

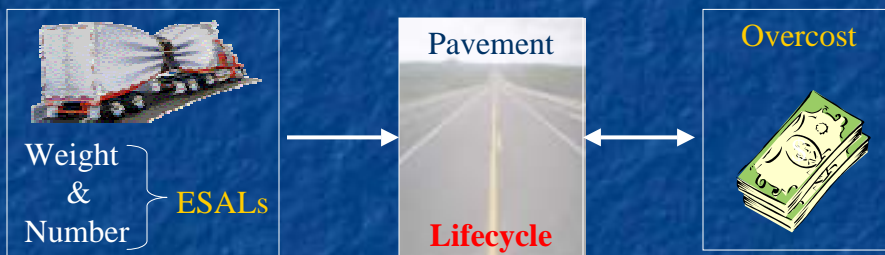
# EVALUATION OF SPRING LOAD RESTRICTIONS (SLR) EFFECTS ON PAVEMENTS

Denis St-Laurent, ing. M.Sc.  
Service des chaussées

Québec   
Ministère  
des Transports

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Montréal

## PRESENTATION OUTLINE



# Heavy trucks



$$\text{Truck factor} = \left[ \frac{\text{Axle weight}}{\text{Reference axle w.}} \right]^4$$

- **2 x weight = 16 x damages**

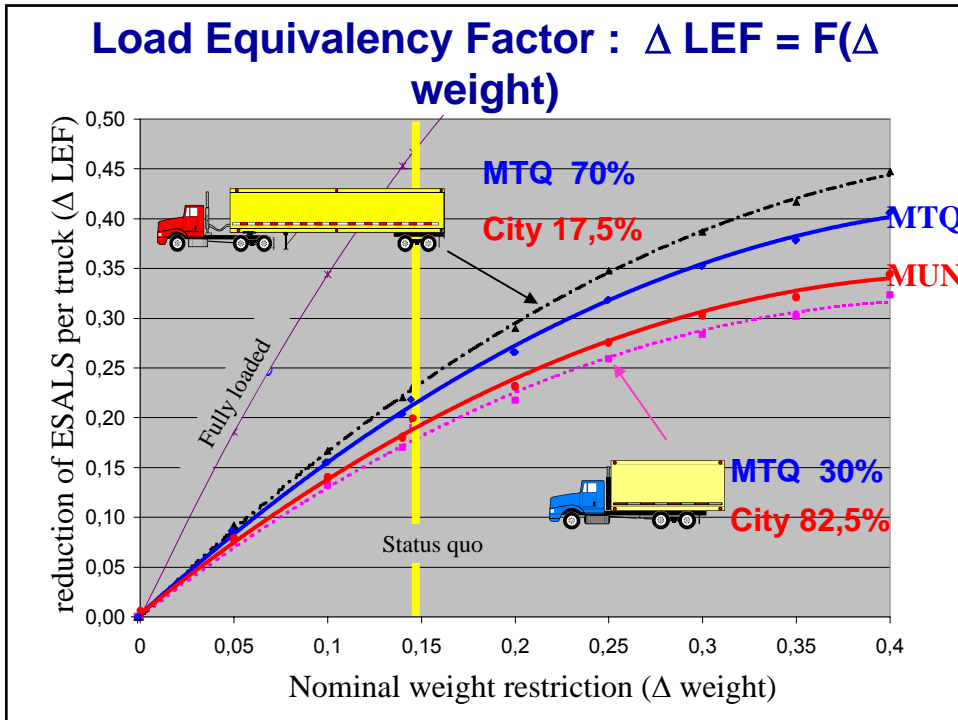
- AASHTO :

- 1 ESAL = 1 single axle of 8 165 kg
- = 1 tandem axle of 15 200 kg
- = 1 tridem axle of 21 800 kg

# Traffic evaluation



- 3,500 counting and classification stations
- 10 Weigh-In-Motion (WIM) scales
- **ESALS calculated with ASTM E1318**



## Heavy Traffic during the spring period

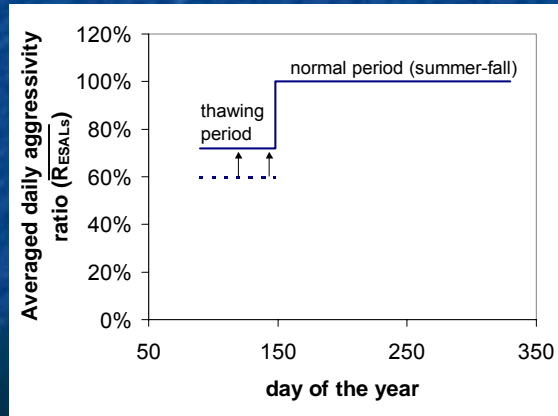


- ESAL per day  $\approx$  60% of summer
  - Average truck  $\approx$  LEF 20% smaller (SLR of 15%)
  - Shipments needs about  $\approx$  20% less than normal period
- SLR removal hypothesis
  - Average truck load same as summer
  - $\approx$  7% less displacements  $\Rightarrow$  **ECONOMY OF THE INDUSTRY**
  - Shipments needs about  $\approx$  20% less than normal period

Increase ESALS of 19% (18 % inside cities)

# If We Remove Spring Load Restrictions (SLR)

=> 19% more ESALS per day  
(18% inside cities)



