the deficiencies for each of the identified black spots
- Finding countermeasures implies a methodical analysis to design suitable countermeasures for each black spot, based on actual problems and deficiencies
- Estimating effects is the process to estimate the safety (and if necessary also other) effects and costs of suitable countermeasures
- Prioritizing implies finding the best action plan (or investment program), according to some defined criteria, and based on estimated effects and costs as well as budget restrictions
- Implementation is the actual realization of the prioritized measures included in the action plan (or investment program)
- Follow-up and evaluation is the last and very important step, which aim is to assess the actual results (effects and costs)

ACCIDENT FREQUENCY METHOD

- The frequency method ranks locations by the number of accidents: the location with the highest number of accidents is ranked first, followed by the location with the second highest number of accidents, and so on
- This method does not take into account the differing amounts of traffic at each location, thus tends to rank high volume locations as hazardous ones, even if those locations have a relatively low number of accidents for the traffic volume
- As a first ste, the frequency method is suitable to select a group of locations with high frequency of accidents, but then it is recommended to use some other method to rank locations in order of priority

ACCIDENT RATE METHOD

- The accident rate method compares the number of accidents at a location with the number of vehicles or vehicle-kilometers of travel at another location
- This comparison results in an *accident rate* representing *accident risk:*

  Number of accidents / Unit of exposure

- The locations are then ranked in descending order by accident rate aiming to define priority order of interventions aiming to improve road safety

EXPOSURE

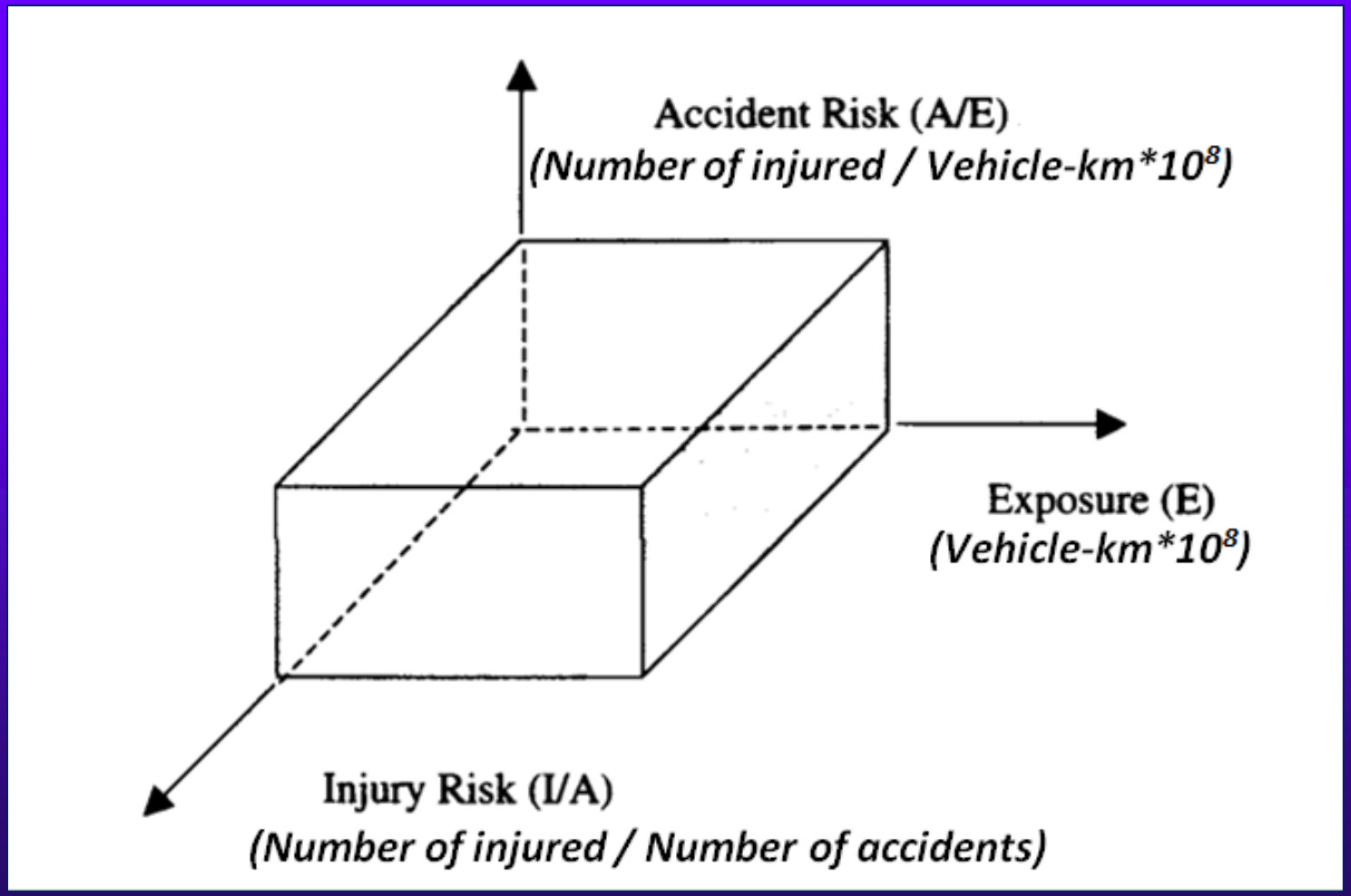
- The *exposure* at any location is the number of vehicles that travel over a segment of roadway or through a spot on the roadway, such as an intersection
  1. *Spot Exposure* - The exposure at a spot, such as an intersection, is measured by the total number of vehicles entering the intersection for the period under consideration:

EXPOSURE (entering vehicles) = AADT*365*YRS

  2. *Section Exposure* - The exposure over a roadway section is measured by the total vehicle-kilometers of travel over the section for the period:

EXPOSURE (vehicle-km of travel)=AADT*365*KM*YRS

ROAD SAFETY PROBLEM



The road safety problem (human injury) illustrated by the *volume of the box*

ACCIDENT SEVERITY

- **Severity weighted accident frequency related to spots could be used as an indicator to define priority order of interventions**

Severity weighted number of accidents: A_s = number of fatal accidents (f)*W_{fa} + number of serious injury accidents (b)*W_{se} + number of slight injury accidents (c)*W_{sl} + number of property damage only accidents (d)*W_{pdo}

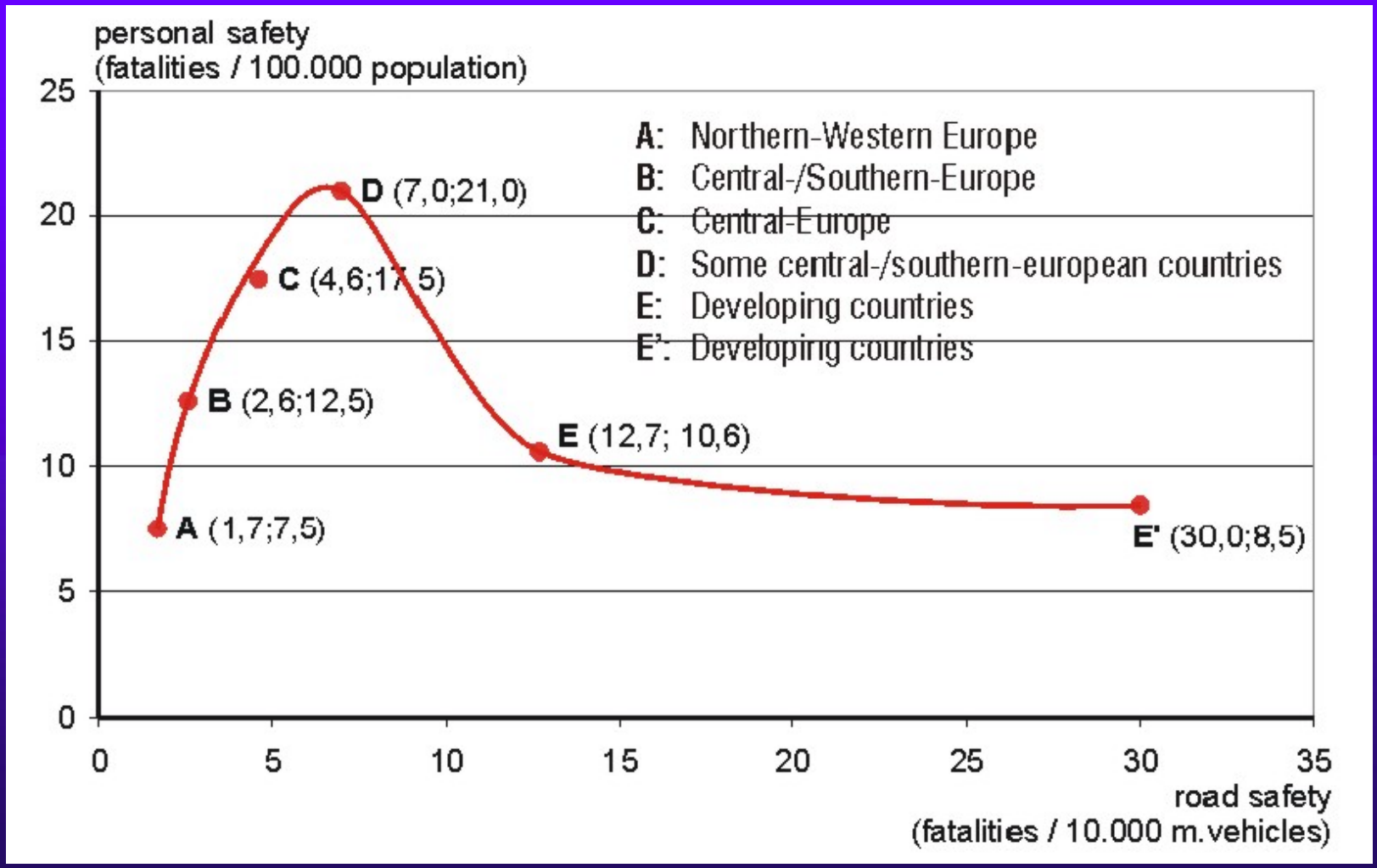
where W_{fa} ; W_{se} ; W_{sl} ; W_{do} **are weights (e.g.** *130; 70; 5; 1* **respectively) reflecting the order of magnitude of average damage caused**

- **This value can be divided by a suitable value - one such value could be the *number of accidents***
- **The *relative severity value* is then, which means severity per accident:** A_s / (f + b + c + d)

