



Vehicle vibration & health

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Lateral forces are hazardous

The test trailer had a rollover on E6 at Smalåsen, just before the Roadex IV test at 14th – 15th Oct. 2011.



Thanks to Norwegian Haulier's Association (NLF)!
They came up with a replacement truck in 30 min 😊

Outline

Health and safety aspects on ride vibration.

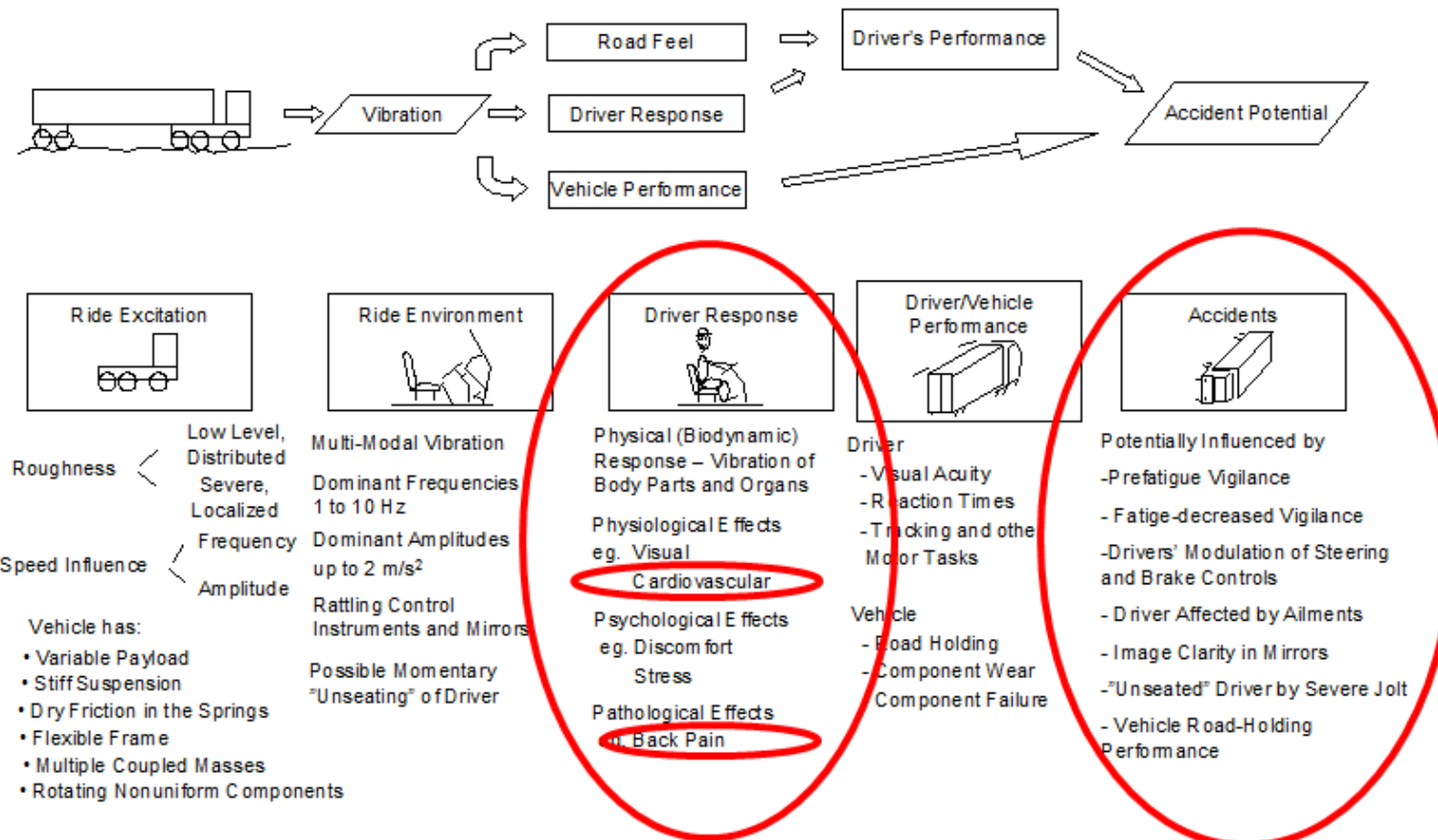
Disproportionate risk on rural low volume roads.

EU legislation on vibration at work.

