3rd EU-ASEAN Road Safety Workshop
& Capacity Building

7-9 February 2023, Bangkok, Thailand

Deciding on the most cost-effective and appropriate road safety interventions

George Yannis, Professor NTUA
www.nrso.ntua.gr/geyannis

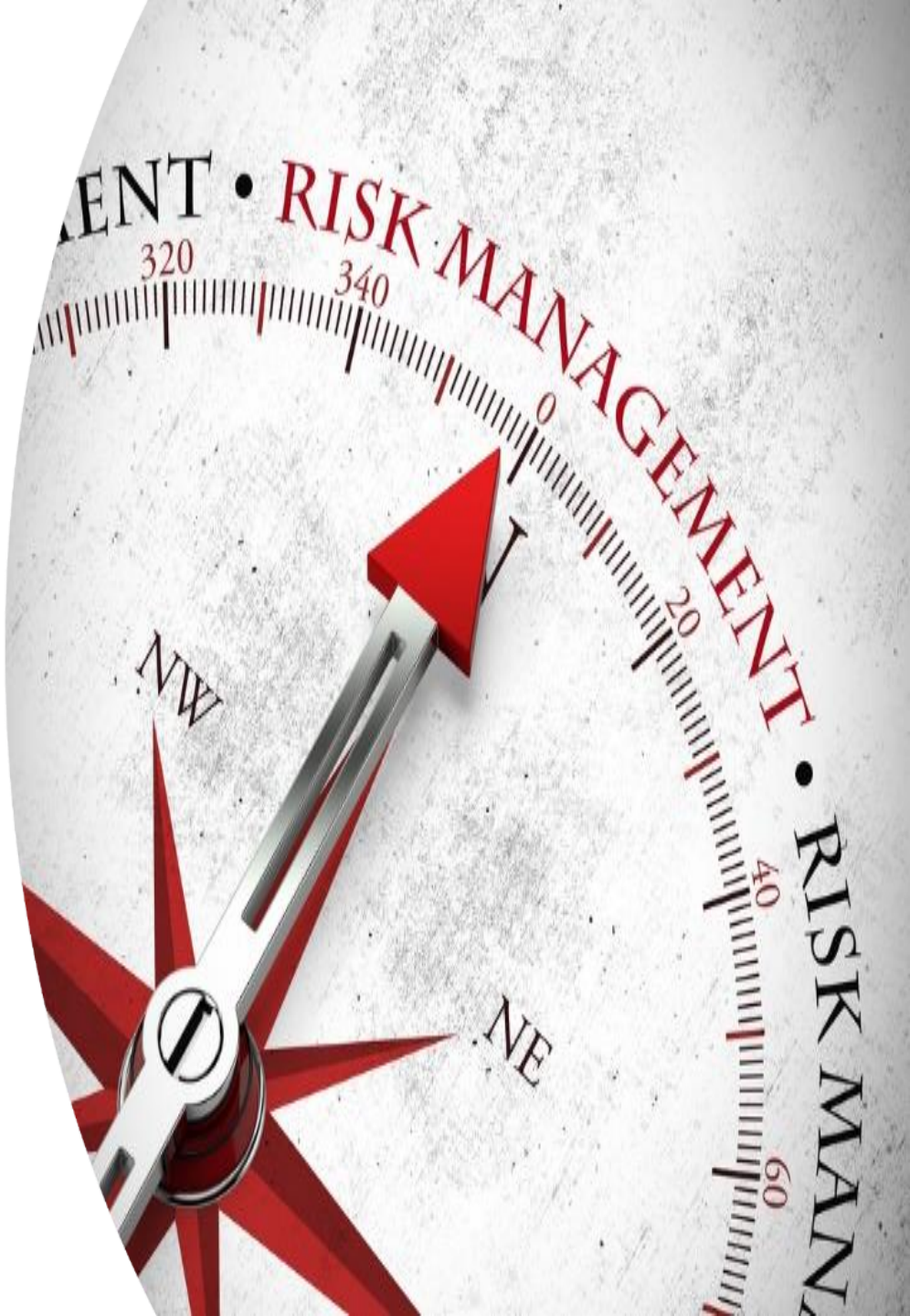
Department of Transportation Planning and Engineering,
National Technical University of Athens

Initial motivation

- Road crashes have plateaued in recent years (WHO, 2021); it is crucial to take **targeted action** to reduce crash occurrence and consequences.
- Road Safety is a typical field with high risk of important investments **not yielding results**.
- **Budget constraints** are especially important when struggling to maintain good performance levels and also in times of financial recessions or competing crises (e.g. Covid-19).
- Absence of **monitoring** and **accountability** can seriously hinder road safety performance.

Safe System Approach [1/3]

- It has been established that humans are fallible and road users may make mistakes.
- The Safe System Approach (SSA) establishes that road safety is now considered to be a responsibility shared by everyone.
- This includes road users and also road designers, constructors and operators, i.e. both citizens and authorities.
- All parts of transport networks must be enhanced with redundancies, so that if one part fails, the others can provide back-up support and protect human life.



Safe System Approach [2/3]

SSA:

- Aims to develop a road transport system better able to accommodate human error through better management of crash energy.
- Incorporates strategies for better management of crash forces (e.g. road network improvements, speed limits).
- Relies on strong economic analyses to understand the scale of the trauma problem and apply direct investments to achieve the greatest potential benefit to society.

Safe System Approach [3/3]

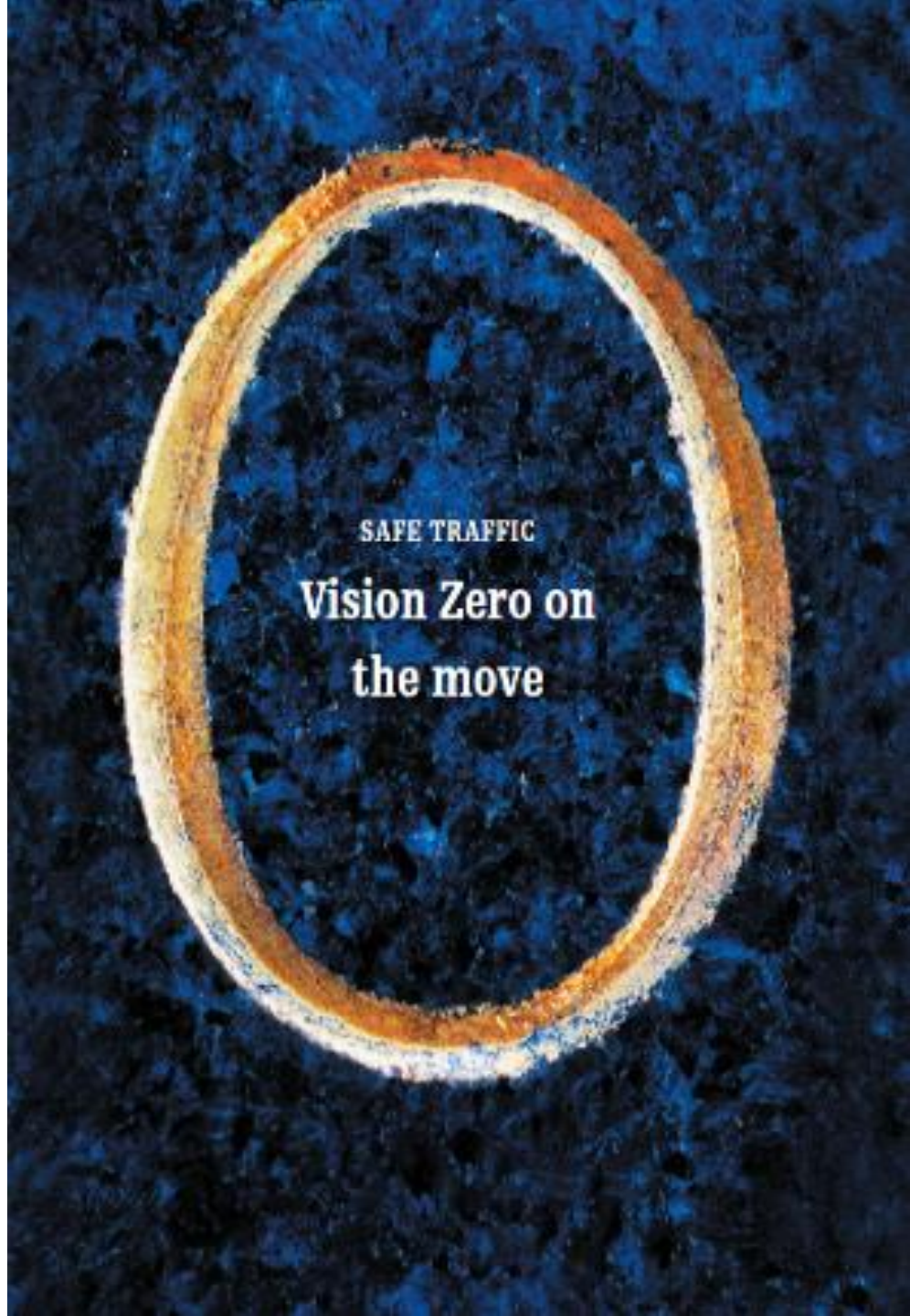
- Key government agencies with a role in determining safe functions of the transport system are incorporated in comprehensive management and communication structures.