ROAD SAFETY INDICATORS

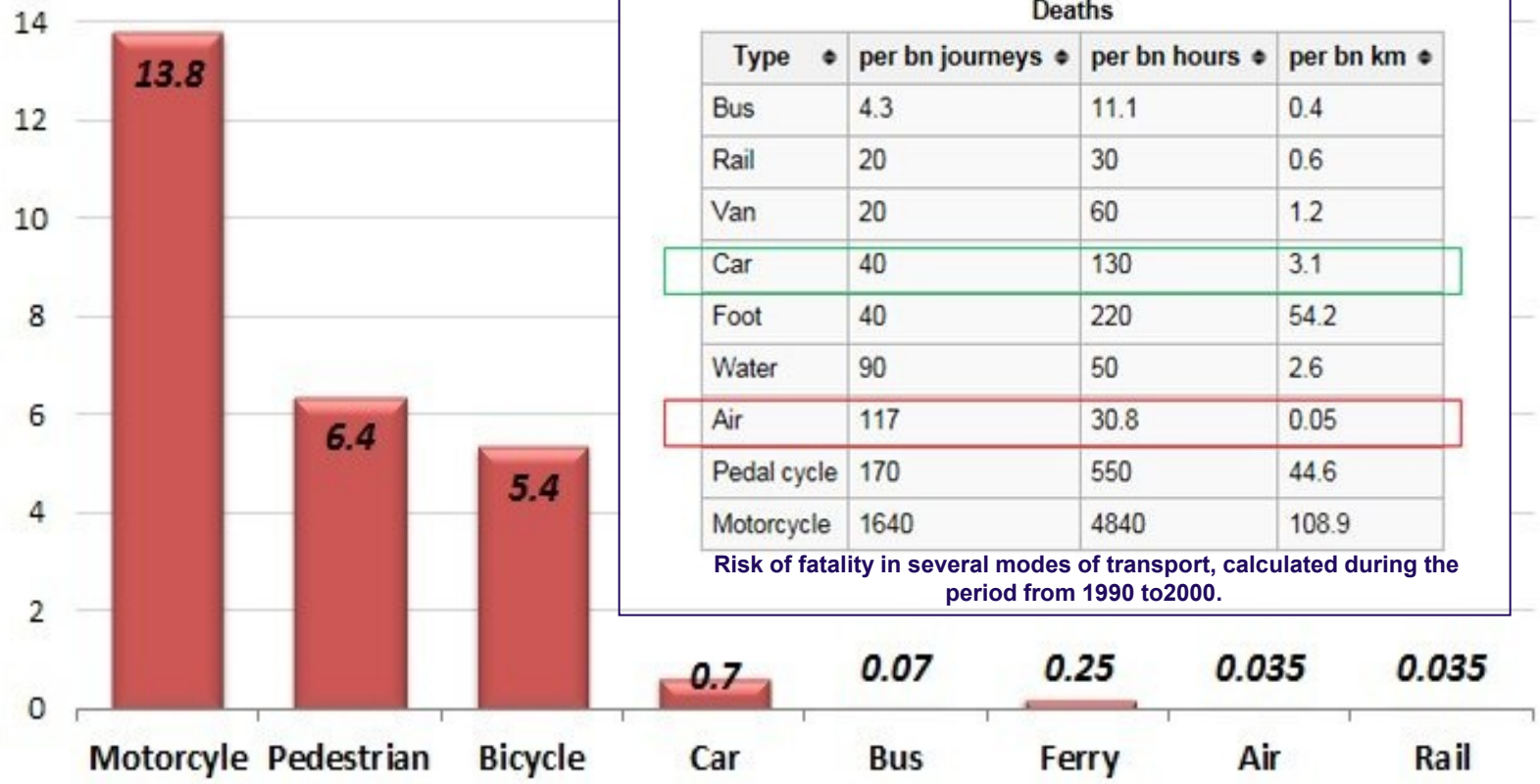
- The reliability and availability of the different exposure data (rates) show a great variety
- The three most widely used rates in the professional practice are as follows:
  - Fatality rate or traffic risk (deaths/10^8 vehicle-kms)
  - Fatality rate or traffic risk (deaths/10^4 vehicles)
  - Mortality rate or health/personal risk
- If only one of these indicators is used, the ranking orders of the individual countries are entirely different
