Bridge management application

Hocine IMINE

LCPC Laboratoire Central des Ponts et Chaussées

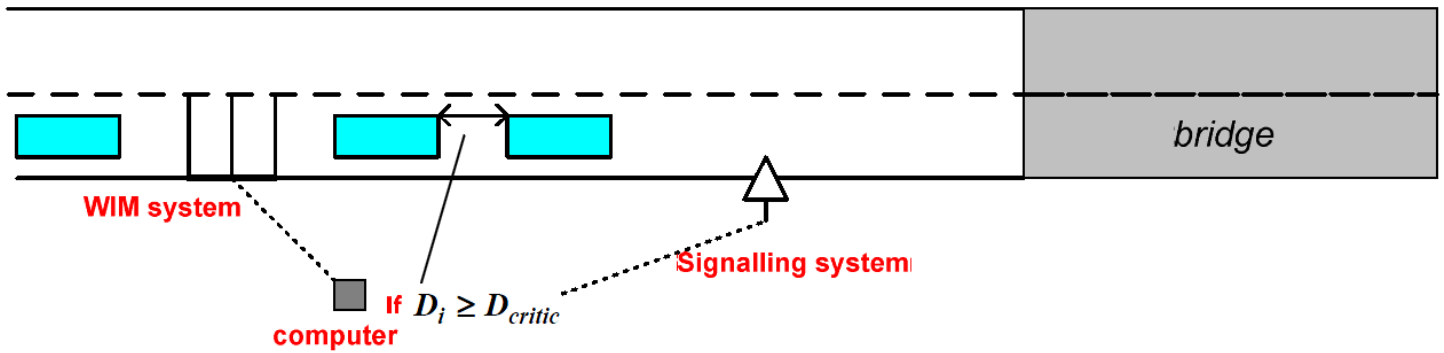
Objectives

To design and to develop algorithms and softwares in order to:

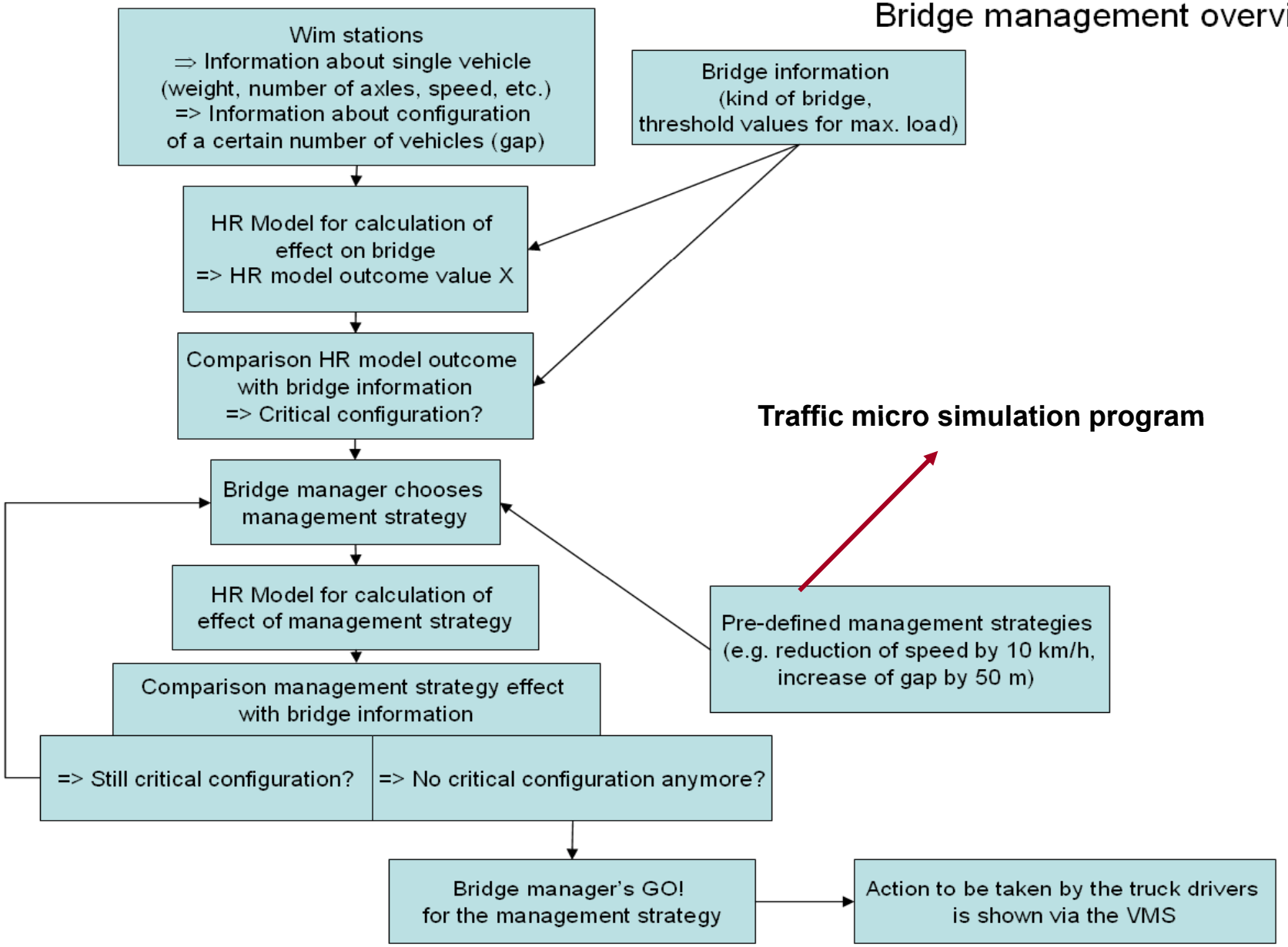
1- reduce the heavy traffic effect on bridges and to avoid bridge overload.

2- decrease the infrastructure cost and increase the bridge lifetime.

3- better management of the bridges by infrastructure manager.



Bridge management overview

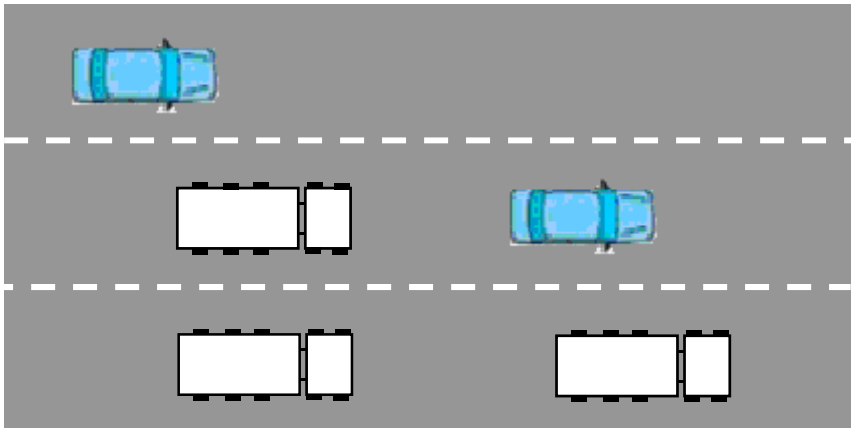


System components

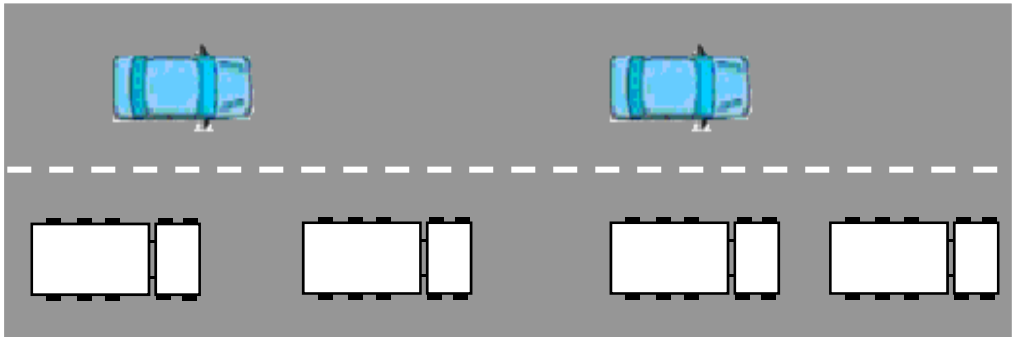
Sensors (WIM station, loops..)	To collect information about the vehicles and traffic
Micro-simulation software	To generate traffic configurations and to define management strategy
CASTOR/POLLUX software	To calculate the effects of HGV on the bridge
VMS or/and fixed panels	To inform the drivers about actions to be taken

Critical configurations

Trucks meeting event
(load effect sensitivity)



Group of trucks
(fatigue and load effect sensitivity)