## (2) Pavement Damage

19% more  
ESALS if we  
remove SLR

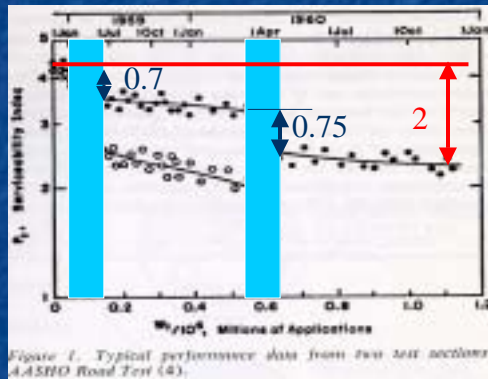


# Structural Damages ⇒ Wheelpath Distresses



## Damages During Spring Thaw

- 1a-Literature (example from AASHTO)



$$D_p = \frac{\Delta PSI_{thaw}}{\Delta PSI_{total}}$$

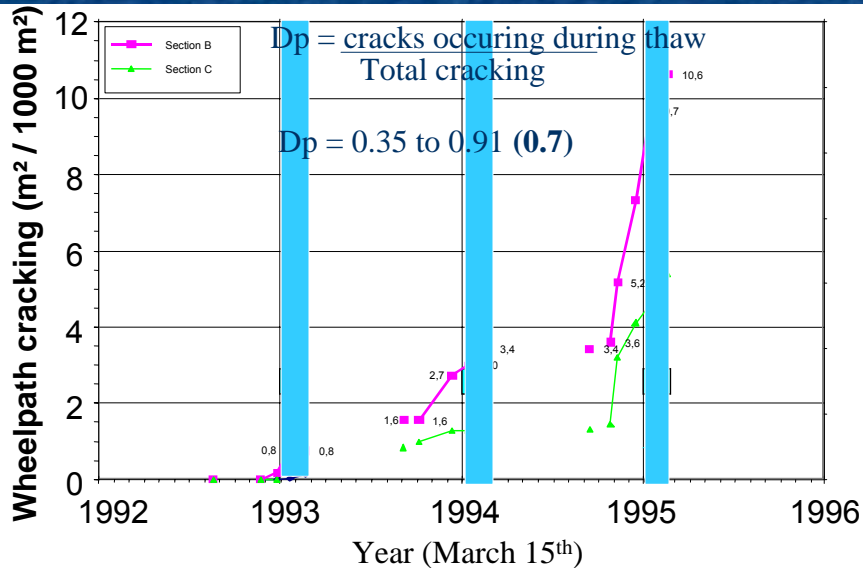
$$D_{p1} \approx 1.45 / 2 = 0.725$$

$$D_{p2} \approx 1.3 / 2.2 = 0.55$$

From all the cases found in literature, spring thaw damages varies from 0.3 to 0.85