Results from Roadex demonstration projects in Finland, Scotland, Norway and Sweden:

- Daily exposure $A(8)$ below the EU Exposure Limit = 1.15 m/s^2 , so the trucking is not prohibited.
- However, $A(8)$ exceed EU A.V. = 0.5 m/s^2 .
=> Action (medical survey et c) is mandatory.
- Spinal compression stress S_{ed} exceed 0.5 MPa in many bumpy operations.

Health and safety aspects



[Highway Safety Research Institute]

Recent medical knowledge reviews on health effects from WBV

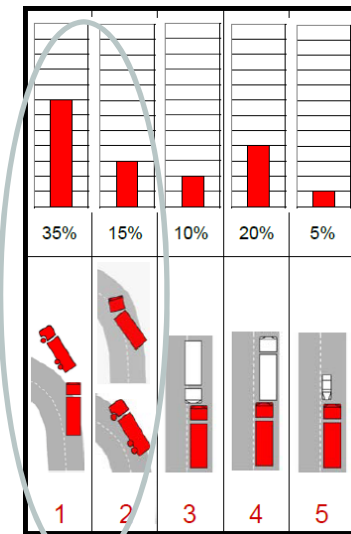
- Low Back Pain: **Confirmed!**
- Sciatica / Herniated discs: **Confirmed!**
- Arthrosis: **More research needed.**
- Miscarriage: **More research needed, Regulation.**
- Male fertility: **Clearly indicated, more research...**
- Viscus/Guts: **No scientific support.**
- Heart: **Several findings, more research needed.**
- Prostate cancer: **Handful studies, more research...**
- Motion sickness: **Confirmed!**
- Performance: **Several findings, more research...**
- Mortality: **Complex findings, more research...**

Heavy vehicles are extra susceptible to lateral forces



The crash type where most truck drivers are injured is the rollover. Higher C.o.G. makes the vehicle prone to improperly banked outer-curves.

Crashes with severely injured truck drivers / passengers



Source: Volvo Trucks crash investigation

Typical number of truck rollovers:

- Norway: 200 per year
- Finland: 200 per year
- Sweden: 650 per year



Right hand traffic



Left hand traffic

Source: Insurance-companies IF & LF

Disproportionate risks

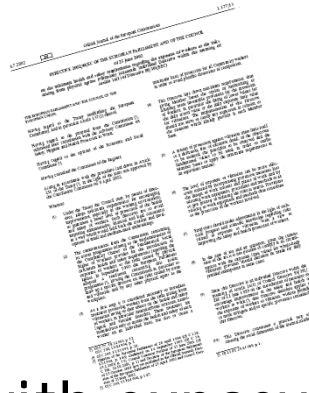
153 % higher risk to die in a vehicle crash in rural Northern Periphery areas, than in Stockholm, Gothenburg & Malmoe.



NP road crashes take 39 % more lives than the worst therapeutically treatable “big killer” Diabetes Mellitus. Of all fatalities at work, 22 % occur in road traffic (SWE). Fatal single crashes have 6:1 ratio between outer-/inner-curves (low volume roads in Sweden).

Truckies 3 times higher prevalence of heart disease.

EU health & safety legislation 2002/44/EC on vibration at work



For truck drivers with exposures exceeding the Action Value $A(8) = 0.5 \text{ m/s}^2$ (or intensive shocks):

- Driver must be sent to special health survey.
- Driver must be informed on all risks.
- Haulier must take technical and organizational actions to MINIMIZE vibration.

Not proper risk assessment, no action taken?

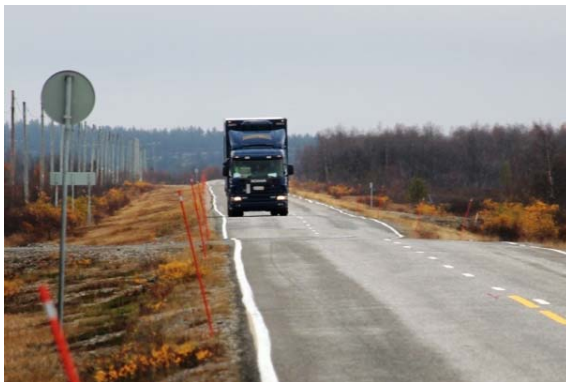
- *Standard fine 100 000 Euro (Sweden).*

Supervision of foreign truck companies?

Roadex IV Demonstration Projects

Reproducing case study from the Beaver Road 331 in Sweden:

1. Measuring truck drivers daily vibration exposure, $A(8)$, comparing to the Action Value 0.5 m/s^2 in 2002/44/EC.
2. Measuring spine compression, S_{ed} , caused by jolts at severe bumps, comparing to 0.5 MPa stress limit in ISO 2631-5.
3. Relating truck roll & lateral buffeting to non-uniform road edge deformation (Rut Bottom Cross Slope Variance).



