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 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.
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?_
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

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<tbody>
<tr>
<td></td>
<td>Economic Development, Strategy and Targets, Regulatory framework (compliance with United Nations regulations)</td>
<td>Transport Modal Split (road, rail, passenger/ freight, private/public), Share of urban areas, Weather conditions</td>
<td>Assessment of measures, Data collection and analysis, International comparisons, Vehicle taxation, Road pricing</td>
<td>Safety targets, stakeholders’ involvement, detail of analysis for intervention selection, economic evaluation</td>
<td>Fatalities / Injuries per million inhabitants, fatalities / injuries per million passenger km</td>
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<td>Existence of motorways, of non-paved roads, of road tunnels, Existence of guidelines for design, RSA etc., Legislation on speeding</td>
<td>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</td>
<td>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</td>
<td>Number of TISAs conducted, Percentage of High Risk Sites treated</td>
<td>Fatalities / Injuries in motorways, in 2-lane rural roads, in urban roads</td>
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<td>Number of registered vehicles, Vehicle age, Technical inspection, legislation (maintenance, roadworthiness, overweight, ADR)</td>
<td>Exposure with regard to vehicle type, Share of SHP, HGU / carriage of dangerous goods vehicles in the vehicle fleet</td>
<td>Renewal rate of vehicles fleet, Measures for second-hand vehicles, Vehicle related roadside controll, Automated driving</td>
<td>Global NAP score, Mean age of the vehicle fleet per vehicle type, Existence of safety equipment, a-safety</td>
<td>Share of motorcycle fatalities out of the total fatalities</td>
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<td>Requirements and regulations on drivers’ licensing, Driver training, Medical exams of drivers, Legislation on alcohol / use of seatbelts / use of helmets</td>
<td>Exposure with regard to age and gender</td>
<td>Enforcement, campaigns, Road safety education, Training</td>
<td>Speeding / Drink and drive infractions, Seatbelts use, Helmets use, Driver distraction, Driver fatigue</td>
<td>Share of pedestrian / bicyclist / motorcyclist fatalities out of the total fatalities, drink-driving-related fatalities</td>
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<td>Trauma management sector level of development Number of hospitals / doctors / Intensive Care (ICU) beds per population</td>
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<td>Emergency response time, Type of first treatment, Speed of treatment in hospital, Number of ambulances per population, Number of good Samaritans per population</td>
<td>Death rate, Hospitalisation in ICU, Total length of hospitalisation</td>
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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
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**

  \[
  \log(\text{Fatalities per Population})_{ti} = A_i + \log(\text{Fatalities per Population})_{(t-\tau)} + B_i * \text{GDP}_{ti} + K_i * [\text{Economy & Management}]_{ti} + L_i * [\text{Transport demand & Exposure}]_{ti} + M_i * [\text{Road Safety Measures}]_{ti} + N_i * [\text{RSPI}]_{ti} + \epsilon_i
  \]

  Where [Composite Variable]
Calculation of composite variables – Economy and Management

\[ \text{Comp}_{EM} = -0.250 \ (EM2_{lt15yo}) + 0.229 \ (EM3_{gt65yo}) + 0.228 \ (EM4_{UrbanPop}) + 0.224 \ (EM7_{NationalStrategy}) + 0.221 \ (EM8_{NationalStrategyFunded}) + 0.222 \ (EM9_{FatalityTargets}) \]
Calculation of composite variables – Transport Demand and Exposure

\[ \text{Comp}_\text{TE} = 0.161 \times (\text{TE1}_\text{RoadNetworkDensity}) + 0.149 \times (\text{TE2}_\text{Motorways}) + 0.238 \times (\text{TE3}_\text{PavedRoads}) + 0.272 \times (\text{TE4}_\text{VehiclesPerPop}) + 0.267 \times (\text{TE5}_\text{PassCars}) - 0.221 \times (\text{TE7}_\text{PTW}) - 0.117 \times (\text{TE10}_\text{PassengerFreight}) \]
Calculation of composite variables - Measures

\[ \text{Comp\_ME} = 0.069 \times (\text{ME2\_ADR}) + 0.045 \times (\text{ME4\_SpeedLimits\_urban}) + 0.064 \times (\text{ME6\_SpeedLimits\_motorways}) + 0.088 \times (\text{ME7\_VehStand\_seatbelts}) + 0.091 \times (\text{ME8\_VehStand\_SeatbeltAnchorages}) + 0.092 \times (\text{ME9\_VehStand\_FrontImpact}) + 0.090 \times (\text{ME10\_VehStand\_SidelImpact}) + 0.090 \times (\text{ME11\_VehStand\_ESC}) + 0.087 \times (\text{ME12\_VehStand\_PedProtection}) + 0.090 \times (\text{ME13\_VehStand\_ChildSeats}) + 0.068 \times (\text{ME15\_BAClimits}) + 0.068 \times (\text{ME16\_BAClimits\_young}) + 0.065 \times (\text{ME17\_BAClimits\_commercial}) + 0.057 \times (\text{ME19\_SeatBeltLaw\_all}) + 0.063 \times (\text{ME20\_ChildRestraintLaw}) + 0.034 \times (\text{ME22\_HelmetFastened}) + 0.038 \times (\text{ME23\_HelmetStand}) + 0.038 \times (\text{ME24\_MobileLaw}) + 0.035 \times (\text{ME25\_MobileLaw\_handheld}) + 0.038 \times (\text{ME27\_PenaltyPointSyst}) + 0.040 \times (\text{ME29\_EmergTrain\_nurses}) \]
Calculation of composite variables - SPIs

\[ \text{Comp_Pi} = 0.144 \text{(PI1 SeatBeltLaw_enf)} + 0.155 \text{(PI2 DrinkDrivingLaw_enf)} + 0.152 \text{(PI3 SpeedLaw_enf)} + 0.160 \text{(PI4 HelmetLaw_enf)} + 0.155 \text{(PI5 SeatBelt_rates_front)} + 0.146 \text{(PI6 SeatBelt_rates_rear)} + 0.150 \text{(PI7 Helmet_rates_driver)} + 0.127 \text{(PI8 SI_ambulance)} + 0.116 \text{(PI9 HospitalBeds)} \]
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
Statistical Model Assessment and Validation

Validation on 20% of the sample

Validation on 30% of the sample
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/
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 project

- **Project partners:**
  - National Technical University of Athens, [www.nrso.ntua.gr](http://www.nrso.ntua.gr)
  - OSeven Telematics ([www.oseven.io](http://www.oseven.io))
  - Tongji University ([https://en.tongji.edu.cn](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
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
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