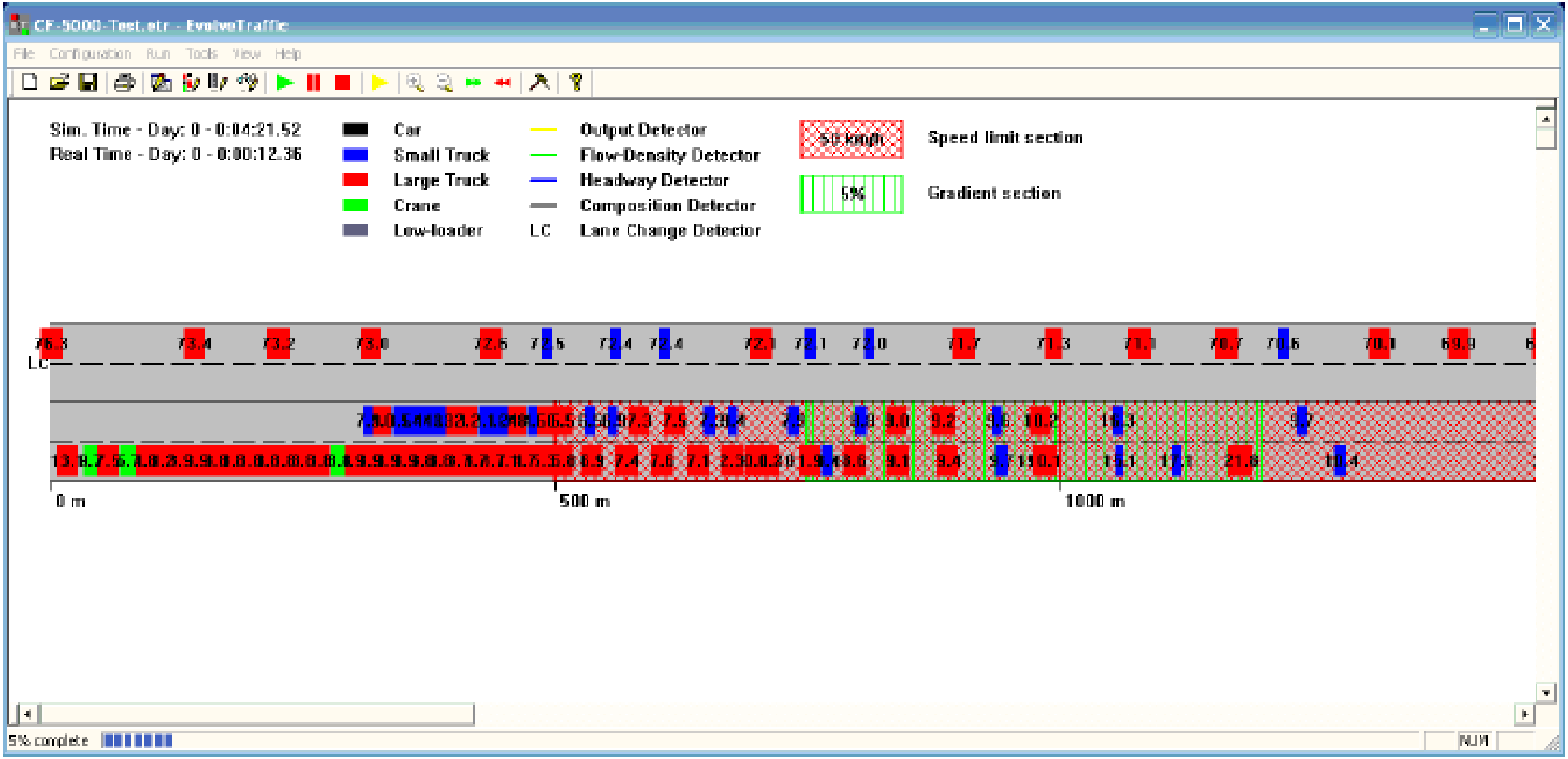


Generate traffic configurations and define management strategy
➔ Traffic micro-simulation program

Characteristics:

- read data from CASTOR or SAFT format vehicle files (From WIM station);
- model roads of up to 8-lanes in width, 4 per direction;
- model one or two directions at the same time, each of up to 4 lanes;
- take into account speed limit sections of road;
- take into account gradient sections of road;
- consider overlapping gradient and speed limit sections of road;
- output Flow & Density information for specified locations on the road at specified time intervals,
- output Headway information for specified locations on the road at specified time intervals,
- output traffic composition information for specified locations on the road at specified time intervals;

Traffic micro-simulation program 'EvolveTraffic'



Before micro-simulation

RN4 Input traffic file:

00001000526110700002842241 4121215 793814757 6213 5913 65
00002000526110700031992244 4181245 704115457 6513 6213 67
00003000526110700043824391 14 252 925 5
00004000526110700200124236 4121185 723514259 7212 6012 66

After micro-simulation

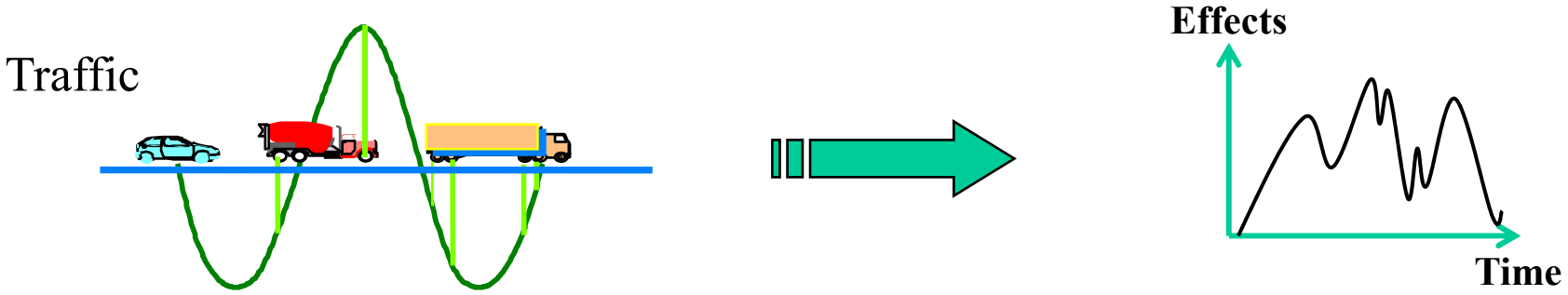
RN4 Output traffic file (modified traffic):

00001200050102080002512623 1 4121215 793814757 6213 5913 65
00002200050102080005570920 9 4181245 704115457 6513 6213 67
00003200050102080007136821 0 14 252 925 5
00004200050102080022295222 3 4121185 723514259 7212 6012 66

Record	Unit	Format
Vehicle order		I5
20000 unused number		I5
Day		I2
Month		I2
Year		I2
Hour		I2
Minute		I2
Second		I2
Second/100		I2
Speed	dm/s	I3
Gross Vehicle Weight - GVW	kN	I4
Length	dm	I3
Number of Axles		I1
Weight Axle 1	kN	I3
Spacing Axle 1 - Axle 2	dm	I2
⋮	⋮	⋮
Spacing Axle 8 – Axle 9	dm	I3
Weight Axle 9	kN	I2

Effects of the traffic on the bridge

POLLUX-Software (**Traffic** **Influence lines**)

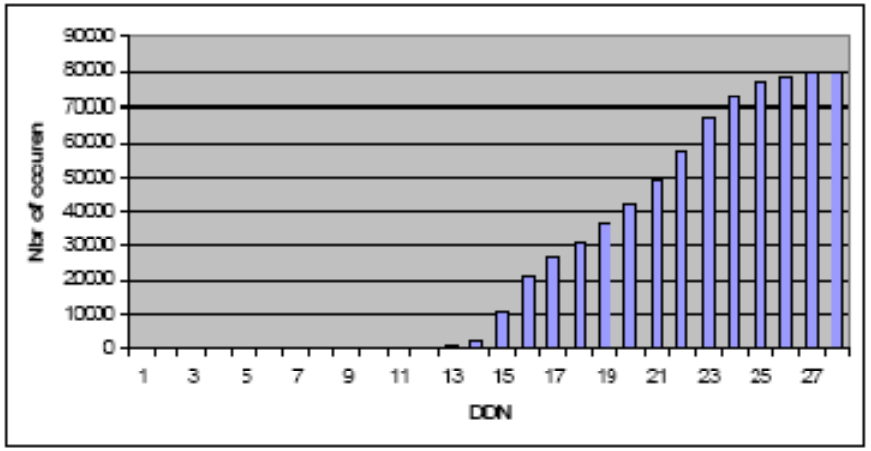


Determination of DDN and Rain-flow histograms

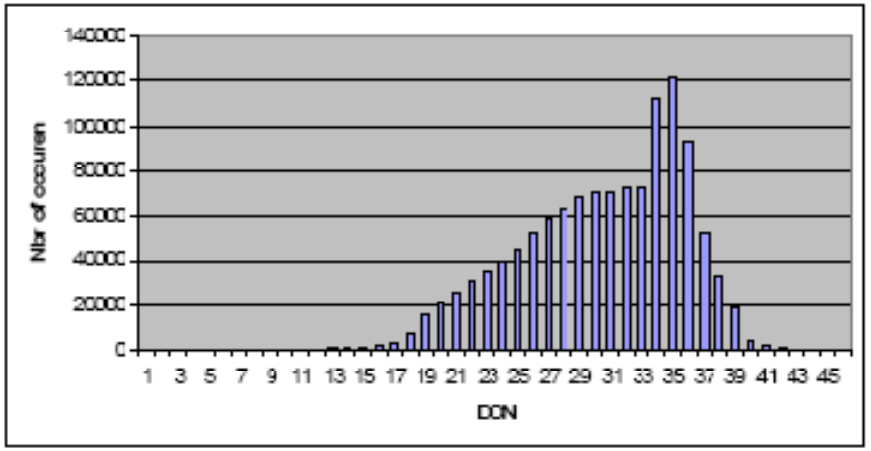
(Level crossing) DDN ➡ calculation of extremes values

Rain-flow ➡ fatigue calculation (S-N curve)

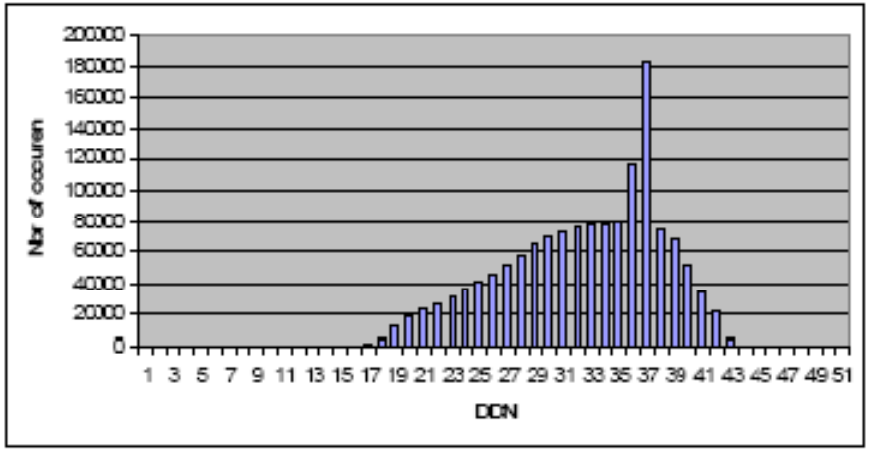
The *damage by load effect :* *depends on the combination of bridge characteristics and the intensity of the traffic configuration and concerns essentially prestressed concrete bridges (VIPP).*



