The 7th International Symposium on Transportation Safety
Shanghai, 9-10 July 2019

Advanced Safety Modeling and Management Platform

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Presentation Outline

1. Road Safety Performance
2. Evidence-driven Safety
3. The SafeFITS Application
4. i-Safe Models Platform
5. Concluding Remarks

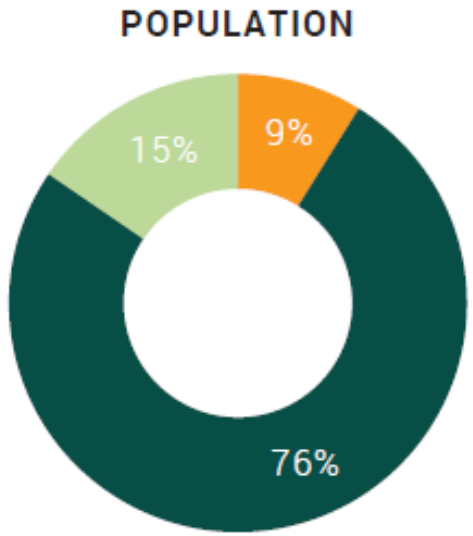
Road Safety Performance

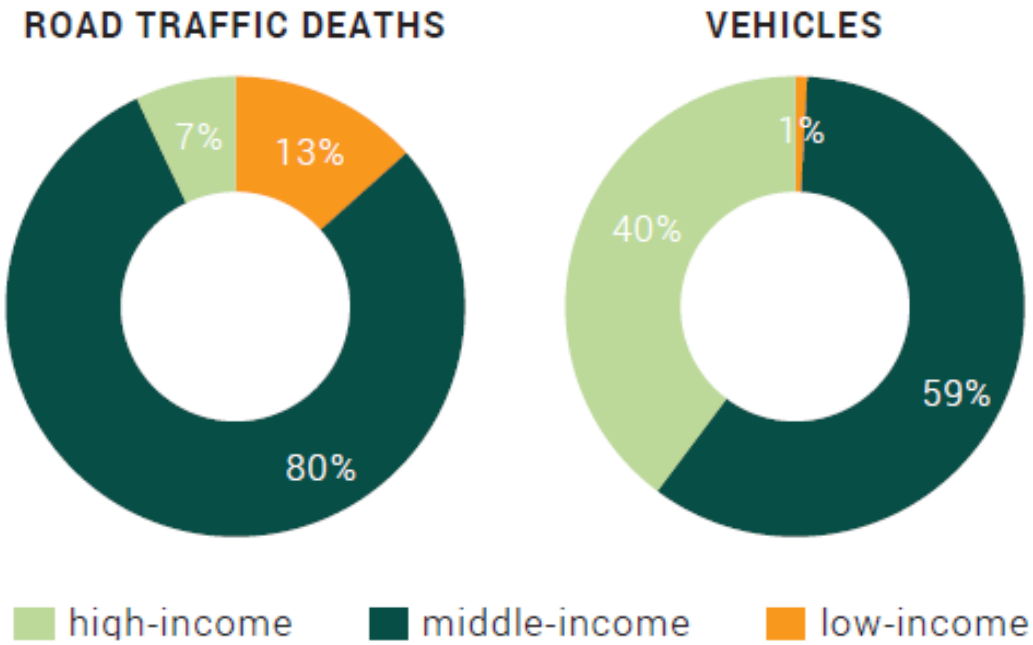
Road Safety Worldwide

- 1,35 million road traffic deaths per year (World Health Organization 2018).
- Road traffic injuries are:
  - the 8th leading cause of death worldwide
  - the 1st cause of death among children and young adults (5-29 years old).
- SDG 3.6 target to halve road deaths and injuries by 2020 will not be met without drastic action.
- Instead a 7% fatalities increase was observed between 2013 and 2016.

Road Safety Progress

- Progress in road safety is not uniform across regions and income levels.
- Although only 1% of the world's motor vehicles are in low income countries, 13% of deaths occur in these countries.
- In high income countries, 40% of the world's vehicles are in traffic, but only 7% of all deaths correspond to these countries.
- The risk is more than 3 times higher in low-income countries than in high-income countries.
- No reduction in the number of road traffic deaths in any low-income country has been recorded since 2013.

