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Creating forest sector solutions

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Why TPCS?
Why Now?

Low Impact Vehicles and TPC
Stirling. June 23, 2010

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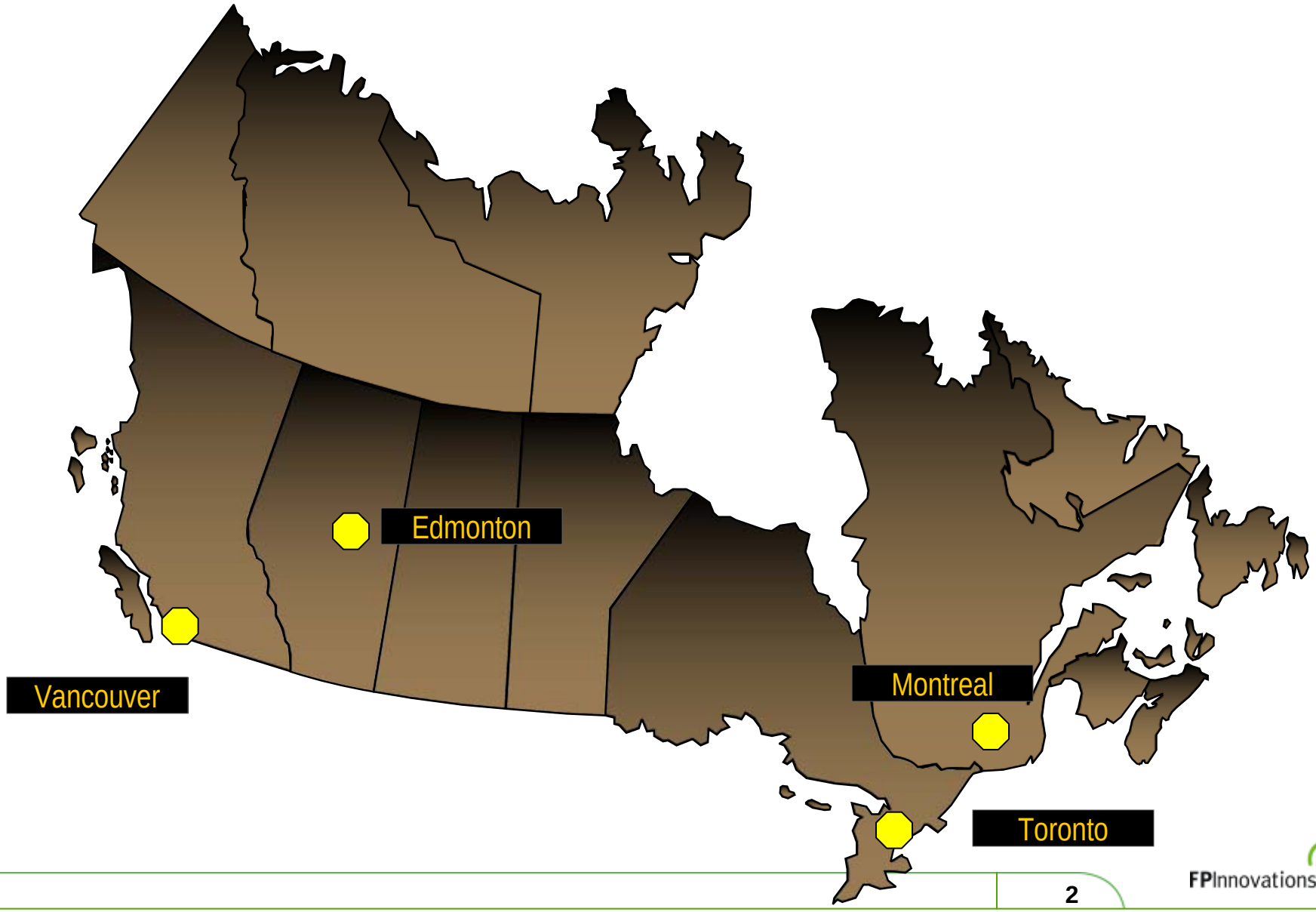
Senior Researcher, Roads

Where we call home



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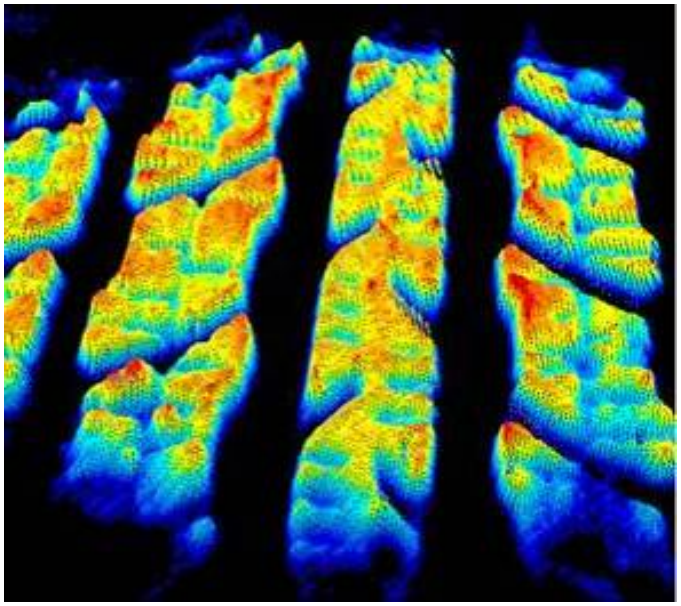
Outline

- CTIS to TPCS
- Variable tire pressure principles
- VTP and roads – research highlights
- Government TPCS Initiatives
- Why TPCS? Why now?



CTIS to TPCS

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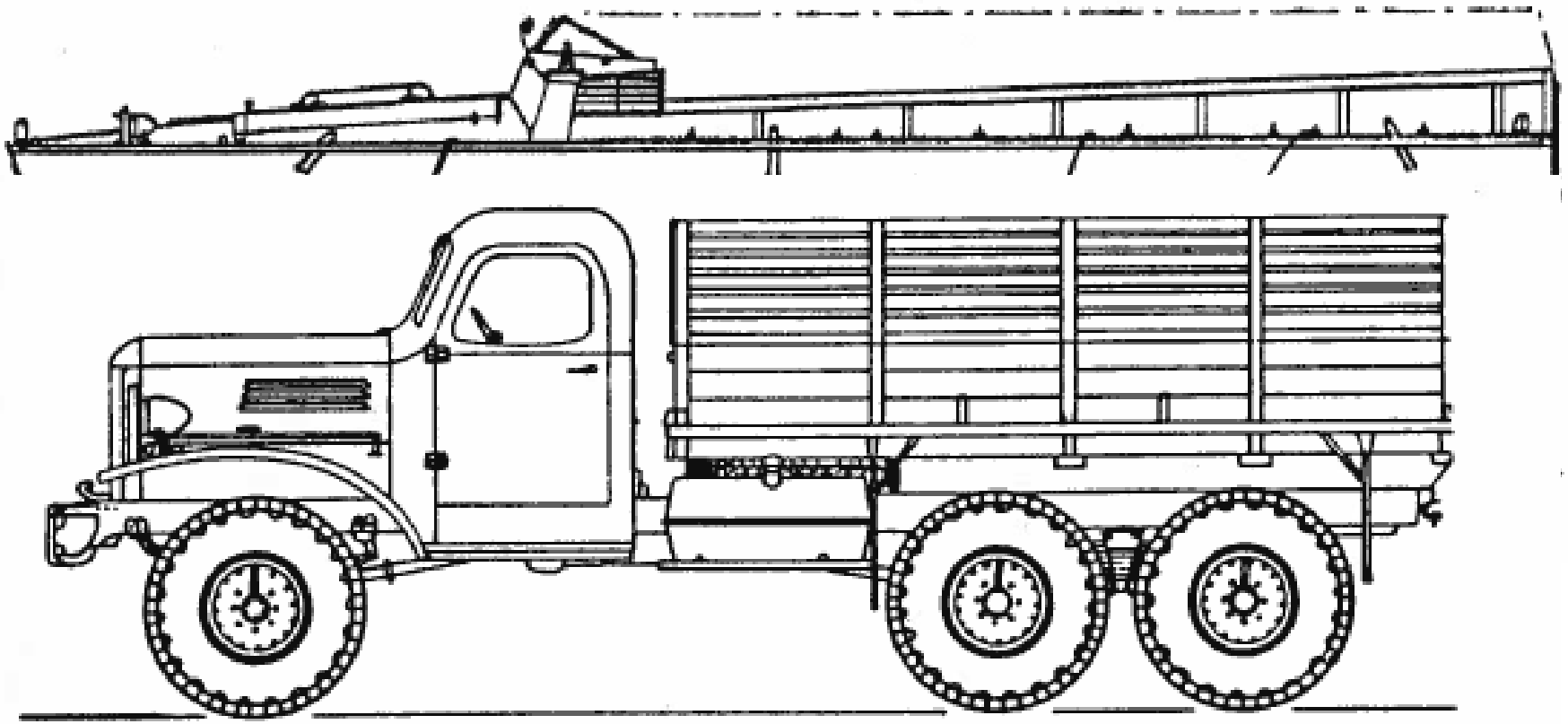
Development of CTI Systems

- 1942 US amphibious landing craft.
- 1950 US prototype truck with internal axle



Development of CTI Systems

- 1942 US amphibious landing craft.
- 1950 US prototype truck with internal axle seals.
- 1944-1960 Soviets develop internal axle seals and adapt CTI to trucks; widespread use.
- 1960-1970 widespread use by Warsaw Pact; adapted to log truck, oilfield transport; airplanes; developed CTI-ready tire designs.

