SafeFITS
A Global Road Safety Model
For Future Inland Transport Systems

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SafeFITS Objectives

• To develop a macroscopic road safety decision making tool that will assist governments and decision makers, both in developed and developing countries, to decide on the most appropriate road safety policies and measures in order to achieve tangible results.

• The tool is based on the related scientific knowledge available worldwide, with emphasis on recent academic research and project results.
SafeFITS Report and Presentation Outline

- SafeFITS Conceptual framework
- Literature review of existing research on accident causalities
- Focused literature review on quantified accident causal relations
- SafeFITS Database development
- SafeFITS Model development
- SafeFITS Tool, including:
  - Intervention analysis module
  - Forecasting module
  - Benchmarking module

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Conceptual Framework

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

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

**SafeFITS pillars**
1. Road Safety Management
2. Road Infrastructure
3. Vehicle
4. User
5. Post-Crash Services
Review of accident causalities

- Literature review of existing research on accident casualties was performed for each of the pillars separately.
- Causal relationships between policies or measures and road safety outcomes were summarized.
- Review on specific quantified causal relations linking these indicators with the road safety outcomes was performed.

- Very limited available information from studies in middle and low-income countries.
- In some cases, a quantitative relation to estimate an overall accident reduction attributed to a specific indicator is not available.
- Some causal relationships identified in literature were found to be incompatible with each other.
- Some identified detailed causalities have been based on logical assumptions.

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Overview of the SafeFITS model

1. Intervention analysis: testing specific interventions
2. Forecasting: testing of policy scenarios
3. Benchmarking: benchmark a country against other countries
The SafeFITS Database

- Architecture of the project Database
- Data indicators from the five layers:
  - Economy and Management
  - Transport Demand and Exposure
  - Road Safety Measures
  - Road Safety Performance Indicators
  - Fatalities and Injuries
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
Economy and Management

Demographic and Economic Characteristics
• Population (World Bank Database)
• Area (World Bank Database)
• GNI per capita in US dollars (World Bank Database)
• Projected GDP per capita for 2015-2030 in 2010 US dollars (ERS International Macroeconomic Data Set)

Road Safety Management Indicators (WHO)
• Existence of RS lead agency
• The lead agency is funded
• Existence of national RS strategy
• The RS strategy is funded
• Existence of RS fatality targets
Transport Demand and Exposure

Roads
- Road network density (IRF)
- Percentage of motorways (IRF)
- Percentage of paved roads (IRF, CIA)

Vehicles (IRF)
- Number of vehicles in use in total and by type of vehicle

Traffic (IRF)
- Traffic Volume
- Inland surface passengers transport
- Inland surface freight transport
Road Safety Measures (1/2)

**Roads** (WHO)
- Road safety **audits on new roads**
- Existence of **speed law**
- Max **speed limits on urban roads** (no speed limits; >50 km/h; ≤50 km/h)
- Max **speed limits on rural roads** (no speed limits; 100-120 km/h; 70-90 km/h; ≤70 km/h)
- Max **speed limits on motorways** (no speed limits; ≤100 km/h; 100-120 km/h; ≥120 km/h)

**Vehicles**
- Existence of **ADR law** (UNECE)
- **Vehicle standards** include seat-belts, electronic stability control, pedestrian protection (WHO)
- New cars subjected to **NCAP** (WHO)

**Post-crash care** (WHO)
- Training in emergency medicine for doctors
- Training in emergency training for nurses
Road Safety Measures (2/2)

Road User (WHO)
- Existence of drink-driving law
- Allowed BAC limits (3 separate variables for general population, young/novice drivers, commercial drivers)
- Existence of national seat-belt law
- The seat-belt law applies to all occupants
- Existence of national child restraint law
- Existence of national helmet law
- The law requires helmet to be fastened
- The helmet law defines specific helmet standards
- Existence of national law on mobile phone use while driving
- The law applies to hand-held phones
- The law applies to hands-free phones
- Existence of penalty point system

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Road Safety Performance Indicators