Photos: J Granlund & M Risberg

Northern Periphery demonstration sites

3700 km of measurements in remote areas of Finland, Norway, Sweden and Scotland.



Measuring truck ride quality



Vibration sampling at 1 kHz per point / axis.

Roll, pitch & yaw at 100 Hz.

Seat vibration filtered as per ISO 2631 standard.

For reference: Road profiling at 16(64) kHz per profile (1 or 17).

Demo projects on truck ride quality



Partner	Location	Transport task
Lapland	Hw 21 Pello – Kilpisjarvi. Raattamaa road. Total 763 km	Grocery/Beer
Highland	Local roads at Fort William B8004, B8005. A82 to Inverness. Total 512 km	Timber haulage
NPRA	E6 Fauske - Trondheim. Total 636 km	Chilled fish
STA	E4, roads 87, 323, 331, 335, 1035 and local roads in Ramsele forest area. 1417 km during spring thaw (very rough). 450 km reproduced in autumn.	Timber haulage

Daily vibration exposure

exceeding EU Action Value $A(8)=0.5 \text{ m/s}^2$



Pello-Kilpisjarvi route, Hw 21: 0.56 m/s^2 (83 km/h)

Raattamaa route, Rd 956/957/21: 0.59 m/s^2 (78 km/h)



Loch Arkaig route, Rd B8004/5: 0.77 m/s^2 (40 km/h)

S Laggan, A82 TPCS on/off: $0.66 / 0.80 \text{ m/s}^2$ (60 km/h)

Inverness route, A82: 0.65 m/s^2 (60 km/h)



Fauske-Trondheim route, E6: 0.47 m/s^2 (65 km/h)

Unload return, white road, frost? $> 0.5 \text{ m/s}^2$ expected



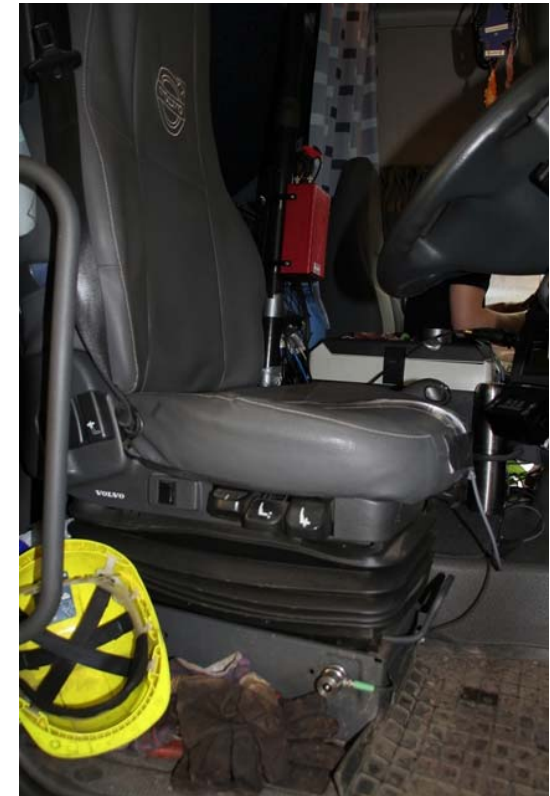
Ramsele-Rundvik, frost, TPCS off: 0.91 m/s^2 (68 km/h)

Same, TPCS on: 0.86 m/s^2 (73 km/h)