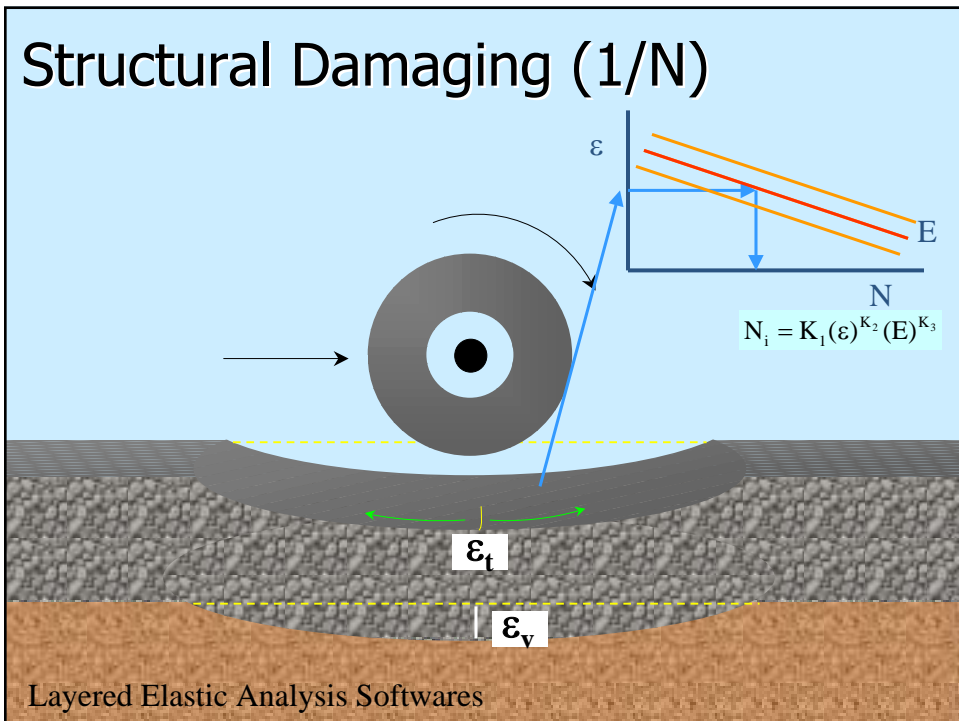
# Damages During Spring Thaw

## ■ 1b-Performance monitoring (H10, Fleurimont)

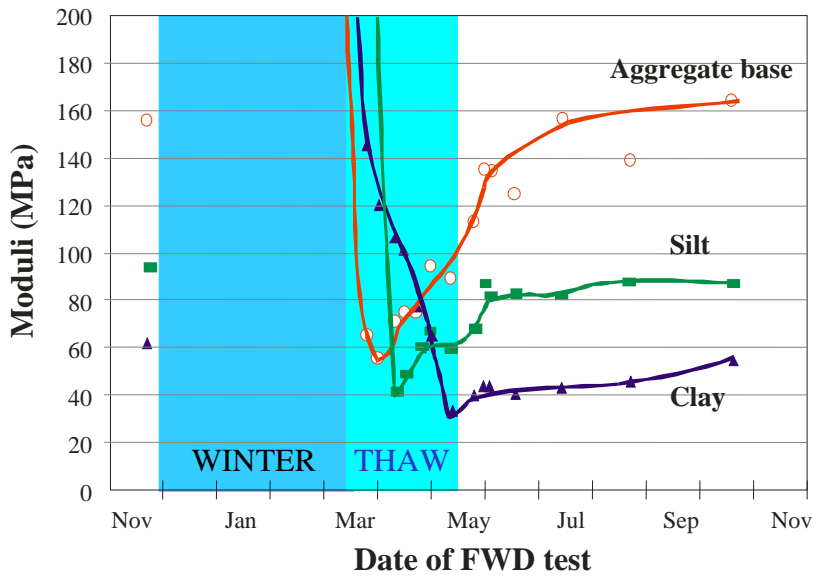


## Annotations

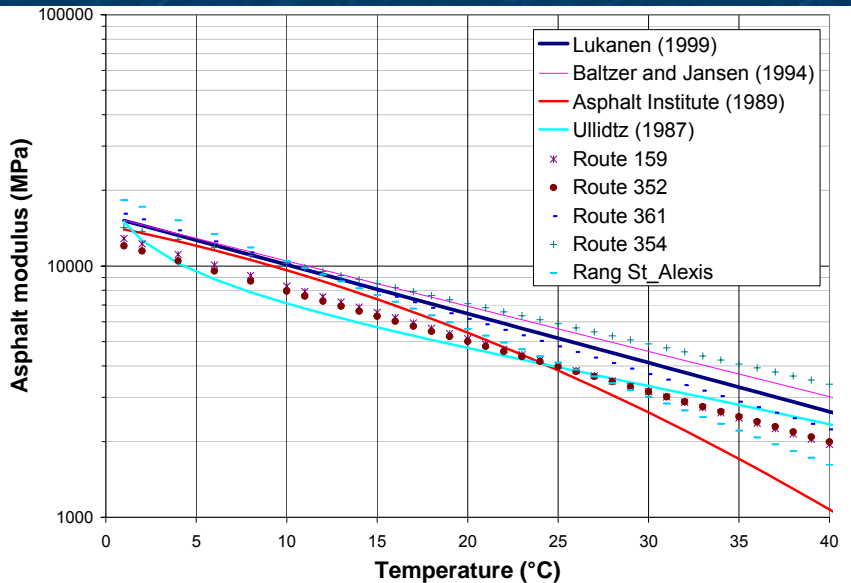
- A lot of pavement damaging occurs during winter thawing events
  - Climatic variability between different years
- Ability to raise SLR during each thawing events, including those in winter, would be the ideal of beauty
- Winter Weight Premiums does not appear as a very good feature



## Unbound Materials Moduli Rang Saint-Alexis, Saint-Maurice



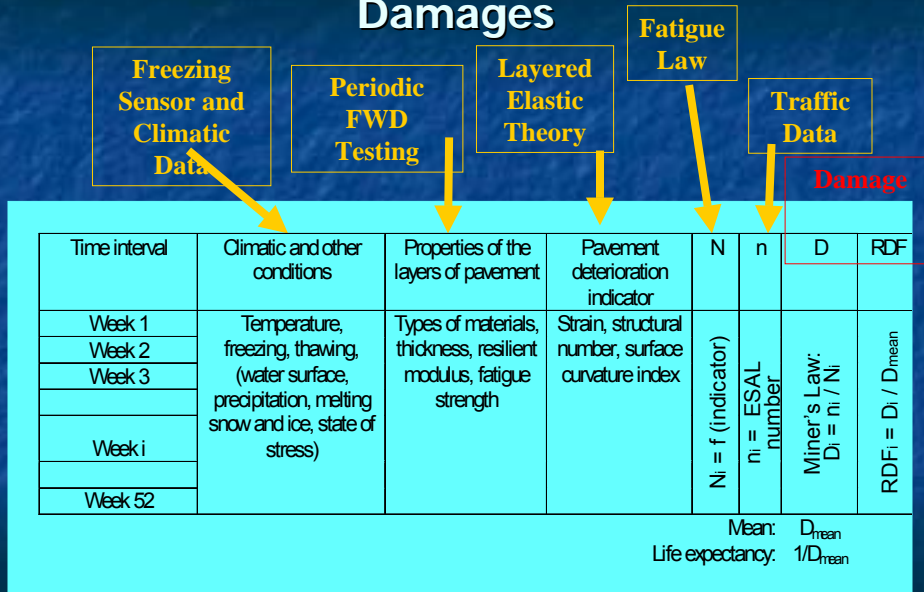
## AC modulus



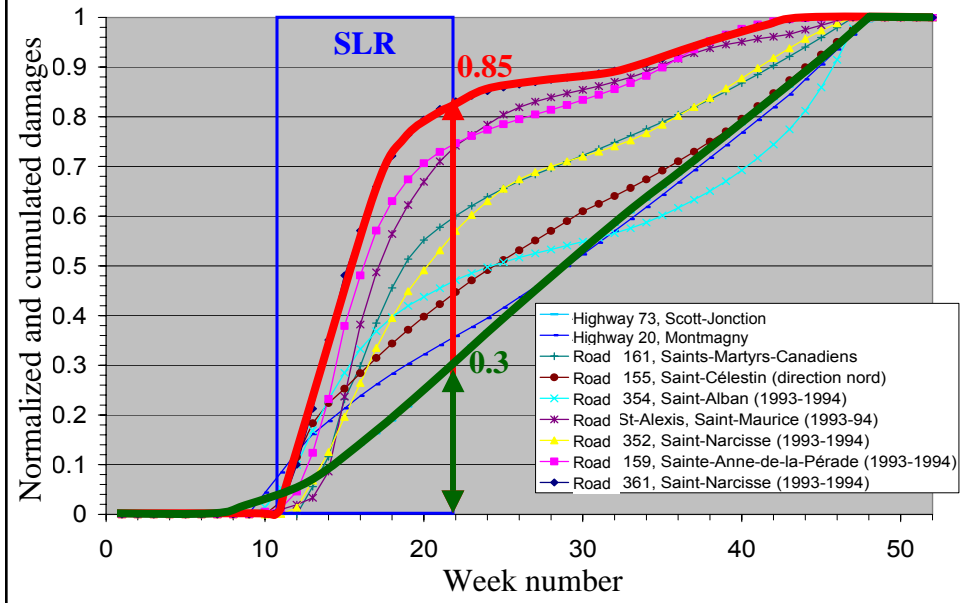
# Structural Indicators

- $\epsilon_t$ : AC elongation (fatigue cracking)
  - Six models from MTQ laboratory
  - Models from Norway, Alaska, Shell, Asphalt Institute
  - Empirical criteria based on  $SCI_{20^\circ C}$
- $\epsilon_v$ : rutting by permanent settlements
- PSI: AASHTO-1993 model
  - $SN_1$  corrected at  $20^\circ C$

