What drives speed on rural roads?

Exploratory study using floating car data

Jiří Ambros
Ondřej Gogolín

TRANSPORT RESEARCH CENTRE

10/05/2016
5th NTSA Annual Scientific Seminar
LiU, Norrköping, Sweden

Introduction: speed

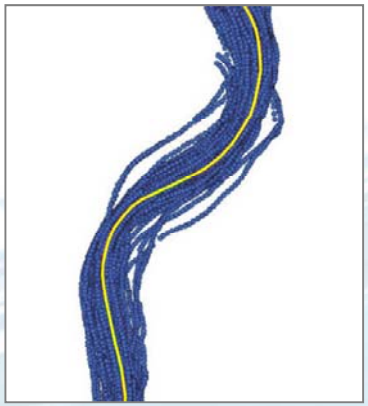
- A key element in road design, linked to safety: speeding is the most frequent cause of road deaths on Czech roads
- What influences speed choice (and can be treated in order to manage speed)?
  - alignment (curvature, radius…)
  - cross section (shoulders, number of lanes…)
  - roadside, signing/marking, vegetation…

Contact Information:
Jiří Ambros, jiri.ambros@cdv.cz
Ondřej Gogolín, ondrej.gogolin@cdv.cz

Introduction: speed measurement

- Traditionally: spot speed
  - roadside traffic counters
  - hand-held speed guns
  - loops, tubes, etc.

- New approach: floating car data
  - GPS positions of vehicle fleet units
  - not limited in time and space



Contact Information:
Jiří Ambros, jiri.ambros@cdv.cz
Ondřej Gogolín, ondrej.gogolin@cdv.cz

Background/motivation

- Ideal (safe) driving = without unexpected changes, reflected in speed diferences
- Speed consistency = $speed_{curve}$ – $speed_{tangent}$
- Negative value = unexpected braking?
- Identified inconsistent curves can be treated (warning signs, speed limits, re-design…)
- Consistent design will lead to consistent speeds… and self-explaining roads

Contact Information:
Jiří Ambros, jiri.ambros@cdv.cz
Ondřej Gogolín, ondrej.gogolin@cdv.cz

The study

- „What drives speed on rural roads?“
- Floating car data ⇒ speeds in tangents and curves
- Road environment data on potential speed choice factors
- The data were used to build multivariate models (factors ⇒ speed ⇒ accidents)

Contact Information:
Jiří Ambros, jiri.ambros@cdv.cz
Ondřej Gogolín, ondrej.gogolin@cdv.cz