Development of CTI Systems

- US desert ambitions fueled re-adoption of CTI in 1980s; reverse engineered and redesigned for modern trucks and technologies
- Widespread adoption by US and western European militaries in 1990s;
- By 1990, 30+ types of CTI used around world

- In 1982, USFS began CTI research program; applied to various forestry vehicles
- In 1993, first two TPCS for commercial trucks

Soviet VTP tires

- but…shorter life

VTP tires used by the US military

Michelin XL

Goodyear AT-2A

Michelin XS

TPCS

Like CTIS, TPCS allow operational use of VTP.

TPCS were developed to meet the specific needs of commercial trucks.

Development of TPCS

SAE Recommended Practice for CTI System Performance Requirements (1993 DRAFT)

CTIS (TPCS) should allow for:

- Adequate air drying capacity
- Isolate leaking tires and manual re-inflation
- Operation under extreme service conditions
- Readily understood display, with audible and visual warnings in case of speeding or low air
- Air brake priority over CTIS (TPCS)
- Pressures/ speeds/ loads as per Tire &Rim A.
- Reach 80%/ 100% of target in 5/ 15 minutes
- 10% or 3 psi accuracy

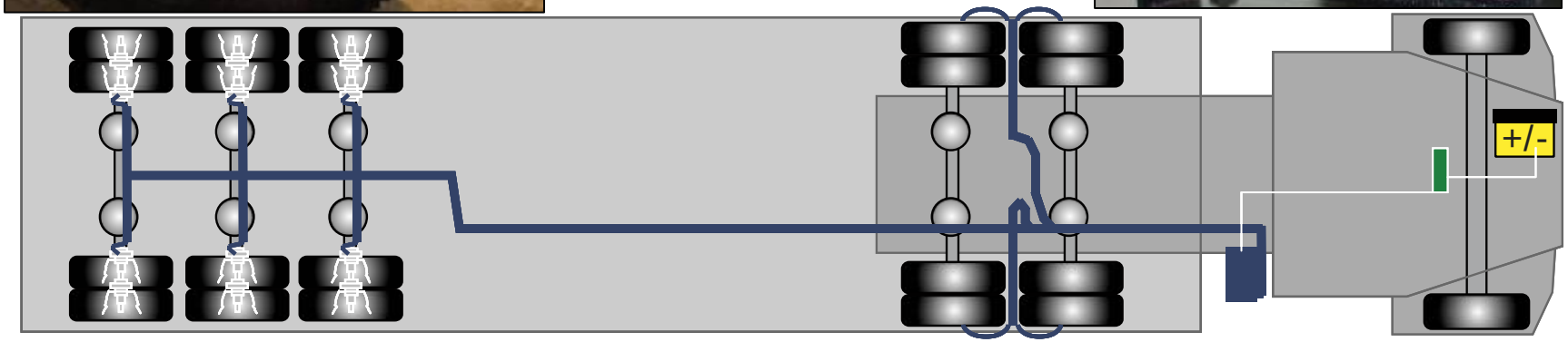
Development of TPCS

Additional design elements developed through field testing or required by regulators

TPCS should include:

- 75%/100% of target in 15/ 25 minutes
- Auto inflate in case of speeding
- Pre-programmed inflation mode settings based on tire manufacturers' recommendations (TRA)
- Allow for normal heat build-up with tire operation (e.g., +10-15% (<15 psi))
- Only flexible, air brake quality, elements extend past width limit
- Ability to be monitored by OBC (optional)

TPCS components



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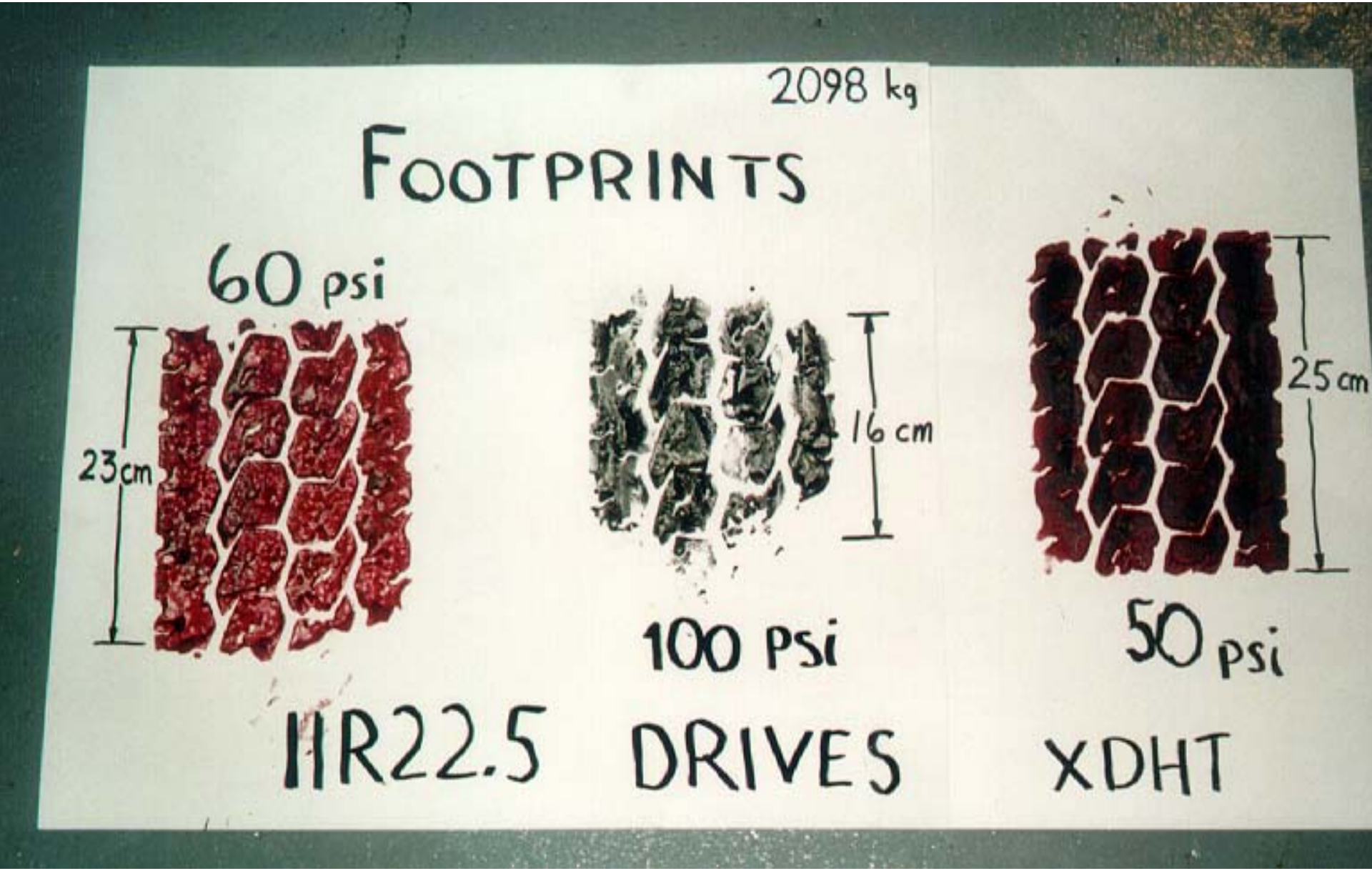
Over 1000 TPCS in use in Canada

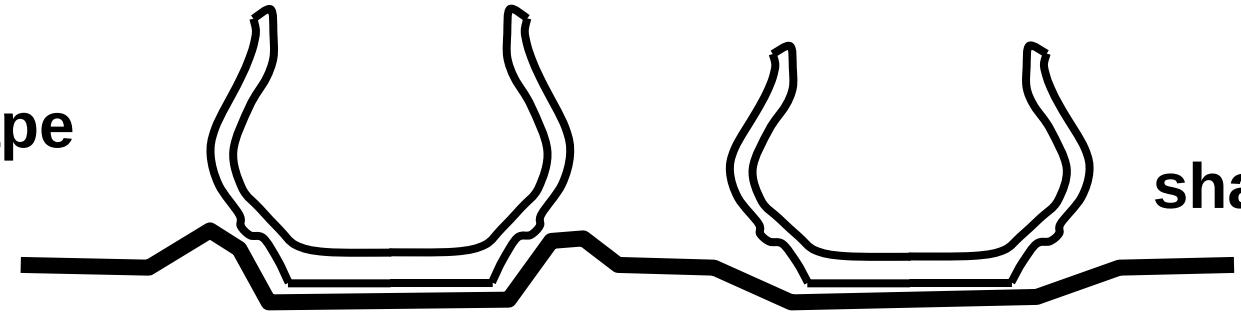
Variable tire pressure principles

Inflation changes footprint size and shape



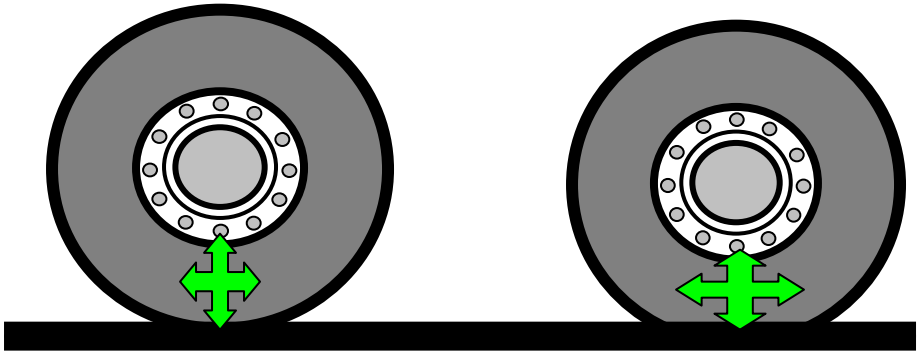
Reducing tire pressure causes fundamental changes to the tire-road interaction