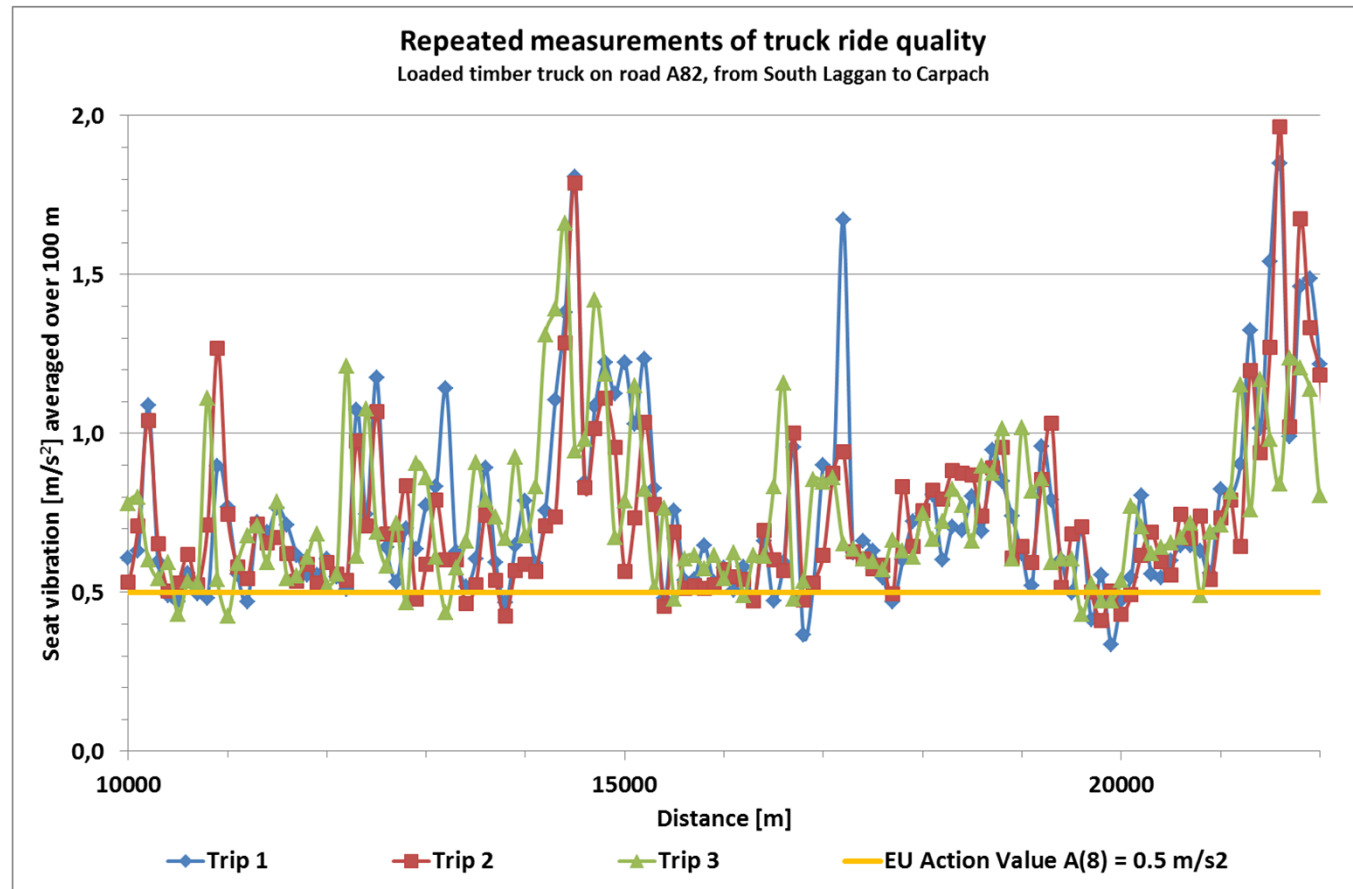
Same, autumn (no frost, no TPCS*): 0.66 m/s^2 (75 km/h)

**At the autumn, TPCS was clogged by balancing powder*

Highland demo: Timber haulage



Repeatability: Three runs at A82



Average values 0.744, 0.734 and 0.745 m/s².

Standard deviation in arbitrary section: 0.13 m/s².

Demo in Highlands: Loch Arkaig route

Mainly on roads B8004, B 8005 and unsealed forest road.



Photo: J Granlund

TPCS reduces wheel hop vibration

Highlands: TPCS on drive and bogie axles



With TPCS off at Loch Arkaig dirt road, the cab was shaking so hard that the measurement computer fell into the floor.

A(8) at Loch Arkaig: 0.77 m/s² (TPCS on)



		Vibration intensity	Exposure time		Partial exposure	Distance [km]
		m/s ²	hours	minutes	m/s ²	
Sawmill - Loch Arkaig	Empty	1,00		37	0,278	25
Dirtroad	Empty	1,53		9	0,210	2,3
Loading	-	0,00		30	0,000	0
Dirtroad	Loaded	1,28		9	0,175	2,3
Loch Arkaig - Sawmill	Loaded	0,79		37	0,219	25
Unloading	-	0,00		20	0,000	0
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Loch Arkaig - Corpach	Loaded	0,79		37	0,219	25
Unloading	-	0,00		20	0,000	0
					0,000	0
Pause, non-driving time		0,00		54	0,000	0
		Daily exposure value, m/s ² A(8)			0,77	164

Summary

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Implementing Accessibility