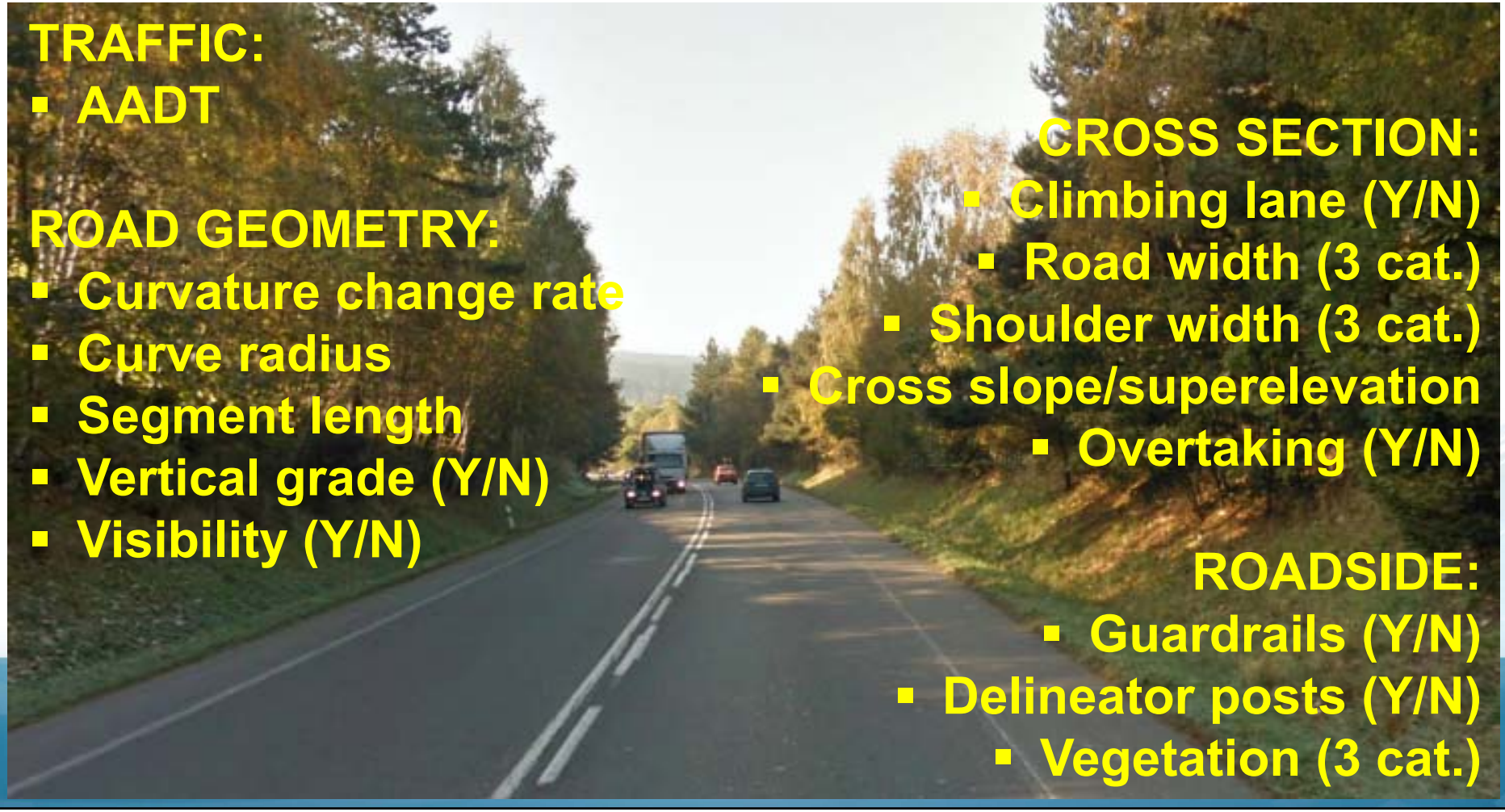
Data: speed

- Floating car data (FCD) from company fleets
- ~1000 vehicles, 8 months, frequency 4 Hz
- Selection of rural sections of national roads
- Segmentation into tangents and curves, discarding segments < 200 m and < 100 vehicles in each direction
- Detection of „uninfluenced“ speeds ⇒ 85th percentile ⇒ weighted average

Contact Information:
Jiří Ambros, jiri.ambros@cdv.cz
Ondřej Gogolín, ondrej.gogolin@cdv.cz