Rut shape



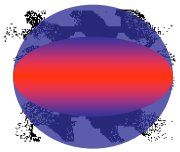
Wider, shallower rut

Stiffness and spring rate

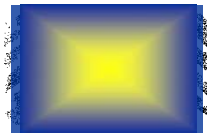


Less impact energy

Contact area

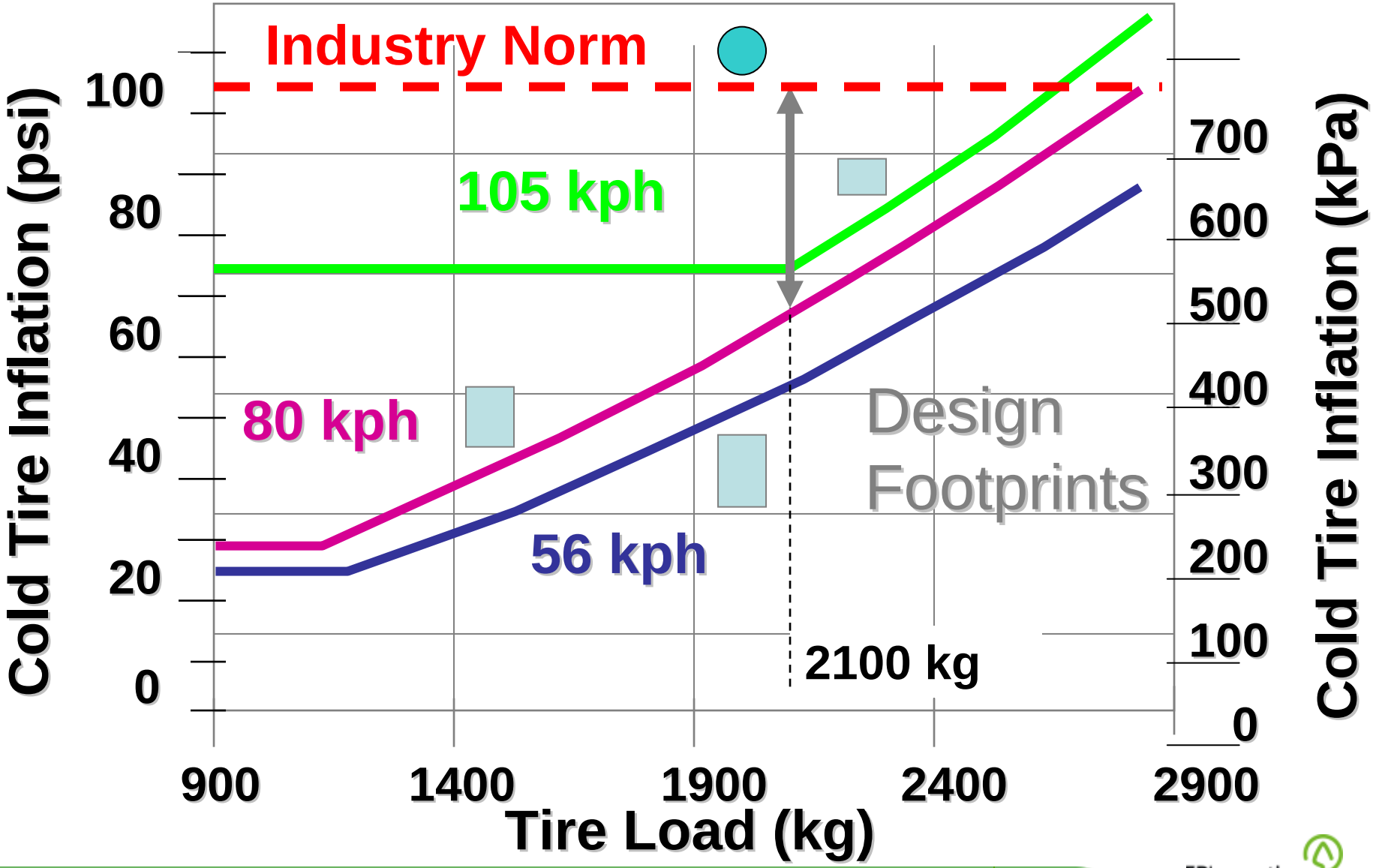


Contact stress distribution



Lighter footprint, more tread

Truck tire load/ speed/ inflation



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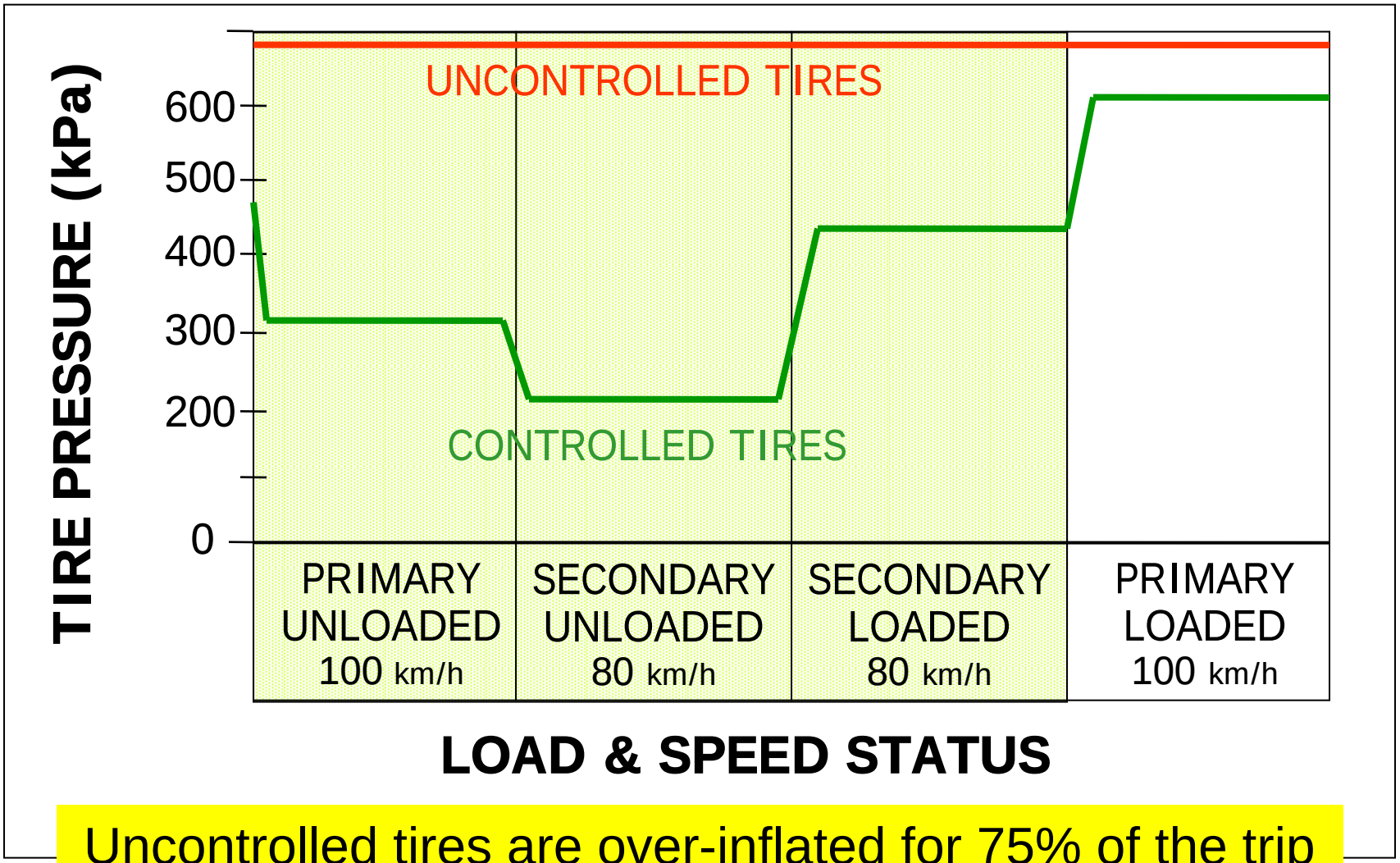
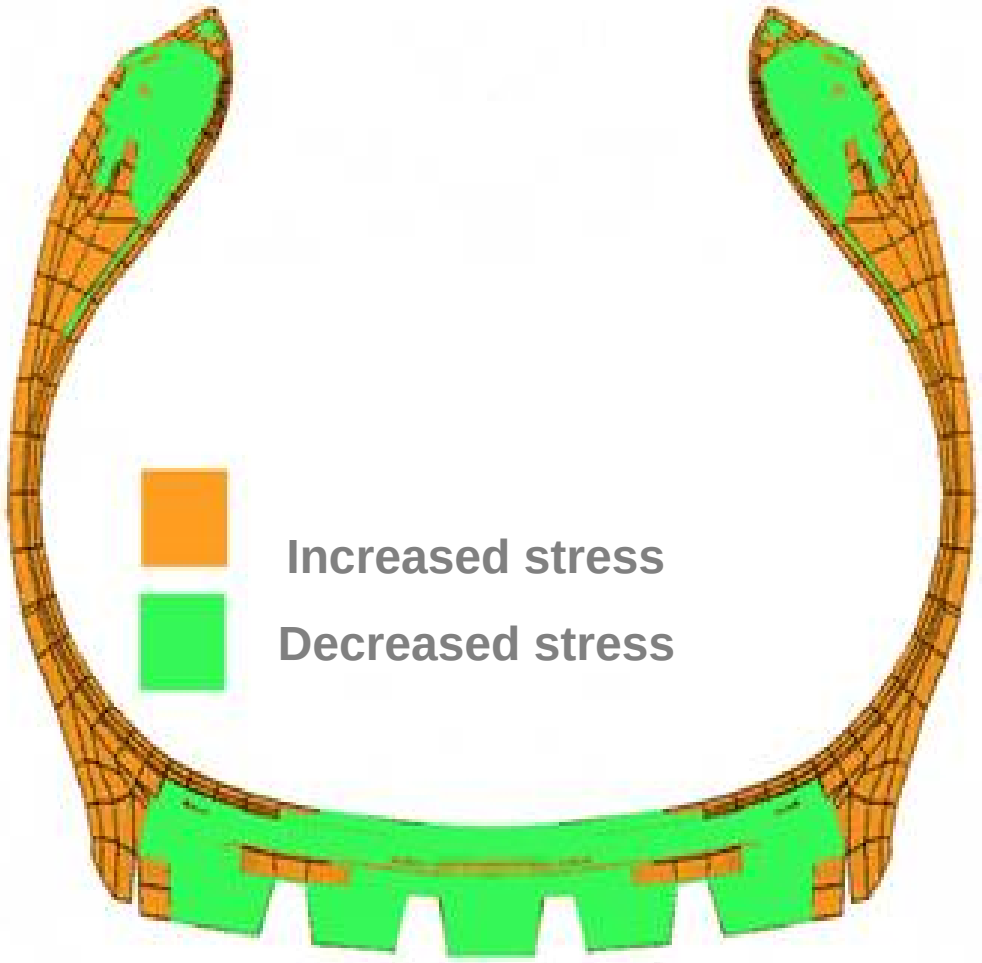
Typical resource road hauling