- Safety management decision making is aligned with a broader societal decision making to meet economic goals and human and environmental health goals, and to create a safe commercial transport environment.

- Embraces "shared responsibility" for road safety among the various actors of the road transport system.

The Vision Zero Concept [1/2]

- A traffic safety policy developed in Sweden (1997), expressing an ethical imperative to eliminate death and serious injury from the transport system.
- Responsibility for crashes and injuries is shared between the providers of the system and the road users.
- The road user remains responsible for following basic rules.
- The system designers and enforcers are responsible for the functioning of the system.
- When road users make errors or fail to follow the rules, the responsibility reverts to the system designers to ensure that these failings do not result in death or serious injuries.



The Vision Zero Concept [2/2]

- Human beings make errors and there is a critical limit beyond which survival and recovery from an injury are not possible.

- The road transport system should be able to take account of human failings and absorb errors in a way to avoid deaths and serious injuries.
  Crashes and minor injuries need to be accepted.

- The components of the road transport system (incl. road infrastructure, vehicles and restraint systems) must be designed so that they are linked to each other. The amount of energy in the system must be kept below critical limits by ensuring that speed is restricted.

Cost-Benefit Analysis - Overview

- Very often researchers are forced to look where the data are and **not where the problems and solutions** are.
- **Decision making** in road safety management is critically dependent on appropriate and high-quality data and calculations.
- **Cost-Benefit Analysis (CBA)** is a potent tool to decide on **most cost effective and appropriate road safety interventions,** providing the respective scientific basis
- CBA weighs crash mitigation figures against costs and allows for **financial optimization**

Cost-Benefit Analysis – Safety Performance

Road safety performance data primarily fall under three categories, equally crucial:

- **Crash data:**
  As detailed as possible, describing crash circumstances accurately with as many variables as possible while mitigating underreporting
- **Exposure data:**
  Augment crash data by standardizing risk measurement (e.g. vehicle/person-kilometres, vehicle fleet, road length, driver population)
- **KPI data:**
  need to be present for additional context and to enable regional and seasonal comparisons

Cost-Benefit Analysis – Monitoring

➢ Monitoring Actions' Implementation

- systematic collection of information
- progress reports
- use of monitoring indicators

➢ Road Safety Performance Monitoring

- final road safety results (road crashes and casualties)
- interim results - KPIs (road users' behaviour, road infrastructure safety, vehicle safety, emergency response time)

➢ Evaluation of Actions' Effectiveness

- collection of necessary data
- appropriate methods and evaluation indicators
- reliable implementation of the evaluation methods
- publication of evaluation results

Data needed for Road Safety Decision Support

Data to identify the problems:

- Crash data
- Risk exposure and performance indicators

Data to identify the solutions:

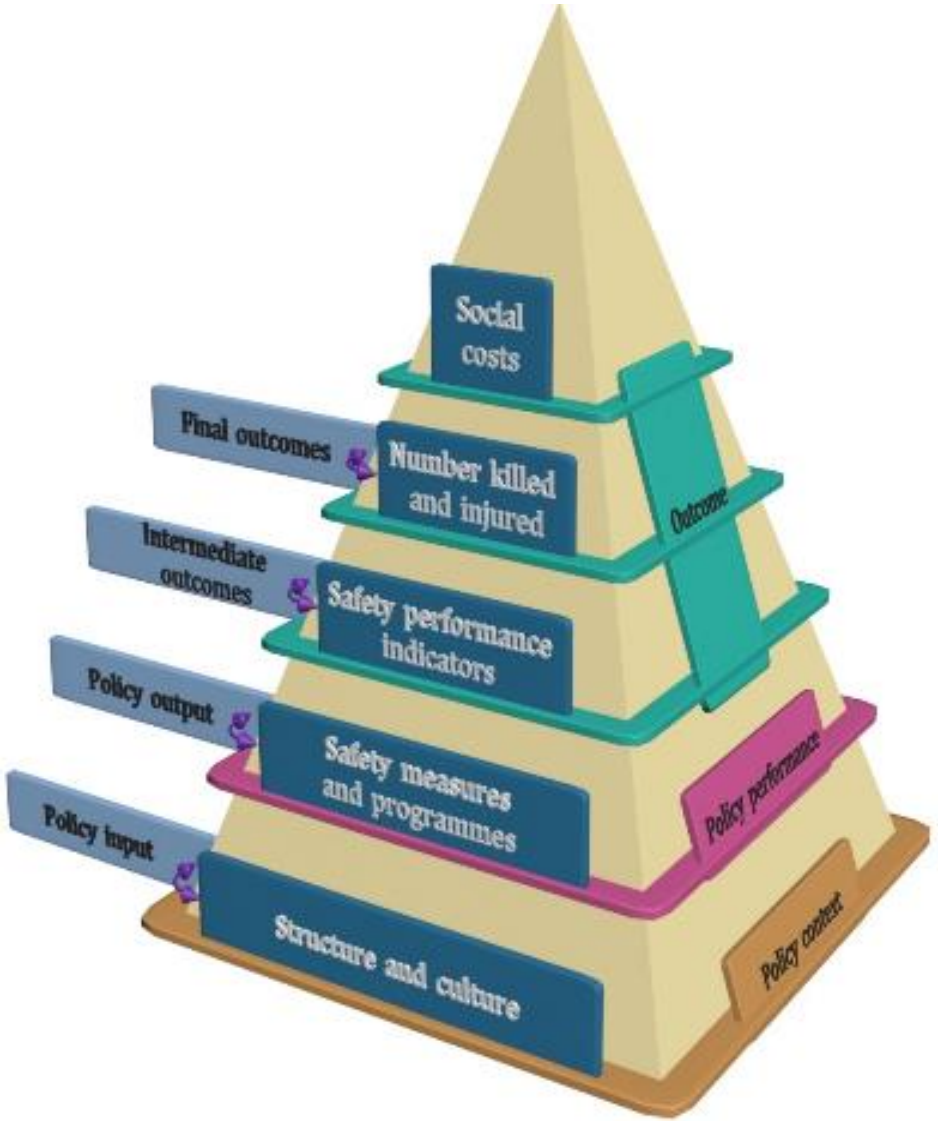
- Data on measure implementation
- Data on measure effectiveness

Macroscopic data:

- For the entire population
- For an arterial, city, region, country, globally

Microscopic data:

- driver, pedestrian, overall road user behaviour and performance
- junction, road segment, vicinity performance
- specific crash analysis data



Success in Cost-Benefit Analysis?

For a CBA to be successful, we need both sides of the 'scales', thus:

Good problem/ crash data

…combined with…

Good solution/ /intervention data!

… as assisted by Road Safety Observatories.

Road Safety Observatories and Decision Support Systems

...the basis for selection of the most cost effective & appropriate road safety interventions!