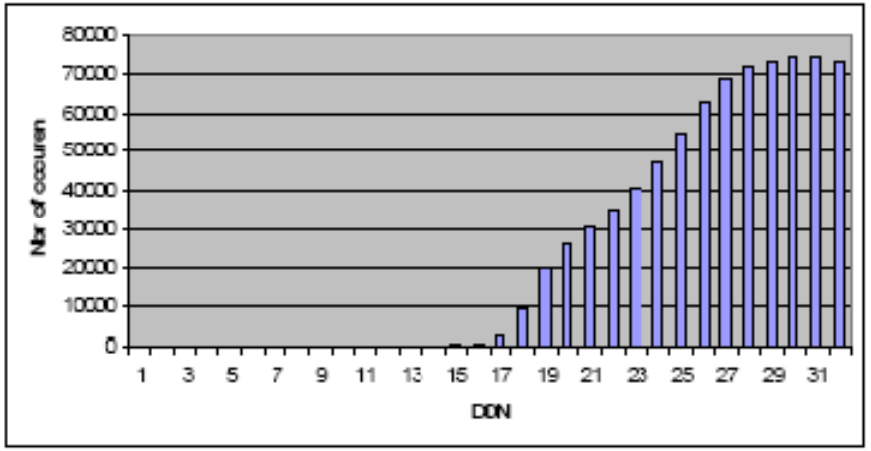
Auxerre-mi1



Baucaire-mi3

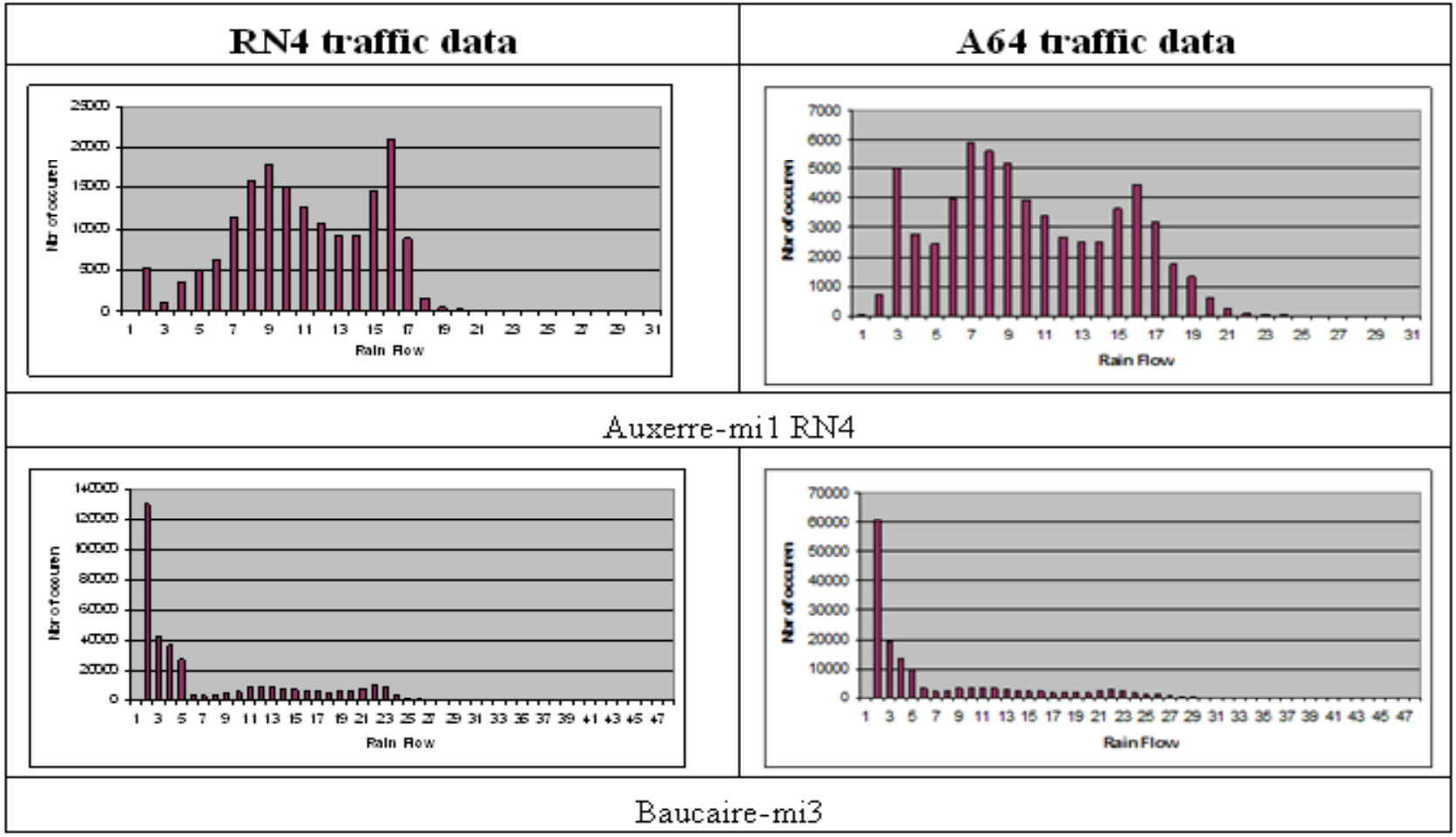


Jargeau-mi1



Joigny-mi1

Level crossing (DDN) histograms using RN4 traffic data



Rain-flow histograms

Fatigue results

	Real RN4 traffic (11days)		Simulated RN4 traffic (11days) Gap=70m		Simulated RN4 traffic (11days) Gap=70m - Weight limitation to : 39tonnes/40t/45t	
	C-71	C-90	C-71	C-90	C-71	C-90
Auxerre mi1	281.59	8665.56	296.28	12695.53	112471.00 12050.46 384.53	∞ ∞ 881031.88
Beaucaire mi3	13.50	45.39	13.56	47.42	38.63 27.45 14.51	169.86 108.39 51.29
Joigny mi1	259.34	2630.55	432.85	15785.79	∞ ∞ 636.04	∞ ∞ ∞
Millau mi1	1554.44	24449.34	58320.11	765744.75	∞ ∞ ∞	∞ ∞ ∞
Jargeau mi3	16.49	59.53	17.91	66.80	53.96 37.07 19.28	310.08 170.47 73.13
Kervitous mi1	198.76	5549.29	205.04	6841.38	6202.29 1845.08 247.89	∞ ∞ 113345.61
Libourne mi1	41.49	320.71	43.97	610.32	166.97 103.06 47.62	∞ 70482.55 924.12
Layrac mi2	43.98	246.85	72.06	2905.58	464.44 214.18 79.12	∞ ∞ 251723.41

FEHRL

Bridge Management

Dynamic Effects

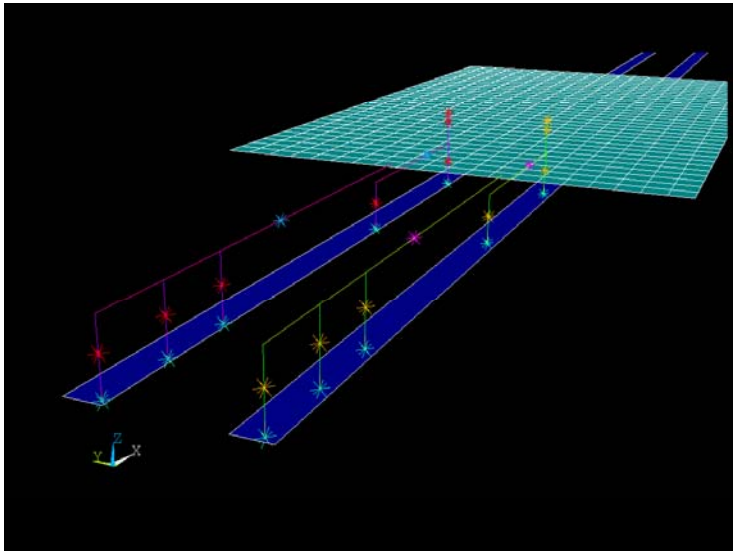
Stefan Deix

arsenal research
A Company of Austrian Research Centers

HEAVY ROUTE

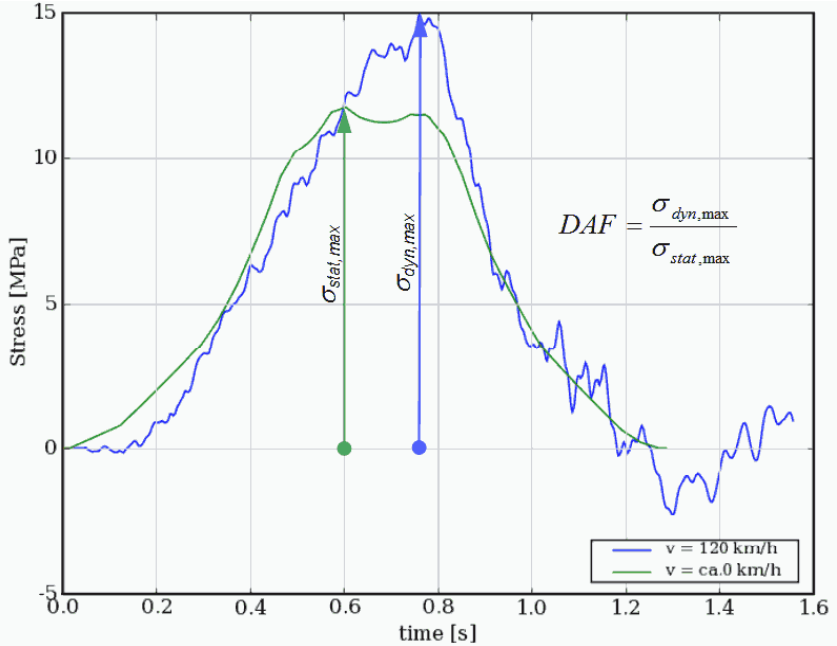
Dynamic Bridge Vehicle Interaction

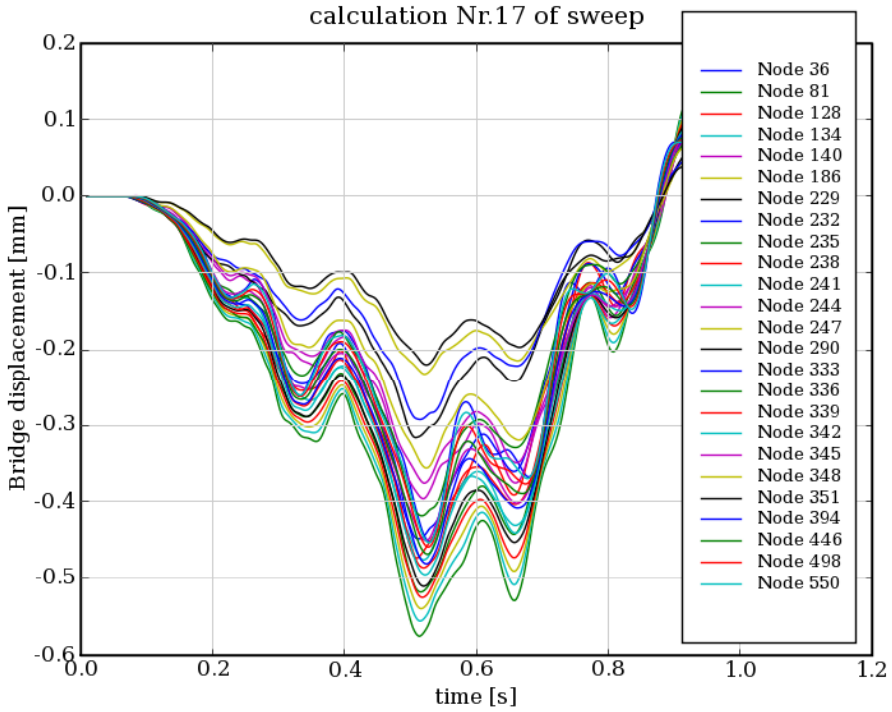
- Full bridge vehicle interaction
- Transient finite element analysis