- The best compromise is the application of more than one indicators at the same time

INTERNATIONAL COMPARISON OF ROAD SAFETY



WHICH TRANSPORT MODE IS SAFER? 1

Fatalities per 100 million person-kilometers (EU, 2001/2002)



Deaths

Type	per bn journeys	per bn hours	per bn km
Bus	4.3	11.1	0.4
Rail	20	30	0.6
Van	20	60	1.2
Car	40	130	3.1
Foot	40	220	54.2
Water	90	50	2.6
Air	117	30.8	0.05
Pedal cycle	170	550	44.6
Motorcycle	1640	4840	108.9

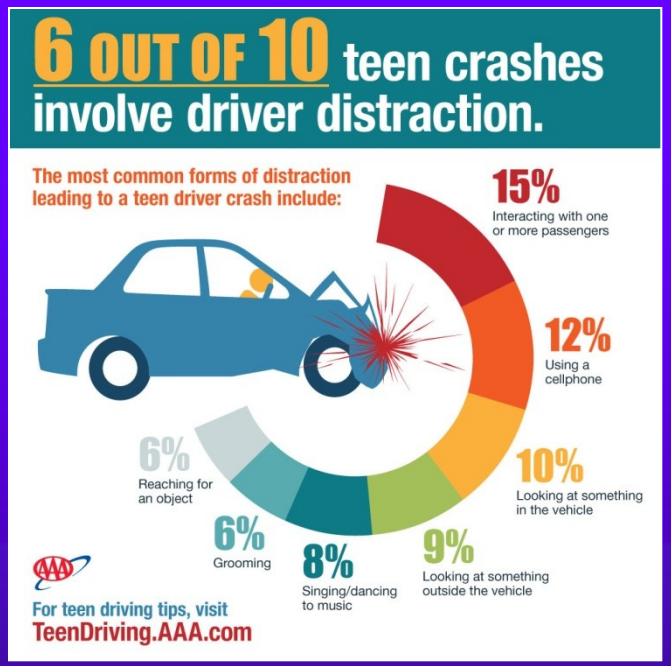
Risk of fatality in several modes of transport, calculated during the period from 1990 to2000.