Data: potential risk factors

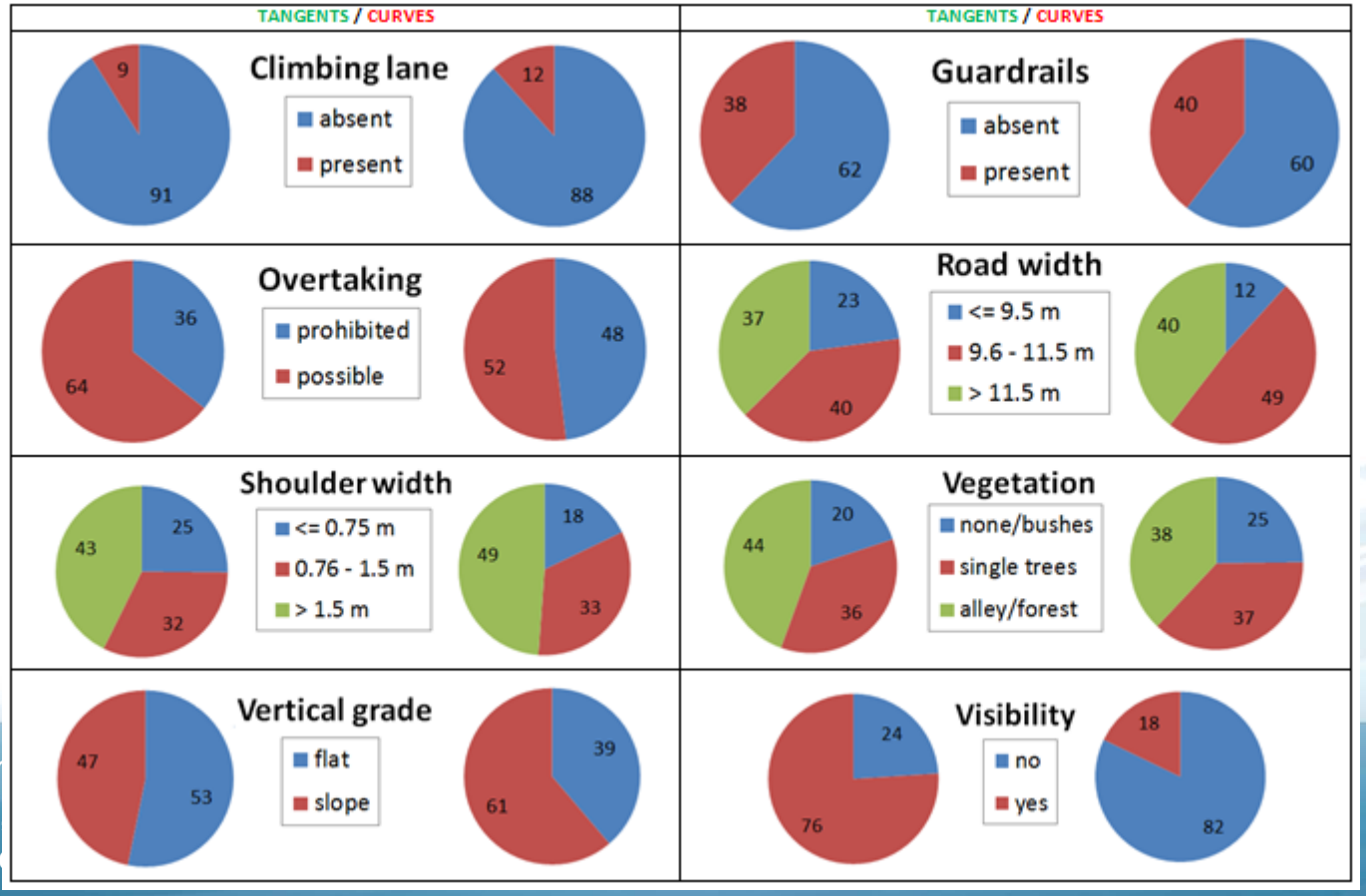
From databases, own measurement, GoogleMaps...