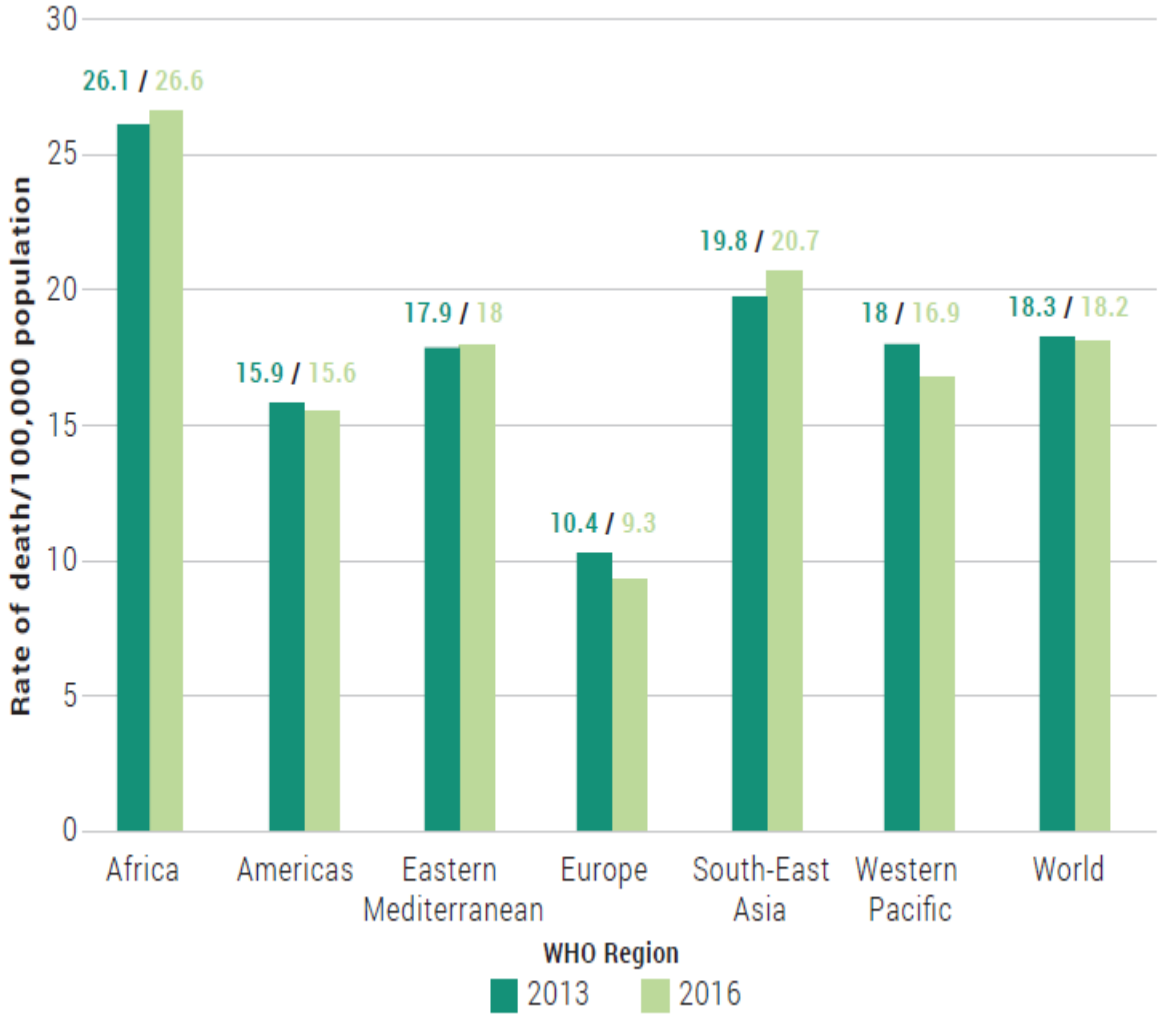




Source: WHO, 2018

Road Safety in Regions

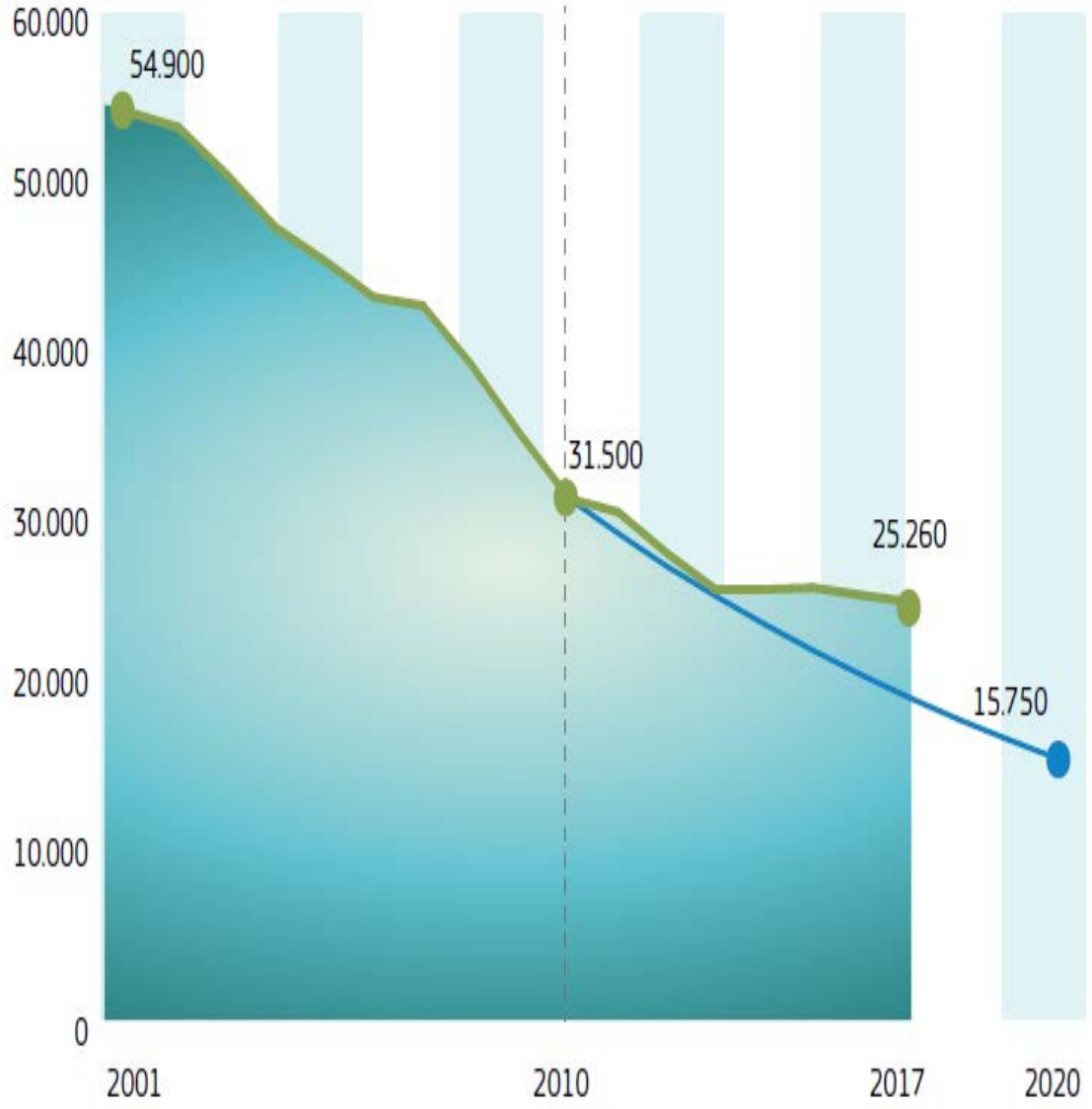
- The rates of road traffic deaths are highest in Africa (26.6/100,000 people) and South-East Asia (20.7/100,000 people).
- The rate of road traffic deaths per population generally decreases as income increases (after a certain level of motorization: ~220 vehicles per 1000 people).
- More than half of all road traffic deaths are among vulnerable road users: pedestrians & cyclists (26%) and motorcyclists (28%).



Source: WHO, 2018

Road Fatality Trend in the EU

- EU has made **significant progress** in road safety during the last two decades.
- However, the progress rate has lately **slowed down**.
- After two years of stagnation (2014 and 2015), the number of **road fatalities** was reduced by 2% in 2016 and by another 2% in 2017.
- **More efforts are required** in order to meet the target of halving road fatalities between 2010 and 2020.

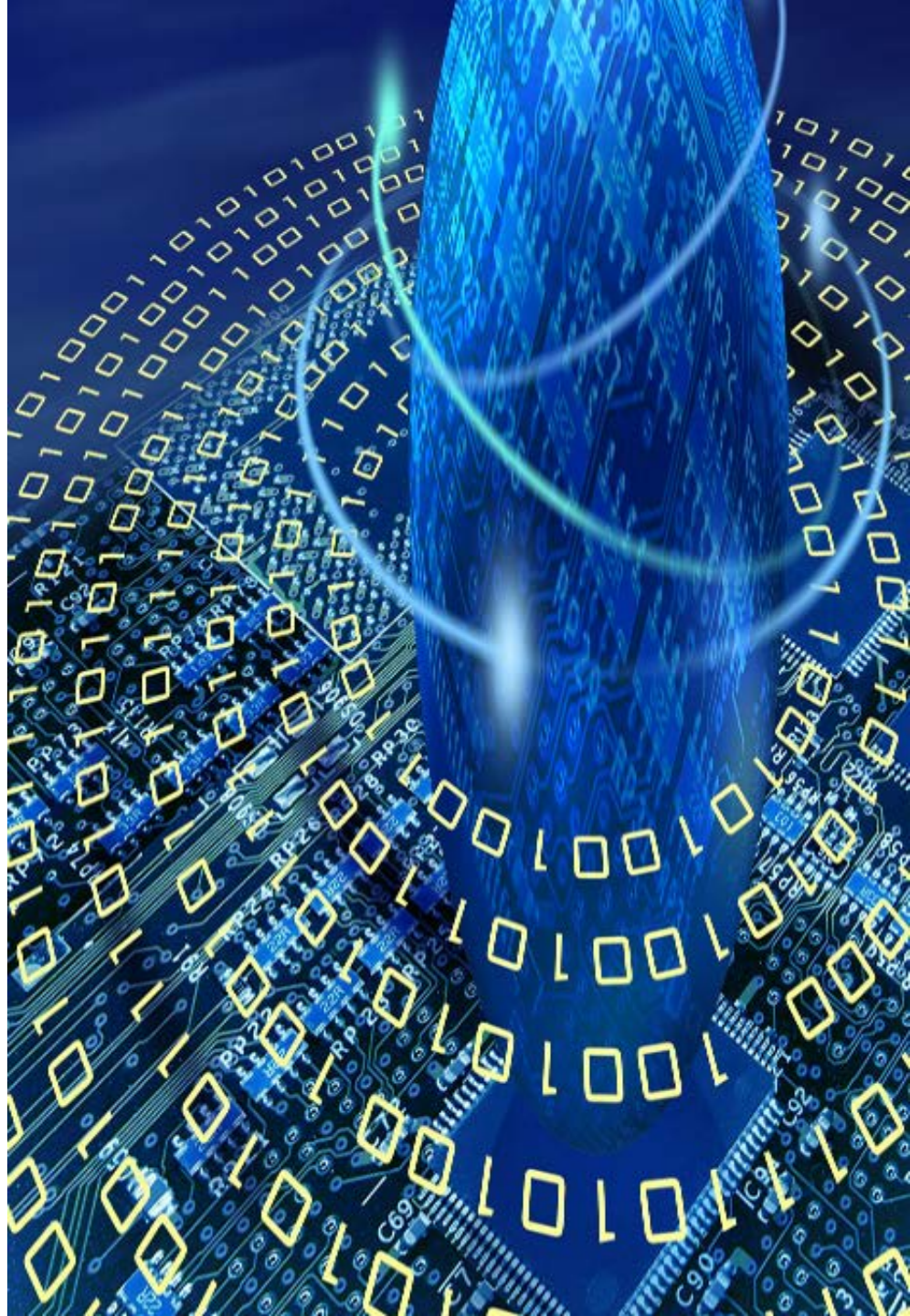


Source: EC, 2018

Evidence-driven Safety

Why Road Safety Data?

- Road Safety is a typical field with high risk of important investments not bringing results.
- Absence of monitoring and accountability limits seriously road safety performance.
- Decision making in road safety management is highly dependent on appropriate and quality data.
- Very often we look where the data are and not where the problems and solutions are.