WHICH TRANSPORT MODE IS SAFER? 2

Fatality risk of passenger per mode of transport in European Union	
Transport mode used by user	Fatalities per billion passenger kilometers
Airline passenger	0.101
Railway passenger	0.156
Bus/Coach occupant	0.433
Car occupant	4.450
Powered two-wheelers	52.593

Fatality risk ratios for transports	Airline passenger	Railway passenger	Bus/Coach occupant	Car occupant	Powered two-wheelers
Powered two-wheelers	520	337	121	12	1
Car occupant	44	28.5	10	1	
Bus/Coach occupant	4.3	2.8	1		
Railway passenger	1.5	1			
Airline passenger	1				

Sources: Intermediate report on the development of railway safety in the Eropean Union, European Railway agency;
EU transport in figures (Statistical Pocketbook 2012), DG MOVE 2012, European Commission



WHICH TYPE OF ROAD IS SAFER?

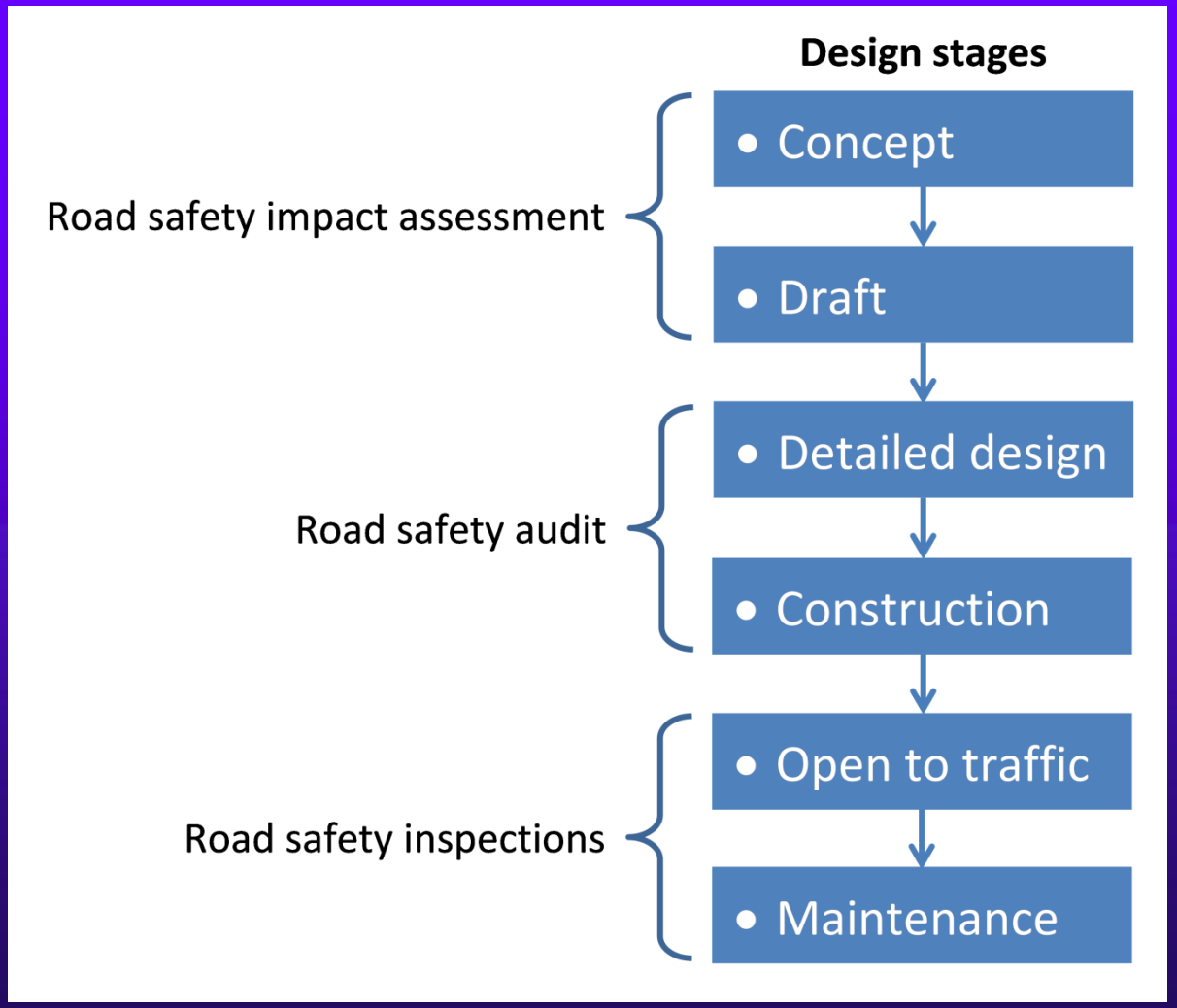
❖ **Comparison of different road types' safety to motorways:**