Uncontrolled tires are over-inflated for 75% of the trip

Changes in tire stress with low pressure



Source for next 4 slides:

Randy Clark, Michelin Tire
SAE Paper 933059

620 kPa → 350 kPa. (Load 1930 kg)

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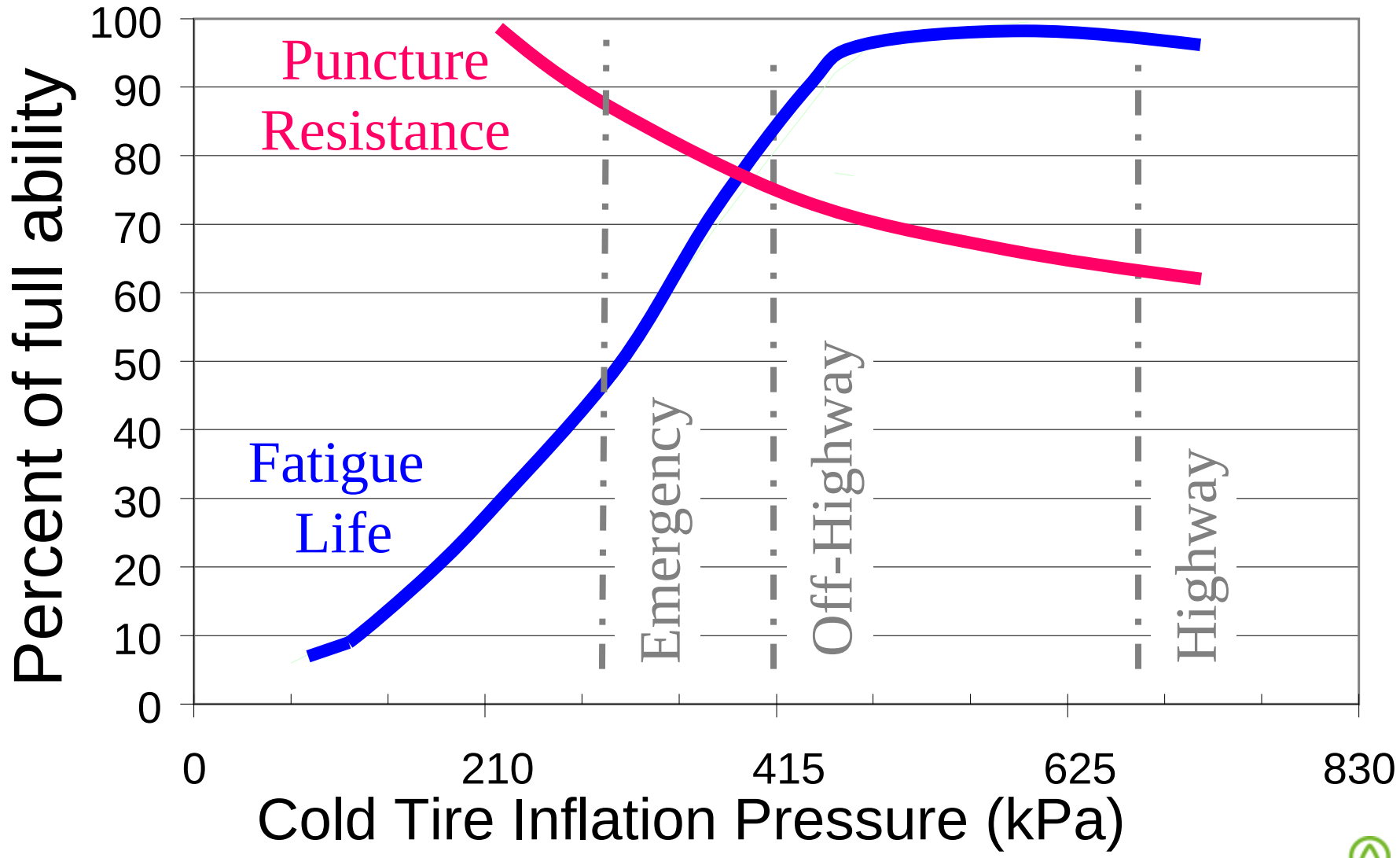
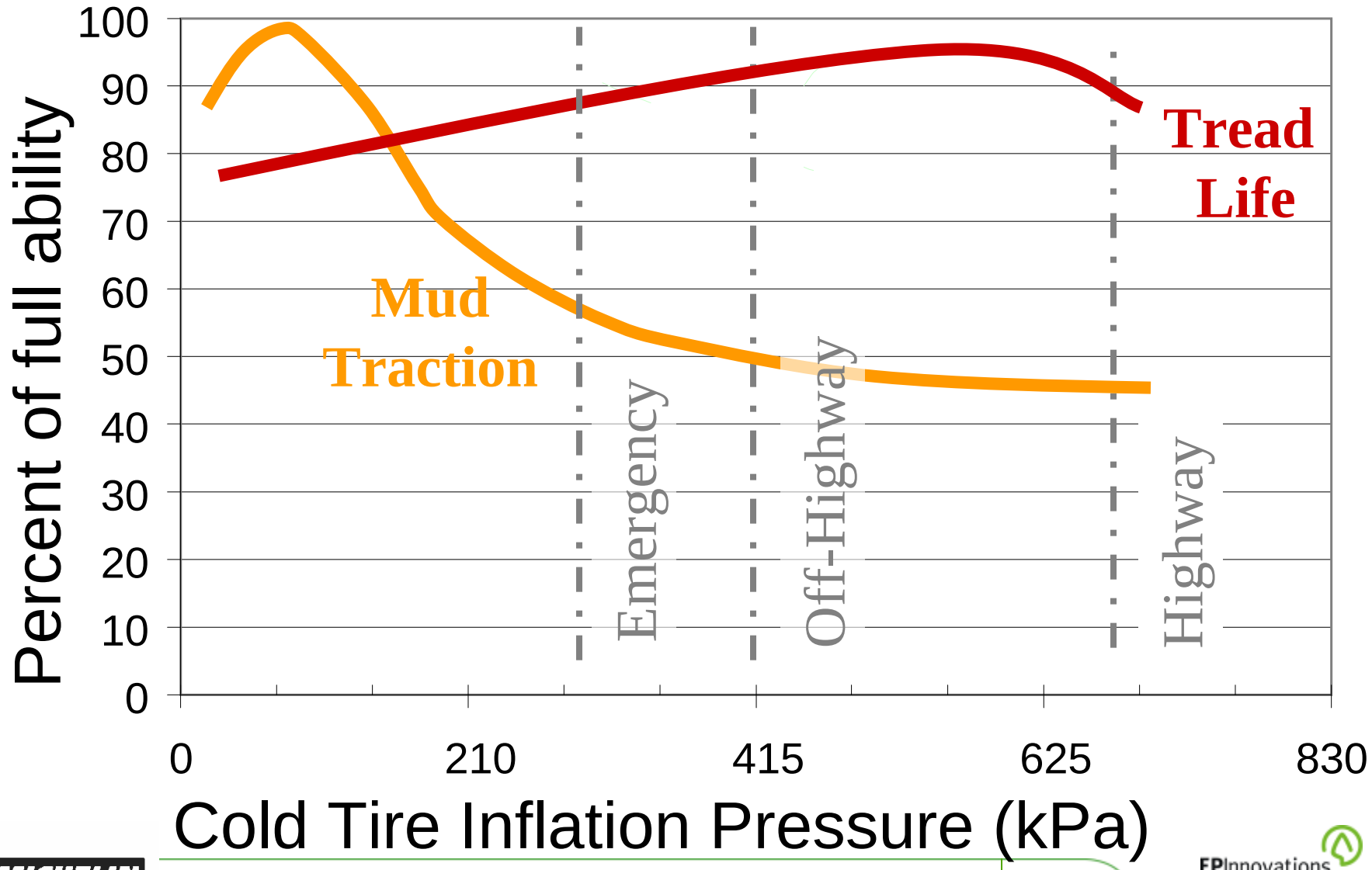
Puncture resistance and fatigue life