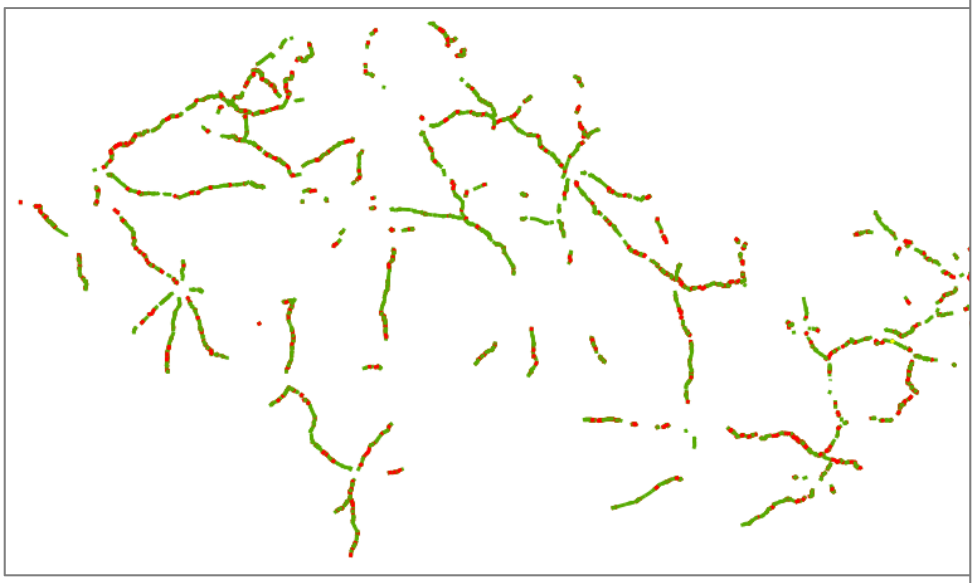
TANGENTS / CURVES

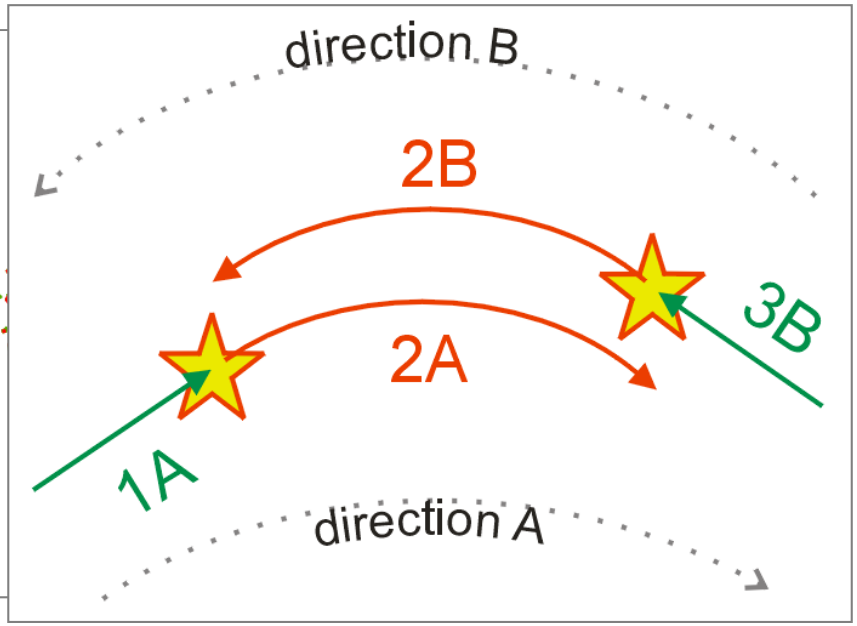
	Min.	Max.	Mean
AADT	2268,5	8846,5	5023,8
length	201,32	3193,22	642,83
CCR	,25	122,78	13,72
cross_slope	-1,7	3,5	1,3

	Min.	Max.	Mean
AADT	2268,5	8846,5	5054,4
length	204,46	1477,32	407,57
CCR	21,03	454,81	75,85
superelevation	,3	4,4	1,5
radius	106,72	2068,64	975,66