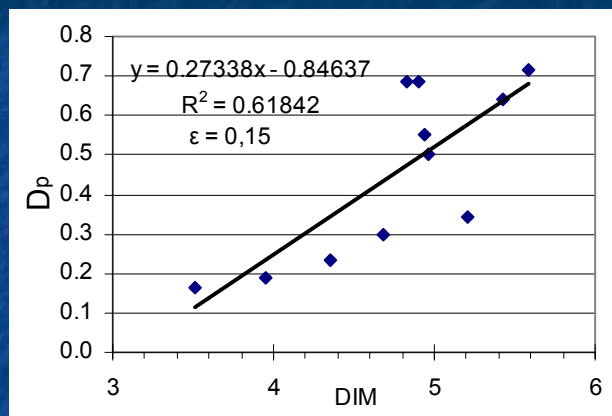
## Theoretical Simulation of Structural Damages



## Theoretical simulations (damaging)



## Spring damages $\approx f$ (summer deflection)

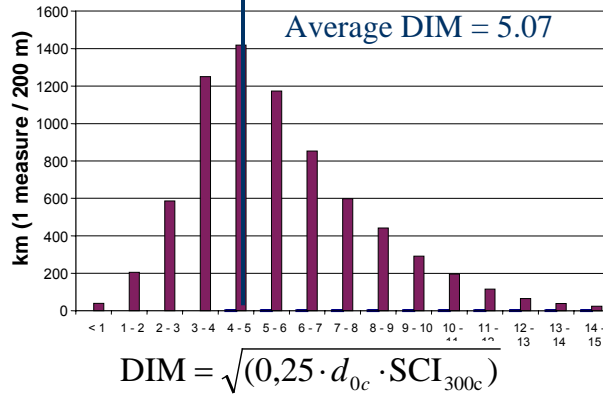
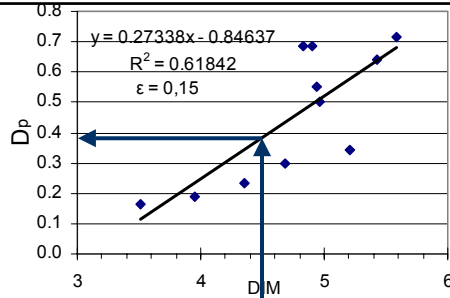


- Allow to use deflection inventory in order to extend conclusions for the whole pavement network

(Adjusted values to account for actual traffic conditions)

1410 km with DIM  
between 4 à 5  
⇒ Dp = 0.38  
Weighted average = 0,63

Dynalect inventory  
ex: national roads



## If We Remove Spring Load Restrictions (SLR)

$$\% \text{ life reduction} = D_p \times \Delta \text{ ESALS}$$

Highways	0.08	( 0.37 x 0.19 )
National roads	0.12	( 0.63 x 0.19 )
Régional roads	0.14	( 0.71 x 0.19 )
Collector roads	0.15	( 0.78 x 0.19 )
Municipal roads	0.14	( 0.74 x 0.18 )

- A typical kilometer of *National Road* cost 10 000\$ per year to maintain. The reduced life expectancy of 12% means a minimum annual overcost of 1200 \$ per km

Dp = Damages during SLR period

## Damages not related to heavy vehicles

DEGRADATION

Exclusion of the km where  
 $\Delta IRI \geq 2$ :

AUT	3.5 %
NAT	11.2 %
REG	21.6 %
COL	20.1%

trucks

climate

construction

materials

time



# Actual maintenance cost of the pavement network

Class of road	Cost (k\$ / km / year)	
	LCCA	PMS
Highways	14,5 à 18,1	<b>14,5</b>
National	9,2 à 11,9	<b>9,7</b>
Regional	6,8 à 9,2	<b>4,4</b>
Collector	5,6 à 7,6	<b>5,8</b>
Municipal	9,5 à 12,8	<b>5,8</b>

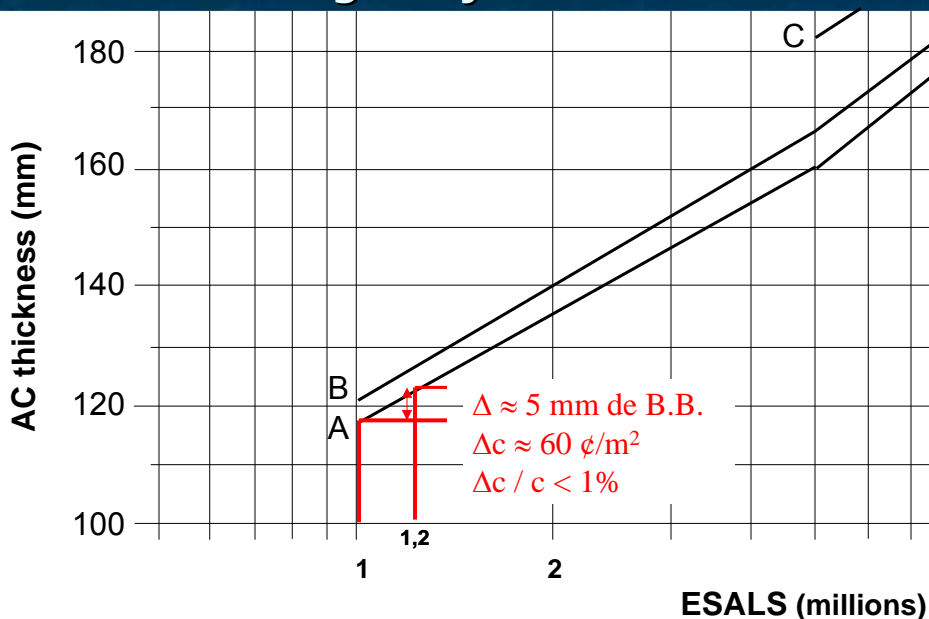
Network (km)	Cost (M\$ / y)
3 571	<b>51.8</b>
8 843	<b>85.8</b>
4 535	<b>20.0</b>
6 382	<b>36.9</b>
32 859	<b>190.0</b>