The Need for Evidence-Based Decision Making

- The policy making cycle
  - Vision and strategy
  - Problem identification
  - Target Setting and priority setting
  - Development of measures
  - Establishing and implementing the program
  - Monitoring of and evaluation of outcomes

The use of high quality road safety data is involved in each stage

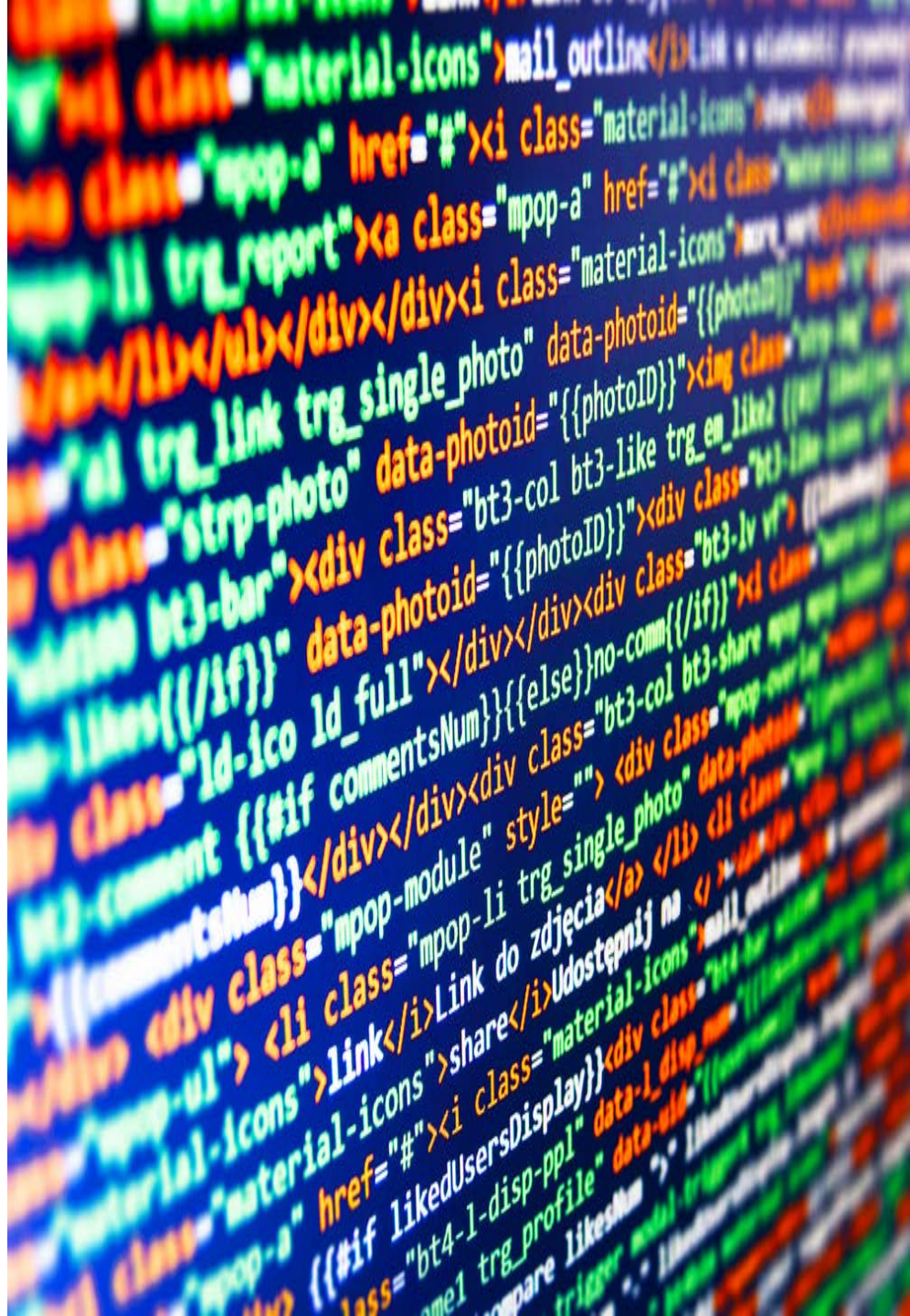
- Necessity to:
  - Consolidate and organize existing data
  - Make data and information available
  - Provide a complete tool-kit (analyses, methodologies, benchmarking tools)
  - Support road safety decision making at all stages

Road Safety Data to Support Evidence-based Policies

- Fatalities and their evolution
- Exposure
- Safety Performance Indicators
- Causation (in-depth accident investigations)
- Health indicators
- Economic indicators
- Driver behavior, attitudes, etc.
- Road safety rules and regulations
- Road safety measures assessment

Do we have the data we need?

Do we need the data we have?



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The Necessary Exposure Data and SPIs

- Exposure Indicators
  - Vehicle- and person-kilometres of travel
  - Time spent in traffic
  - Number of trips
  - Vehicle fleet
  - Population
- Safety Performance Indicators
  - Road user behavior (e.g. speeding, alcohol)
  - Vehicles (e.g. crashworthiness, fleet age etc.)
  - Infrastructure (e.g. meeting design standards)

The most useful data are the least available

The Need for an Integrated Approach

- A conceptual framework
  - Five pillars (Management, Infrastructure, Vehicle, User, Post-Crash Services)
  - Five layers (Crash, SPIs, Measures, Demand and Exposure, Economy)

- First application at SafeFITS
  - The first global road safety model
  - Forecasting and benchmarking

- New application at the ISM Platform
  - Testing in selected regions (Europe, China, US)
  - Cities and Interurban
  - Data holistic approach

Conceptual Framework

- Based on the five pillars of WHO Global Plan of Action (WHO, 2011) and an improved version of the SUNflower pyramid (2002):

- Five layers
  - Economy and Management
  - Transport Demand and Exposure
  - Road Safety Measures
  - Road Safety Performance Indicators
  - Fatalities and Injuries

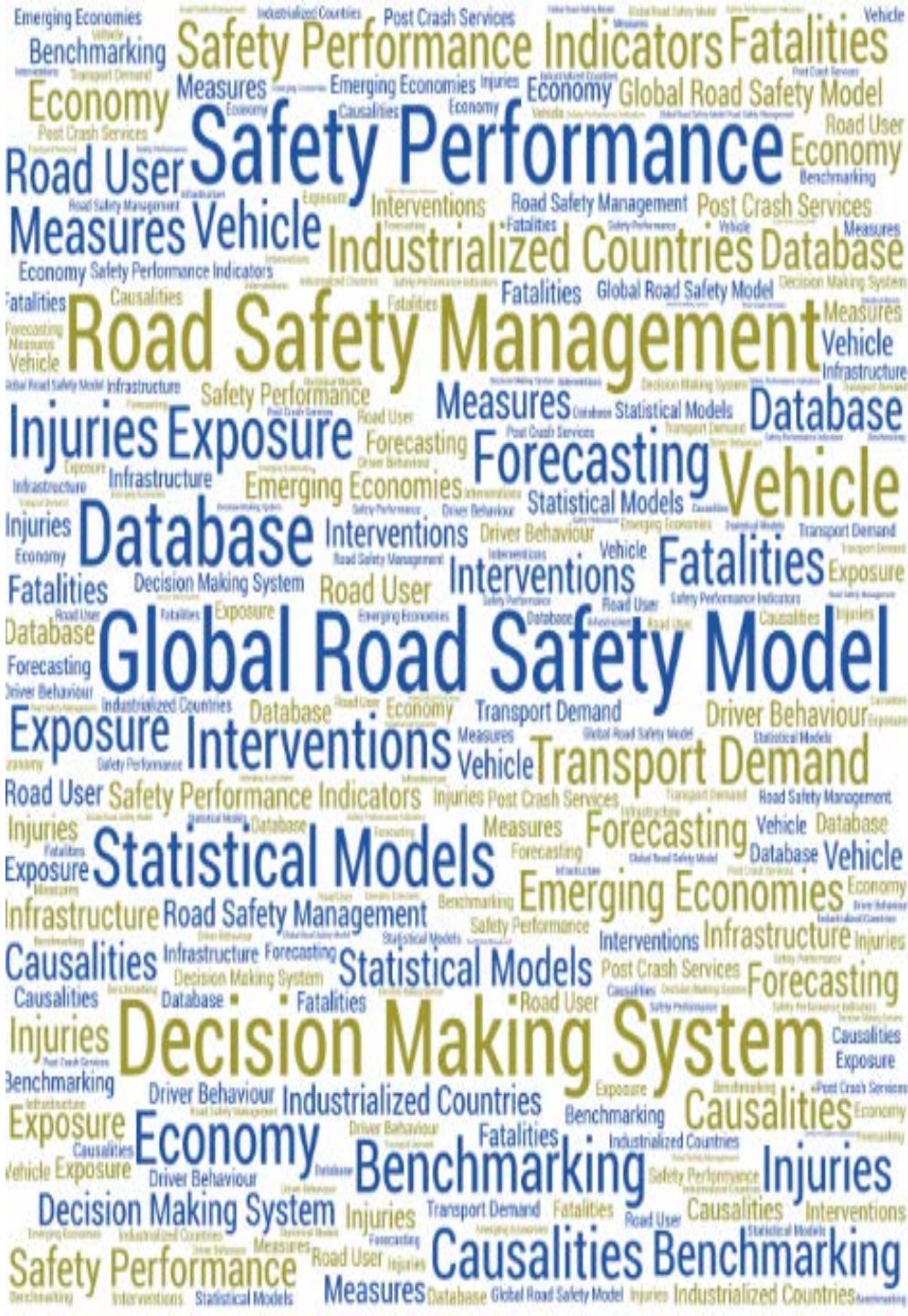
- Five pillars
  - Road Safety Management
  - Road Infrastructure
  - Vehicle
  - User
  - Post-Crash Services