Contact Infor
Jiří Ambros
Ondřej Gog



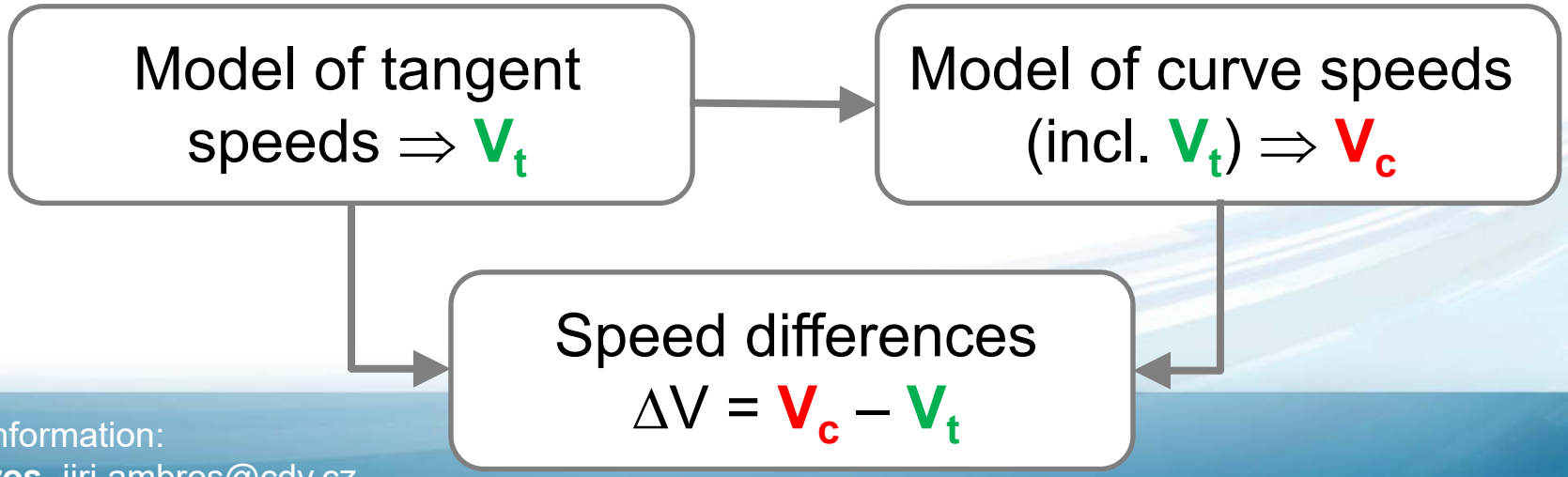


- 509 pairs of curves and preceding tangents
- Discarded urban, divided, multilane… ⇒ sample of ~100 two-lane rural undivided road segments (not a complete network)
- Added geo-located accidents

Contact Information:
Jiří Ambros, jiri.ambros@cdv.cz
Ondřej Gogolín, ondrej.gogolin@cdv.cz

Why models?

- The objective is application for a road agency (all national roads), without additional field measurements… but our sample cover a part only
- From collected data we build prediction models for future network-wide application



Contact Information:
Jiří Ambros, jiri.ambros@cdv.cz
Ondřej Gogolín, ondrej.gogolin@cdv.cz

Modelling

1. Exploratory analysis ⇒ discarding categorical variables with one of categories < 10%
2. Checking correlations between predictors ⇒ not using highly correlated pairs (> 0.5)
3. Multivariate linear regression: backward stepwise, keeping the variables with significance level < 5%

Contact Information:
Jiří Ambros, jiri.ambros@cdv.cz
Ondřej Gogolín, ondrej.gogolin@cdv.cz

Results: tangent speeds

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	92,639	3,393		27,305	,000
	AADT	-,001	,000	-,141	-2,023	,045
	length	,003	,001	,224	3,158	,002
	CCR	-,079	,033	-,173	-2,384	,018
	cross_slope	-1,974	,860	-,163	-2,297	,023
	road_width	1,597	,744	,157	2,147	,033
	overtaking	3,841	1,213	,237	3,165	,002
	visibility	2,901	1,287	,160	2,254	,026
	climbing_lane	10,043	2,190	,366	4,586	,000

n = 117

R^2 = 0.295

- Length, width, overtaking/climbing, visibility *increase* speed
- AADT, curvature, cross slope *reduce* speed
- Strongest effects: overtaking/climbing, length

