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International Comparisons of Safety Performance Functions

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Accident Prediction Basics

Accident Prediction Model (APM) = a full model that allows an evaluation of the predicted number of crashes in a given condition

Safety performance function (full APM)

SPF (base APM) x CMFs x C

- **Safety Performance Functions** (SPFs) are developed for specific facility types and "base conditions".
- **Crash Modification Factors** (CMFs) account for differences between the base conditions and local conditions of the considered site.
- **Calibration Factor** (C) accounts for differences between the road network for which the models were developed and the one for which the predictive method is applied.

SPFs in HSM Predictive Method

Safety Performance Functions (SPFs) are typically a function of only a few variables, primarily average annual daily traffic (AADT) volumes and segment length.

Example SPFs in HSM:

- For 2-lane rural roads:

$$N_{spf} = (AADT) \times (L) \times (365) \times (10^{-6}) \times e^{(-0.312)}$$

- For freeways:

$$N_{spf} = (0.001 \times AADT)^{b} \times (L) \times e^{a}$$

where a and b are a function of the type of crash (single vehicle or multi vehicle) and the crash severity (fatal+injury of property damage only crashes).

Objectives of Presentation

- The presentation focuses on the estimation of SPFs for freeways and 2-lane roads in Europe:
  - Germany,
  - Italy,
  - United Kingdom,
  - Greece,
  - The Netherlands.

  and their comparison to HSM models.
- Results obtained from PRACT Research Project.
- Recommendations on SPF transferability are provided.

pract

www.practproject.eu
www.pract-repository.eu

The PRACT Project

Predicting road accidents - A transferable methodology across Europe
(http://www.practproject.eu/)

Apr 2014 – May 2016

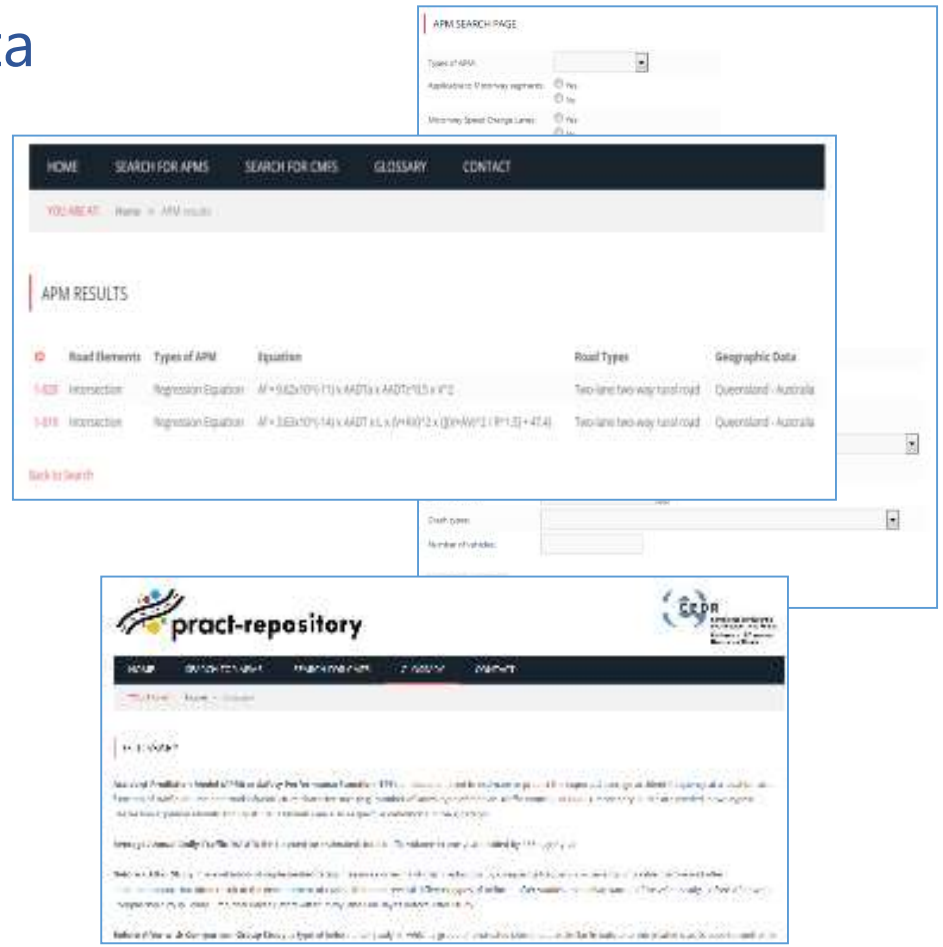
funded by the National Road Authorities of Germany, Ireland, UK and the Netherlands

within the Transnational Research Programme on Safety of the European Conference of Road Directors (**CEDR**)