**Traffic law enforcement** (WHO)
- Assessment of effectiveness of seat-belt law enforcement
- Assessment of effectiveness of drink-driving law enforcement
- Assessment of effectiveness of speed law enforcement
- Assessment of effectiveness of helmet law enforcement

**Road User** (WHO)
- Seat-belt wearing rates in front seats
- Seat-belt wearing rates in rear seats
- Helmet wearing rates – driver

**Post-crash care**
- Estimated percentage of seriously injured patients transported by ambulance (WHO)
- Number of hospital beds per population (World Bank Database)
Fatalities and Injuries

- Estimated number of road traffic fatalities (WHO)
- Estimated road traffic fatality rates per 100,000 population (WHO)
- Distribution of road traffic fatalities by road user type (WHO)
- Distribution of road traffic fatalities by gender (WHO)
- Percentage of road traffic fatalities attributed to alcohol (WHO)
SafeFITS Database

• Wherever data for 2013 were not available, the latest data available were used.

• The missing values of each indicator of the countries were filled with the mean value of the indicator in their regions.

• The respective information of each variable is properly represented in the database for the statistical process.

• Data for most variables were available for almost all countries.

• Low data availability is observed for few variables regarding:
  - the restraint use rates
  - the percentage of fatalities attributed to alcohol
  - the distribution of fatalities by road user type
  - transport demand and exposure indicators
SafeFITS Model Development

- Data Analysis Methodology
- Estimation of Composite Variables
- Development of Statistical Model
  Correlating road safety outcomes with composite variables
- Model Validation
- Customisation for Groups of Countries

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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

• For efficient forecasting, it is necessary to make explicit consideration of time dimension

• Identification of groups of countries for better description by dedicated analyses

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Calculation of composite variables – Economy and Management

\[ \text{Comp}_ {EM} = -0.250 \times (\text{EM2}_{lt15yo}) + 0.229 \times (\text{EM3}_{gt65yo}) + 0.228 \times (\text{EM4}_{UrbanPop}) + 0.224 \times (\text{EM7}_{NationalStrategy}) + 0.221 \times (\text{EM8}_{NationalStrategyFunded}) + 0.222 \times (\text{EM9}_{FatalityTargets}) \]

Indicator loadings and coefficients on the estimated factor (composite variable) on Economy and Management

<table>
<thead>
<tr>
<th>Component</th>
<th>Loadings</th>
<th>Score coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>EM1_Popdensity</td>
<td>0.091</td>
<td>0.029</td>
</tr>
<tr>
<td>EM2_Lt15yo</td>
<td>-0.778</td>
<td>-0.250</td>
</tr>
<tr>
<td>EM3_gt65yo</td>
<td>0.714</td>
<td>0.229</td>
</tr>
<tr>
<td>EM4_UrbanPop</td>
<td>0.709</td>
<td>0.228</td>
</tr>
<tr>
<td>EM5_LeadAgency</td>
<td>0.284</td>
<td>0.091</td>
</tr>
<tr>
<td>EM6_LeadAgencyFunded</td>
<td>0.226</td>
<td>0.073</td>
</tr>
<tr>
<td>EM7_NationalStrategy</td>
<td>0.697</td>
<td>0.224</td>
</tr>
<tr>
<td>EM8_NationalStrategyFunded</td>
<td>0.626</td>
<td>0.201</td>
</tr>
<tr>
<td>EM9_FatalityTargets</td>
<td>0.692</td>
<td>0.222</td>
</tr>
</tbody>
</table>
Calculation of composite variables – Transport Demand and Exposure

\[
[\text{Comp}_\text{TE}] = 0.161 (\text{TE1\_RoadNetworkDensity}) + 0.149 (\text{TE2\_Motorways}) + 0.238 (\text{TE3\_PavedRoads}) + 0.272 (\text{TE4\_VehiclesPerPop}) + 0.267 (\text{TE5\_PassCars}) - 0.221 (\text{TE7\_PTW}) - 0.117 (\text{TE10\_PassengerFreight})
\]