Contact Information:
Jiří Ambros, jiri.ambros@cdv.cz
Ondřej Gogolín, ondrej.gogolin@cdv.cz

Results: curve speeds

n = 129
R^2 = 0.323

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	32,957	15,567		2,117	,036
	tangent_speed_prediction	,642	,158	,337	4,052	,000
	radius	,003	,001	,206	2,610	,010
	superelevation	-1,835	,910	-,161	-2,017	,046
	climbing_lane	4,272	1,992	,173	2,144	,034

- Preceding tangent speed, curve radius and climbing lanes *increase* speed
- Superelevation *reduces* speed
- Strongest effects: tangent speed, curve radius

Contact Information:
Jiří Ambros, jiri.ambros@cdv.cz
Ondřej Gogolín, ondrej.gogolin@cdv.cz

Validation (1/3)

- Relationship directions are logical
  - Overtaking/climbing and tangent length provide speeding opportunity
  - Increased tangent speeds are transferred into following curves; radius also increases speed
- Further validation: comparison of speed differences to „objective safety“ = empirical Bayes (EB) estimate of accident frequency

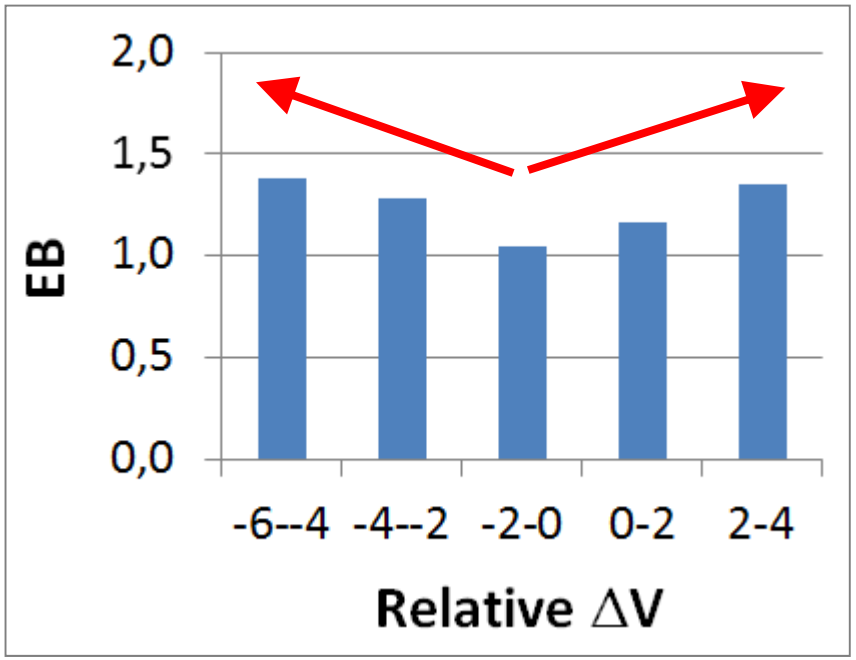
Contact Information:
Jiří Ambros, jiri.ambros@cdv.cz
Ondřej Gogolín, ondrej.gogolin@cdv.cz