Dynamic Bridge Vehicle Interaction

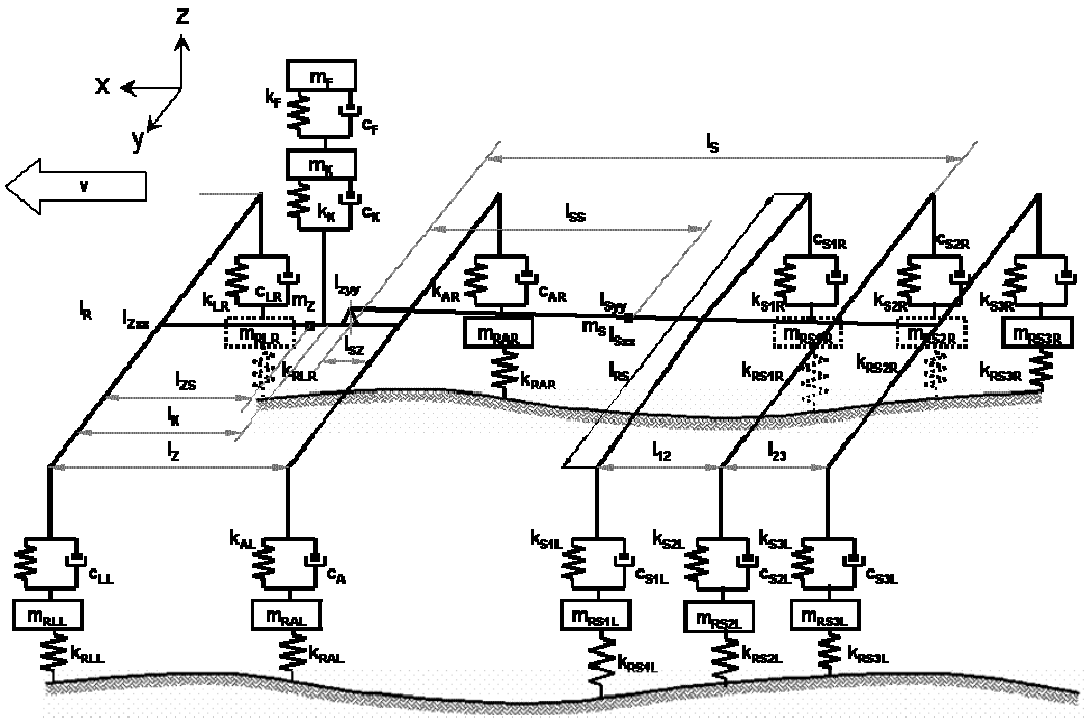
- Dynamic influence
- Increased material stresses
- Dynamic amplification factor (DAF)





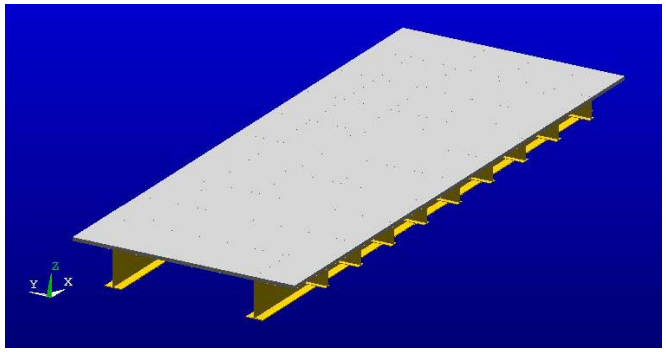
Vehicle Model

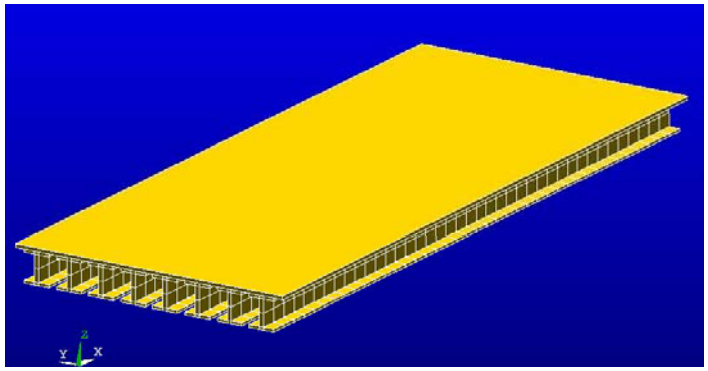
- 17-DOF HGV model
- 40 ton middle European truck
- 60 ton northern European truck

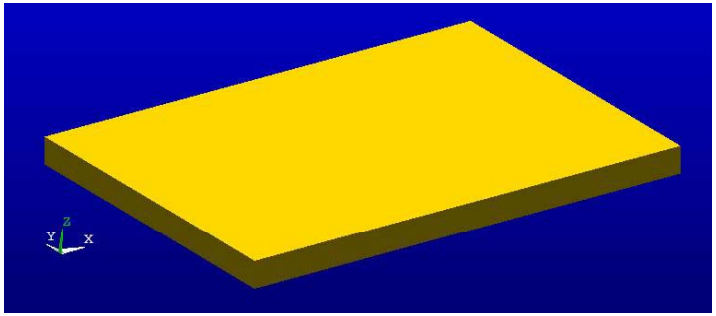


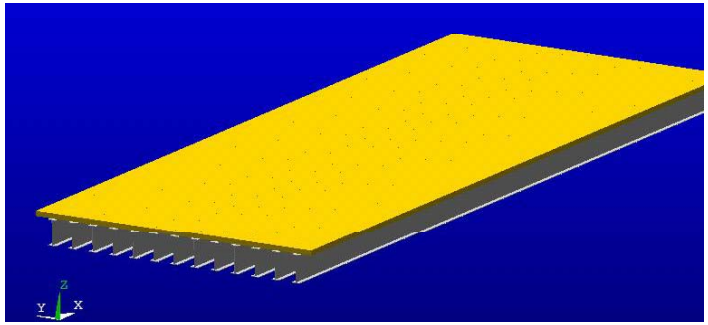
Bridge Models

- Reinforced concrete plate
- PC prefabricate girder
- Steel orthotropic
- Composite
- Spans 8 – 40 m (short span)