ERSO – European Road Safety Observatory
IRTAD, ITF Road Traffic and Accident Group
Regional/National Observatories
(African, Asia-Pacific, Ibero-American,
EASTT Partnership, Western Balkan)
NRSO – NTUA Road Safety Observatory

SafetyCube, EU Road Safety DSS
SafeFITS, UNECE-Global Road Safety Model
iRAP, Road Safety ToolKit
PRACT, CEDR
PIARC, WRA Road Safety Manual
US NHTSA/FHWA CMF Clearinghouse
AustRoads Road Safety Engineering Toolkit

Road Safety Observatories

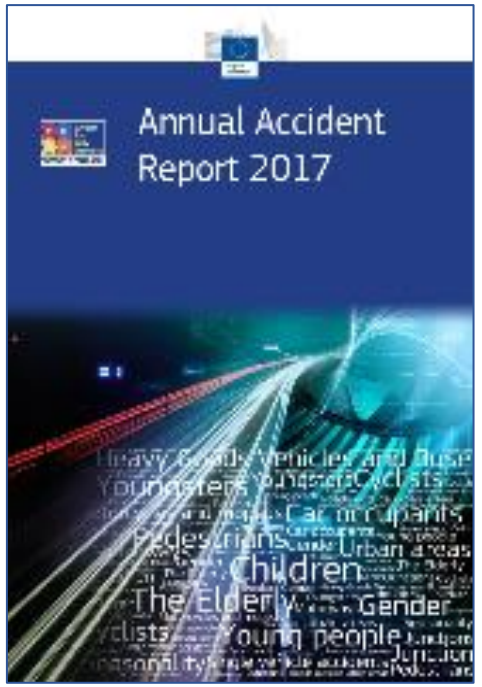
European Road Safety Observatory, EC [1/2]

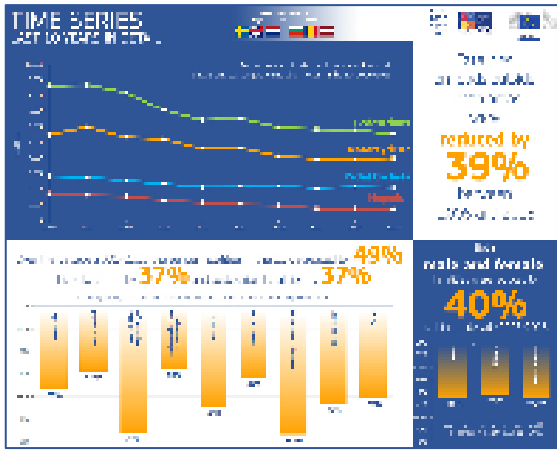
The ERSO is the **information system** of the European Commission with specialist information on road safety practices and policy in European countries. ERSO and CARE are Managed by the EC – DG Move – Road Safety Unit

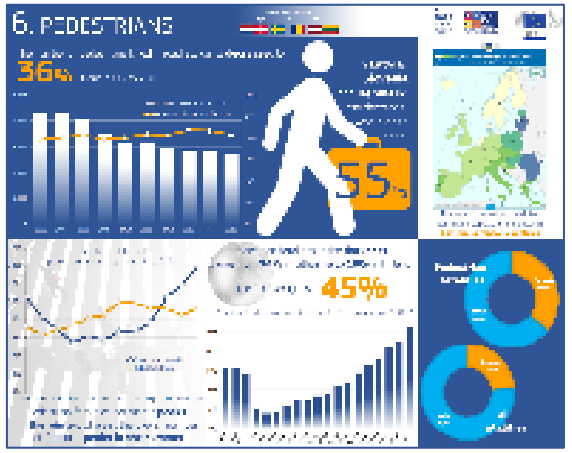
- Cooperation with **Eurostat** (EC Statistical Office)
- Assisted by the Road Accident Statistics National Experts Group (**CARE** Experts Group)

Methodology:

- **Common** protocols for data collection
- **Availability**, systematic collection and analyses of data and information
- **Presentation** of the results responding to users' needs
- **Continuity** in making all results publicly available

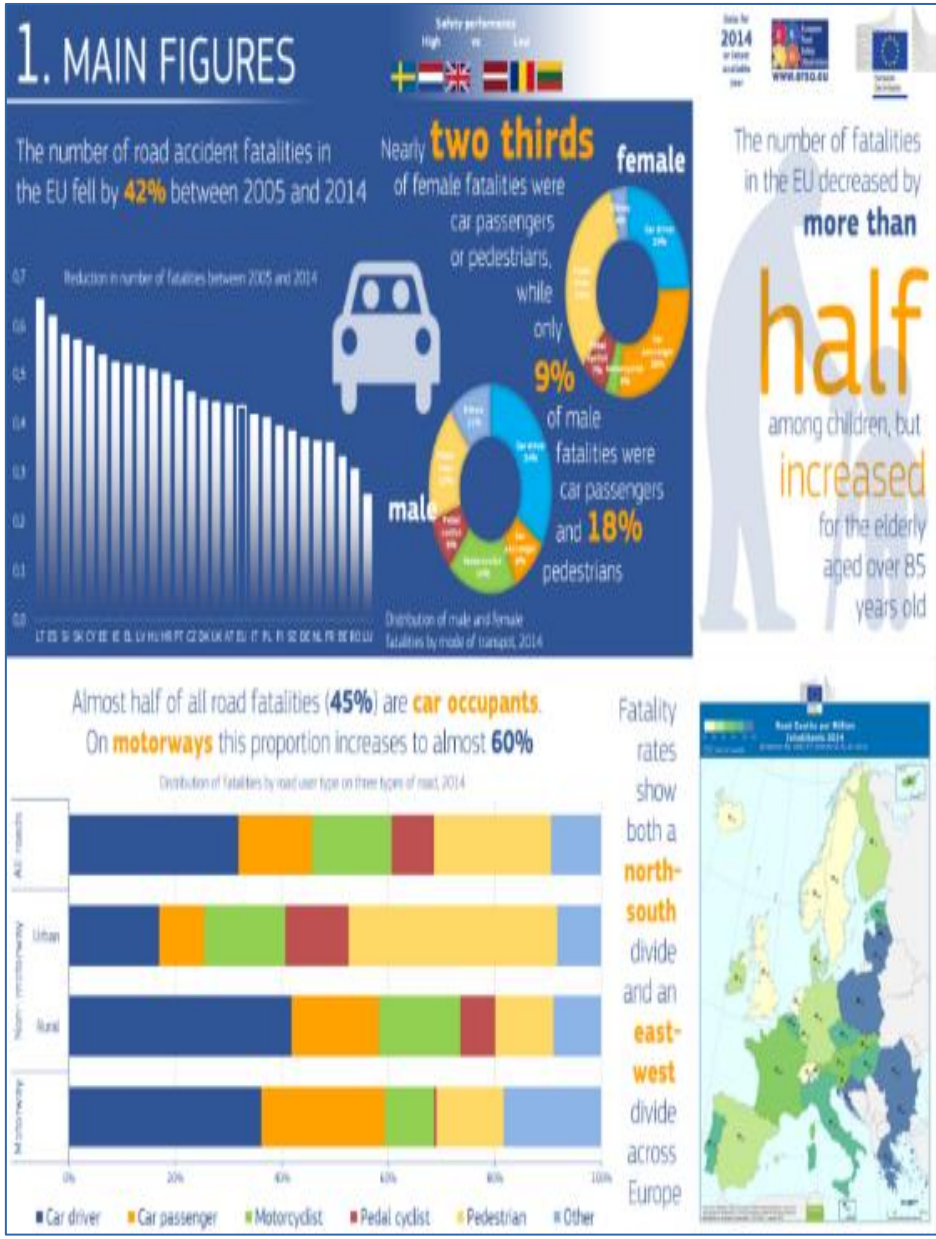






European Road Safety Observatory, EC [2/2]

- **14 Thematic Reports** (2021-2022)
  - Advanced driver assistance systems (ADAS)
  - Alcohol, drugs and medicines
  - Cyclists
  - Driver Distraction
  - Fatigue
  - Level Crossings
  - Novice drivers
  - Pedestrians
  - Personal mobility devices
  - Road Safety Performance Indicators (RSPIs)
  - Seat belt and child restraint systems
  - Seniors
  - Serious injuries
  - Speed
- **Annual Statistical Report** (2021)
- **Country Profiles** (27 EU & 3 EFTA)
- **Facts & Figures** (10 with 2019 data & 4 with 2020 data)



IRTAD, ITF/OECD [1/2]

IRTAD Objectives:

- **Exchange** of information and methodologies on safety trends and road safety policies
- **Collect** crash data, complementary to other sources
- **Suggest** possible improvements to crash and related traffic data collection and analyses.
- **Conduct** data analysis to provide advice on specific road safety issues.
- **Contribute** to international co-operation on road crash data and its analysis.