**Indicator loadings and coefficients on the estimated factor (composite variable) on Transport Demand and Exposure**

<table>
<thead>
<tr>
<th>Component</th>
<th>Loadings</th>
<th>Score coefficients</th>
</tr>
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<td>\text{TE1_RoadNetworkDensity}</td>
<td>0.497</td>
<td>0.161</td>
</tr>
<tr>
<td>\text{TE2_Motorways}</td>
<td>0.460</td>
<td>0.149</td>
</tr>
<tr>
<td>\text{TE3_PavedRoads}</td>
<td>0.734</td>
<td>0.238</td>
</tr>
<tr>
<td>\text{TE4_VehiclesPerPop}</td>
<td>0.839</td>
<td>0.272</td>
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<tr>
<td>\text{TE5_PassCars}</td>
<td>0.825</td>
<td>0.267</td>
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<tr>
<td>\text{TE6_VansLorries}</td>
<td>-0.132</td>
<td>-0.043</td>
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<tr>
<td>\text{TE7_PTW}</td>
<td>-0.681</td>
<td>-0.221</td>
</tr>
<tr>
<td>\text{TE8_Vehkm_Total}</td>
<td>0.269</td>
<td>0.087</td>
</tr>
<tr>
<td>\text{TE9_RailRoad}</td>
<td>0.136</td>
<td>0.044</td>
</tr>
<tr>
<td>\text{TE10_PassengerFreight}</td>
<td>-0.360</td>
<td>-0.117</td>
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</table>
Calculation of composite variables - Measures

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

<table>
<thead>
<tr>
<th>Component</th>
<th>Loadings</th>
<th>Score coefficients</th>
</tr>
</thead>
<tbody>
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<td>ME1_RSA</td>
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<td>,025</td>
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<tr>
<td>ME2_ADR</td>
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<td>,069</td>
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<td>ME3_SpeedLaw</td>
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<td>,023</td>
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<tr>
<td>ME4_SpeedLimits_urban</td>
<td>,443</td>
<td>,045</td>
</tr>
<tr>
<td>ME5_SpeedLimits_rural</td>
<td>,200</td>
<td>,020</td>
</tr>
<tr>
<td>ME6_SpeedLimits_motorways</td>
<td>,634</td>
<td>,064</td>
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<tr>
<td>ME7_VehStand_seatbelts</td>
<td>,877</td>
<td>,088</td>
</tr>
<tr>
<td>ME8_VehStand_SeatbeltAnchorages</td>
<td>,906</td>
<td>,091</td>
</tr>
<tr>
<td>ME9_VehStand_FrontImpact</td>
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<td>,092</td>
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<td>ME10_VehStand_Sidimpact</td>
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<td>ME11_VehStand_ESC</td>
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<tr>
<td>ME12_VehStand_PedProtection</td>
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<td>,090</td>
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<tr>
<td>ME14_DrinkDrivingLaw</td>
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<tr>
<td>ME15_BAClimits</td>
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<td>,068</td>
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<tr>
<td>ME16_BAClimits_young</td>
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<td>ME18_SeatBeltLaw</td>
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<td>ME19_SeatBeltLaw_all</td>
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<td>ME20_ChildRestraintLaw</td>
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<td>ME21_HelmetLaw</td>
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<td>,024</td>
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<td>ME22_HelmetFastened</td>
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<td>,034</td>
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<tr>
<td>ME23_HelmetStand</td>
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<td>,038</td>
</tr>
<tr>
<td>ME24_MobileLaw</td>
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<td>,038</td>
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<td>ME25_MobileLaw_handheld</td>
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<td>,035</td>
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<tr>
<td>ME26_MobileLaw_handfree</td>
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<td>,030</td>
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<tr>
<td>ME27_PenaltyPointSyst</td>
<td>,378</td>
<td>,038</td>
</tr>
<tr>
<td>ME28_EmergTrain_doctors</td>
<td>,178</td>
<td>,018</td>
</tr>
<tr>
<td>ME29_EmergTrain_nurses</td>
<td>,399</td>
<td>,040</td>
</tr>
</tbody>
</table>