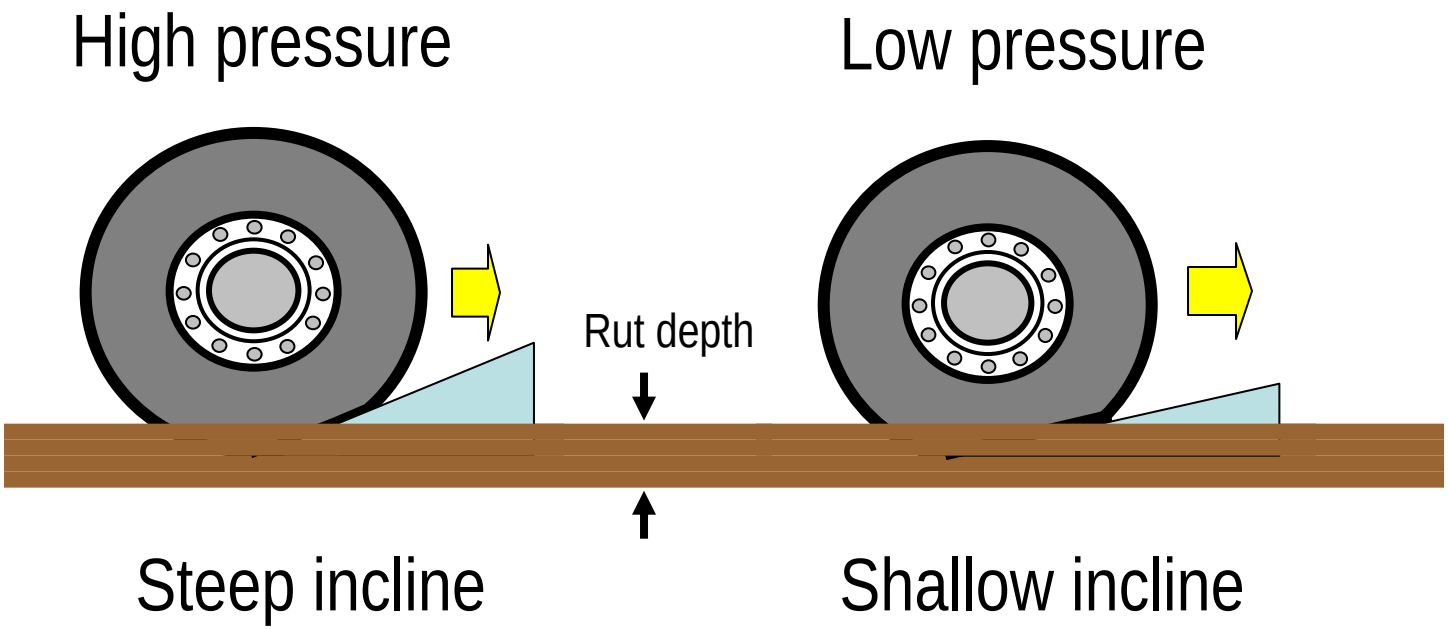
because road hazards come in many forms

Mud traction and tread life



Motion resistance – incline effect and tire pressure

Two tires with same load, rut depth, tire size



Lower pressure has less motion resistance

reduced inflation might have helped…

…but it won't let you walk on water

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What is possible with reduced inflation?

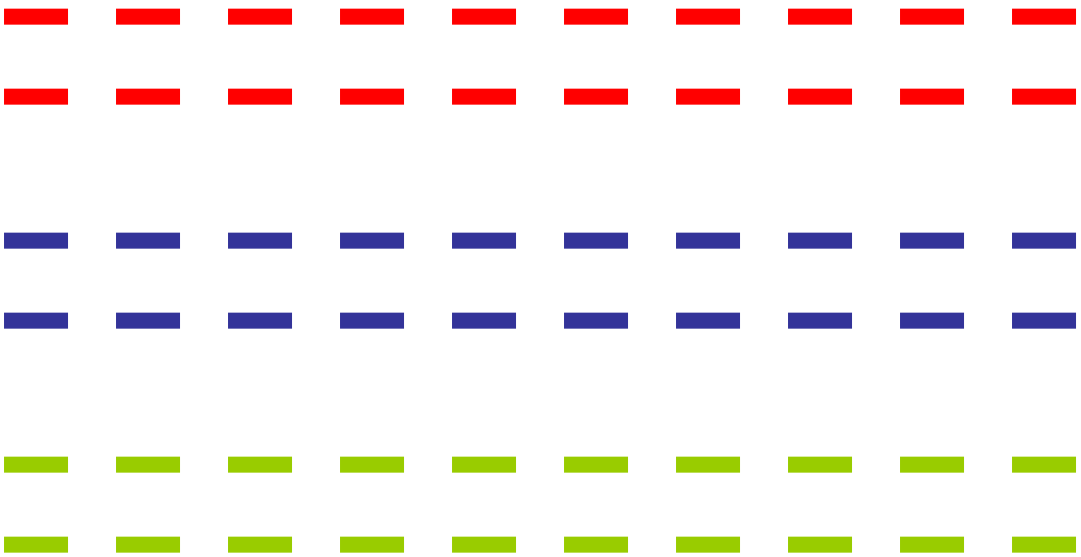
Road surface	Highway inflation (kPa)	TPCS tire pressure (psi)	Measured tractive increase
Loose gravel*	610	210	42%
Sugar sand	690	450	34%
Wet clay	690	450	17%