The IRTAD Group publishes **regularly special reports** on analyses of topical data collection and methodological issues and organizes **open conferences.**

OECD

International Transport Forum

irtad

International Traffic Safety Data and Analysis Group

IRTAD, ITF/OECD [2/2]

International Transport Forum

➢ Information comes directly from relevant national data providers.

➢ Data provided in a common format and definitions, covering:

- Injury Crashes by Road Network
- Road Fatalities by Road Usage, Age, Gender and Age or by Road Network
- Hospitalised Road Users by Road Usage, Age or Road Network
- Crash Involvement by Road User Type and Casualty Data
- Risk Indicators: Fatalities, Hospitalised or Injury Crashes Related to Population or Mileage figures
- Population Figures by Age Bands
- Vehicle Population by Vehicle Types
- Network Length Classified by Road Network
- Mileage Classified by Road Network or Vehicles
- Passenger Mileage by Transport Mode
- Seat Belt Wearing Rates of Car Drivers by Road Network

Speed and Crash Risk

irtad
International Traffic Safety Data and Analysis Group
Research Report

➢ Data concern 55 countries. Available at: https://www.itf-oecd.org/IRTAD

OECD

NTUA Road Safety Observatory

- An international reference website - information system of road safety data and knowledge: www.nrso.ntua.gr
- More than 2100 items since 2007, more than 800 scientific publications
- All important road safety news in Greece, Europe and worldwide
- Updated reports covering all latest road safety issues
- Latest available road safety data for Greece and the European Union
- Scientific road safety conferences in Greece and worldwide
- Links to dozens of road safety resources worldwide

Regional Road Safety Observatories

- African Road Safety Observatory
- Asia Pacific Road Safety Observatory
- Ibero-American Road Safety Observatory
- EASTT Partnership Observatory
- Western Balkan Road Safety Observatory
- European Road Safety Observatory

Road Safety Decision Support Systems

SafeFITS Global Model, UNECE [1/2]

- A **macroscopic road safety decision making tool** to aid stakeholders in developed and developing countries, decide the most appropriate road safety policies - measures to achieve tangible results.

- Based on the **related scientific knowledge** available worldwide, with emphasis on recent academic research and project results.

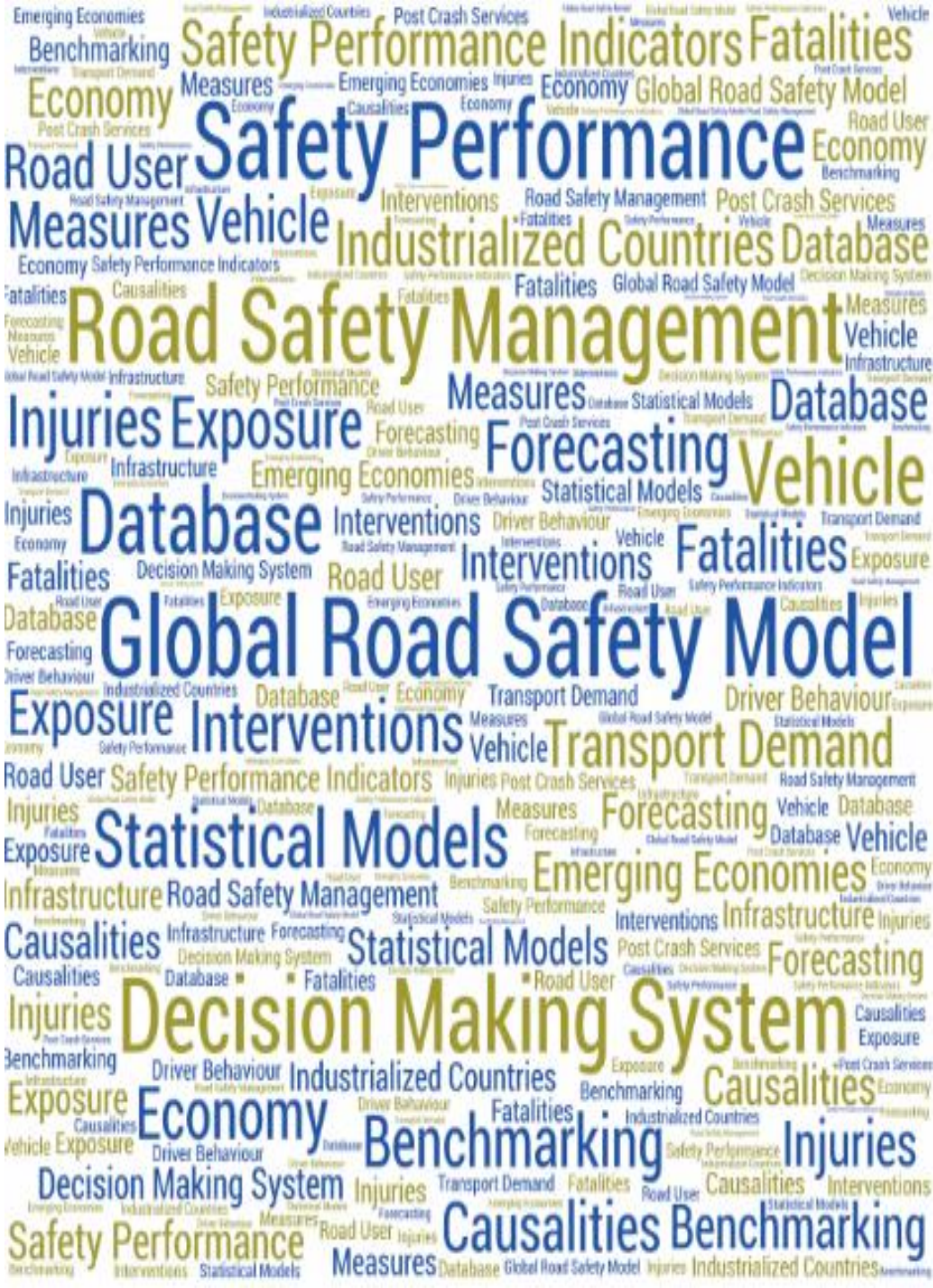
- Developed within the framework of the **"Safe Future Inland Transport Systems (SafeFITS)"** project of the United Nations Economic Commission for Europe (UNECE), financed by the International Road Union (IRU).

SafeFITS Layers

1. Economy and Management
2. Transport Demand & Exposure
3. Road Safety Measures
4. Safety Performance Indicators
5. Fatalities and Injuries

SafeFITS Pillars

1. Road Safety Management
2. Road Infrastructure
3. Vehicle
4. User
5. Post-Crash Services



SafeFITS Global Model, UNECE [2/2]