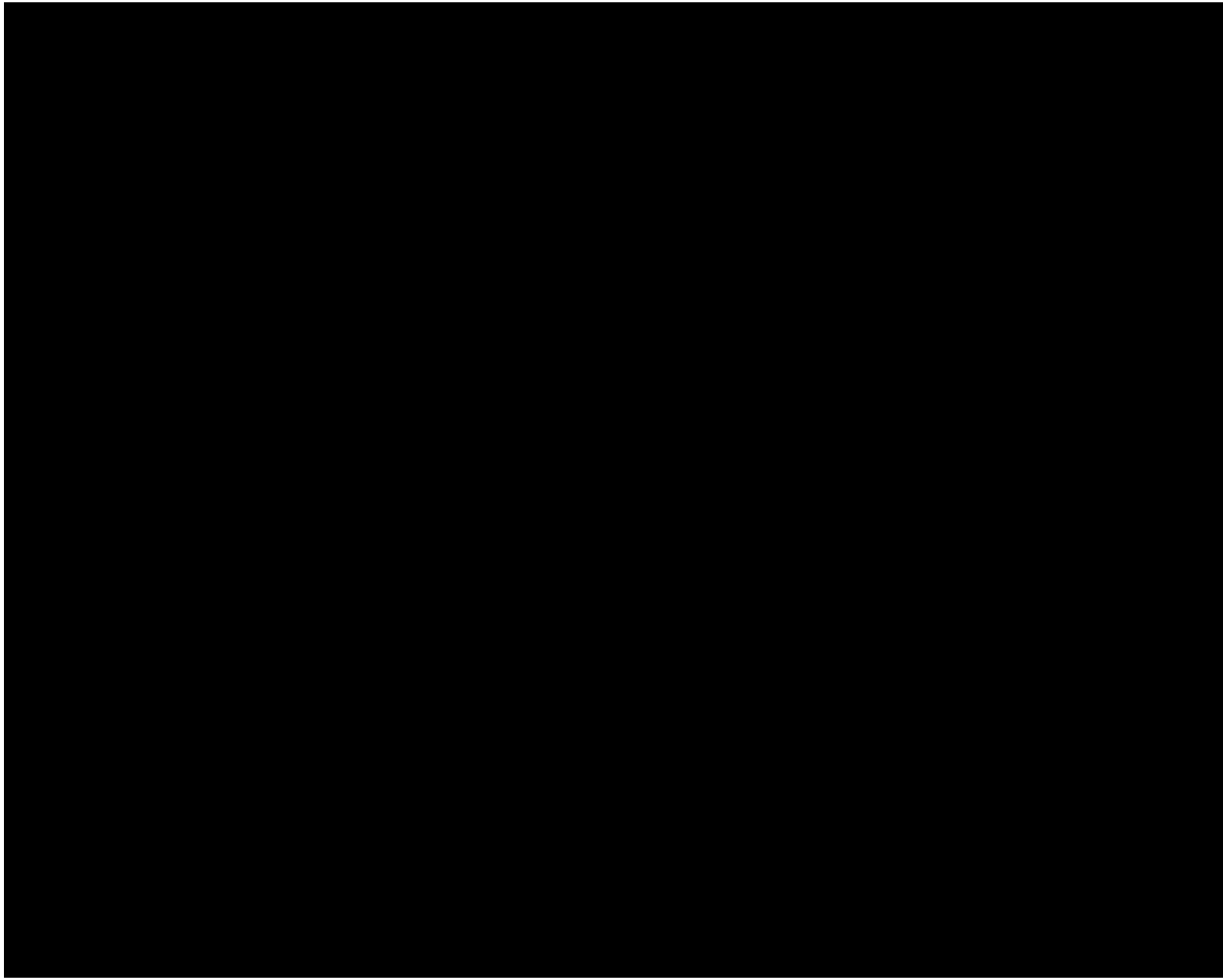






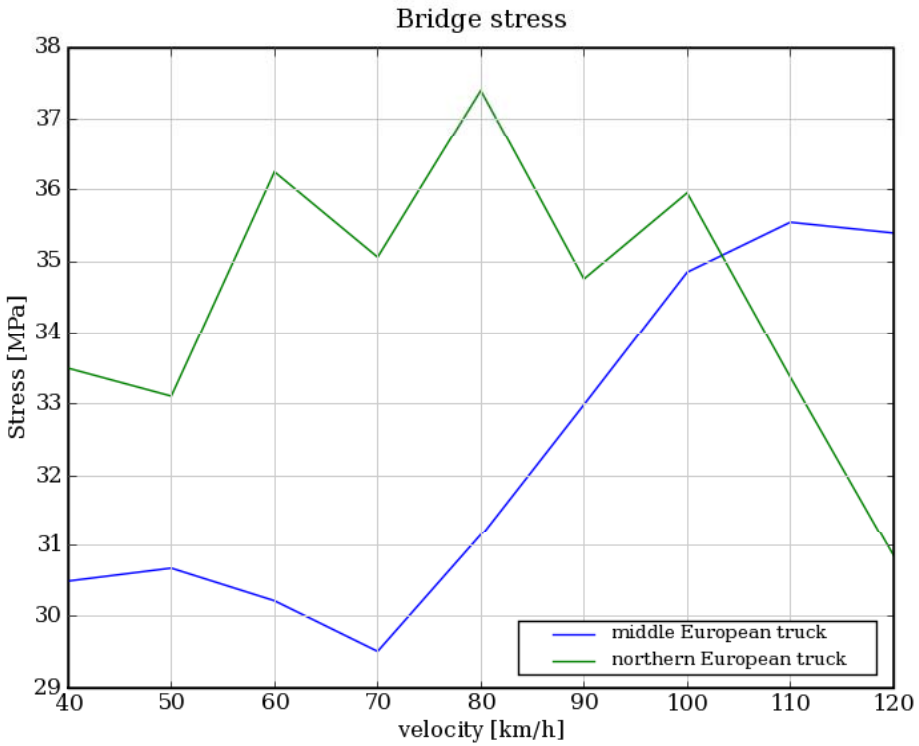


Transient Finite Element Analysis

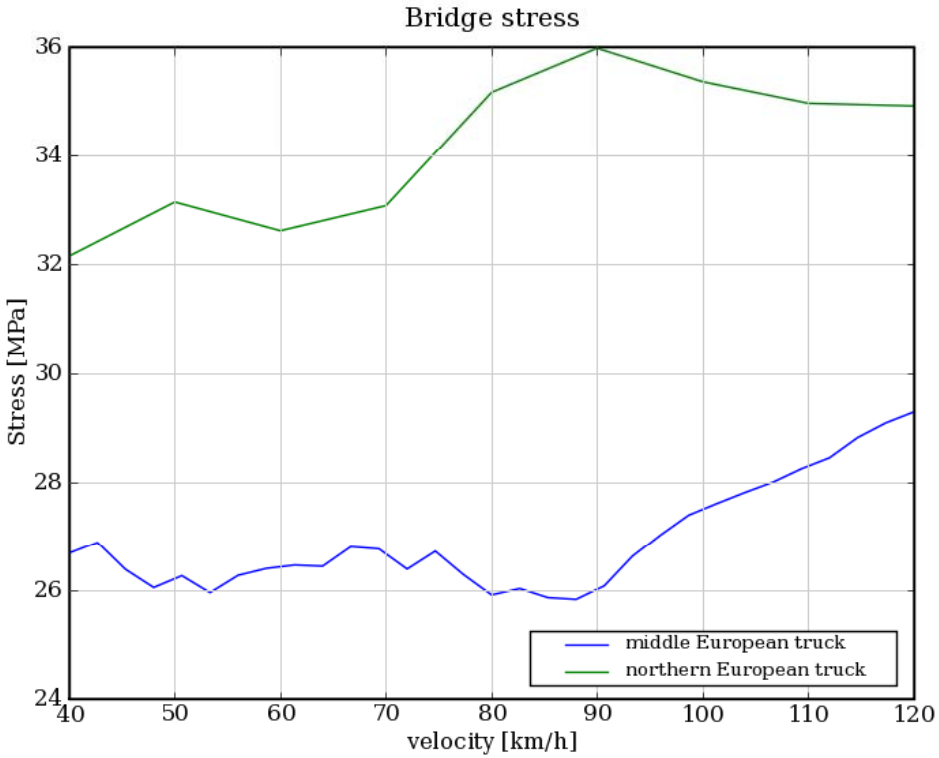


Impact of Different HGV Models

20m composite bridge

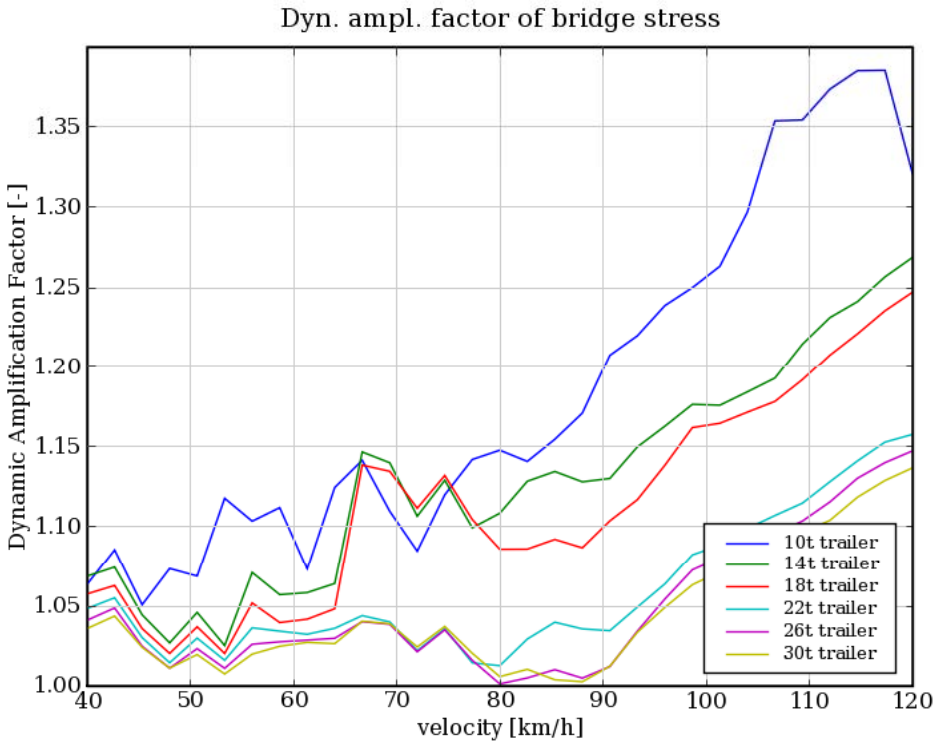


30m composite bridge

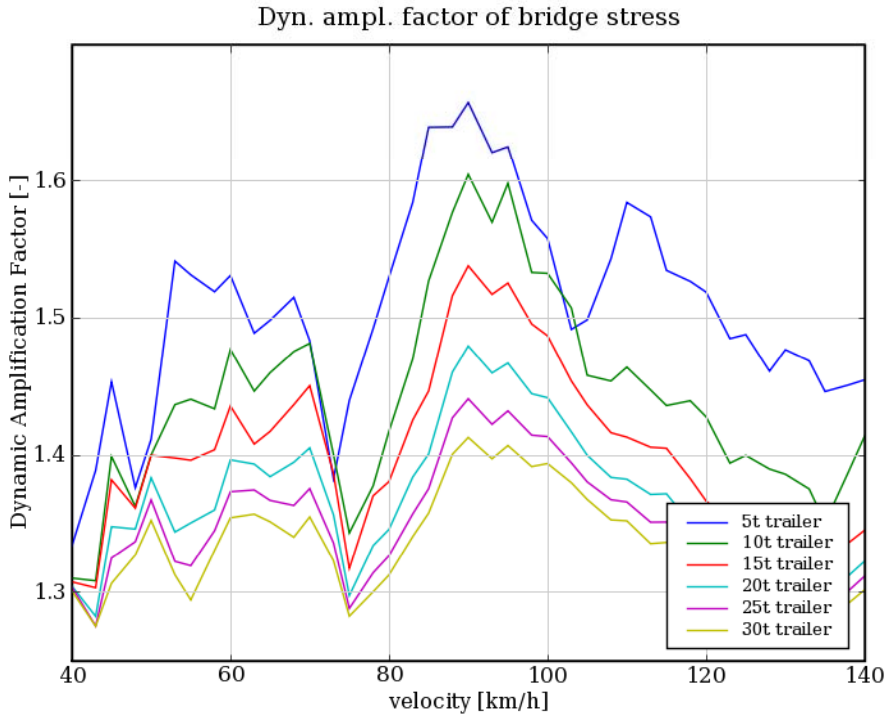


Impact of Different HGV Weights

30m composite bridge



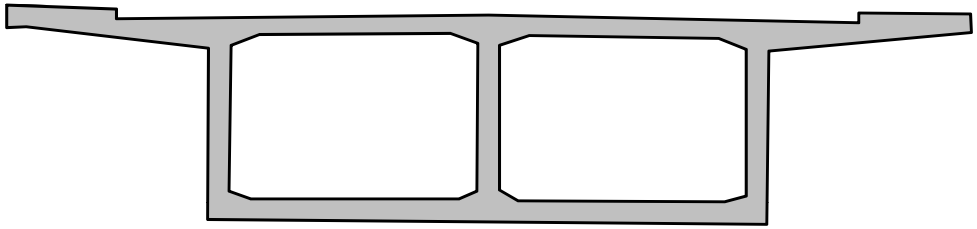
30m steel bridge



Heavier vehicles have lower DAF

Validation Test

Austrian bridge “Freudenauer Hafenbrücke”