Carriage Type	Fatal	KSI	All Accidents
Motorway 2 Lane	1	1	1
Dual Carriageway 2 Lane	3	3	3
Three-Lane Undivided	8	8	3
All 2-Lane Undivided	*7*	*9*	*5*
Improved Wide 2 Lane	6	8	4
Improved Standard 2 Lane	9	8	4
Unimproved 2 Lane	6	9	5

Note: *KSI (killed an seriously injured)* Source: *D. O'Cinneide et al, 2004*

- ❖ **In general motorways are 5 times safer than undivided two lane rural roads**
- ❖ **Looking at fatal accidents, motorways are 7 times safer than undivided two lane roads and 3 times safer than dual carriageways, but only 8 times safer than undivided 3 lane roads (two lanes with climbing lane)**

ROAD SAFETY CHECKS



ROAD SAFETY AUDIT 1

- A *Road Safety Audit* is defined as "the formal safety performance examination of an existing or future road or intersection by an independent, multidisciplinary team”
- It qualitatively estimates and reports on potential road safety issues and identifies opportunities for improvements in safety for all road users
- A key feature of a road safety audit is the use of a team of professionals with varied expertise, which should include road safety engineers, road design engineers, as well as road maintenance and law enforcement experts

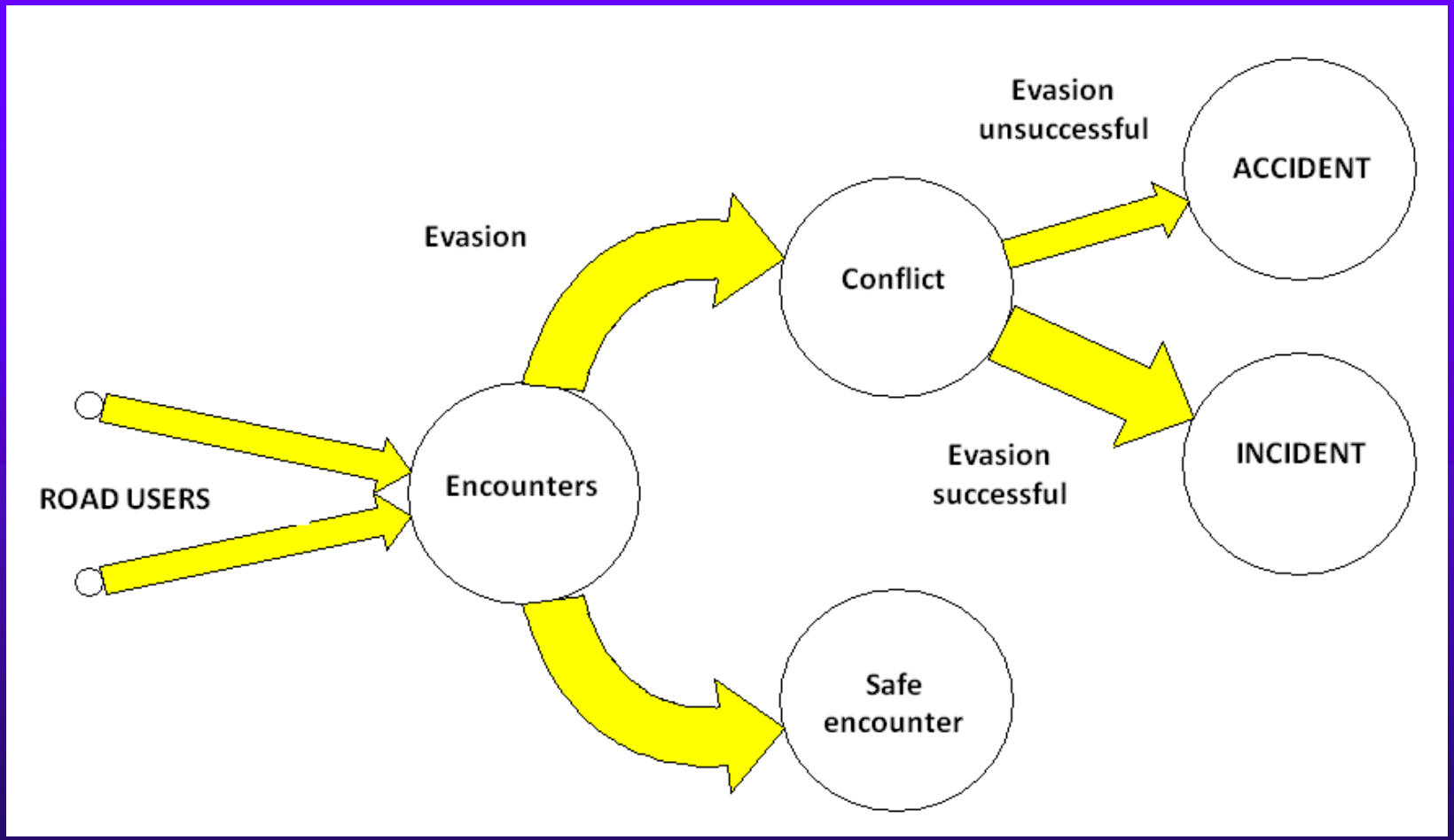
ROAD SAFETY AUDIT 2

- Three basic forms of road safety audit:
  - Audit of an existing road or road network
  - Audit of a roadworks project at various stages of completion (feasibility study, design, construction & post-construction stage)
  - Thematic audit focused on particular aspects of a road and may be used to investigate road safety issues brought up by road user groups, or conducted to support a land development application
- The value of road safety audit is critically dependent on the knowledge and training of the individuals undertaking it

TRAFFIC CONFLICT ANALYSIS 1