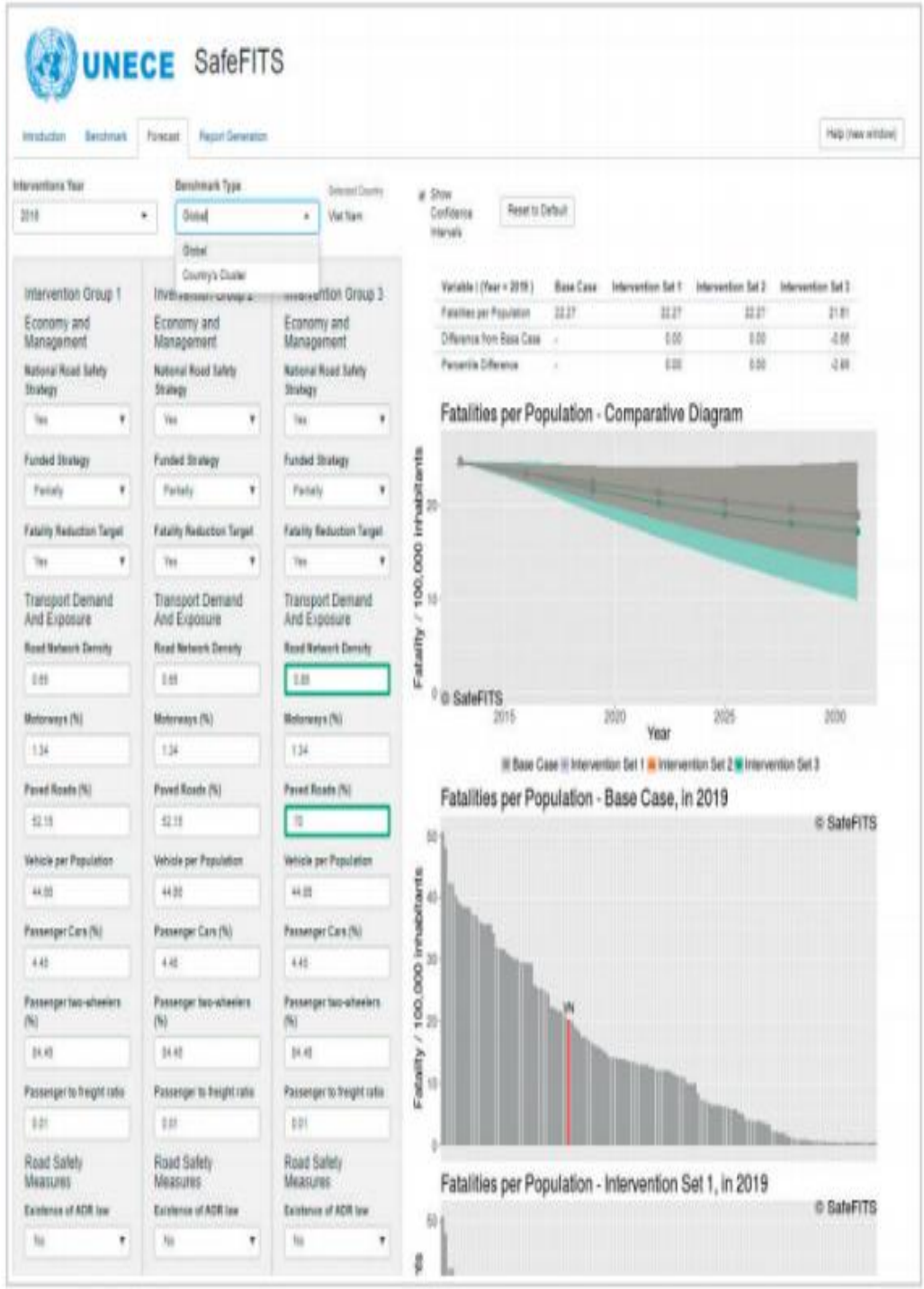
The SafeFITS Tool consists of **two background components:**

- **SafeFITS database** with data on indicators from all layers of road safety management system for 130 countries worldwide
- **SafeFITS set of statistical models** of global causalities, estimated on the basis of the database

The SafeFITS Tool is composed by **3 complementary modules:**

- **Intervention analysis:** allows the user to examine the effects of single interventions at national or country cluster level
- **Forecasting analysis:** allows the user to define own scenarios of measures (or combinations of measures) in a country and obtain medium/long term forecasts of each scenario
- **Benchmarking analysis:** allows the user to benchmark a country against a group of countries (e.g. all countries, countries of similar economic or road safety performance)

Available at: https://unecetrans.shinyapps.io/safefits/

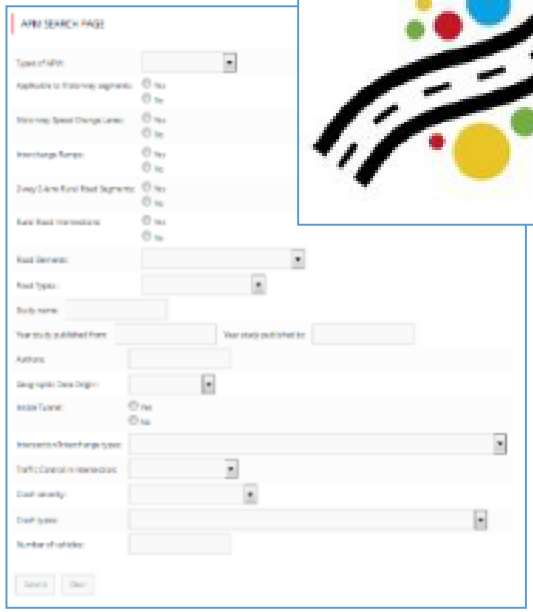


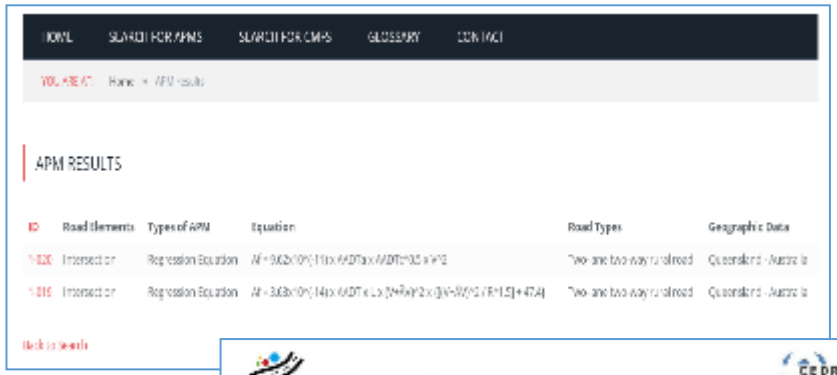
iRAP Road Safety Toolkit

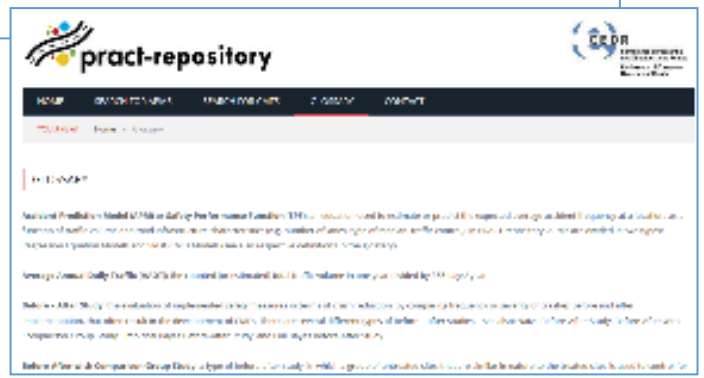
- Includes 58 treatments (infrastructure, vehicle & user related)
- No CMFs included
- Rough assessment of each treatment's effectiveness using a four scale system (0-10%, 10-25%, 25-40%, 60% or more)
- Available at: http://toolkit.irap.org/

PRACT APM and CMF Repository, CEDR

- A Trans-European Accident Prediction Model with a single structure and different parameters for different countries. The model has been fitted to data from 5 Countries (Italy, UK, Greece, Netherlands, Germany).
- A user friendly tool to assist in the application of APMs according to data availability and local conditions. Enables Search for APMs and CMFs.
- All types of data required in accident prediction are available (CMFs, SPFs, and Regression Equation APMs).
- The quality of included CMFs has been verified through an evaluation process.
- A procedure to check the transferability of CMFs, incorporated in the tool.
- A CMF and APM Repository has been developed and is freely available at: www.pract-repository.eu