** Less or no tractive hop at reduced tire pressure*

Getting unstuck from sand

Reduce tire inflation and rock to & fro

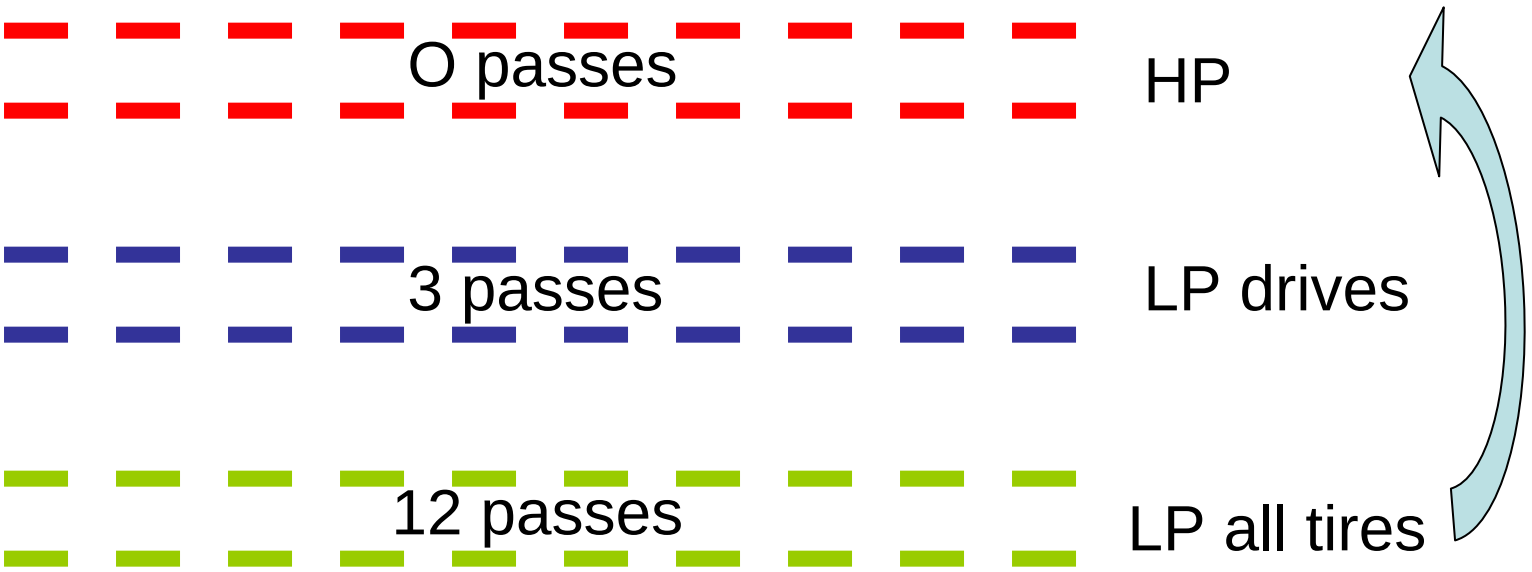
TPCS soft ground mobility demo



TPCS soft ground mobility demo

Trailer tires strongly influence truck mobility

TPCS soft ground mobility demo



Climbing steep grades when unloaded


Climbing steep grades
when loaded

VTP and roads - research highlights

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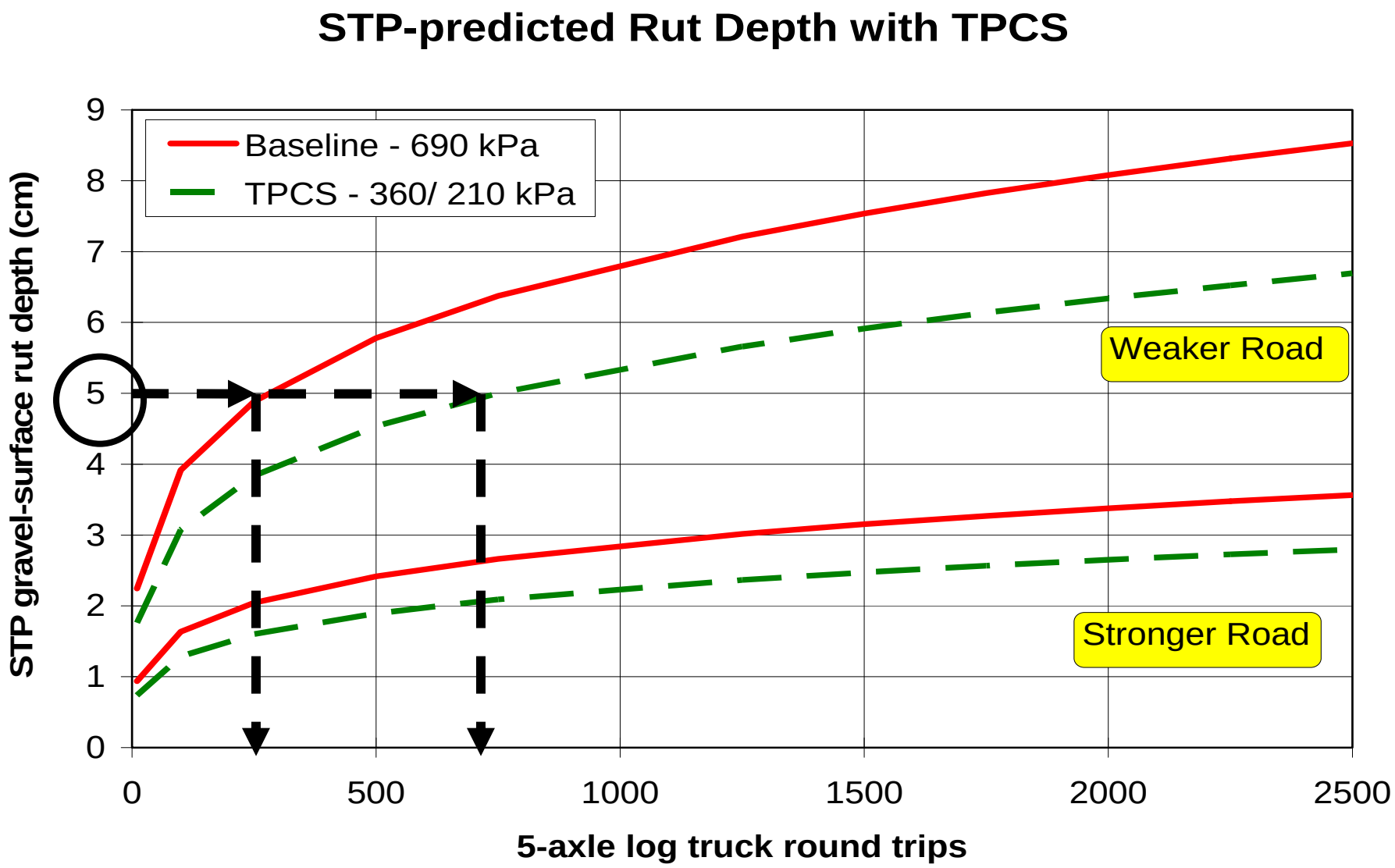
Summary of USFS findings (1982-2002) on variable tire pressures & resource roads

- Enhances traction and mobility under steep or slippery conditions
- Slower rutting rate – especially on very weak roads and for low traffic volumes. Wider, shallow ruts
- Less gravel loss (less dust control & re-gravelling)
- Reduces pot holing and washboard
- Heals existing damage (ruts and washboard)
- Reduces or eliminates maintenance grading
- Less environmental impact (sediment & erosion, dust)
- Reduces structural requirements (thinner base)

Surfacing Thickness Program (USFS)



Norwegian Road Authority research into reducing damage to county roads

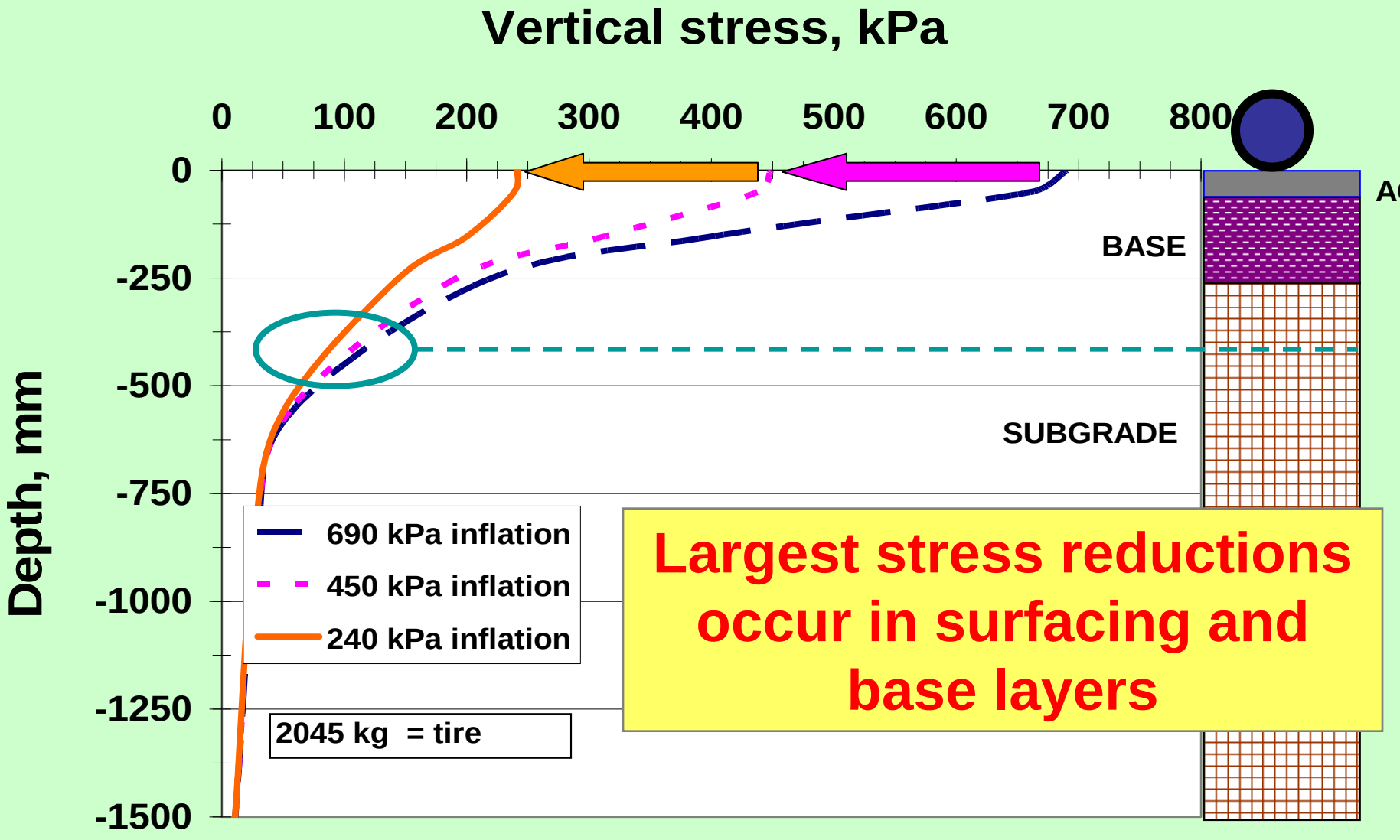
Spring thaw problems on county roads are mostly due to fines in the road base rather than base thickness.