LAYERS	PILLARS				
	1. Road safety management	2. Road Infrastructure	3. Vehicle	4. User	5. Post-crash services
1. Economy and management	Economic Developments, Strategy and Targets, Regulatory framework (compliance with United Nations regulations)	Existence of motorways, of non-paved roads, of road tunnels, Existence of guidelines (for design, RSA etc.), Legislation on speeding	Number of registered vehicles, Vehicle age, Technical inspection legislation (maintenance, roadworthiness, overweight, ADR)	Requirements and regulations on drivers' licensing, Drivers' training, Medical exams of drivers, Legislation on alcohol / use of seatbelts / use of helmets	Trauma management sector level of development Number of hospitals / doctors / Intensive Care (IC) beds per population
2. Transport demand and exposure	Transport Modal Split (road/rail, passenger/freight, private/public), Share of urban areas, Weather conditions	Exposure with regard to road type, Length of road per road type, Share of Motorway length out of the total road network, Number of railway level crossings	Exposure with regard to vehicle type, Share of PTW, HGV / carriage of dangerous goods vehicles in the vehicle fleet	Exposure with regard to age and gender	
3. Road safety measures	Assessment of measures, Data collection and analysis, International comparisons, Vehicle taxation, Road pricing	Treatment of High Risk Sites, Road Safety Audits, Tunnel Road Safety Management, Improvement of signage, Installation of road restraint systems, Lighting, Speed limits in urban areas, Traffic Calming	Renewal rate of vehicle fleet, Measures for second-hand vehicles, Vehicle related roadside controls, Automated driving	Enforcement, campaigns, Road safety education, Training	e-call, First aid training, Existence and organization of trauma centres
4. Road safety performance indicators	Safety targets, stakeholders' involvement, detail of analysis for intervention selection, economic evaluation	Number of RSAs conducted, Percentage of High Risk Sites treated	Global NCAP score, Mean age of the vehicle fleet per vehicle type, Existence of safety equipment, e-safety	Speeding / Drink and drive infringements, Seatbelts use, Helmets use, Driver distraction, Driver fatigue	Emergency response time, Type of field treatment, Speed of treatment in hospital, Number of ambulances per population, Number of good Samaritans per population
5 Fatalities and Injuries	Fatalities / injuries per million inhabitants, fatalities / injuries per million passenger cars, fatalities / injuries per 10 billion passenger-km	Fatalities / injuries in motorways, in 2-lane rural roads, in urban roads	Share of motorcycle fatalities out of the total fatalities	Share of pedestrian / bicyclist / motorcyclist fatalities out of the total fatalities, drink-driving-related fatalities	Death rate, Hospitalization in IC Unit, Total length of hospitalization

The SafeFITS Application

SafeFITS Global Model

- 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).
- Available at: http://www.unece.org/?id=47239



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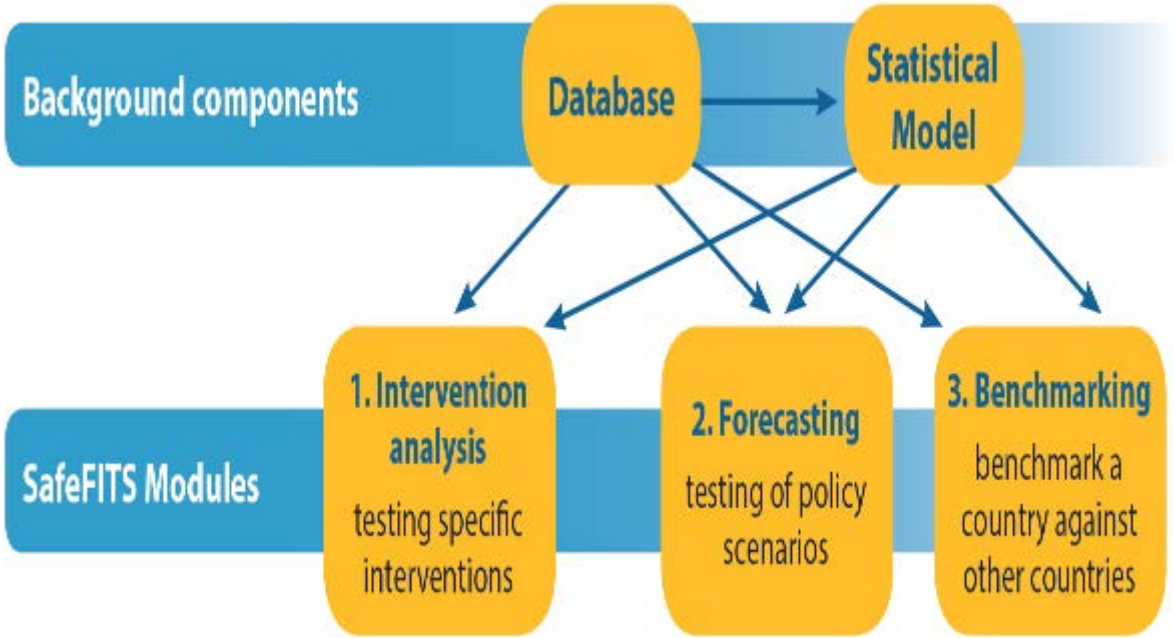
Overview of the SafeFITS Tool

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
- and three 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 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 & road safety performance)



Architecture of the Database

- Data from the five layers and the five pillars
- International databases explored: WHO, UN, IRF, OECD, etc.
- Data for 130 countries with population higher than 2,8 million inhabitants
- Data refer to 2013 or latest available year

Data Analysis Methodology

- **Two-step approach** of statistical modeling:
  - Estimation of **composite variables** (factor analysis) in order to take into account as many indicators as possible of each layer
  - Correlating road safety outcomes with indicators through composite variables by developing a **regression model** with explicit consideration of the time dimension

- **Model specification**

$$Log(Fatalities\ per\ Population)ti = Ai + Log(Fatalities\ per\ Population)(t-\tau) + Bi * GDPti + Ki * [Economy\ \&\ Management]ti + Li * [Transport\ demand\ \&\ Exposure]ti + Mi * [Road\ Safety\ Measures]ti + Ni * [RSPI]ti + \varepsilon i$$

Where [Composite Variable]

Calculation of composite variables – Economy and Management

[Comp_EM] = -0.250 (EM2_lt15yo) + 0.229 (EM3_gt65yo) + 0.228 (EM4_UrbanPop) + 0.224 (EM7_NationalStrategy) + 0.221 (EM8_NationalStrategyFunded) + 0.222 (EM9_FatalityTargets)

Indicator label	Definition	Component	
		Loadings	Score coefficients
EM1_Popdensity	Population per area	0.091	0.029
EM2_lt15yo	Percentage of popualtion under 15 years old	**-0.778**	**-0.250**
EM3_gt65yo	Percentage of popualtion over 65 years old	**0.714**	**0.229**
EM4_UrbanPop	Percentage of urban population	**0.709**	**0.228**
EM5_LeadAgency	Existence of a road safety lead agency	0.284	0.091
EM6_LeadAgencyFunded	The lead agency is funded	0.226	0.073
EM7_NationalStrategy	Existence of national road safety strategy	**0.697**	**0.224**
EM8_NationalStrategyFunded	The strategy is funded	**0.626**	**0.201**
EM9_FatalityTargets	Existence of fatality reduction target	**0.692**	**0.222**