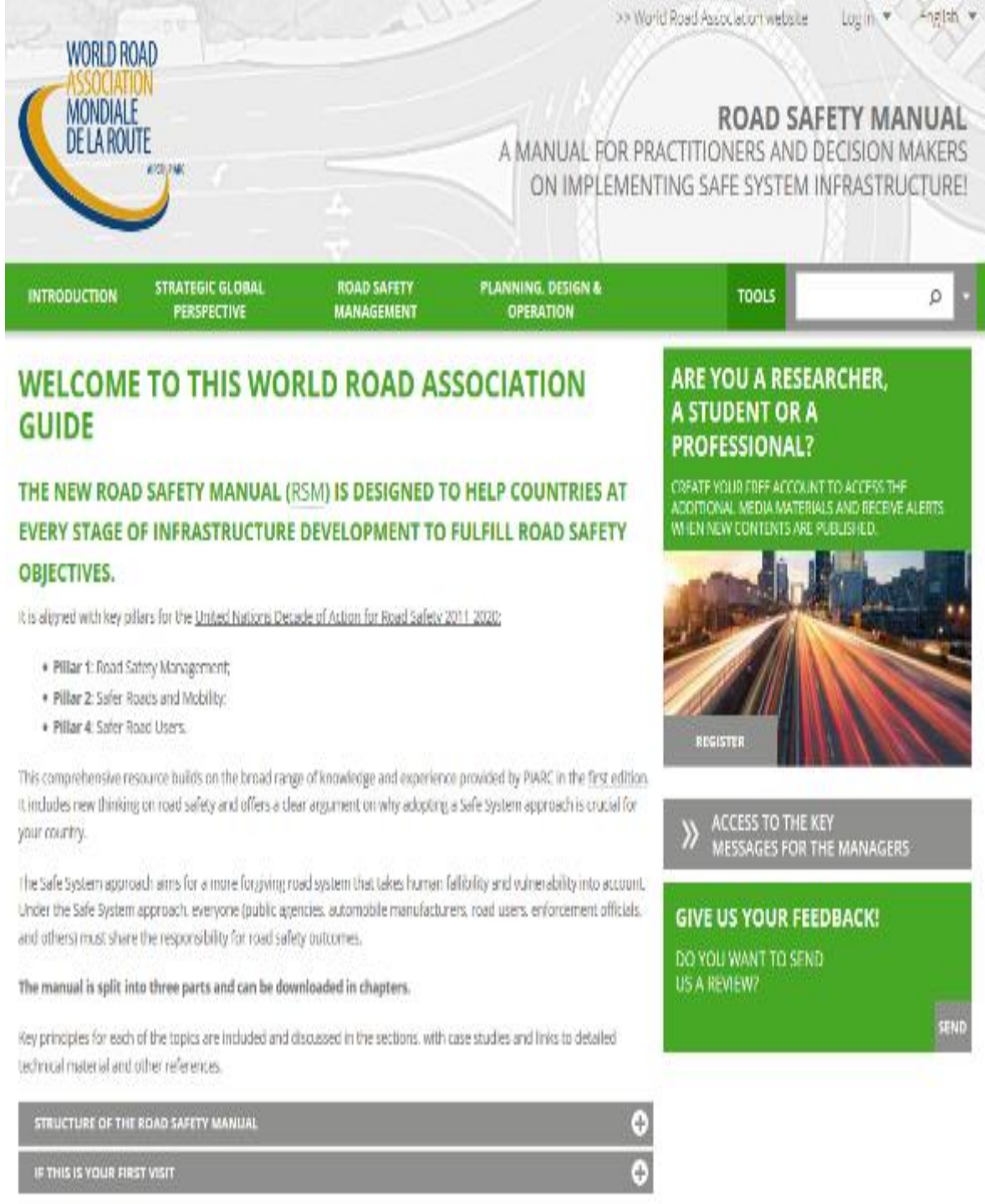






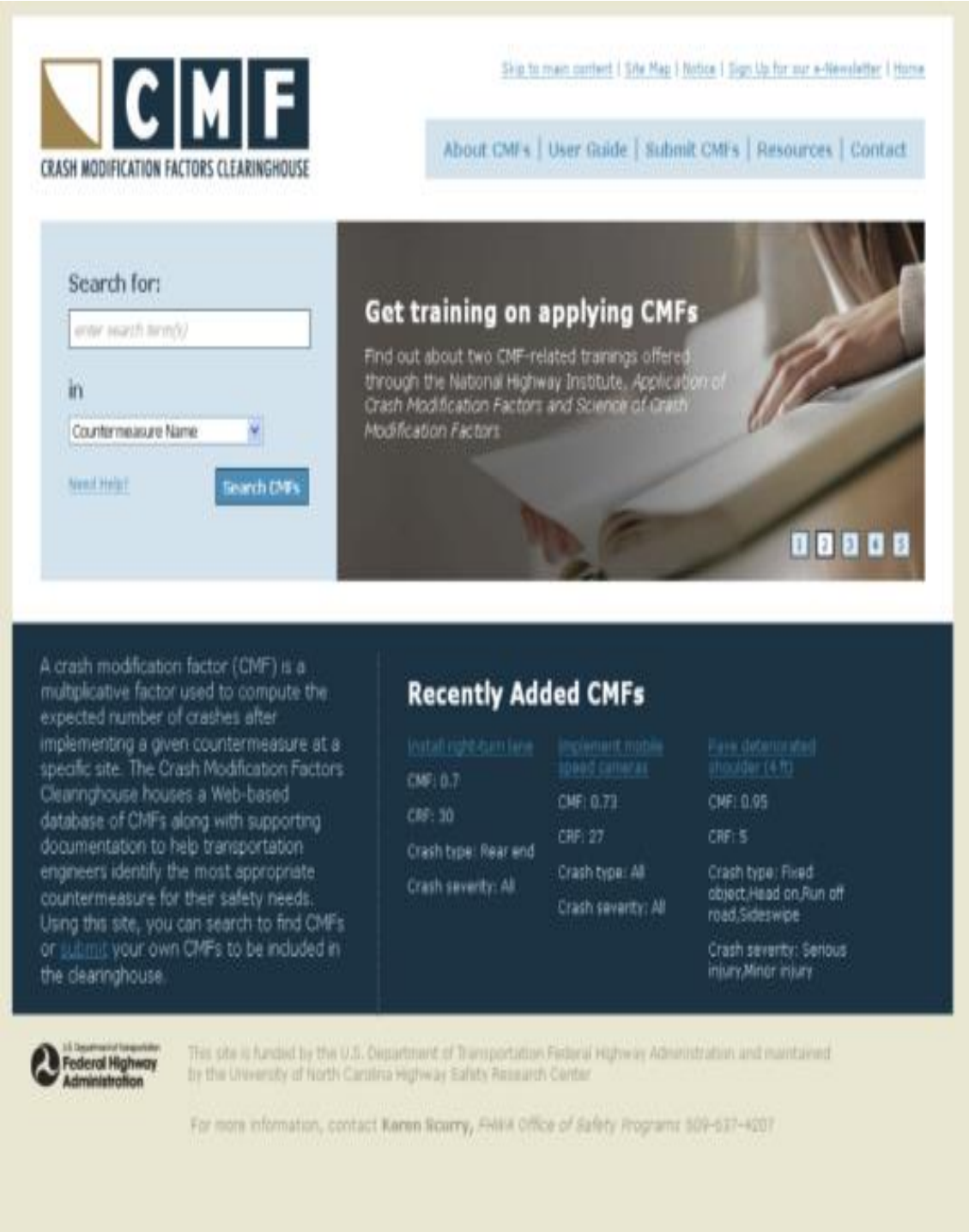
PIARC - WRA Road Safety Manual

- The PIARC Road Safety Manual is intended to provide clear and accessible information on the effective management of road safety infrastructure.
- Includes 15 case studies, with the possibility of additions and updates.
- Estimates of high/medium/low cost for up to 35 Treatments
- Categorized for 3 effectiveness categories and for up to 6 accident types.
- Organization of the Manual is in three Parts:
  - Part I "Strategic Global Perspective"
  - Part II "Road Safety Management"
  - Part III "Planning, Design & Operation"
- Available at: https://roadsafety.piarc.org/en



US NHTSA/FHWA CMF Clearinghouse

- **Directly related** to the Highway Safety Manual (AASHTO, 2010)
- Includes **more than 8300 CMFs** on road infrastructure
- **Detailed background information** on presented CMFs is available
- Available online: http://www.cmfclearinghouse.org



AustRoads Road Safety Engineering Toolkit

- **67 treatments** are included

- **Searchable database** according to:
  - Treatment type/name,
  - Crash type,
  - Safety issue,
  - Road user group

- **Detailed background information** on included CMFs generally not available

- Available online: http://www.engtoolkit.com.au

SafetyCube Road Safety DSS

Why SafetyCube?