384.4

Municipal : **5,8** based upon values on collector roads  
PMS (Pavement Management System)

PMS costs from Jocelyn Beaulieu, ing. Service Orientations stratégiques

## Design adjustments



## If We Remove Spring Load Restrictions (SLR)

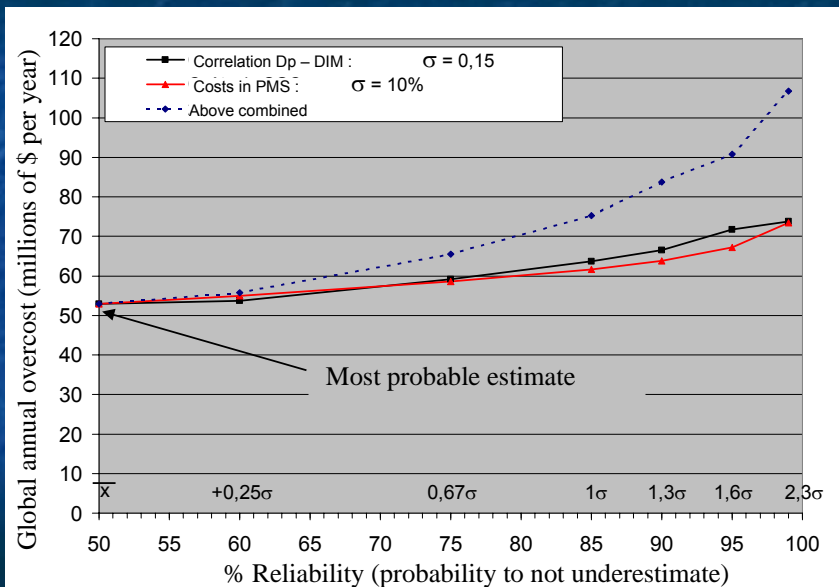
**MTQ : 24.4**

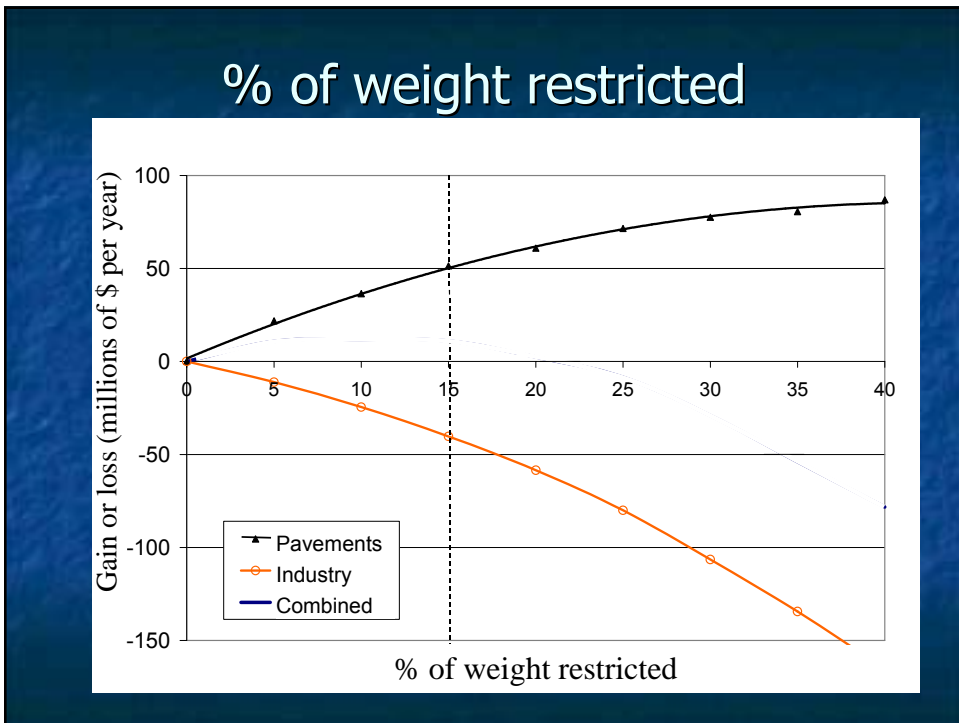
Highways : 4.2  
National : 11.5  
Regional : 2.9  
Collector : 5.8