Calculation of composite variables – Transport Demand and Exposure

[Comp_TE] = 0.161 (TE1_RoadNetworkDensity) +
0.149 (TE2_Motorways) +
*0.238 * (TE3_PavedRoads) +*
*0.272 * (TE4_VehiclesPerPop) +*
*0.267 * (TE5_PassCars) –*
*0.221 *(TE7_PTW) –*
*0.117 *(TE10_PassengerFreight)*

Indicator label	Definition	Component	
		Loadings	Score coefficients
TE1_RoadNetworkDensity	Road network per area	**0.497**	**0.161**
TE2_Motorways	Percentage of motorways of total road network	**0.460**	**0.149**
TE3_PavedRoads	Percentage of paved roads of total road network	**0.734**	**0.238**
TE4_VehiclesPerPop	Total number of vehicles in use	**0.839**	**0.272**
TE5_PassCars	Number of passenger cars in use	**0.825**	**0.267**
TE6_VansLorries	Number of vans and lorries in use	-0.132	-0.043
TE7_PTW	Number of powered two wheelers in use	**-0.681**	**-0.221**
TE8_Vehkm_Total	Total number of vehicle kilometers in millions	0.269	0.087
TE9_RailRoad	Ratio rail/road passenger kilometers	0.136	0.044
TE10_PassengerFreight	Roads transport – passenger kilometers/freight kilometers	**-0.360**	**-0.117**

Calculation of composite variables - Measures

[Comp_ME] = 0.069 (ME2_ADR) + 0.045 (ME4_SpeedLimits_urban) + 0.064 (ME6_SpeedLimits_motorways) + 0.088 (ME7_VehStand_seatbelts) + 0.091 (ME8_VehStand_SeatbeltAnchorages) + 0.092 (ME9_VehStand_FrontImpact) + 0.091 (ME10_VehStand_SideImpact) + 0.090 (ME11_VehStand_ESC) + 0.087 (ME12_VehStand_PedProtection) + 0.090 (ME13_VehStand_ChildSeats) + 0.068 (ME15_BAClimits) + 0.068 (ME16_BAClimits_young) + 0.065 (ME17_BAClimits_commercial) + 0.057 (ME19_SeatBeltLaw_all) + 0.063 (ME20_ChildRestraintLaw) + 0.034 (ME22_HelmetFastened) + 0.038 (ME23_HelmetStand) + 0.038 (ME24_MobileLaw) + 0.035 (ME25_MobileLaw_handheld) + 0.038 (ME27_PenaltyPointSyst) + 0.040 (ME29_EmergTrain_nurses)

Indicator label	Definition	Component	
		Loadings	Score coefficients
ME1_RSA	Road Safety Audits on new roads	0.245	0.025
ME2_ADR	Existence of ADR law	0.681	0.069
ME3_SpeedLaw	Existence of national speed law	0.229	0.023
ME4_SpeedLimits_urban	Maximum speed limits on urban roads	0.443	0.045
ME5_SpeedLimits_rural	Maximum speed limits on rural roads	0.200	0.020
ME6_SpeedLimits_motorways	Maximum speed limits on motorways	0.634	0.064
ME7_VehStand_seatbelts	Vehicle standards-seat belts	0.877	0.088
ME8_VehStand_SeatbeltAnchorages	Vehicle standards-seat belt anchorages	0.906	0.091
ME9_VehStand_FrontImpact	Vehicle standards-frontal impact	0.908	0.092
ME10_VehStand_SideImpact	Vehicle standards-side impact	0.904	0.091
ME11_VehStand_ESC	Vehicle standards-Electronic Stability Control	0.891	0.090
ME12_VehStand_PedProtection	Vehicle standards-Pedestrian Protection	0.862	0.087
ME13_VehStand_ChildSeats	Vehicle standards-child seats	0.896	0.090
ME14_DrinkDrivingLaw	Existence of national drink-driving law	0.126	0.013
ME15_BAClimits	BAC limits less than or equal to 0.05 g/dl	0.670	0.068
ME16_BAClimits_young	BAC limits lower than or equal to 0.05g/dl for young/novice drivers	0.670	0.068
ME17_BAClimits_commercial	BAC limits lower than or equal to 0.05g/dl for commercial drivers	0.645	0.065
ME18_SeatBeltLaw	Existence of national seat-belt law	0.297	0.030
ME19_SeatBeltLaw_all	The law applies to all occupants	0.570	0.057
ME20_ChildRestraintLaw	Existence of national child restraints law	0.628	0.063
ME21_HelmetLaw	Existence of national helmet law	0.236	0.024
ME22_HelmetFastened	Law requires helmet to be fastened	0.334	0.034
ME23_HelmetStand	Law requires specific helmet standards	0.379	0.038
ME24_MobileLaw	Existence of national law on mobile phone use while driving	0.375	0.038
ME25_MobileLaw_handheld	The law applies to hand-held phones	0.350	0.035
ME26_MobileLaw_handsfree	The law applies to hands-free phones	-0.295	-0.030
ME27_PenaltyPointSyst	Demerit/Penalty Point System in place	0.378	0.038
ME28_EmergTrain_doctors	Training in emergency medicine for doctors	0.178	0.018
ME29_EmergTrain_nurses	Training in emergency medicine for nurses	0.399	0.040

Calculation of composite variables - SPIs

[Comp_PI] = 0.144 (PI1_SeatBeltLaw_enf) + 0.155 (PI2_DrinkDrivingLaw_enf) + 0.152 (PI3_SpeedLaw_enf)+ 0.160 (PI4_HelmetLaw_enf) + 0.155 (PI5_SeatBelt_rates_front) + 0.146 (PI6_SeatBelt_rates_rear) + 0.150 (PI7_Helmet_rates_driver)+ 0.127 (PI8_SI_ambulance) + 0.116 (PI9_HospitalBeds)

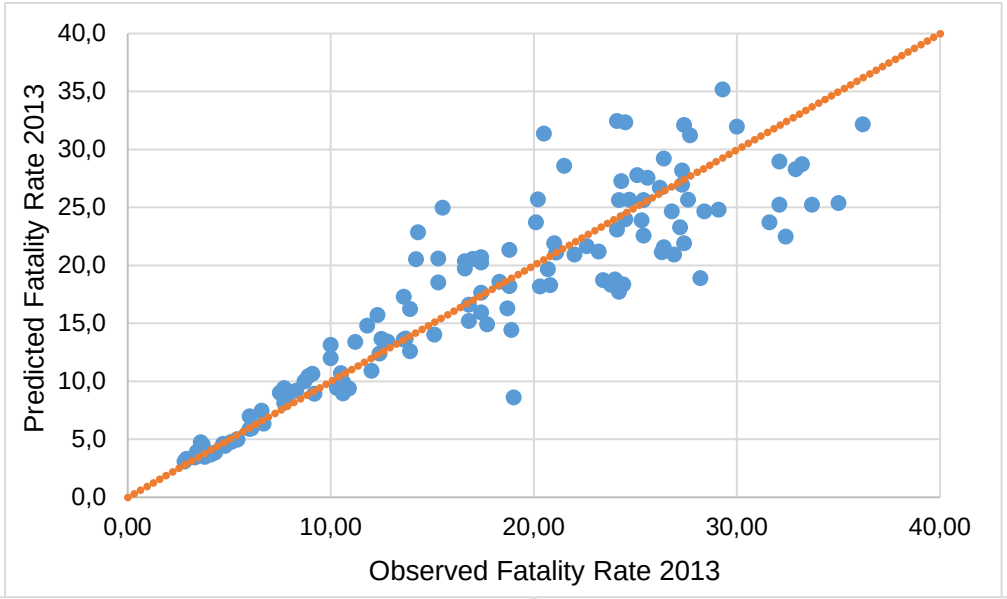
Indicator label	Definition	Component	
		Loadings	Score coefficients
PI1_SeatBeltLaw_enf	Effectiveness of seat-belt law enforcement	0.756	0.144
PI2_DrinkDrivingLaw_enf	Effectiveness of drink-driving law enforcement	0.812	0.155
PI3_SpeedLaw_enf	Effectiveness of speed law enforcement	0.795	0.152
PI4_HelmetLaw_enf	Effectiveness of helmet law enforcement	0.837	0.160
PI5_SeatBelt_rates_front	Seat-Belt wearing rate-Front	0.811	0.155
PI6_SeatBelt_rates_rear	Seat-Belt wearing rate-Rear	0.766	0.146
PI7_Helmet_rates_driver	Helmet wearing rate-driver	0.784	0.150
PI8_SI_ambulance	Estimated % seriously injured patients transported by ambulance	0.667	0.127
PI9_HospitalBeds	Number of hospital beds per 1,000 population	0.607	0.116