- Before SafetyCube, road safety knowledge was fragmented and often purely theoretical & academic
- The more industry-oriented everyday practitioners lacked evidence-based support for measure selection and policymaking
- SafetyCube aimed to bridge this gap by collecting and crystallizing scientific knowledge for practical applications
- The SafetyCube DSS is the most comprehensive, complete and accessible tool that can provide insights for choosing appropriate road safety measures

SafetyCube, an EC Horizon 2020 Project

- SafetyCube aims to provide the European and Global road safety community a **user friendly, web-based, interactive** Decision Support System.

- The **SafetyCube DSS** can be **accessed freely**: https://www.roadsafety-dss.eu/#/

- It combines **new and existing** road safety knowledge using scientific studies as basis.

The **main contents** of the SafetyCube DSS concern:

- Road crash risk factors and problems
- Road safety measures
- Best estimate of effectiveness
- Cost-benefit evaluations
- All related analytic background
- Special focus on linking road safety problems with related measures and interventions.

SafetyCube DSS Structure:

- **Search:**
  (5 entry points)
- **Results pages:**
  (Introduction, Colour codes, Synopses, Coded studies)
- **Individual Studies:** pages
  (Disaggregate level, detailed effects listed, some studies not in synopses)
- **Calculator:**
  Economic Efficiency Evaluation
- **Links between Risk Factors:**
  Information about which risks can be remedied by which types of measures
- **Methodology:**
  System documentation
- **Support:**
  Contact, help, feedback

SafetyCube DSS Contents

The SafetyCube DSS contains:

- more than 1,250 scientific studies
- with more than 7,500 estimates of risks/measure effects on
- 4 pillars: road user, infrastructure, vehicle, post impact care
- 38 risk categories, 50 measure categories (88 in total) e.g. distraction, roadside factors,
- 120 specific risks, 193 specific measures (313 in total) e.g. mobile phone use,
- 211 summarizing Synopses documents
- 36 Cost-benefit Analyses (in a CBA calculator which the user can adjust according to their needs)

Behavior	Infrastructure	Vehicle	Post Impact Care
Law and enforcement	Traffic flow	Frontal impact	Ambulances/helicopters
Education and voluntary training or programmes	Traffic composition	Side impact	Extraction from vehicle
Driver training and licensing	Formal tools to address road nettwork deficiencies	Rear impact	Pre-hospital medical care
Fitness to drive assessment and rehabilitation	Speed management & enforcement	Rollover	Triage and allocation to trauma facilities
Awareness raising and campaigns	Road type	Pedestrian	First aid training drivers
	Road surface treatments	Child	
	Visibility / Lighting treatments	PTW	
	Workzones	Cyclist	
	Horizontal & vertical alignment treatments	HGV	
		Longitudinal	

SafetyCube DSS Calculator [1/2]

- Combines information about the effectiveness of a measure (i.e. the percentage of crashes or casualties prevented) with the costs of this measure.
- Integrates updated information of crash costs in European countries
- Allows to express all costs and benefits of a measure in monetary values and conduct cost benefit analysis.

Main Functions

- Perform cost-benefit analysis with own input data
- Select one of the SafetyCube CBA examples
- Measures with high effectiveness
- For which reliable cost information could be found

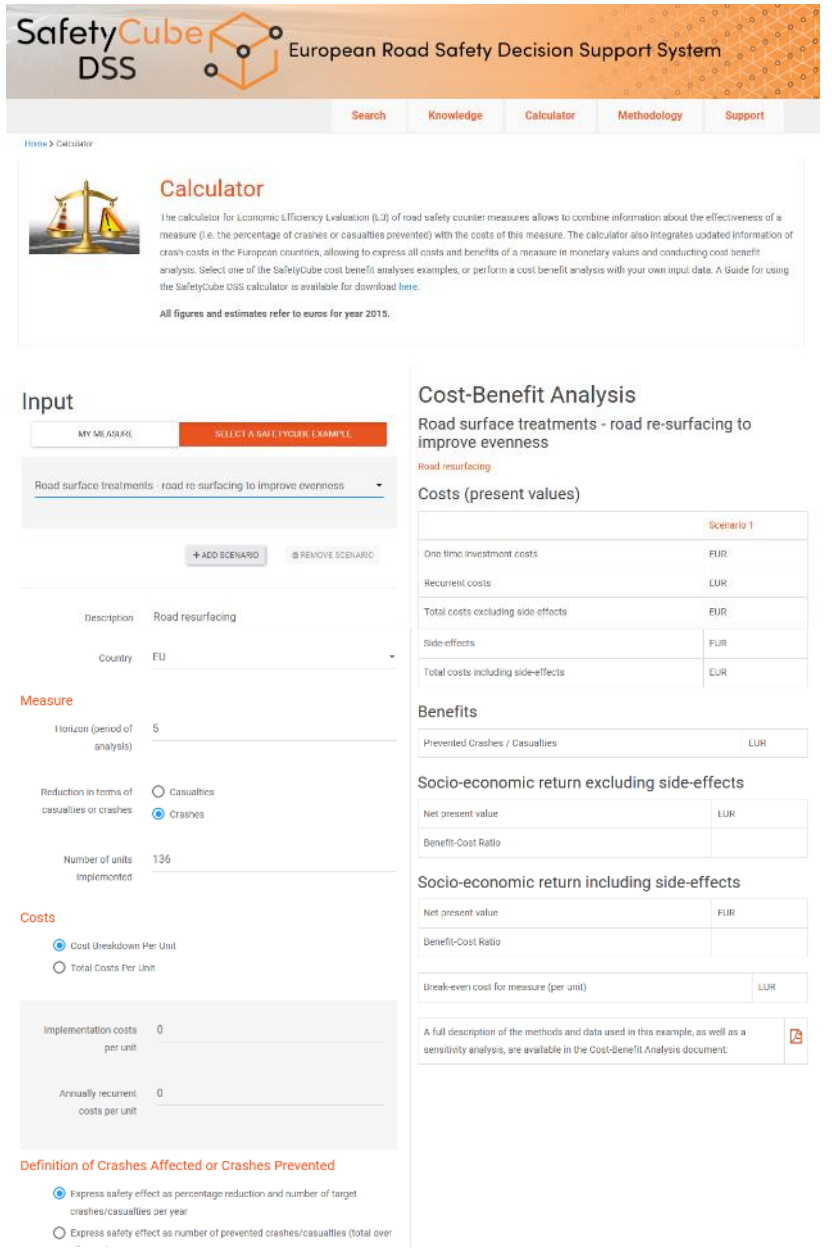
SafetyCube DSS Calculator [2/2]

Economic Efficiency Evaluation Tool (E3)

- Fully integrated in the DSS
- Enables users to create their custom CBA "My Measure" function with free input on:
- Country, years of analyses
- Basis: Crashes or Casualties
- Costs (implementation and annual)
- Measure effectiveness (per severity category)
- Penetration rate and side effects

Contains all SafetyCube example CBAs on:

- Behaviour (12 examples)
- Infrastructure (19 examples)
- Vehicle systems (4 examples)
- Post-impact care (1 example)



SafetyCube CBA Methodology

For the selected measures:

- Crash cost data
  Distinguishing between injury severity categories
- Measure effectiveness and implementation costs, obtained from high quality studies and reports

$$Benefits = \sum_s Target\ Crashes_s * Effectiveness_s * Crash\ costs_s$$

- Formation of a common baseline
  Reference currency: €, Reference year: 2015

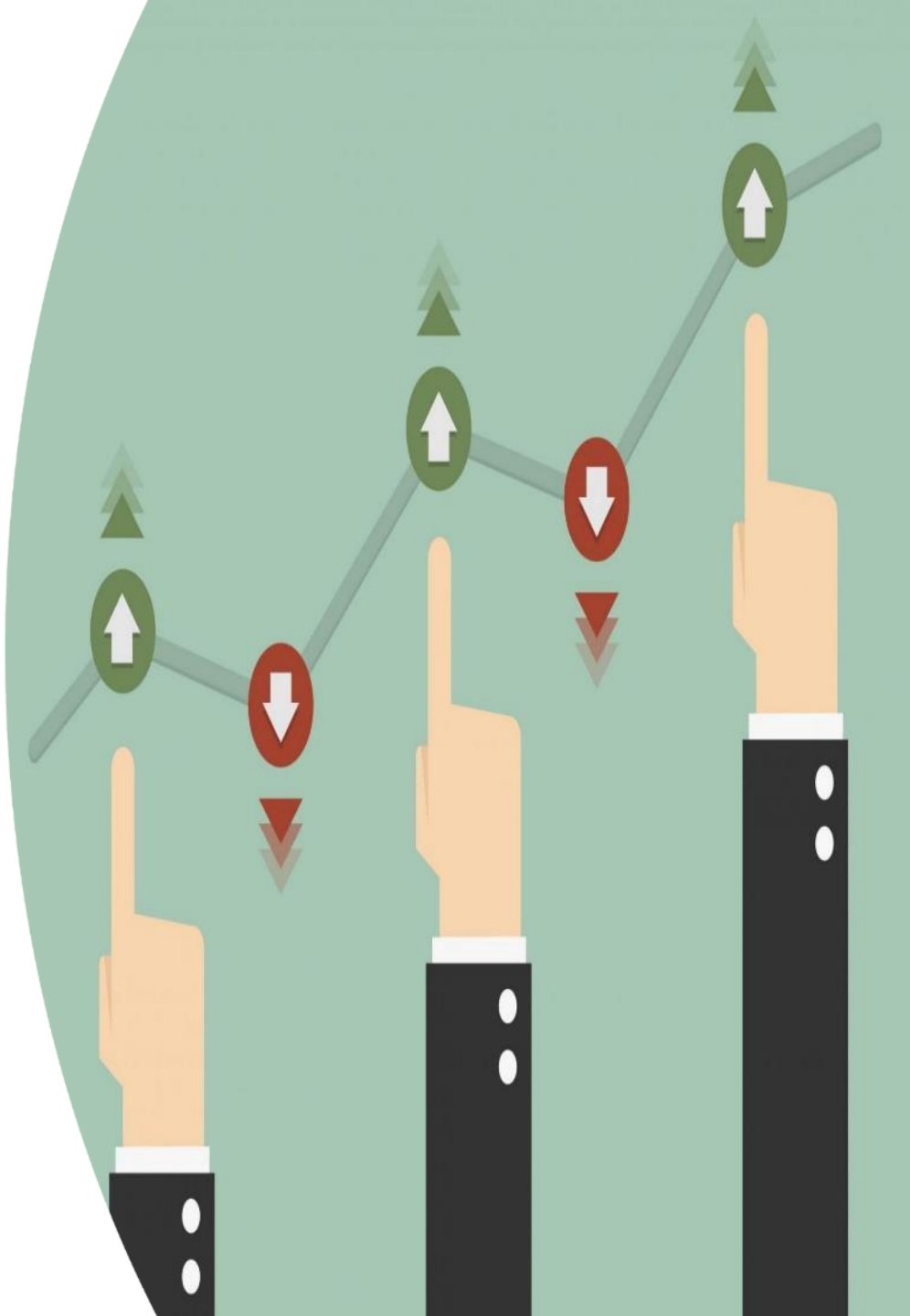
$$present\ value = \frac{actual\ value}{(1 + discount\ rate)^{year}}$$

- Different scenario predictions to mitigate uncertainty

SafetyCube CBA Scenarios

Formation of 7 possible prediction scenarios with respective Cost-Benefit Ratio (CBR) calculations:

1. Best estimate
2. Low measure effectiveness (lower limit of 95% CI)
3. High measure effectiveness (upper limit of 95% CI)
4. Low measure cost (-50%)
5. High measure cost (+100%)
6. Worst case (combining 2 and 5)
7. Best case (combining 3 and 4)



Example SafetyCube CBA outputs [1/2]

Example CBR calculations of the 7 scenarios for:
5 infrastructure measures &
2 behavior measures

(2 measures warranted separation into two sub-categories)

29 infrastructure CBRs also available in:

Daniels, S., Martensen, H., Schoeters, A., Van den Berghe, W., Papadimitriou, E., Ziakopoulos, A., ... & Perez, O. M. (2019). A systematic cost-benefit analysis of 29 road safety measures. Accident Analysis & Prevention, 133, 105292.

	Measure	Benefit-to-cost ratio (BCR)						
		Best estimate	Low measure effect	High measure effect	Low measure cost: -50%	High measure cost: +100%	Worst case scenario = high cost + low effect	Best case scenario = low cost + high effect
Road infrastructure	Road safety audits – light measure case	**21.7**	16.4	27.0	43.5	10.9	8.2	54.0
	Installation of safety barriers	**19.5**	10.6	25.4	39.1	9.8	5.3	21.2
	High risk sites treatment	**16.1**	13.2	18.4	32.2	8.1	6.6	36.8
	Traffic signal installation – highways	**3.7**	1.8	5.2	7.4	1.9	0.9	10.5
	Road safety audits – heavy measure case	**2.9**	2.2	3.6	5.7	1.4	1.1	7.1
	Installation of chevron signs	**2.7**	1.4	5.5	5.5	1.4	0.7	10.9
	Traffic signal installation – county roads	**1.1**	0.5	1.5	2.2	0.5	0.3	3.1
Behavior	Law and enforcement – DUI checkpoints, breath testing	**7.3**	5.7	9.4	14.6	3.7	2.9	18.8
	Law and enforcement – General police enforcement of speeding	**1.0**	0.7	1.3	2.0	0.5	0.4	2.6

Example SafetyCube CBA outputs [2/2]

Interpreting the results:

- Road safety measures addressing hotspots in a focused manner (road safety audits, installation of safety barriers and high risk sites treatment) have highest BCRs
- Overall, most measures appear to be cost-effective (BCR >1)
- 5 measures appear to be cost-effective consistently – in all 7 scenarios
- CBA is a tool to enable comparisons
- However, singular cases must be treated with caution, taking site/country particularities into account

Concluding Remarks

In summary [1/2]

- The need to decide on the most cost-effective and appropriate road safety interventions is increasingly urgent due to stagnation in crash reductions and budgetary constraints.

- The solution(s) can only come through the extensive and systematic data collection and intervention monitoring offered by Road Safety Observatories

- During the last 15 years, several Road Safety Observatories and Decision Support Systems have been developed, adding significant value to the quest for safer roads worldwide.

In summary [2/2]

- CBA is the main tool for informed and effective selection of road safety interventions

- Road Safety Information Systems with CBA capabilities are key management tools for developing road safety capacity and engaging stakeholders (not only for providing scientific evidence but also for monitoring efforts)

- The more developed Information Systems are associated with Countries and Regions with higher road safety performance and are a direct sign of advanced road safety culture.

Future Challenges

- The current great potential of current Road Safety Systems should be multiplied with:
  - more data and knowledge
  - broader geographical coverage

- Upgrading usefulness of the systems entail:
  - more accurate road accident data (LMIC Counties)
  - exposure data and performance indicators
  - measures and policies effectiveness evaluation

- Global impact to be optimized through:
  - a network of Regional Observatories (Global coverage)
  - standardisation of data, processes and systems
  - evidence-based & customized best practices

Conclusions

- Data, knowledge and systems require considerable effort with equivalent budget, but are highly profitable in terms of investment returns:
  - with thousands of lives and injuries saved and
  - road safety investments properly prioritized and exploited

- The deployment of national, regional and international road safety observatories and decision support systems, should be:
  - progressive
  - interconnected
  - properly funded

- Regional and Global coordination and funding are current key challenges for the serious upgrade of the current systems

3rd EU-ASEAN Road Safety Workshop
& Capacity Building

7-9 February 2023, Bangkok, Thailand

Deciding on the most cost-effective and appropriate road safety interventions

George Yannis, Professor NTUA
www.nrso.ntua.gr/geyannis

Department of Transportation Planning and Engineering,
National Technical University of Athens