



7° Πανελλήνιο Συνέδριο Οδικής Ασφάλειας Λάρισα, 11-12 Οκτωβρίου 2018

SafeFITS – A Global Road Safety Model

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Objective

- 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.
- Based on work carried out in 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







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

			PILLARS								
		1 Road Safety Management	2. Road Infrastructure	3. Vehicle	4. User	5. Post-Crash Services					
	1. Economy & Management	Economic Deve- lopments, Strategy & Targets, Regu- latory framework (compliance with UN regulations)	Existence of motorways, of non-paved roads, of road tunnels, Existence of guidelines (for design, RSA etc.), Legislation on speeding	Number of regi- stered vehicles, Vehicle age, Technical inspe- ction legislation (maintenance, roadworthiness, overweight, ADR)	Requirements & 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 & exposure	Transport Modal Split (road/rail, passenger/finsight, 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 & gender						
LAYERS	3 Road Safety Measures	Assessment of measures, Data collection & analysis, International comparisons, Vehicle taxation, Road pricing	Treatment of High Risk Sites, Road Safety Audits, Tunnel Road Safety Manage- ment, Improve- ment of signage, Installation of road restraint systems, Lighting, Speed limits in urban areas Traffic Caliming	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 & organisation of trauma centers					
	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 & drive infringe- ments, 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 samaritanians per population					
	5. Fatalities & Injuries	Fatalities / injuries per million inhabitants, fatalities / injuries per million passenger cars, fatalities / injuries per 10 billion passenger-km	Fatalities / injuries in motowwys, 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 fotal fatalities, drink-driving related fatalities	Death rate, Hospitalization in IC Unit, Total length of hospitalization					



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





Database Overview

- 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





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

 $\begin{array}{l} Log(Fatalities \ per \ Population)_{ti} = A_i + Log(Fatalities \ per \\ Population)_{(t-\tau)} + B_i \ ^* \ ^GDP_{ti} \ + K_i \ ^* \ ^[Economy \ \& \ Management]_{ti} \ + Li \\ ^* \ ^[Transport \ demand \ \& \ Exposure]_{ti} \ + M_i \ ^* \ ^[Road \ Safety \ Measures]_{ti} \\ + \ N_i \ ^* \ ^[RSPI]_{ti} \ + \ \varepsilon_i \end{array}$

Where [Composite Variable]



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

	Comp	ponent
	Loadings	Score coefficients
EM1_Popdensity	,091	,029
EM2_lt15yo	-,778	-,250
EM3_gt65yo	,714	,229
EM4_UrbanPop	,709	,228
EM5_LeadAgency	,284	,091
EM6_LeadAgencyFunded	,226	,073
EM7_NationalStrategy	,697	,224
EM8_NationalStrategyFunded	,626	,201
EM9_FatalityTargets	,692	,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 loadings and coefficients on the estimated factor (composite variable) on Transport Demand and Exposure

	Comp	onent
	Loadings	Score coefficients
TE1_RoadNetworkDensity	,497	,161
TE2_Motorways	,460	,149
TE3_PavedRoads	,734	,238
TE4_VehiclesPerPop	,839	,272
TE5_PassCars	,825	,267
TE6_VansLorries	-,132	-,043
TE7_PTW	-,681	-,221
TE8_Vehkm_Total	,269	,087
TE9_RailRoad	,136	,044
TE10_PassengerFreight	-,360	-,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)