**MUNICIPAL : 26.9**

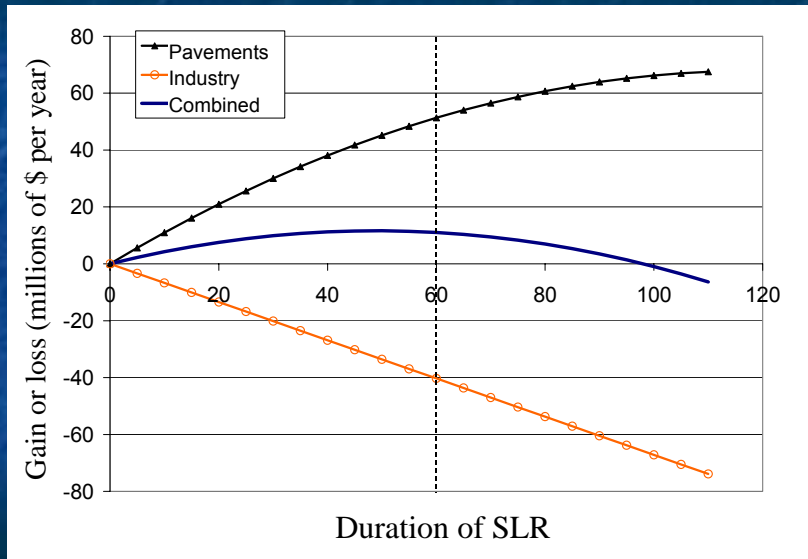
**TOTAL : 51.3 millions of \$**

### Sensitivity and reliability within standard deviation of data





## Duration restricted



## Annotations

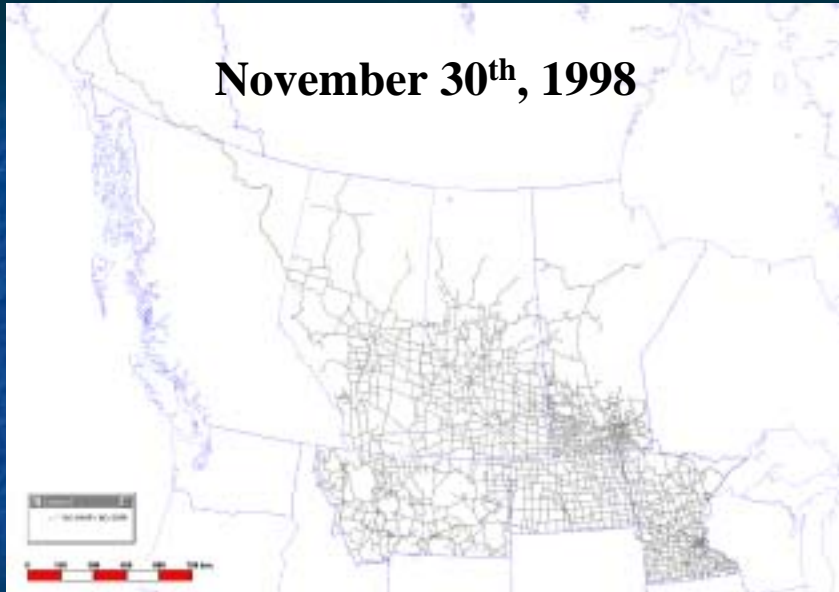
- Actual SLR are believed to provides at least about 50 millions of \$ per year to the public road administrations (+50 > -40)
- When comparing with the industry counterpart, the Status quo appear as the optimum homogeneous solution

# Heterogeneous approaches

## Examples

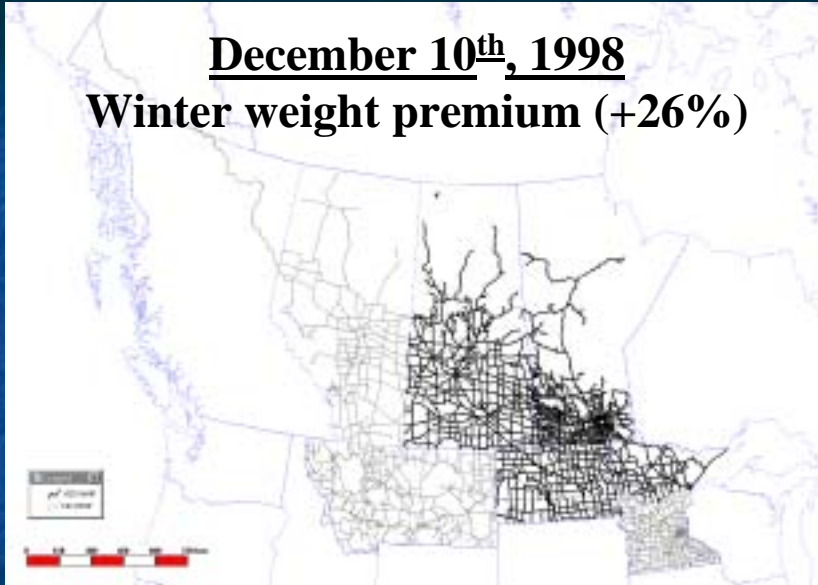
- Norway:
  - SLR : 0 / 12,5 / 25 / 50 % (removed in 1995)
  - Road network divided in three class of permitted loads all year long: 6 / 8 / 10 metric tons
- West of North-America (Canada – USA)
  - One slide per month from November 30<sup>th</sup>, 1998 to July 1<sup>st</sup>, 1999.

**November 30<sup>th</sup>, 1998**



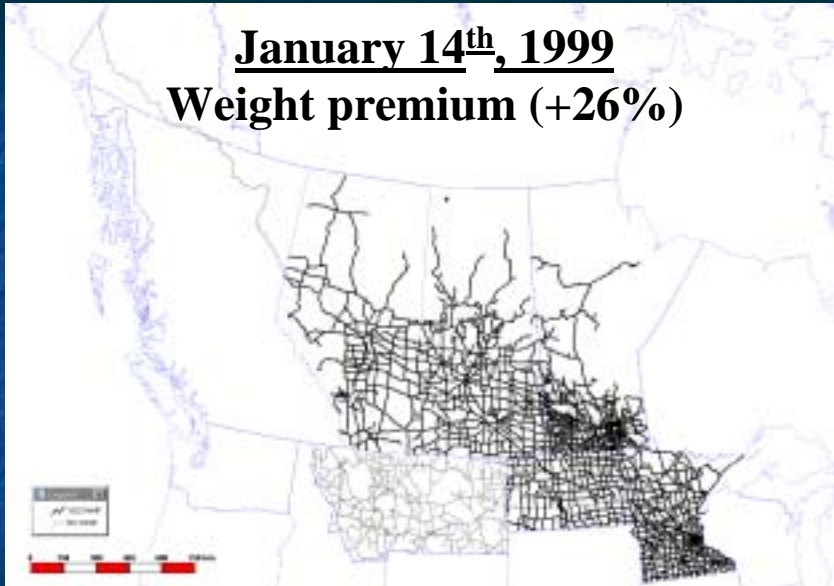
From McLeod, D.R., D. Palsat and A. Clayton (TAC, 2002)