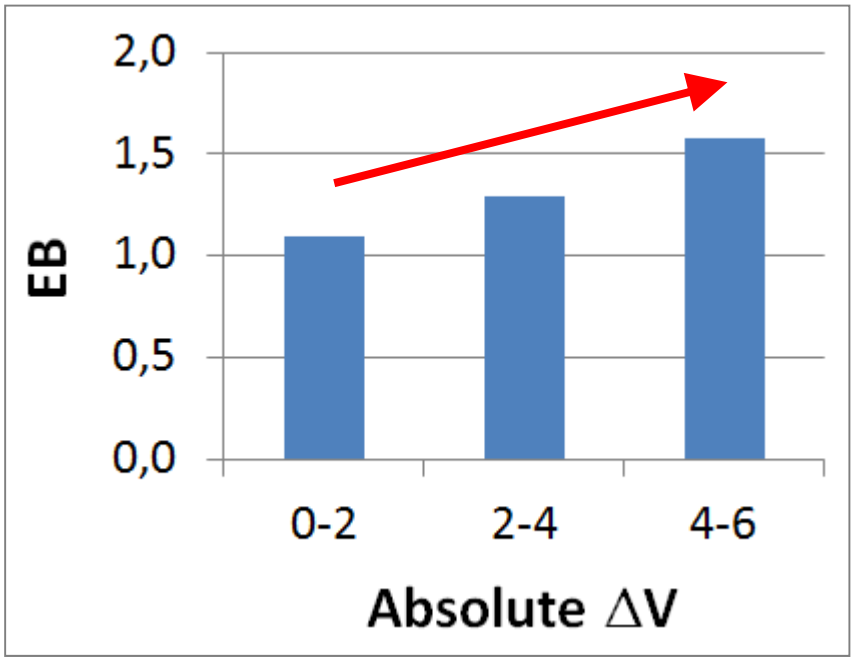
Validation (2/3)

- 6-year frequency of single-vehicle accidents (all severity levels)
- Simple prediction model (with AADT and length) combined with accident history $\Rightarrow$ EB
- Two variants of speed differences
  - relative (braking/accelerating from tangent to curve)
  - absolute (braking/accelerating combined)

Contact Information:
Jiří Ambros, jiri.ambros@cdv.cz
Ondřej Gogolín, ondrej.gogolin@cdv.cz

Validation (3/3)





- Both tendencies (braking/acceleration) increase accident frequency – minimal difference is the safest
- The same confirmed by absolute speed differences

Contact Information:
Jiří Ambros, jiri.ambros@cdv.cz
Ondřej Gogolín, ondrej.gogolin@cdv.cz

Discussion

- Using FCD has some disadvantages
  - company fleets ⇒ biased sample of drivers
  - uncertain selection of free-flowing vehicles
  - low R^2 of regression models (often 0.3 – 0.5)
- Comparison of FCD with traffic counters
  - 7 profiles ⇒ FCD speed ~ 2 km/h higher
- Cross-comparison of methods would be valuable (Aalborg, BRSI, Technion…)

Contact Information:
Jiří Ambros, jiri.ambros@cdv.cz
Ondřej Gogolín, ondrej.gogolin@cdv.cz

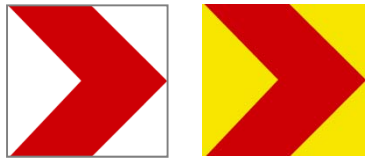
Conclusions (1/2)

- The project objective is to increase self-explaining character of Czech national roads (i.e. decrease speed differences)
- To this end we developed a method of identification of speed inconsistencies
- During analysis of speed data we found strong influence of several variables

Contact Information:
Jiří Ambros, jiri.ambros@cdv.cz
Ondřej Gogolín, ondrej.gogolin@cdv.cz

Conclusions (2/2)

- Overtaking possibility, tangent length, curve radius increase speed ⇒ reconstructions?
- Uniform low-cost treatments may also help
  - chevrons (according to ΔV levels)
  - advisory speed limits
  - road marking



Consistent signing/marking → Consistent (self-explaning) „look“ → Consistent speeds → Improved safety

Contact Information:
Jiří Ambros, jiri.ambros@cdv.cz
Ondřej Gogolín, ondrej.gogolin@cdv.cz

Thank you for your attention!

Jiří Ambros
jiri.ambros@cdv.cz

Ondřej Gogolín
ondrej.gogolin@cdv.cz

CDV – Transport Research Centre
Líšeňská 33a
636 00 Brno
Czech Republic