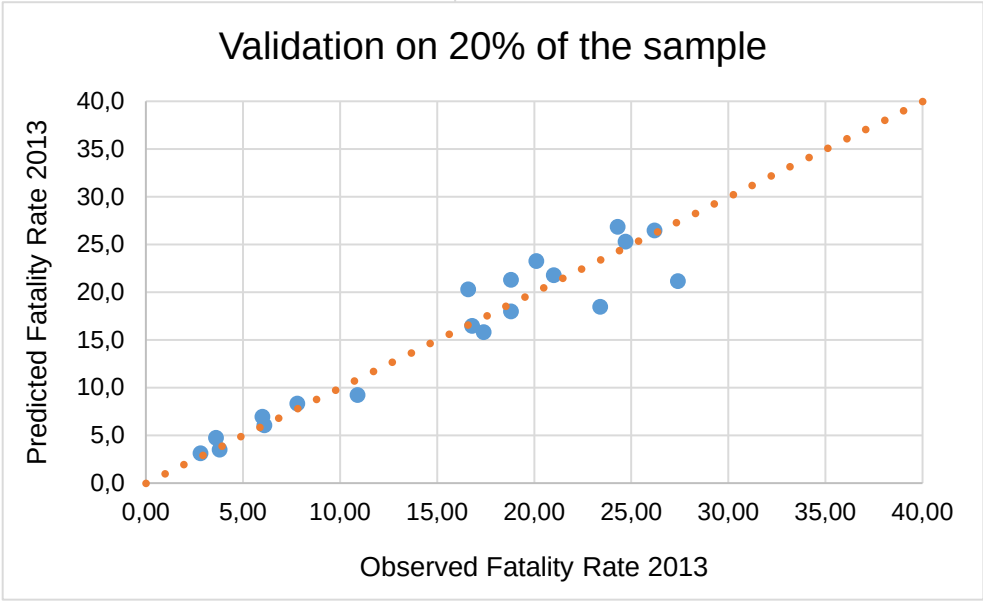
Final Statistical Model

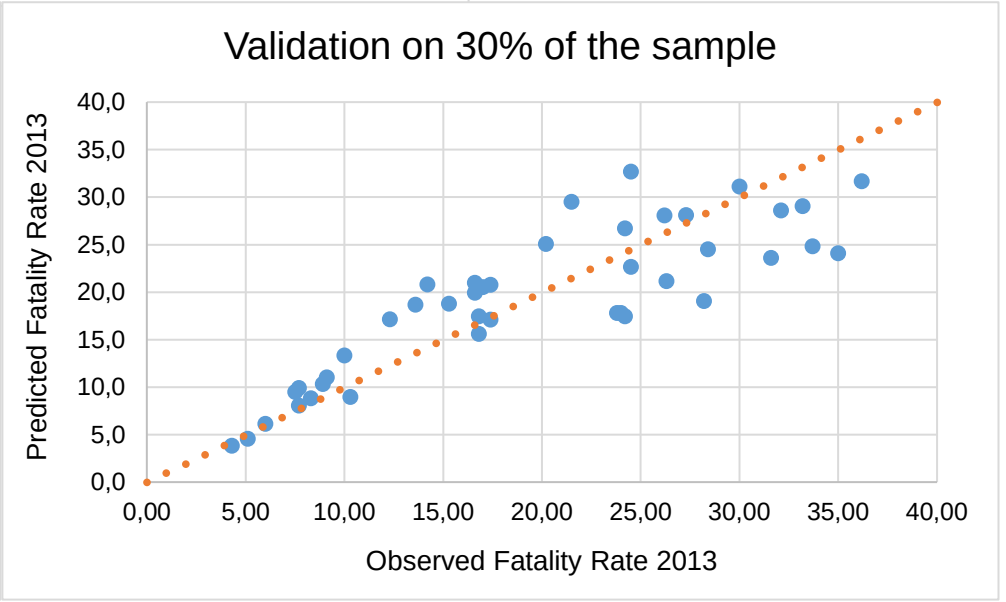
- The optimal performing model for the purposes of SafeFITS
- Dependent variable is the logarithm of the fatality rate per population for 2013
- The main explanatory variables are the respective logarithm of fatality rate in 2010 and the respective logarithm of GNI per capita for 2013
- Four composite variables: the economy & management, the transport demand and exposure, the measures, and the SPIs

Parameter	B	Standarderror	95% confidence interval		Hypothesis test		
			Lower	Upper	Wald chi-square	df	p-value
(Intercept)	1.694	0.2737	1.157	2.230	38.291	1	<0.001
Comp_ME	-0.135	0.0646	-0.261	-0.008	4.358	1	0.037
Comp_TE	-0.007	0.0028	-0.013	-0.002	7.230	1	0.007
Comp_PI	-0.007	0.0030	-0.013	-0.001	5.652	1	0.017
Comp_EM	0.007	0.0051	-0.003	0.017	2.009	1	0.156
LNFestim_2010	0.769	0.0462	0.678	0.859	276.322	1	<0.001
LNGNI_2013	-0.091	0.0314	-0.153	-0.030	8.402	1	0.004
(Scale)	0.038						
Likelihood ratio	1,379.00						
df	6						
p-value	<0.001						