Prestressed concrete 2-box girder

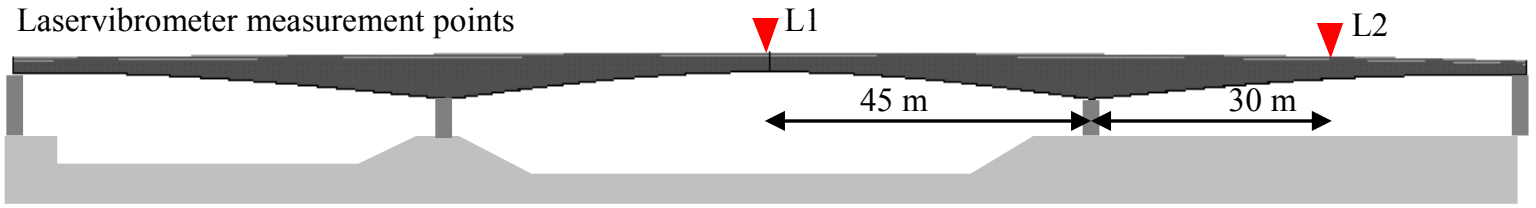
Spans: 60 m, 90 m, 60 m

Lanes: 2

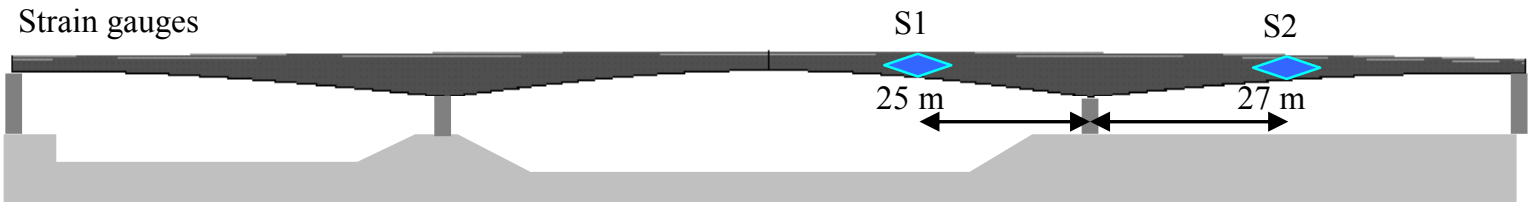
Constructed in: 1958

Test Plan

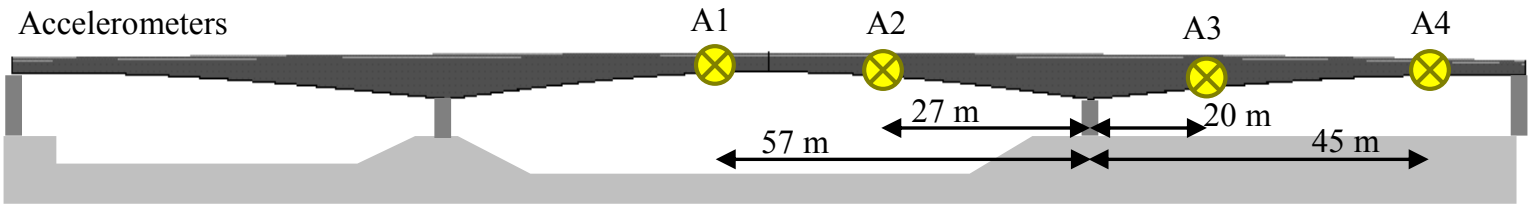
Laservibrometer measurement points



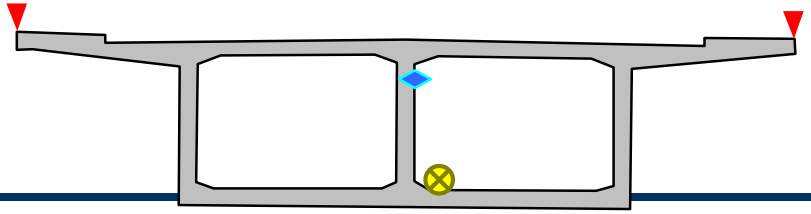
Strain gauges



Accelerometers

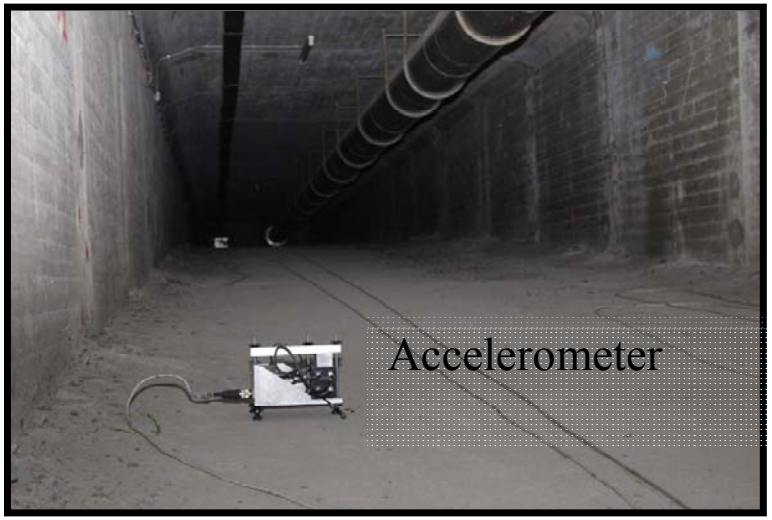


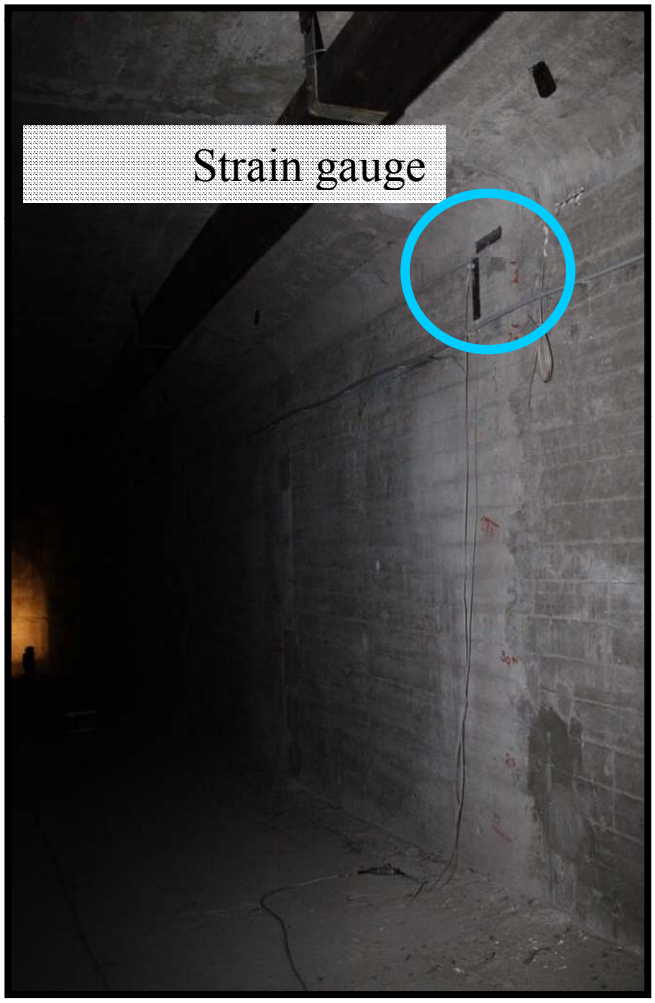
Position in cross-section



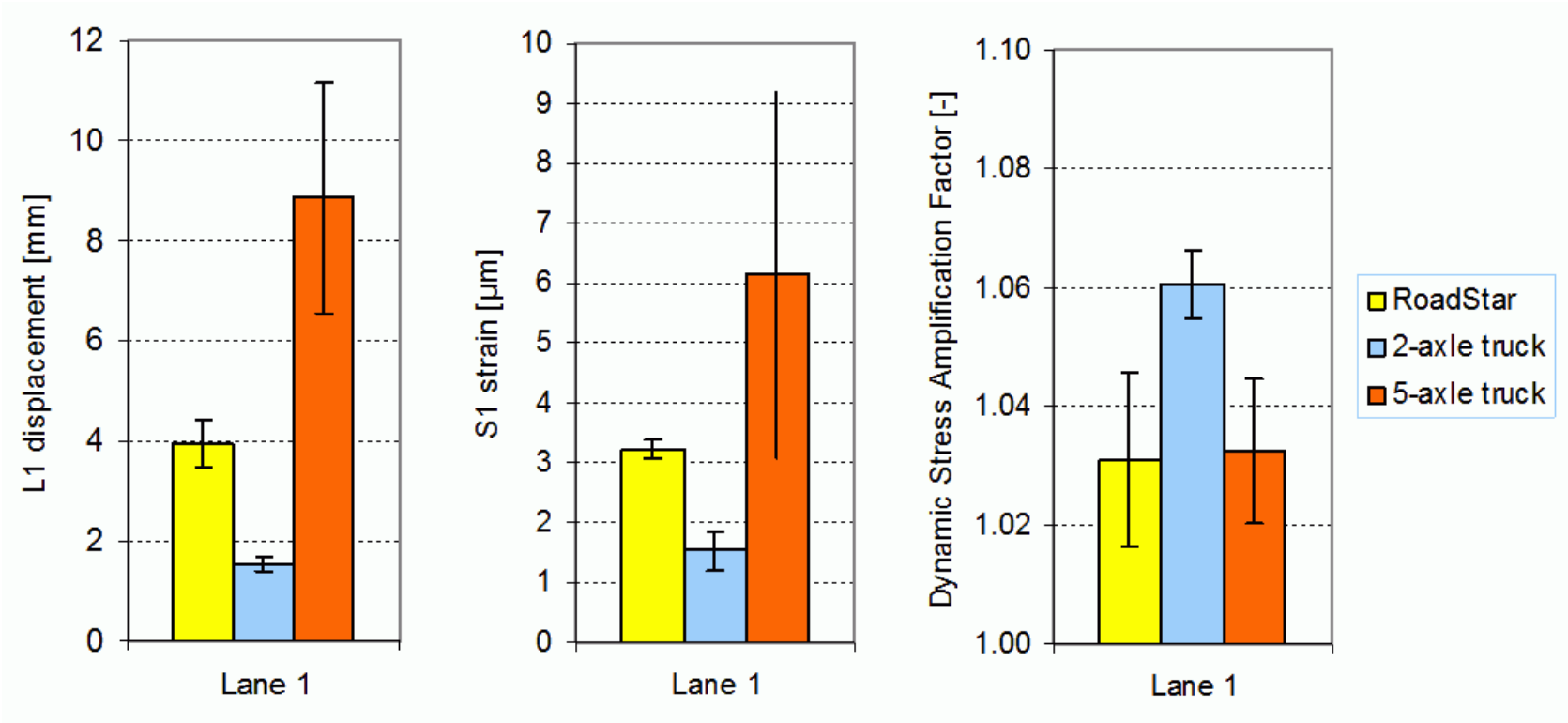
Test Equipment

Laservibrometer head



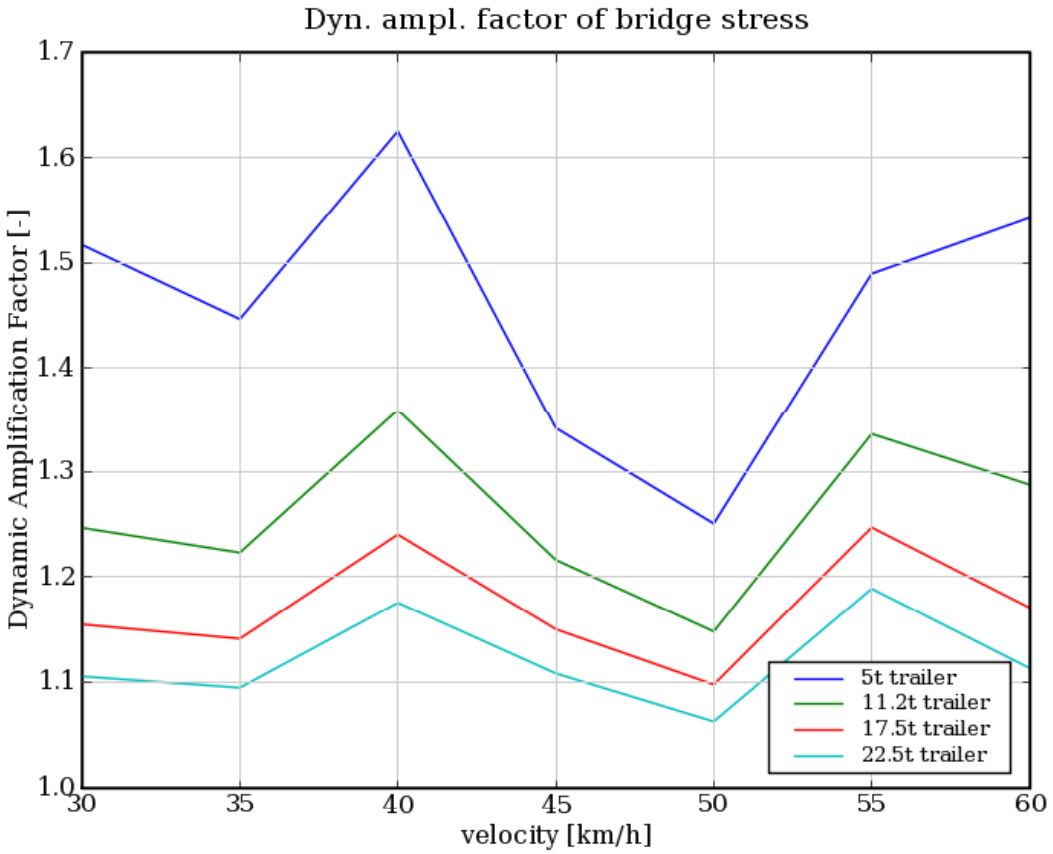


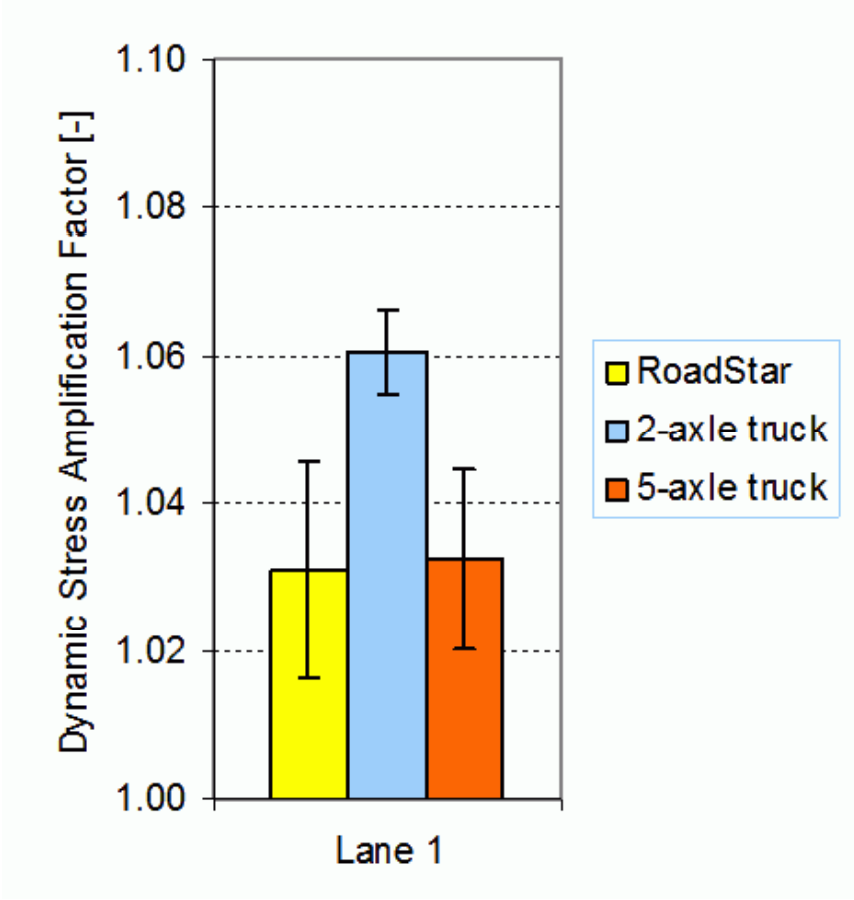
Measurement Results



Model Validation