In order to reduce overall road deterioration in the spring-thaw period, NRA recommend using:

- lighter axle weights
- dual tire assemblies in place of single tires
- lower tire pressures ***
- reduced travel speeds
- night operations (to take advantage of night frost)

****estimated to have the greatest impact*

Vertical stress distribution in a low standard road using layered elastic theory



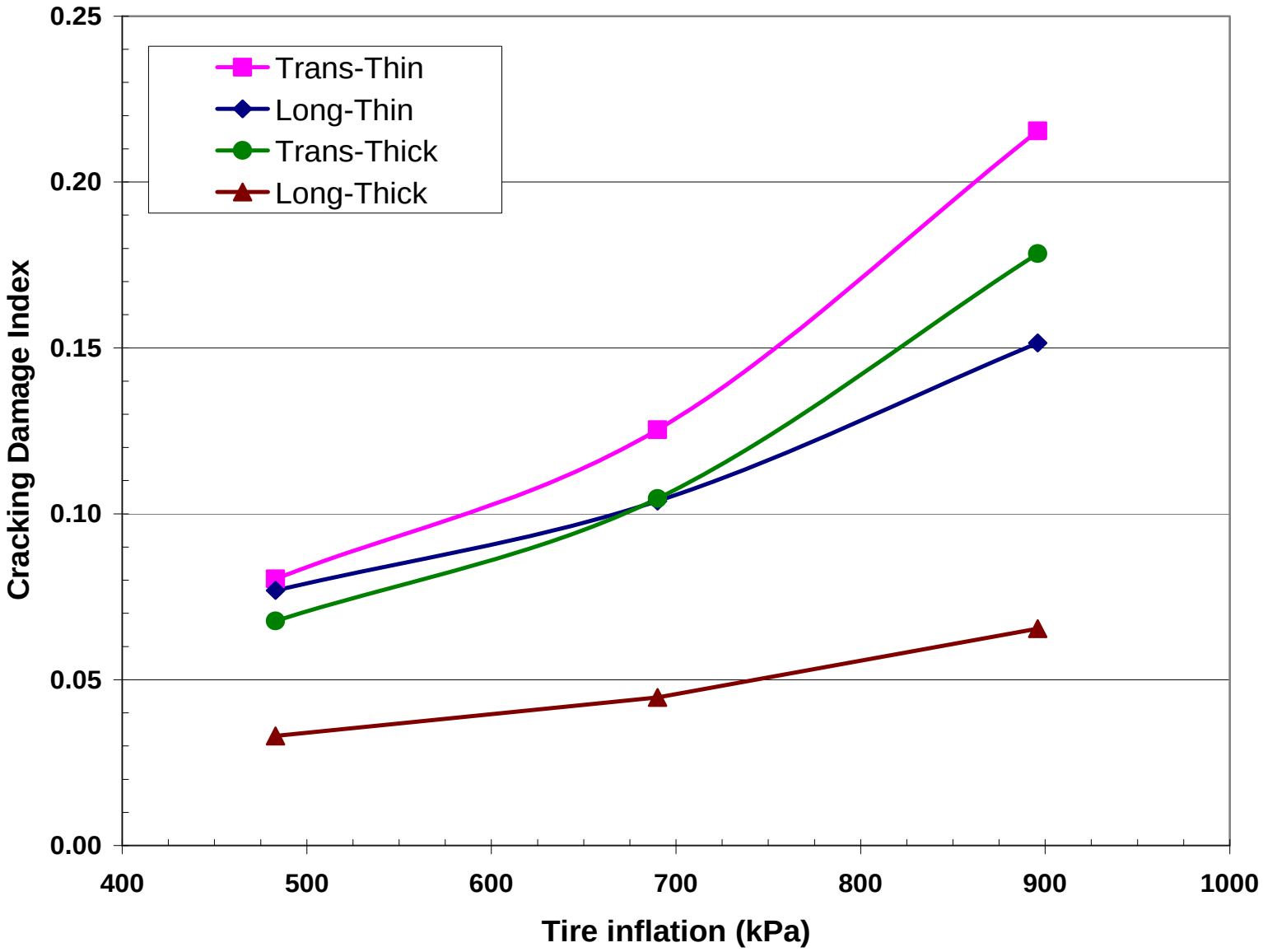
Inflation pressure and pavements literature

- Many studies on inflation pressure in the literature.
- Most studies are for pressures > 518 kPa but radial truck tires increase footprint rapidly below 345 kPa (50 psi).
- Layered elastic modeling predicts smaller strain reductions in thicker and stiffer A/C pavements.
- Thick A/C are less susceptible to fatigue cracking than thin A/C.

Effect of tire pressure on pavement strains

- Thin A/C experiences higher strains at the bottom of the mat than thick A/C.
- Transverse strains are more sensitive to low tire pressure than longitudinal strains but both respond.
- Steering tires create larger transverse strains than longitudinal strains; the reverse is true for dual-tired assemblies.
- Truck steering tires are fewer and have less pavement impact than the dual-tired assemblies, however, their impacts become more comparable at lower tire pressures.

Inflation and strains in thin and thick A/ C (Wang, Machemal 2006)



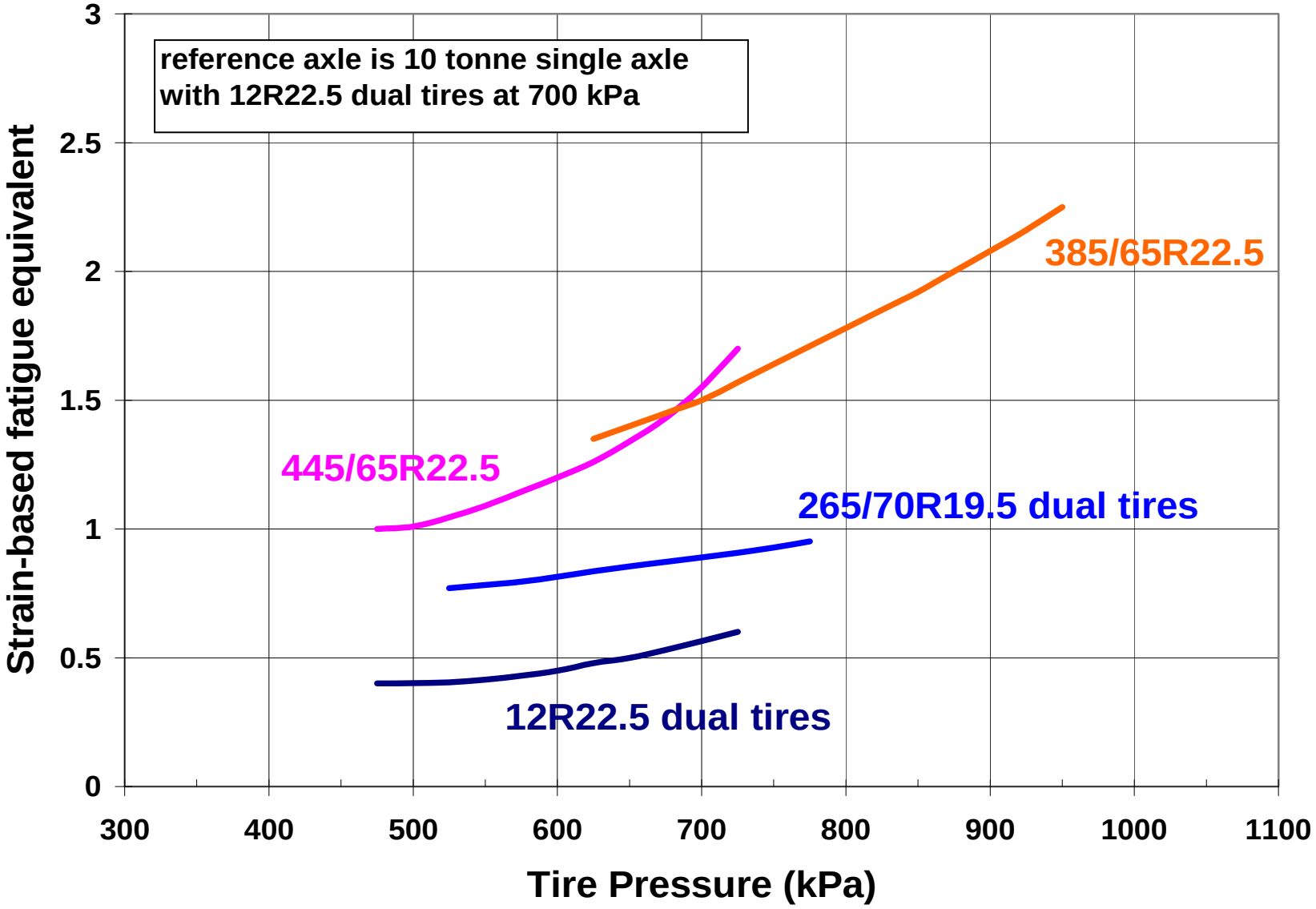
Preliminary results (U.Laval)