Statistical Model Assessment and Validation



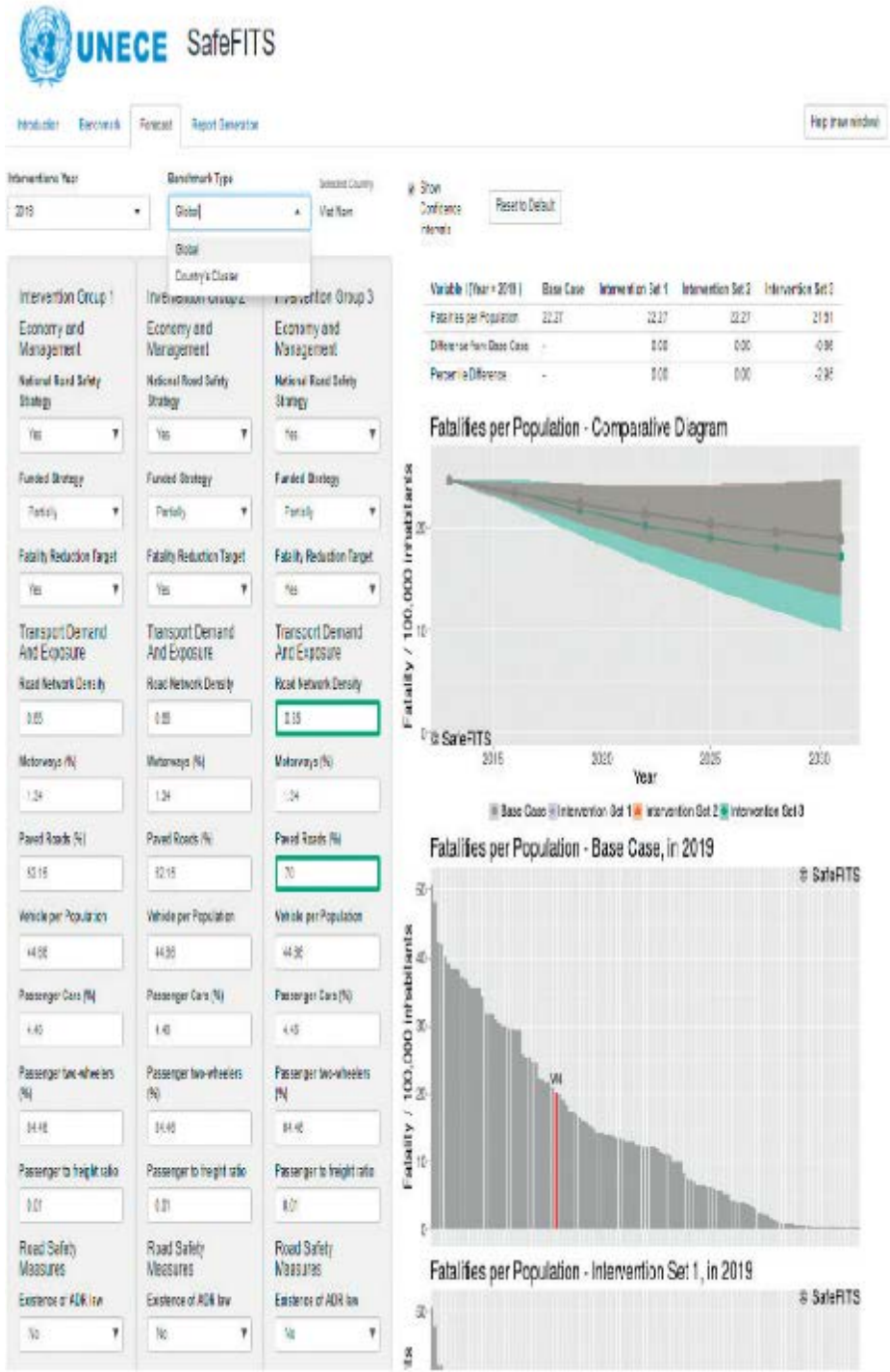




SafeFITS Tool Demonstration

- The overall model implementation includes three distinct steps:
  - Step 1 – Countries Benchmark
  - Step 2 – Forecast with no new interventions
  - Step 3 – Forecast with interventions

- Access the SafeFITS model at: https://unecetrans.shinyapps.io/safefits/



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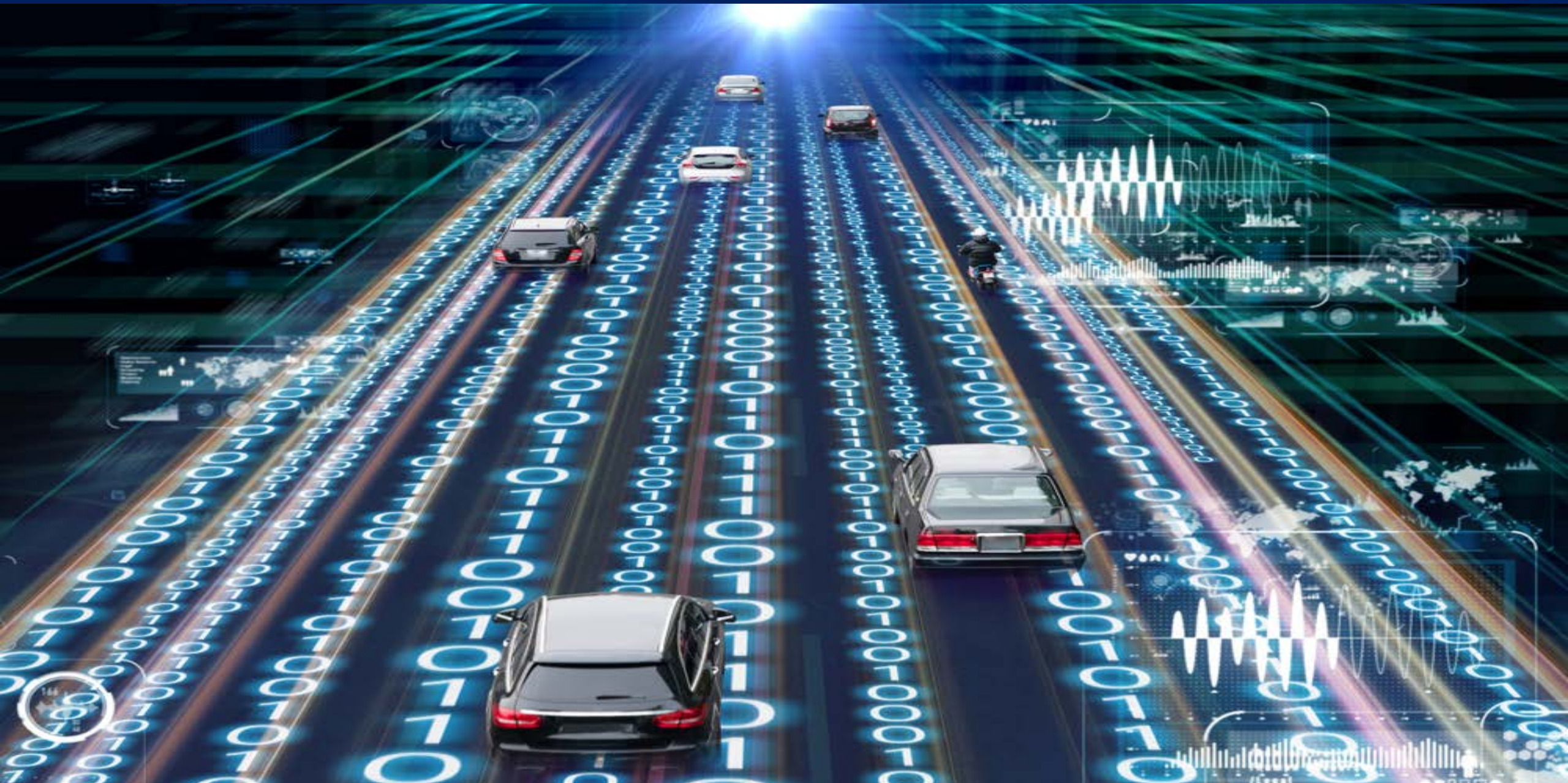
Benefits for the Policy Makers

- The first global road safety model to be used for policy support
  - Global assessments (i.e. monitoring the global progress towards the UN road safety targets)
  - Individual country assessments of various policy scenarios
- A framework which enhances the understanding of road safety causalities, as well as of the related difficulties.
- Full exploitation of the currently available global data, and use of rigorous analysis techniques, to serve key purposes in road safety policy analysis: benchmarking, forecasting.
- An important step for monitoring, evidence-base and systems approach to be integrated in decision-making.

i-Safe Models Platform



i-Safe Models project

- **Project partners**:
  - **National Technical University of Athens**, (www.nrso.ntua.gr)
    Department of Transportation Planning and Engineering
  - **OSeven Telematics** (www.oseven.io)
  - **Tongji University** (https://en.tongji.edu.cn)
  - **Third country partners:**
    University of Central Florida, US
    Purdue University, US.
    Loughborough University, UK
    German Aerospace Center, DE
- **Duration of the project**:
  36 months (estimated June 2019 – June 2022)
- **Operational Program**:
  Greece - China Joint R&D Projects, funded by China and Greece Research Authorities
- **Objective of the project**:
  Propose international comparative analyses of road traffic safety statistics and safety modeling at both macroscopic (e.g. country, region) and microscopic level (roadway locations).