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Calculation of composite variables - SPIs

$$[\text{Comp}_PI] = 0.144 (\text{PI1}_\text{SeatBeltLaw_enf}) + 0.155 (\text{PI2}_\text{DrinkDrivingLaw_enf}) + 0.152 (\text{PI3}_\text{SpeedLaw_enf}) + 0.160 (\text{PI4}_\text{HelmetLaw_enf}) + 0.155 (\text{PI5}_\text{SeatBelt_rates_front}) + 0.146 (\text{PI6}_\text{SeatBelt_rates_rear}) + 0.150 (\text{PI7}_\text{Helmet_rates_driver}) + 0.127 (\text{PI8}_\text{SI_ambulance}) + 0.116 (\text{PI9}_\text{HospitalBeds})$$

<table>
<thead>
<tr>
<th>Component</th>
<th>Loadings</th>
<th>Score coefficients</th>
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<tbody>
<tr>
<td>PI1__SeatBeltLaw_enf</td>
<td>0.756</td>
<td>1.144</td>
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<tr>
<td>PI2__DrinkDrivingLaw_enf</td>
<td>0.812</td>
<td>1.155</td>
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<tr>
<td>PI3__SpeedLaw_enf</td>
<td>0.795</td>
<td>1.152</td>
</tr>
<tr>
<td>PI4__HelmetLaw_enf</td>
<td>0.837</td>
<td>1.160</td>
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<tr>
<td>PI5__SeatBelt_rates_front</td>
<td>0.811</td>
<td>1.155</td>
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<tr>
<td>PI6__SeatBelt_rates_rear</td>
<td>0.766</td>
<td>1.146</td>
</tr>
<tr>
<td>PI7__Helmet_rates_driver</td>
<td>0.784</td>
<td>1.150</td>
</tr>
<tr>
<td>PI8__SI_ambulance</td>
<td>0.667</td>
<td>1.127</td>
</tr>
<tr>
<td>PI9__HospitalBeds</td>
<td>0.607</td>
<td>1.116</td>
</tr>
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</table>
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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>B</th>
<th>Std. Error</th>
<th>95% Confidence Interval</th>
<th>Wald Chi-Square</th>
<th>df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>1.694</td>
<td>0.2737</td>
<td>1.157, 2.230</td>
<td>38.291</td>
<td>1</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Comp_ME</td>
<td>-0.135</td>
<td>0.0646</td>
<td>-0.261, -0.008</td>
<td>4.358</td>
<td>1</td>
<td>.037</td>
</tr>
<tr>
<td>Comp_TE</td>
<td>-0.007</td>
<td>0.0028</td>
<td>-0.013, -0.002</td>
<td>7.230</td>
<td>1</td>
<td>.007</td>
</tr>
<tr>
<td>Comp_PI</td>
<td>-0.007</td>
<td>0.0030</td>
<td>-0.013, -0.001</td>
<td>5.652</td>
<td>1</td>
<td>.017</td>
</tr>
<tr>
<td>Comp_EM</td>
<td>0.007</td>
<td>0.0051</td>
<td>-0.003, 0.017</td>
<td>2.009</td>
<td>1</td>
<td>.156</td>
</tr>
<tr>
<td>LN_Festim_2010</td>
<td>0.769</td>
<td>0.0462</td>
<td>0.678, 0.859</td>
<td>276.322</td>
<td>1</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>LNGNI_2013</td>
<td>-0.091</td>
<td>0.0314</td>
<td>-0.153, -0.030</td>
<td>8.402</td>
<td>1</td>
<td>.004</td>
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<tr>
<td>(Scale)</td>
<td>0.038</td>
<td></td>
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<tr>
<td>Likelihood Ratio</td>
<td>1379.00</td>
<td></td>
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<tr>
<td>df</td>
<td>6</td>
<td></td>
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<tr>
<td>p-value</td>
<td>&lt;.001</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
In order to **assess** the model, a comparison of the observed and the predicted values was carried out:

- The mean absolute prediction error is estimated at **2.7 fatalities per population**, whereas the mean percentage prediction error is estimated at **15%** of the observed value.
- The model is of **very satisfactory performance** as regards the good performing countries (low fatality rate) and of **quite satisfactory performance** as regards the medium performing countries.
Statistical Model Validation

In order to validate the model, a cross-validation was carried out with two subsets:

- **80%** of the sample was used to develop (fit) the model, and then the model was implemented to predict the fatality rate for 2013 of the **20%** of the sample not used.
- **70%** of the sample was used to develop (fit) the model, and then the model was implemented to predict the fatality rate for 2013 of the **30%** of the sample not used.

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Examples of statistical model application:

• one low performance country

• two middle performance countries

• one high performance country
SafeFITS Model Demonstration

The overall model implementation includes 3 distinct steps:

• Step 1 – Countries Benchmark

• Step 2 – Forecast with no new interventions

• Step 3 – Forecast with interventions
Step 1: Benchmark

User input:
The user has the option to select a country, the category of indicators to be displayed and benchmark type.

Analysis:
The outputs are based only on the database and no statistical modeling implementation is taking place.

Benchmarking results:
• Reactive diagrams presenting a benchmark of the base year situation for a selected category
• Benchmarking takes place on a global and regional scale
Step 2: Forecast with no new interventions

User input:
The user selects the intervention year and the benchmark type

Analysis:
The SafeFITS model is implemented for the year of reference on the basis of GNI and demographic indicators projection

Forecasting results:
The trend for the variable fatalities per population through the years (2013-2031), alongside with the confidence intervals

Benchmarking results:
• Overall ranking
• Regional ranking

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Step 3: Forecast with interventions

**User input:**
The user selects the intervention year and then 3 different sets of interventions

**Analysis:**
The SafeFITS model is implemented for the forecasting year on the basis of the intervention set selected

**Forecasting results:**
The trend for the variable fatalities per population through the years (2013-2031), on which the forecast for the intervention year is also identifiable.

**Benchmarking results:**
- Overall ranking
- Regional ranking

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Model limitations and future improvements

• The SafeFITS model was developed on the basis of the most recent and good quality data available internationally, and by means of rigorous statistical methods. However, data and analysis methods always have some limitations.

• Data are primarily directed at vehicle occupants and thus, effects on road safety outcomes of VRUs may not be captured.

• The effects of interventions may not reflect the unique contribution of each separate intervention. It is strongly recommended to test combinations of “similar” interventions (e.g. several vehicle standards, several types of enforcement or safety equipment use rates etc.)

• The factor analysis procedure does not assume or indicate that a direct causal relationship exists.

• The calibration with new data will be the ultimate way to fully assess the performance of the model.
Optimal use of the model

- **Optimal use** depends on:
  - Good knowledge of national data and their limitations
  - Good understanding of the SafeFITS model purpose and limitations

- Start from **“no new intervention” scenario** - reference case
- **Mind the data**: some are estimated numbers (WHO), some were statistically imputed
- **Uncertainty of forecasts**: confidence intervals are provided
- Carefully select the groups of interventions to be tested jointly - what else would be likely to change, together with a given change?
- **Countries with very particular characteristics** (very low GDP, very high share of motorcycle or cyclist fatalities) may exhibit larger inaccuracies
- Model forecasts of **countries with already very good road safety performance** may be conservative

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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.

• A user-friendly and flexible tool that allows meaningful, structured and fully explanatory analysis.

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Next Steps

• **Pilot operation phase**: Model tested by selected users and revised at the end of the first year.

• **Annual or bi-annual revisions** of all SafeFITS components (knowledge base, database and statistical models).

• Monitor **global developments in data availability and accuracy**, so that the SafeFITS database is updated regularly and continuously.

• SafeFITS tool will be further enhanced by continuously taking into account **users' feedback**.
SafeFITS

A Global Road Safety Model
For Future Inland Transport Systems

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