Predicted DAF higher than measured





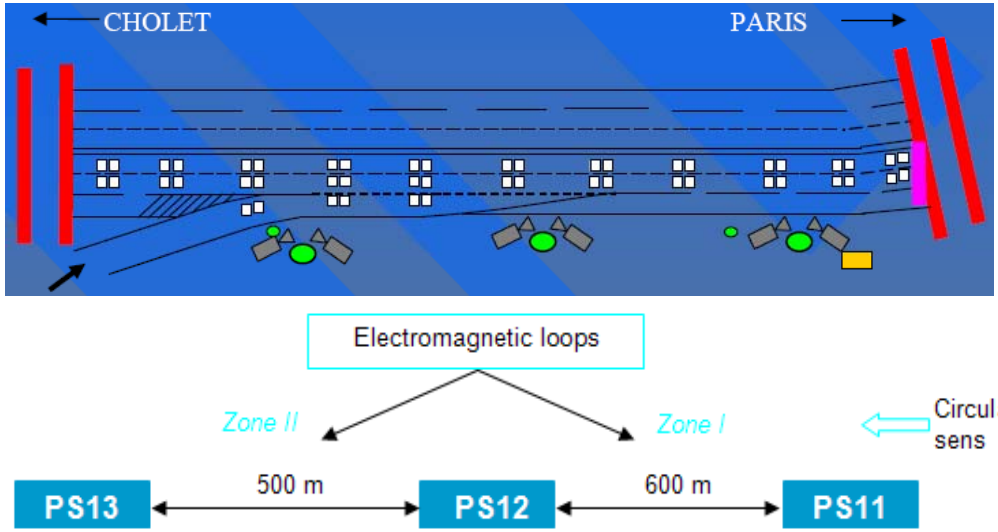
Test site in Angers, France

Evaluation of the drivers behavior with respect to the traffic management instructions ?

Questionnaire → aims to specify drivers waitings compared to the context of the experimentation and to define the message to be posted on the traffic sign.

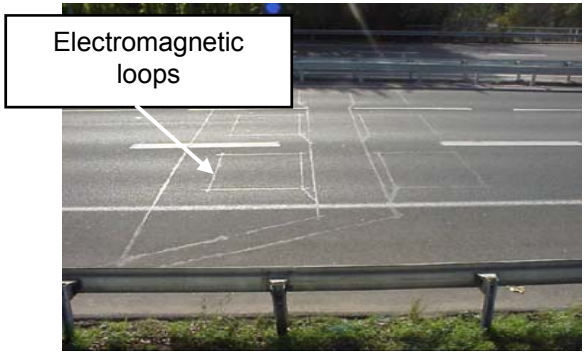
This questionnaire was made on the rest area of A6 motorway in France, with 55 drivers of various nationalities and various ages.

A87 nord in Angers (France)



- Speed measurement
- Inter-vehicular time measurement
- Category detection (VL, PL)
- Speed variation measurement (ps12-ps13)