PRACT Results

- 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.
- A procedure to **check the transferability of CMFs**, incorporated in the tool.
- A **CMF and APM Repository** has been developed and is freely available on line (www.pract-repository.eu)

www.pract-repository.eu



Data Collection for SPF development

- Extensive study on European rural freeways and two-lane two-way secondary roads.
- Data collection:
  - observed crash data,
  - geometric design features,
  - traffic control features,
  - site characteristics for all sites in the study networks.
- Division of network into homogenous roadway segments and assigning of crashes to the individual sites

Data Collection - Freeways

Observation Period: 2009-2013 (5 years)
Target Accident Group: Single- and multiple-vehicle crashes
Accident Severity: Fatal-injury crashes

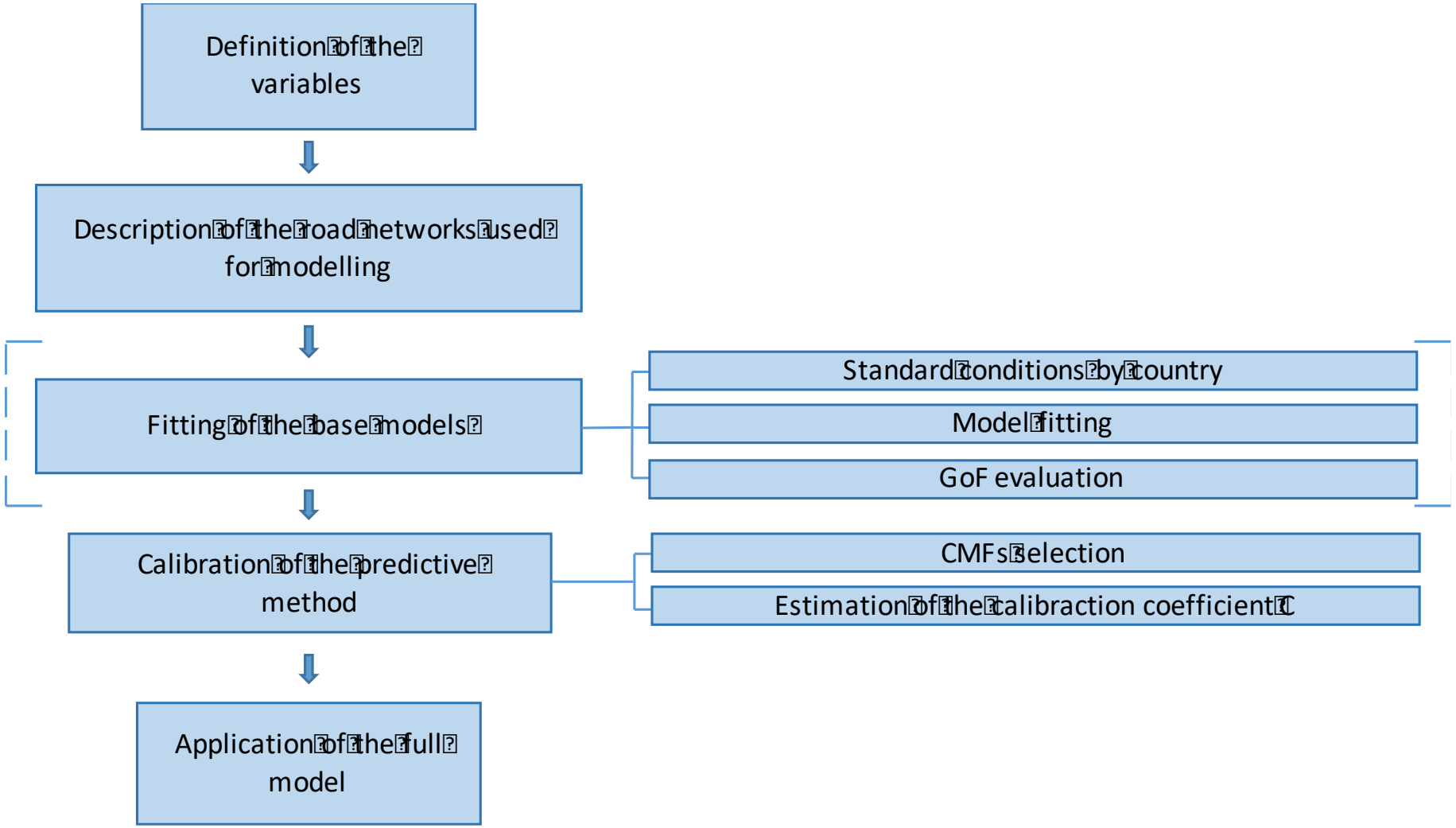
- **Germany (Brandenburg)**
  - Total Length: 1,093 Km
  - Total Accident Number: 2,028 accidents
  - Number of Segments: 1,863 segments
- **Greece**
  - Total Length: 84 Km
  - Total Accident Number: 52 accidents
  - Number of Segments: 95 segments
- **Italy**
  - Total Length: 884 Km
  - Total Accident Number: 3,021 accidents
  - Number of Segments: 884 segments
- **The Netherlands**
  - Total Length: 5,204 Km
  - Total Accident Number: 1,875 accidents (3 years)
  - Number of Segments: 6,966 segments
- **United Kingdom**
  - Total Length: 112 Km
  - Total Accident Number: 486 accidents
  - Number of Segments: 86 segments