- A relatively recent method of traffic safety analysis focusing on *the process* preceding of, or potentially leading to a road traffic accident (*the product*)
- *Encounter*: a traffic situation in which two road users approach each other in time and space and may influence each other's behaviour
- *Critical situation*: encounter in which deviations from normal behaviour occur (*evasion, braking, stopping*)
- "A conflict is a critical traffic situation in which two (or more) road users approach each other in such a manner that a collision is imminent and a realistic probability of personal injury or material damage is present if their course and speed remain unchanged"
  (DOCTOR - Dutch Objective Conflict Technique for Operation and Research)

TRAFFIC CONFLICTS



TRAFFIC CONFLICT ANALYSIS 2

- We do not have to wait for accidents for improving road environment and traffic management
- Systematic observation of behaviour already gives you lots of clues for improving road safety at intersections
- Video observations provide rich source of information for traffic conflict analyses
- No collisions needed to solve traffic safety problems: improvement of safety is justified for traffic streams experiencing a lot of severe conflicts

TRAFFIC CONFLICT ANALYSIS 3

- Most traffic conflicts involving motorized vehicles are observed on highways, usually involving lane changing or sudden changes in vehicle speeds (rear-end collisions), or in intersections, involving a large array of conflict types
- Traffic conflicts are complicated events to define visually, therefore observers are trained to spot traffic conflicts using the same set of videos
- Some research suggests that the correlation between conflicts and collisions is weak, or can vary from site to site, while some argue that a certain amount of subjectivity invalidates traffic conflict analysis involving human observers, thus the use of traffic conflict analysis remains ambiguous and limited