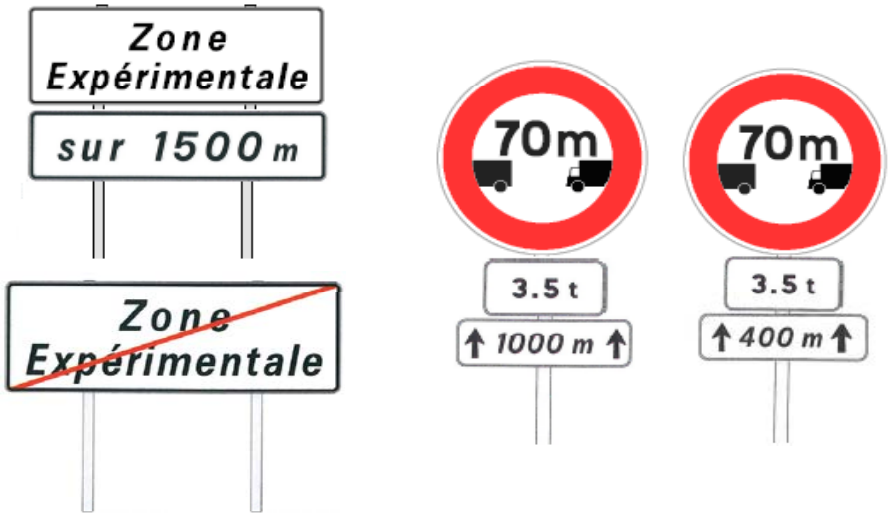
Used material



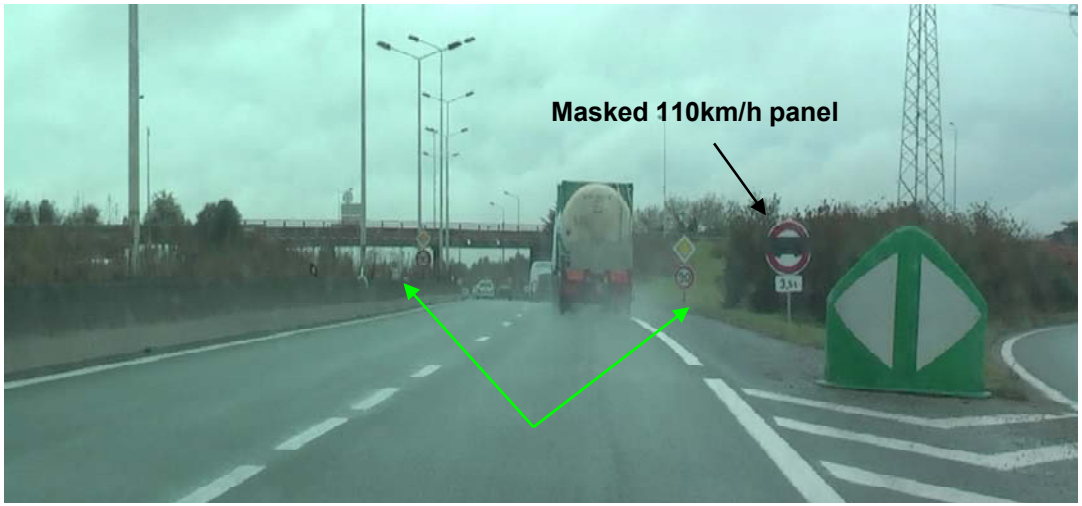
Electromagnetic loops

Laser sensors

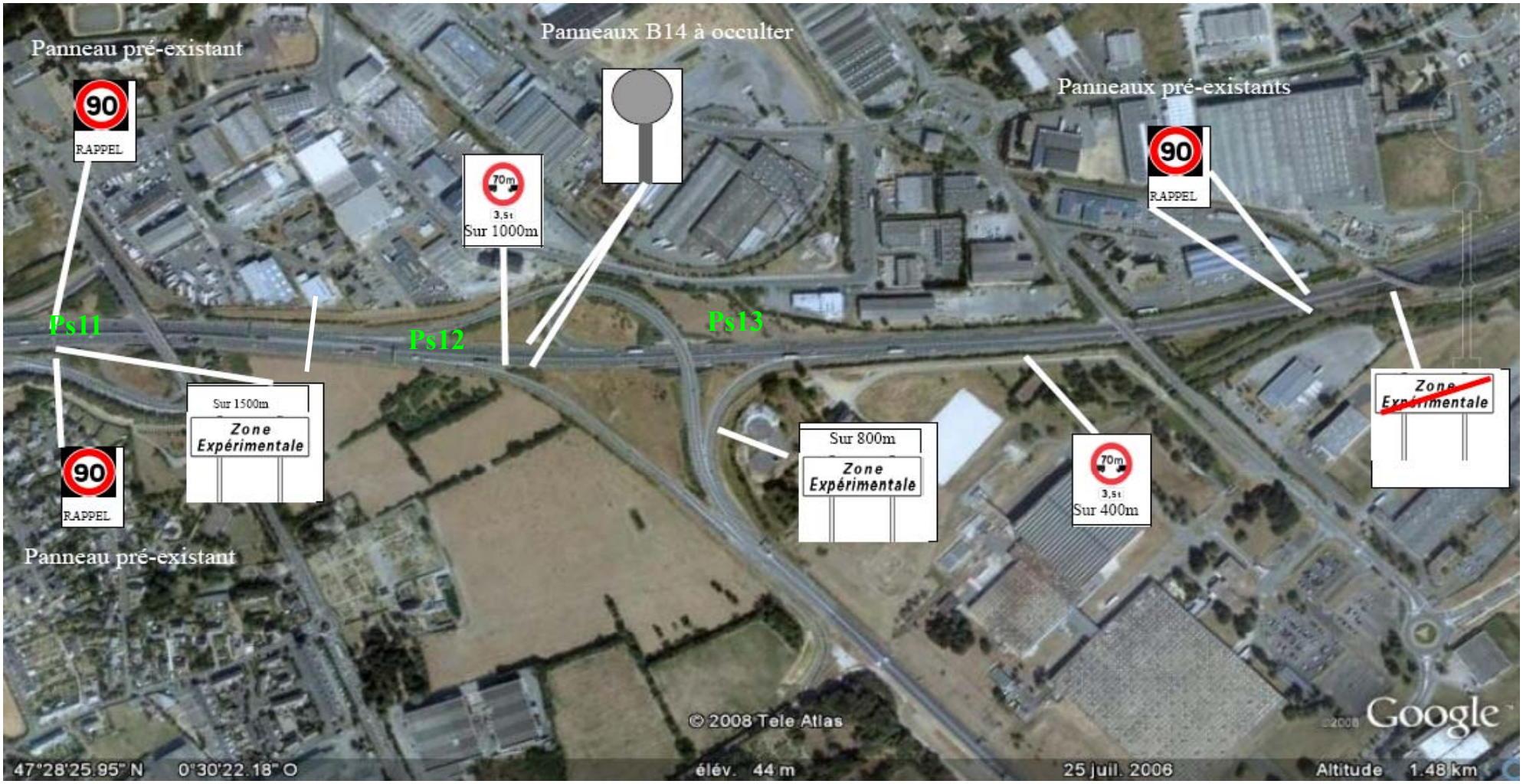
Traffic panel



Traffic signs



Masked 110 km/h signs


Panneau pré-existant
Panneaux B14 à occulter
Panneaux pré-existants
90
RAPPEL
70m
3,5t
Sur 1000m
90
RAPPEL
Ps11
Ps12
Ps13
Sur 1500m
Zone Expérimentale
Sur 800m
Zone Expérimentale
70m
3,5t
Sur 400m
Zone Expérimentale
90
RAPPEL
Panneau pré-existant
© 2008 Tele Atlas
Google
47°28'25.95" N 0°30'22.18" O
élév. 44 m
25 juil. 2006
Altitude 1.48 km

At 90 km/h, the distance covered in 2 seconds is about 50m.

The chosen gap instruction for the experimentation, was fixed at 70m, so that it :

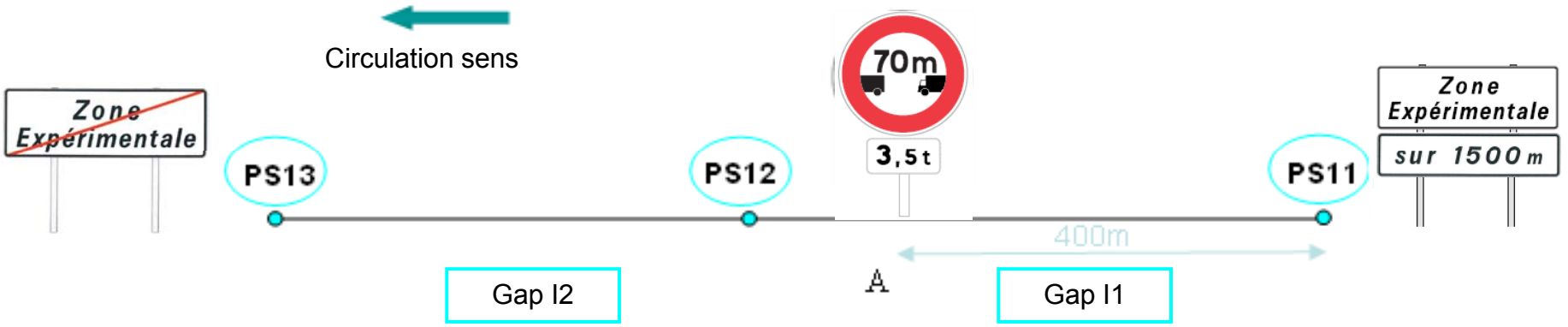
- is sufficiently different from the Highway code regulation, pointed out above, to be able to measure the user's variation behavior;

- remains " acceptable " by the drivers (questionnaire is realized and the results are given in a report).

2 steps:

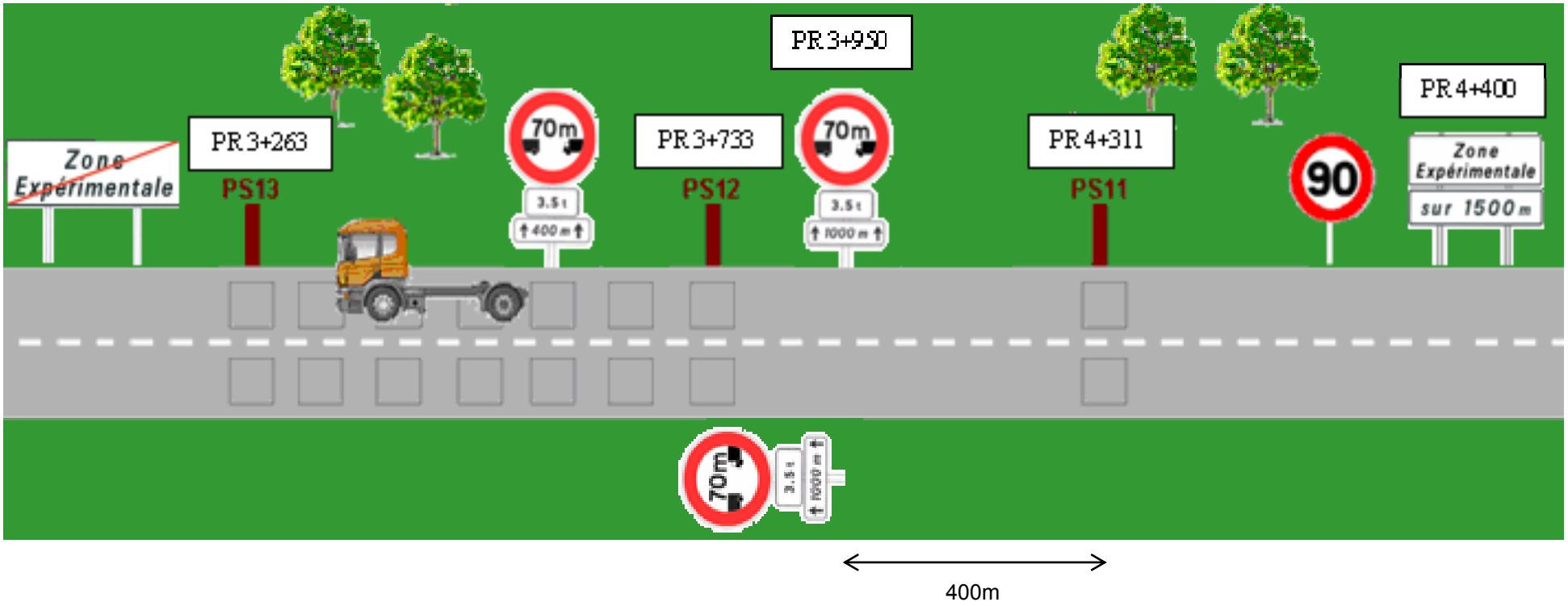
1st step:

The experimentation is done for the period : 01/09/08 to 28/09/08 on SAROT experimental site in Angers without panels. It's used as reference, in order to better estimate the evolution of the HGV driver's behaviors.



2nd step:

The second series extended over the two last weeks of January 2009 from 12/01 to 30/01, after installing the modified panels relating to the instruction of specified gap (70m).



Before the indication :

3rd treatment	Nbr of treated HGV	Moyenne of daily total Ti	Nbr of HGV of which Ti<2s	% of HGV of which Ti<2s	Mean of Ti <2s	Nbr of HGV of which gap<50m
PS11	42105	70.43	2584	6.14 %	1.444	2882 (6.84%)
PS12	36401	84.19	1174	3,23 %	1.523	1466 (4.02%)
PS13	48132	64.86	2282	4,74 %	1.537	2800 (5.82%)

439236 recordings over 19 days (September 2008)

PS12:

→ 36401 trucks ≈ 11% of traffic

→ 1466 ≈ 4.02% of heavy lorries don't respect the gap of 50m

After the indication :

3rd treatment	Nbr of treated HGV	Mean of daily total Ti	Nbr of HGV of which Ti<2s	% of HGV of which Ti<2s	Mean of Ti <2s	Nbr of HGV of which gap<50m	Nbr of HGV of which gap<70m
PS11	31384	75,71	1429	4,35%	1,41	1609 5.12%	2637 8.40%
PS12	64753	86.67	466	4.10%	1.55	4889 7.55%	8059 12.44%
PS13	67099	72.38	2641	3.77%	1.52	4331 6.45%	7575 11.29%

467099 recordings over 15 days (January 2009)

→ 64753 trucks ≈14% of traffic

→ 4889 ≈7.55% of heavy lorries don't respect the gap of 50m

→ 8059 ≈12.44% of heavy lorries don't respect the gap of 70m

CONCLUSION

The data analysis shows that:

- Some of drivers do not respect the inter-vehicular time of 2 seconds (between 2 light vehicles) and the 50 meters between heavy lorries imposed by Highway Code.

- A significant number of drivers have changed behavior in the presence of the panels of " Gap 70m".

- The two measurements series were not successive in time (flow of HGV). The traffic flow is not the same. The comparison can then be influenced.

FUTURE WORK

- It's interesting in the future to do the 2 tests successively.

- The installation of traffic management and control system to regulate speeds and interdistances need the deployment of high technology information services.

- The lawful framework must be simplified, returning it thus more comprehensible and thus better applied and controlled and supporting the emergence of automated solutions;

- The co-operation with the foreign (European) administrations must be reinforced

- Test in real time, the bridge management strategy adding WIM system, VMS and bridge.