Data Collection - 2 Lane Roads

Observation Period: 2009-2013 (5 years)
Target Accident Group: Single- and multiple-vehicle crashes
Accident Severity: Fatal-injury crashes

- Germany (Brandenburg)
  - Total Length: 3,965Km
  - Total Accident Number: 4,714 accidents
  - Number of Segments: 10,171 segments
- Italy (Arezzo province)
  - Total Length: 938 Km
  - Total Accident Number: 402 accidents
  - Number of Segments: 8,379 segments
- United Kingdom
  - Total Length: 394Km
  - Total Accident Number: 394 accidents
  - Number of Segments: 111 segments

SPF Modelling Methodology



Freeway Segments (1/4)

- Dependent variables:
  - number of single-vehicle fatal-and-injury crashes per kilometre per year,
  - number of multiple-vehicle fatal-and-injury crashes per kilometre per year,

  on one direction of travel (differently from HSM)

- Variables included in analysis:

  Segment length, Number of lanes, Horizontal curve radius and length, Lane width, Inside shoulder width, Portion of segment with barrier in the median, Median width, High volume, Portion of segment with barrier in the outside edge, Presence of a rumble strip in the outside shoulder, Outside clearance, Presence of a high friction wearing course, Presence of an average speed enforcement (section control).

Freeway Segments (2/4)

Base Conditions:

- Horizontal curve: not present
- Lane width: 3.65m
- Shoulder width (paved): 1.80m
- Median width: 18.3m
- Median barrier: not present
- Clear zone width: 9.1m
- Volume: < 1,000 veh/h/lane
- Rumble strip: not present
- Friction wearing course: not present
- Automated speed enforcement: not present

<u>For multiple-vehicle only:</u>

- Distance to upstream entrance ramps: > 0.8Km
- Distance to downstream exit ramps: > 0.8Km
- Type B weaving section: not present

Freeway Segments (3/4)

- Fitting of models according to HSM Appendix B, assuming a Generalized Linear Model (GLM) Approach and a negative-binomial distribution.

- For Greece the number of sections with “base” conditions was not sufficient to develop a jurisdiction-specific model. The German model was calibrated using local accident data.

Freeway Segments (4/4)

Freeway full model coefficients

	IT		GE		GR		UK		NE	
	SV	*MV*	*SV*	*MV*	*SV*	*MV*	*SV*	*MV*	*SV*	*MV*
a (2 lanes)	-10.050	-7.215	-7.977	-5.900	Calibration of the German model		-2.946	-3.406	-3.760	-4.919
a (3 or more lanes)	-10.470	-7.394	-8.341	-5.895			-2.792	-2.326	-3.760	-4.919
b	1.955	1.523	1.476	1.173			0.158	0.326	0.208	0.489
c	0.002	0.002	0.002	0.002			0.002	0.002	0.002	0.002
k (inverse dispersion parameter)	0.861	0.771	4.069	1.318			3.646	4.843	1	1
Calibration coefficient C	1.728	1.175	1.577	0.928	0.464	0.189	1.016	0.799	0.391	0.703
χ	1180	711	1195	1280	108	63	485	600	1182	1377
df	882	883	1686	1830	91	94	638	711	907	1028
χ*(0.05,df)	952	953	1783	1930	114	117	698	774	978	1104

Model Form

$$N_{spf} = L \times e^{[a + b \times ln(c \times AADT)]}$$

Two Lane Road Segments (1/4)

- Dependent variable:
  number of single-vehicle and multiple-vehicle fatal-and-injury crashes per kilometre per year, i.e. a single model.