 $(\underline{\mathbf{X}})$

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Indi	cator loadings and coefficients on the e	estimated factor (composite var	riable) on Measures
		Component	
		Loadings	Score coefficients
	ME1_RSA	,245	,025
	ME2_ADR	,681	,069
	ME3_SpeedLaw	,229	,023
	ME4_SpeedLimits_urban	,443	,045
	ME5_SpeedLimits_rural	,200	,020
	ME6_SpeedLimits_motorways	,634	,064
	ME7_VehStand_seatbelts	,877	,088
	ME8_VehStand_SeatbeltAnchorages	,906	,091
	ME9_VehStand_FrontImpact	,908	,092
	ME10_VehStand_SideImpact	,904	,091
	ME11_VehStand_ESC	,891	,090
	ME12_VehStand_PedProtection	,862	,087
	ME13_VehStand_ChildSeats	,896	,090
ng)	ME14_DrinkDrivingLaw	,126	,013
<i>,</i>	ME15_BAClimits	,670	,068
	ME16_BAClimits_young	,670	,068
	ME17_BAClimits_commercial	,645	,065
	ME18_SeatBeltLaw	,297	,030
	ME19_SeatBeltLaw_all	,570	,057
	ME20_ChildRestraintLaw	,628	,063
۱.	ME21_HelmetLaw	,236	,024
) +	ME22_HelmetFastened	,334	,034
	ME23_HelmetStand	,379	,038
	ME24_MobileLaw	,375	,038
	ME25_MobileLaw_handheld	,350	,035
	ME26_MobileLaw_handsfree	-,295	-,030
	 ME27_PenaltyPointSyst	,378	,038
	ME28_EmergTrain_doctors	,178	,018
	ME29_EmergTrain_nurses	,399	,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 loadings and coefficients on the estimated factor (composite variable) on SPIs

	Compc	pnent
	Loadings	Score coefficients
PI1_SeatBeltLaw_enf	,756	,144
PI2_DrinkDrivingLaw_enf	,812	,155
PI3_SpeedLaw_enf	,795	,152
PI4_HelmetLaw_enf	,837	,160
PI5_SeatBelt_rates_front	,811	,155
PI6_SeatBelt_rates_rear	,766	,146
PI7_Helmet_rates_driver	,784	,150
PI8_SI_ambulance	,667	,127
PI9_HospitalBeds	,607	,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

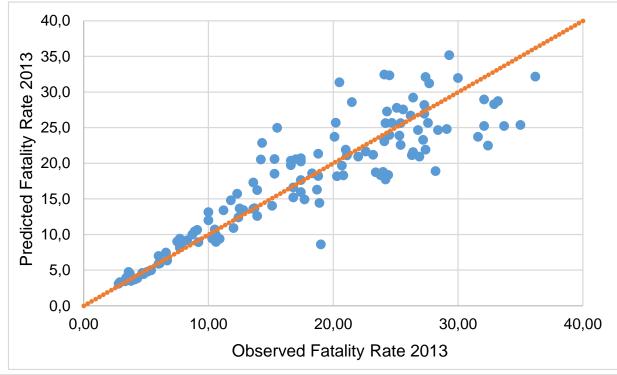
			95% Confid	ence Interval	Нурс	othesis Tes	t
Parameter	В	Std. Error	Lower	Upper	Wald Chi- Square	df	p-value
(Intercept)	1,694	,2737	1,157	2,230	38,291	1	<,001
Comp_ME	-,135	,0646	-,261	-,008	4,358	1	,037
Comp_TE	-,007	,0028	-,013	-,002	7,230	1	,007
Comp_PI	-,007	,0030	-,013	-,001	5,652	1	,017
Comp_EM	,007	,0051	-,003	,017	2,009	1	,156
LNFestim_2010	,769	,0462	,678	,859	276,322	1	<,001
LNGNI_2013	-,091	,0314	-,153	-,030	8,402	1	,004
(Scale)	,038						
Likelihood Ratio	1379,00						
df	6						
p-value	<,001						



Statistical Model Assessment

In order to **assess** the model, a comparison of the observed and the predicted values was carried out:

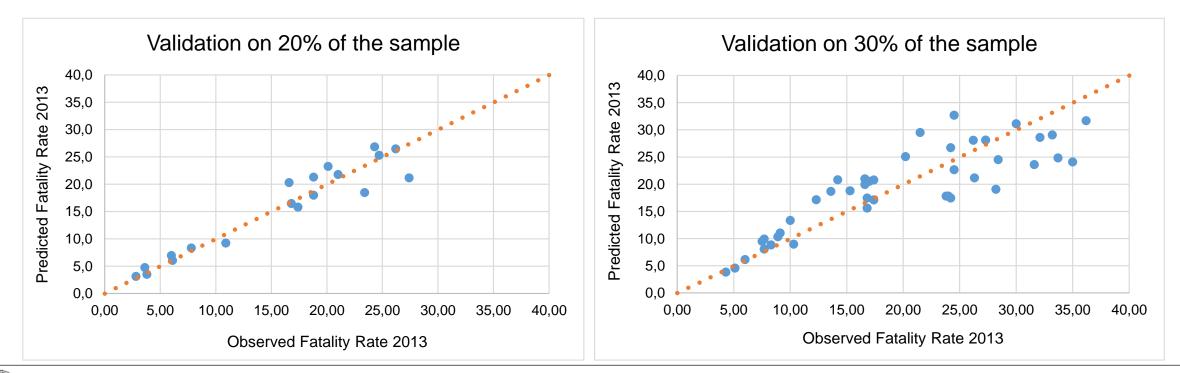
- The mean absolute prediction error is estimated at 2.7 fatalities per population, whereas the mean percentage prediction error is estimated at 15% of the observed value.
- The model is of very satisfactory performance as regards the good performing countries (low fatality rate) and of quite satisfactory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

erventions Year	Poiscest Report General	Benchmark Type								
ervensona rear	5. • 3	Goos		Seeder Durm Attants			Reset to Deta	ut		
		-9008		Alana						
Intervention Group 1	Invervention Group 2	Invervention Group 3			Variable	Base Case	Intervention Set 1	Intervention Set 2	Intervention Set 3	
Economy and	Economy and	Economy and			Faultes	17.85	15.25	16.57	16.72	
Management	Management	Management			Ofference from Base Case		-6.01	-0.47	-0.33	
National Road Safety Strategy	National Road Safety Strategy	National Road Satety Strategy			Percentile Ofference	<u>*1</u>	417	271	4.54	
38	10	Yes •	25-							
Funded Strategy	Funded Strategy	Funded Strategy								
Partially +	Pathing - +	Partaly +						-		
Faulty Reduction Target	Fatality Reduction Target	Fatality Reduction Target	Fatalities							
	10. 1	Vez +	-				-	-		
38 ·	192.	104 *	i i i i i i i i i i i i i i i i i i i							
Transport Demand	Transport Demand And Exposure	Transport Demand And Exposure	Lat 15	~		_				
Transport Demand And Exposure	Transport Demand	Transport Demand	15	~	-	-	_			
Ten Transport Demand And Exposure Road Network Density 0.03	Transport Demand And Exposure	Transport Demand And Exposure	15 10	~				_		
Transport Demand And Exposure Road Network Density	Transport Demand And Exposure Road Network Density	Transport Demand And Exposure Road Network Density	15	2015		2020	Vers	210		2030
Transport Demand And Exposure Road Network Density 0.03	Transport Demand And Exposure Road Network Density 0.05	Transport Demand And Exposure Road Network Density 6:57	15	2)15.	Internentions #		Year			2930
Transport Demand And Exposure Road Network Density 0.03 Motorways (%)	Transport Demand And Exposure Road Network Density 8:03 Mattanways (%)	Transport Defnand And Exposure Road Network Density 612 Motorways (%)	15	2015 alities - Current 1	and a stand of the stand		Year			2030

Access the SafeFITS model at: <u>https://unecetrans.shinyapps.io/safefits/</u>



Analysis

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

Forecasting results

- 11,03 fatalities per 100.000 population are forecasted for 2030
- An increase by 43% is estimated compared to 2013