**December 10<sup>th</sup>, 1998**  
**Winter weight premium (+26%)**



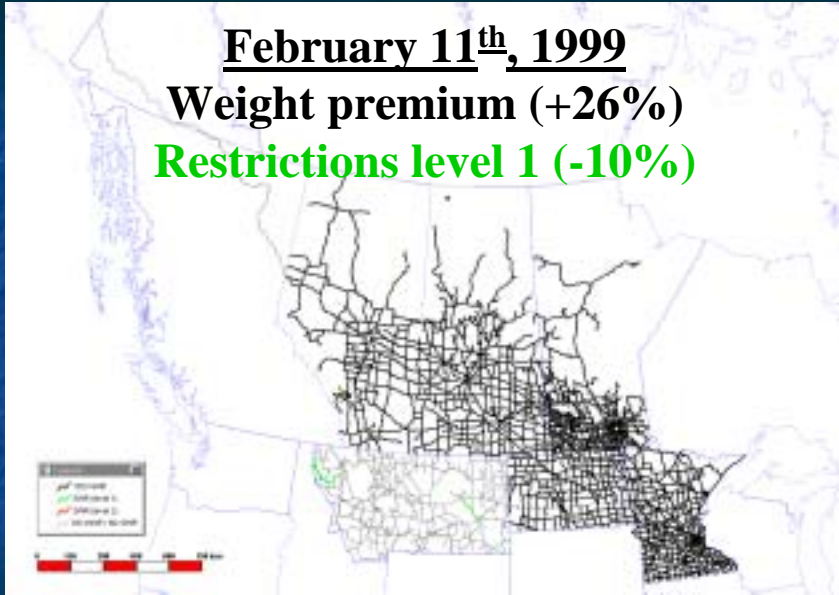
From McLeod, D.R., D. Palsat and A. Clayton (TAC, 2002)

**January 14<sup>th</sup>, 1999**  
**Weight premium (+26%)**



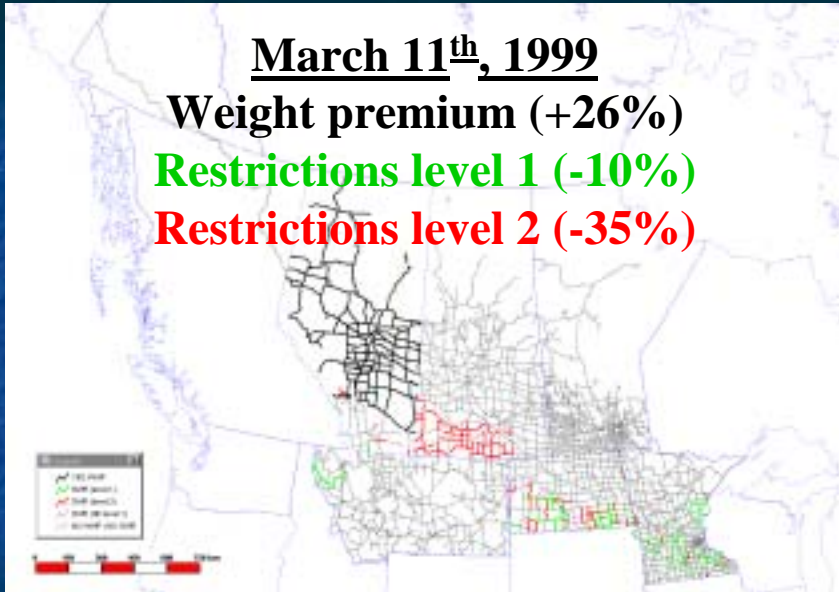
From McLeod, D.R., D. Palsat and A. Clayton (TAC, 2002)

**February 11<sup>th</sup>, 1999**  
**Weight premium (+26%)**  
**Restrictions level 1 (-10%)**



From McLeod, D.R., D. Palsat and A. Clayton (TAC, 2002)

**March 11<sup>th</sup>, 1999**  
**Weight premium (+26%)**  
**Restrictions level 1 (-10%)**  
**Restrictions level 2 (-35%)**

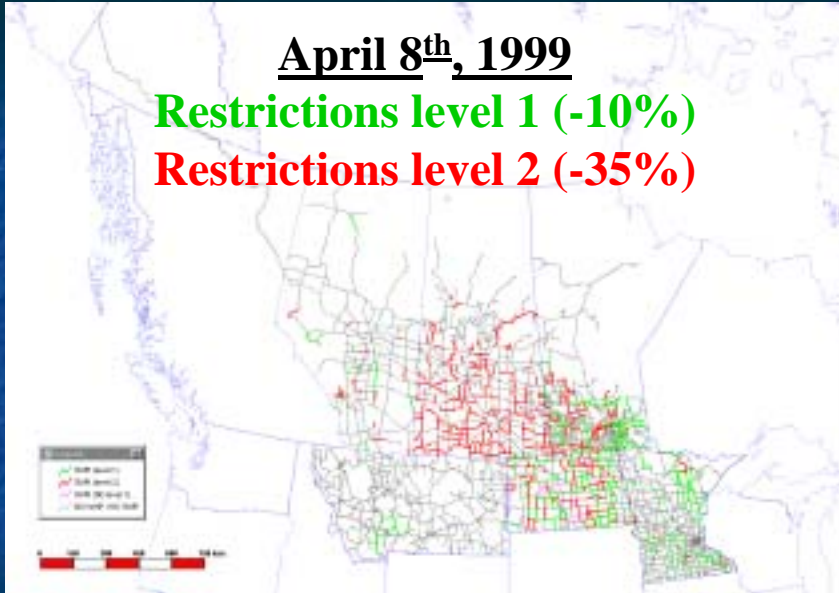


From McLeod, D.R., D. Palsat and A. Clayton (TAC, 2002)