- Variables included in analysis:
  Segment length, AADT, Road width, Horizontal Curvature, Vertical curvature, Grade, Percentage of heavy goods vehicles, Shoulder width and type, Driveway density, Centreline rumble strips, Passing lanes, Two-way left-turn lanes, Roadside design, Lighting, Automated speed enforcement

- Modelling approach: negative binomial distribution

Two Lane Road Segments (2/4)

Base Conditions:

- Horizontal curve: not present
- Vertical curve: not present
- Vertical grade: 0%
- Road width: 4.6m
- Shoulder type: paved
- Roadside hazard rating (RHR): 3
- Driveway density: 3 driveways per Km
- Centerline rumble strip: not present
- Passing lanes: not present
- Two-way left-turn lanes: not present
- Lighting: not present
- Automated speed enforcement: not present
- Percentage of heavy goods vehicles: 0%

Two Lane Road Segments (3/4)

Two-lane two-way rural road full model coefficients

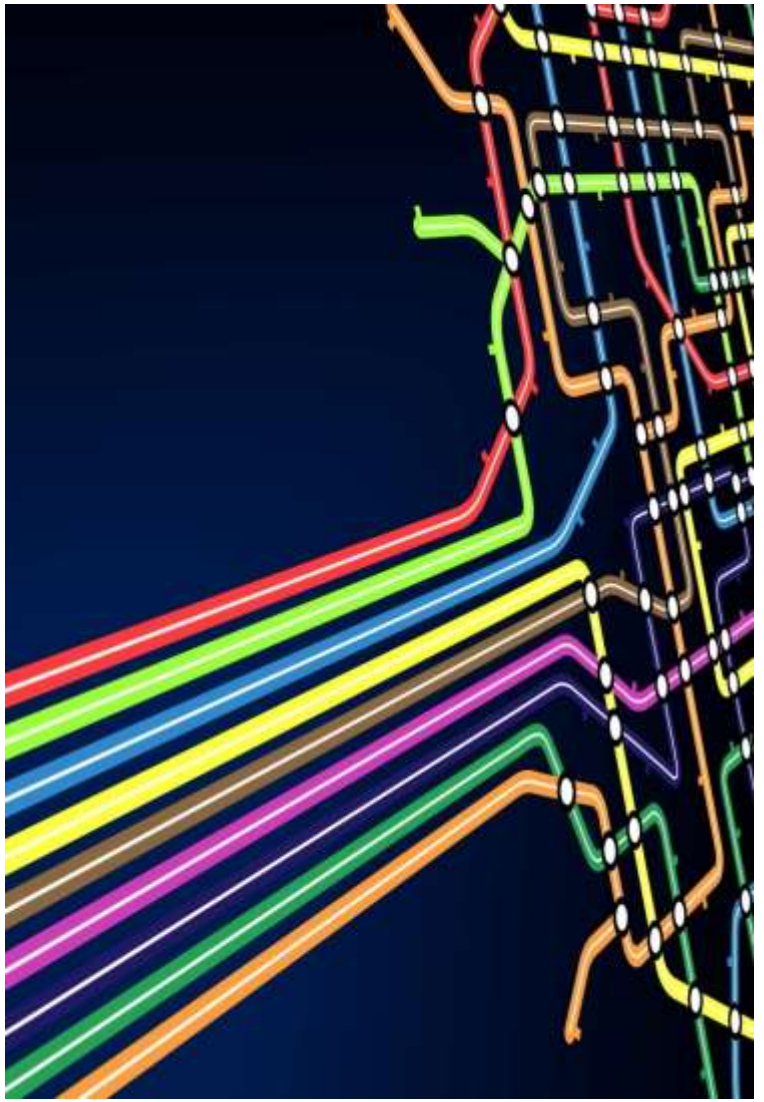
	GE	IT	UK
a	-7.363	Calibration of the German model	Calibration of the German model
b	0.805		
c	1		
k (inverse dispersion parameter)	0.337		
Calibration coefficient C	1.064	0.397	0.559
χ	12284	602	106
df	8763	753	105
χ*(0.05,df)	8982	818	135