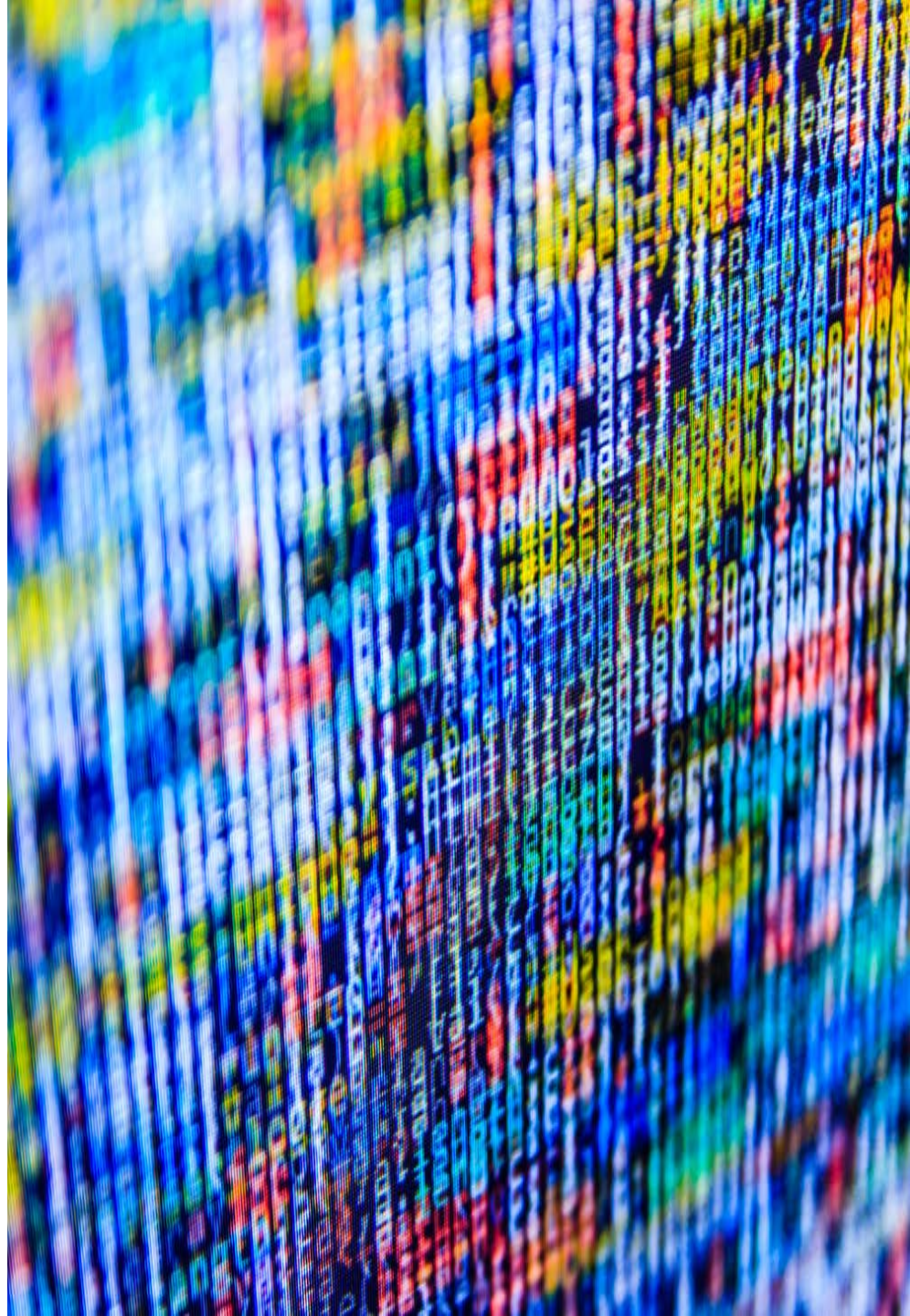
Data Platform Development

Data platform

An online data platform will be established for the convenience of model development and comparative analyses, freely available to researchers and scholars, policy makers and authorities worldwide,

containing knowledge, data and results covering comprehensively all road safety pillars and all road safety layers.

A modern web-based platform, with highly ergonomic interface, simple structure, fully documented and easily updated.



Data Platform Structure

Knowledge section

Based on the respective literature reviews:

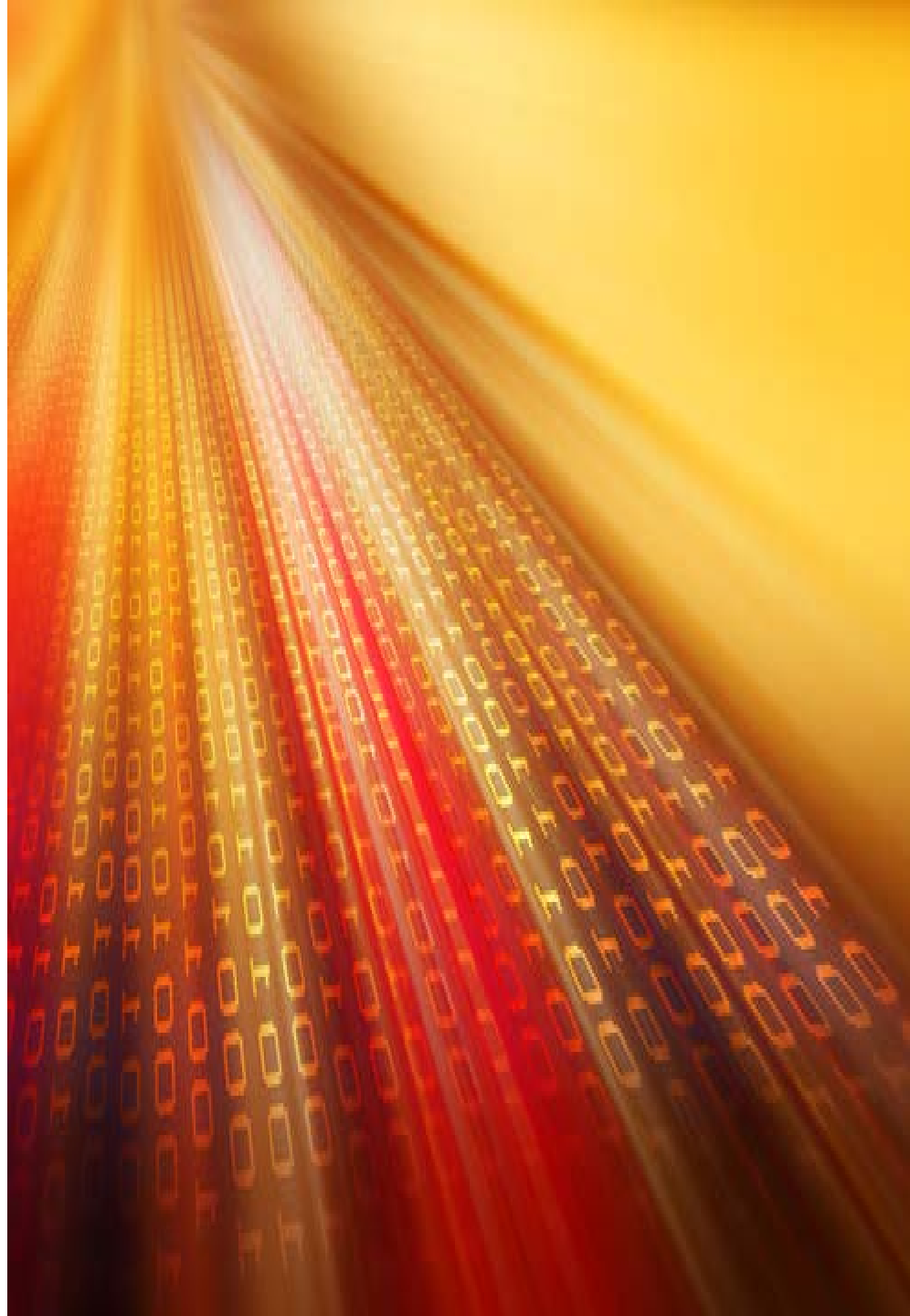
- risk factors & countermeasures
- macroscopic road safety modelling methods
- microscopic road safety modelling methods
- identification of crash hotspots & selection of countermeasures
- model transferability techniques

Data section

- macroscopic road safety data (aggregate data & links to external data sources)
- data from international databases covering all layers and pillars
- at different geographical levels (country, region, city level)

Results section

- i-safemodels project deliverables
- models (macroscopic & microscopic)
- transferability tests
- Decision Support Tool on model transferability and safety management



Expected Outcomes

- Contribution to international road safety knowledge
  - highlight critical issues of road safety and policy making on a global level
  - provide real-world solutions
  - address gaps of knowledge in the generalization of road safety research results

- Contribution to Open Science
  - free online (big) data platform available for researchers and policy makers

- Improvement of road safety decision making practices and development of guidelines
  - policy and decision-making recommendations
  - improve strategies related to proactive traffic management

Concluding Remarks

Conclusions

- Despite the important improvements in road safety, the number of road accident casualties around the world is still unacceptable and there is need for intensification of efforts for further improvement.
- Effective road safety management systems need to be based on rigorous scientific evidence supporting the identification of accident causes and appropriate countermeasures.
- Open knowledge systems are key tools for evidence based policies (ERSO, SafetyCube, SafeFITS, etc.).

Fundamental Directions for Road Safety Research

- Streamline road safety monitoring by exploiting also new technological advances (big data).
- Establish the links between accident causation and injury causation.
- Establish the links:
  - between measures and behaviour
  - between behaviour and risk
- Focus on the most cost-effective measures.
- Improve the transferability of methods and experiences.
- Bridge the gaps between research and policy.

Road Safety Technology Perspectives

- Digitalization opens great new data possibilities for:
  - road user support and guidance
  - evidence based public and private road safety decision making at all levels

- New great potential for seamless data driven procedures from safety problems identification to selection and implementation of optimal solutions.

- New increased net present value of road safety data, available for (real-time) early problem detection and prompt and customized decision support.

The 7th International Symposium on Transportation Safety
Shanghai, 9-10 July 2019

Advanced Safety Modeling and Management Platform

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