**April 8<sup>th</sup>, 1999**

**Restrictions level 1 (-10%)**

**Restrictions level 2 (-35%)**

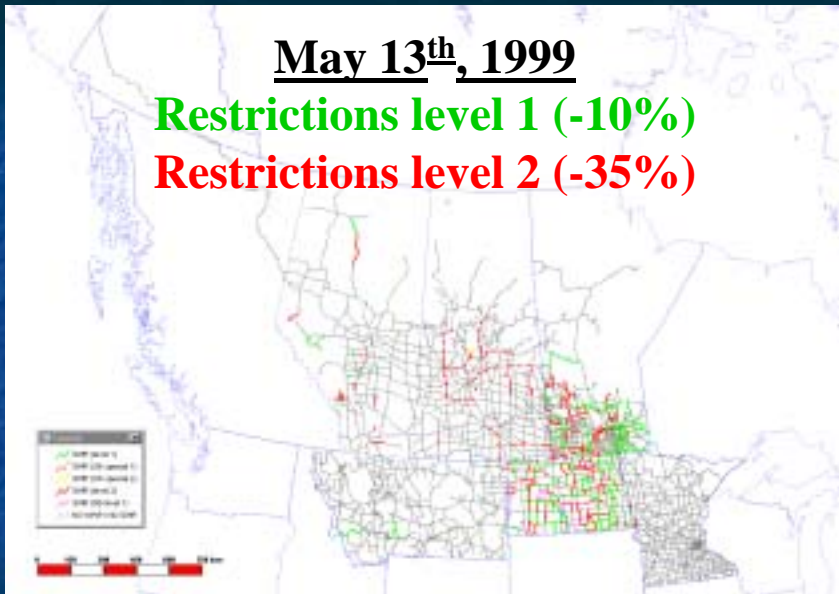


From McLeod, D.R., D. Palsat and A. Clayton (TAC, 2002)

**May 13<sup>th</sup>, 1999**

**Restrictions level 1 (-10%)**

**Restrictions level 2 (-35%)**

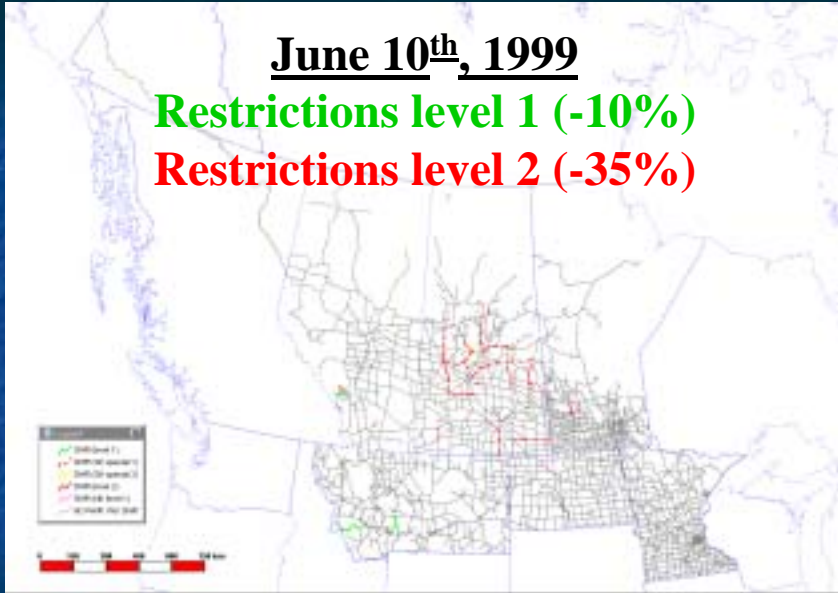


From McLeod, D.R., D. Palsat and A. Clayton (TAC, 2002)

**June 10<sup>th</sup>, 1999**

**Restrictions level 1 (-10%)**

**Restrictions level 2 (-35%)**



From McLeod, D.R., D. Palsat and A. Clayton (TAC, 2002)

## Heterogeneous approaches

- Some problems remains
  - Enforcement
    - Complicated to adequately practice
    - Actual enforcement scales mostly on highways
    - Increased risk of contravening
  - Needs extensive, network level, monitoring of pavement bearing capacity (deflections)
  - Needs harmonisation of a set of predetermined itineraries
    - Each trucks need to use local roads « *before going in* » and « *after going out* » of highways
    - Carefull study needed in order to avoid showing favouritism or being prejudicial to individual interests
  - Increasing restrictions on local roads leads to reduced efficiencies due to unavoidable exceptions (busses, vehicles of public utilities ...)

# Restrictions hétérogènes

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- Problèmes subsistants:
  - Gestion et contrôle des charges
    - Plus complexe à appliquer
    - les stations de pesage sont surtout sur les autoroutes
    - Risques accru de contrevenants
  - Nécessité d'une auscultation soutenue de la portance sur tout le réseau
  - Nécessité d'harmoniser les principaux itinéraires
    - Les camions doivent utiliser une route secondaire pour entrer et sortir des autoroutes
    - Étude minutieuse requise pour éviter des injustices entre les différents intérêts individuels des entreprises
  - Des restrictions accrues sur les routes locales veraient leur efficacité réduite à cause des exceptions inévitables (autobus, véhicules d'utilités publiques, ...)

## CONCLUSION

- Homogeneous restrictions are recommended ...  
until the developpement of acceptables solutions  
against the shortcommings of the heterogeneous  
approach
  - Enforcement more realistic in practice
  - Ensure the same justice for all
  - Status quo appears the optimum homogeneous solution
  - Maintain status quo until further notice
  - Consult all the partners (municipalities and counties, road enforcement services, shippers and industry, other entity concerned).