Model Form

$$N_{spf} = L \times e^{[a + b \times ln(c \times AADT)]}$$

Discussion on PRACT models

- Full models developed with full data from one country and the base model from another (e.g. Greece for motorways with the base model based on German data) were still significant at 95% level.
- This means that, if sufficient base sections are not available in a specific country to develop country-specific SPFs, **the use of a European model as a base model can still work properly**, provided that the calibration dataset is consistent and without anomalies.

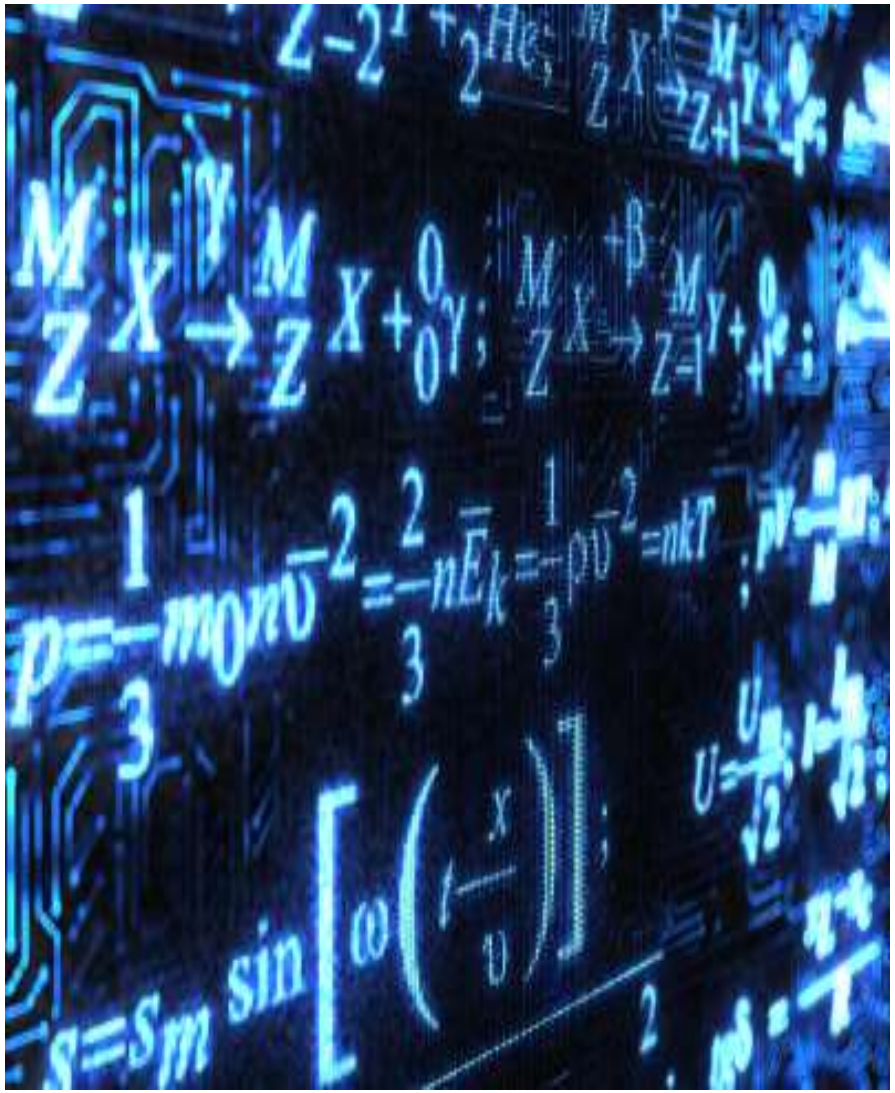


Conclusions

- Decision making for road safety investments is complex by nature.
- The use of SPFs and CMFs is fundamental in identifying the most effective road safety countermeasures.
- This results in a growing demand for accident prediction models in many countries.

Conclusions

- An SPF may or may not be suitable for use in circumstances different from the ones it was developed.
- The use of local accident, geometry and traffic volume data is generally required to calibrate the SPfs.



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