Into	UNI oductor Benchmark	Fore	Sa		S							Haj
Interve	entions Year		Benchman	fk Type		Selected Country	¥ Show					
2022	i	•	Global		٠	Serbia	Confidence intervels	Reset to I	Default			
Inte	ervention Group 1	In	vervention (Group 2	Inverven	tion Group 3	Variable (Ye Fatalities per)	en ressentes	Base Case	Intervention Set 1 10.69	Intervention Set 2 10.69	Intervention Set 3 10.69
	onomy and anagement		conomy and anagement		Economy Manager		110000000000000000000000000000000000000	n Base Case	11000	0.00	0.00	8.00
Nat	bonal Road Safety alegy	Na	dional Road S rategy		National R Strategy		Percentile Diff	ference	<u>ا</u>	0.00	0.00	0.00
21	No T		No	۲	No	T	Fatalities	per Pop	ulation - (Comparative	Diagram	
Fur	nded Strategy	Fu	nded Strategy	¢.	Funded St	rategy	st 15					
3	No T		No	*	No	7	abits					
Fab	ality Reduction Target	Fa	tality Reductio	on Target	Fatality Re	duction Target	fi 10-		1			
0	No Y		No	۲	No		000	-	-		1	
	ansport Demand Id Exposure		ansport Dei nd Exposure		Transpor And Exp	t Demand osure	Fatality / 100,000 inhabitants					
Roa	ad Network Density	Ro	ad Network D	ensity	Road Netw	rork Density	ile i					
D	15	1	15		0,5		0 SafeFITS					
Mot	torways (%)	M	torways (%)		Motorways	s (%)		015		2020 Year	2025	2030
1	,35		1,36		1,36			- Dave Co	an Til Inter	tion Set 1 📥 Interve		and and the



1st set of interventions

- increase of seat-belt law enforcement from 6 to 9
- increase of helmet law enforcement from 8 to 9
- increase of the seat-belt use rates in front seats from 65,8% to 80%
- in the rear seats from 3,1% to 25%
- increase of the helmet use rates from 60 to 78%

Forecasting Results

- The fatality rate for 2025 is estimated at 10,06
- 5,9% lower than the respectively estimated fatality rate in the base case scenario

9	Introduction Benchmark	Forect	est Report Genera	iton							Help (
	Interventions Year	•	Benchmark Type Globel		Selected Country Selbla	Show Confidence Intervals	Reset to (Default			
	Intervention Group 1	Inco	ervention Group 2	Inventor	ntion Group 3	Variabile (Yea	r = 2025 }	Base Case	Intervention Set 1	Intervention Set 2	Intervention Set 3
	Economy and		ervenuon Group 2 pnomy and	Econom	Sector and the sec	Fatalities per P	opulation	10.69	10.06	10.69	10.69
	Management		nagement	Manage		Difference from	Base Case	1	-0.63	0.00	0.00
	National Road Safety Strategy		ional Road Safety degy	National Strategy	Road Safety	Percentile Diffe		-	-5.94	0.00	0.00
	No T	N	0	10	÷		per Popi	ulation - (Comparative	Diagram	
	Funded Strategy	Fun	ded Strategy	Funded S	itrategy	15-					
	No *	N	0	No	•	abite			-	-	and the second
	Fatality Reduction Target	Fata	aity Reduction Target	Fatality R	eduction Target	토 ₁₀ .		1			
	30 *	N	io i	r No	•	000	-	-			_
	Transport Demand		nsport Demand d Exposure	Transpo And Exp	ort Demand posure	Fatality / 100,000 inhabitants					
ty	And Exposure Road Network Density		d Network Density	Road Net	work Density	alt					
ty	And Exposure		d Network Density	Road Net	work Density	Fatalit					
ty	And Exposure Road Network Density	Roa	d Network Density			0 © SafeFITS	Ú15		2020 Year	2025	2030



2nd set of interventions

- the implementation of a national road safety strategy
- increase of the percentage of motorways from 1,36% to 1,9%
- increase of the percentage of paved roads from 66,19% to 85%
- introduction of the ADR law

Forecasting Results

- The fatality rate for 2025 is estimated at 9,66
- 9,6% lower than the respectively estimated fatality rate in the base case scenario

Introduction Benchmark	Forecast Report Generation	Ň							
Interventions Year	Benchmark Type		Selected Country	¥ Show					
2022	• Giobal	3 . •0	Seitiis	Confidence Intervals	Reset to D	Detault			
Intervention Group 1	Invervention Group 2	Invenient	ion Group 3	Variable (Yea	r = 2025)	Base Case	Intervention Set 1	Intervention Set 2	Intervention Set
Economy and	Economy and	Economy	and the second secon	Fatalities per P	opulation	10.69	10.06	8.76	10)
Management	Management	Manager		Difference from	270102000	22	-0.63	-0.94	D.
National Road Safety Strategy	National Road Safety Strategy	National Ro Strategy	ad Safety	Percentile Diffe		ulation . (-5.94 Comparative I	-875 Diagram	0
No V	Yes 🔻	No		i alanues p			Joiniparative i	Jiayiaili	
Funded Strategy	Funded Strategy	Funded Str	ategy	5 15·					
No Y	No *	No		abit					
Fatality Reduction Target	Fatality Reduction Target	Fatality Rec	Juction Target	년 10-				-	
No Y	Na 🔻	No	•	000'	2				
Transport Demand And Exposure	Transport Demand And Exposure	Transport And Expo		Fatality / 100,000 inhabitants					
Road Network Density	Road Network Density	Road Netwo	ork Density	alit					
0,5	0.5	0,5		E Coorerro					
Motorways (%)	Motorways (%)	Motorways	(%)	⁰ [°] © SafeFITS 20	15		2020	2025	20
(herees and here and		Therese and the second	(%)				Year	2020	
1,36	1,9	1,36				-		ntion Set 2 💽 Interv	



3rd set of interventions

- the introduction in the national legislation 4 out of 7 vehicle standards suggested by the UN:
 - seat-belts
 - seat-belt anchorages
 - frontal impact and
 - pedestrian protection

Forecasting Results

- The fatality rate for 2025 is estimated at 9,29
- 13,1% lower than the respectively estimated fatality rate in the base case scenario

erventions Year 022 Intervention Group 1	•	Benchmark Type Globel		Selected Country	¥ Show						
Intervention Group 1		Global	٠								
and the second				Serbia	Confidence Intervals	Reset to 1	Default				
and the second					Variable (Ye	er = 2025)	Base Case	Intervention Set 1	Intervention Set 2	Intervention	Set 3
		ervention Group 2		tion Group 3	Fatalities per l	20-160594.1	10.69	10.05	9.76	machannan	9.29
Economy and Management		nomy and nagement	Economy Manager		Difference from	n Base Case	12	-0.63	-0.94		-1.40
National Road Safety Strategy		onal Road Safety	National R Strategy	oad Safety	Percentile Diff		¥2	-5.94	-8.75	() (<u>)</u>	13.06
No *		es 1	Yes	۲		per Popi	ulation - C	Comparative I	Diagram		
Funded Strategy	Fund	ied Strategy	Funded St	rategy	st 15						_
No 7	N	2 *	No	•	abit				-		
Fatality Reduction Target	Fata	lity Reduction Target	Fatality Re	duction Target	E 10-						
No *	N	• •	No	•	000'	ar					
Transport Demand And Exposure		nsport Demand Exposure	Transpor And Exp	t Demand osure	Fatality / 100,000 inhabitants						
Road Network Density	Roa	d Network Density	Road Netw	ork Density	alit						
0.5	0,5	ĝ.	0,5		Fat						
Motorways (%)	Meter	orways (%)	Motorways	1953	⁰ © SafeFITS	015	3	2020 Year	2025		2030



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.





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.









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