UNIVERSITÉ LAVAL
Faculté des sciences et de génie
Département de génie civil

Effect of tire pressure on pavement strains

Impacts of heavily loaded single tires could be reduced with lower pressures

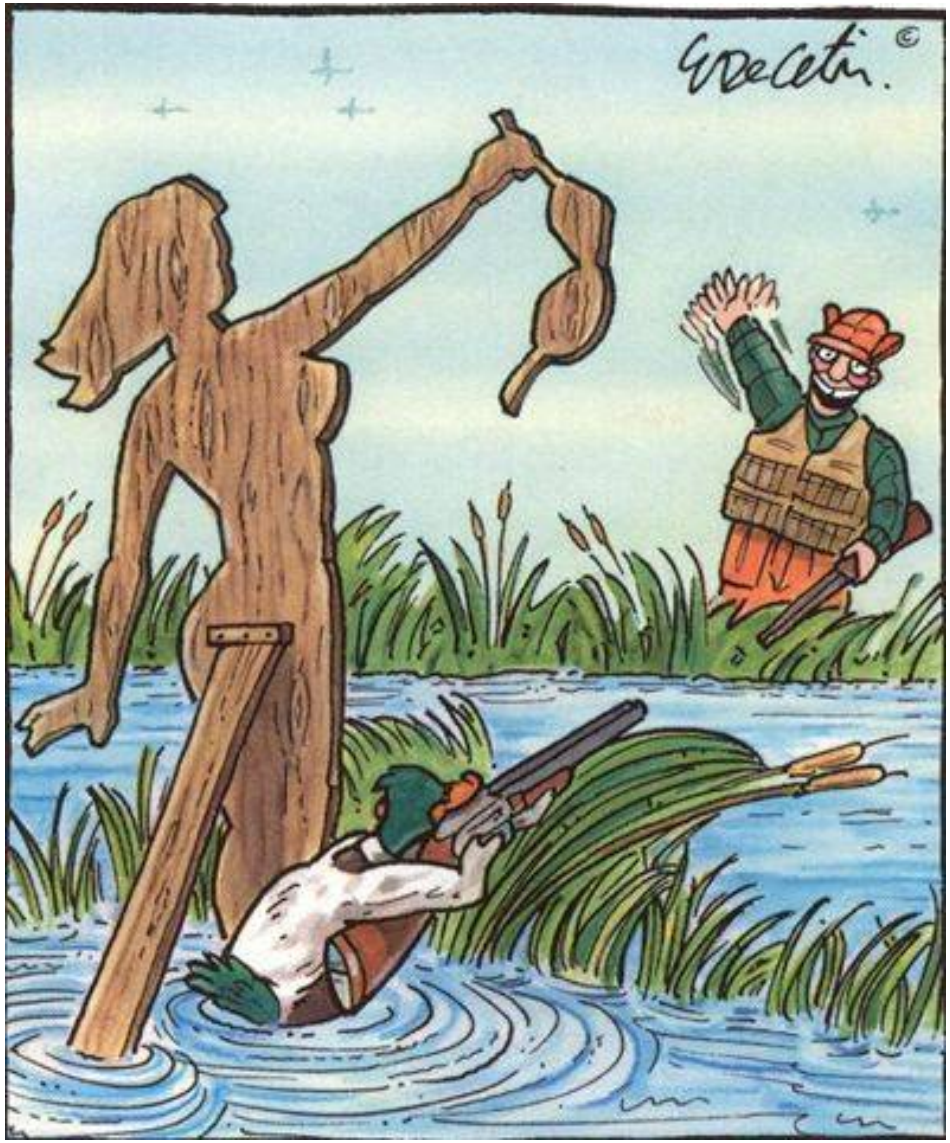
Tire pressure and pavement life (Huhtala 1989)



Effect of tire pressure on dynamic loading

- Truck dynamic axle loadings = 2 to 14x static loadings at rough spots on A/C depending on suspension, speed, bump size, load, etc. (Cebon 1993).
- Damage propagates from these rough spots.
- 200 kPa tires imparted 1/6 vertical energy of 690 kPa tires on smooth pavement and 1/7 on 5 cm-high washboard (NATC 1987).
- Lower tire pressures transmitted 38-43% smaller RMS accelerations and noticeably improved ride of Montreal bus (Rakheja and Wang 2006).

Government TPCS initiatives



Some are skeptical about government initiatives…

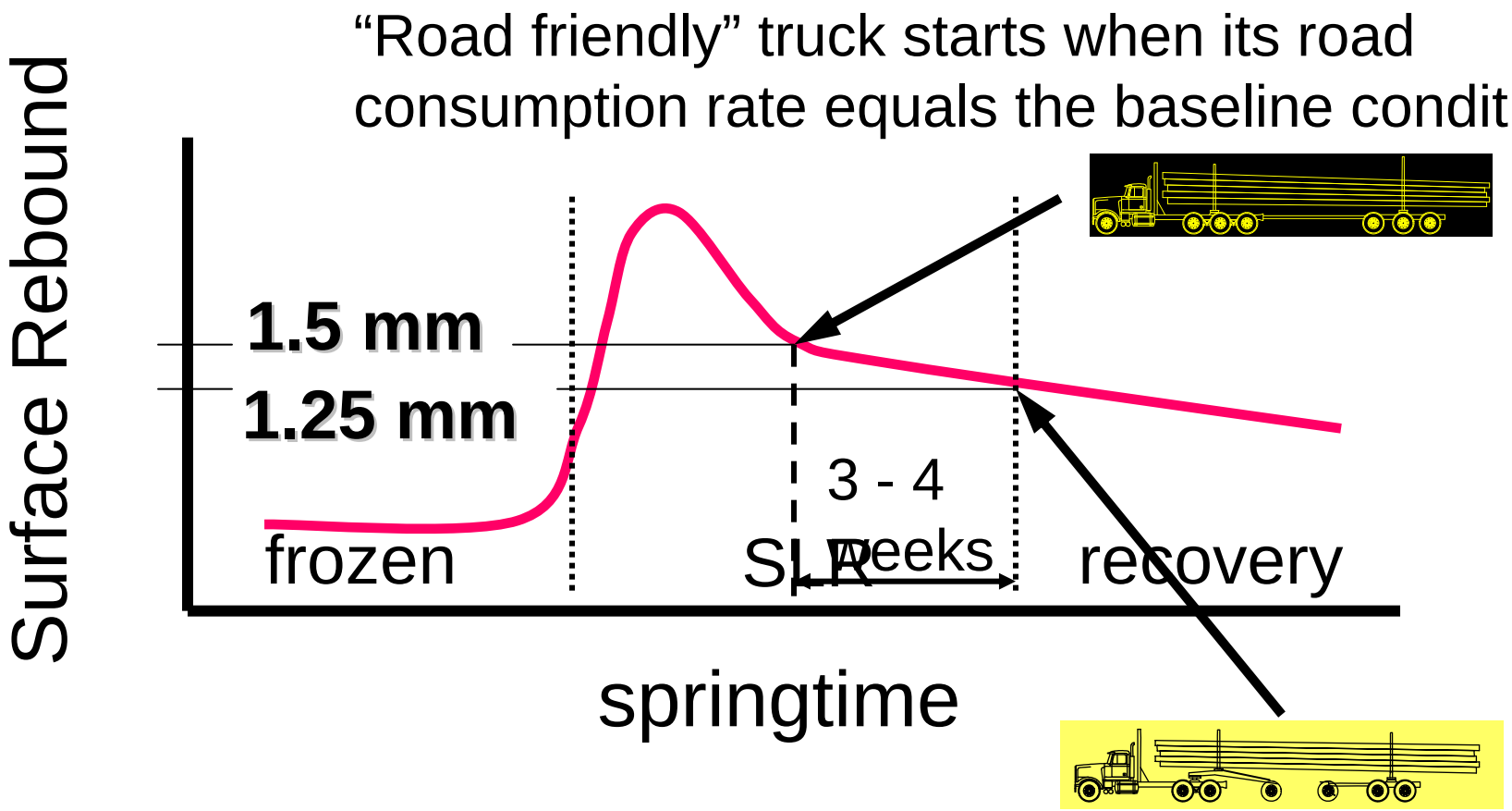
Saskatchewan Transportation Partnership Program recognizes TPCS

- First jurisdiction in North America to promote TPCS use on secondary highways (1998).
- TPCS trucks can haul primary highway weights on secondary highways with no incremental road damage fees (*for approved routes and with applicable monitoring*).
- TPCS-trucks permitted heavier SLR weights.

British Columbia TPCS SLR initiative

- TPCS Spring Hauling Initiative (2004) exempts TPCS-equipped trucks from spring load restrictions on approved routes.
- Truck-based data logger gathers route, speed and tire pressure info that is reported with measured axle weights. Trip info is decrypted, summarized in a compliance report, and posted to a secure website within 3 minutes.
- Program is open to all industries with forestry leading this initiative.

Reduce tire pressure - not payload!



Road consumption rate from "road unfriendly", legal truck at end of SLR period is the baseline condition

Ongoing TPCS SLR initiatives

Ontario government and forest industry start an industry-managed TPCS-SLR Haul Program in spring 2011.

- Industry association audits and manages participants and negotiates with government.
- 3rd party consultant documents road changes.
- Applicant responsible for repair costs of accelerated road damage.

Ongoing TPCS SLR initiatives

- Manitoba government, FPInnovations, and U.Manitoba and U.Laval working with instrumented pavements to evaluate VTP effects.
- Targeting introduction of TPCS-SLR initiative in 2011.
- Modeling to assess reduced incremental road damage fees for TPCS trucks in Manitoba TIPP.

TPCS SLR policy progression in Canada

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Why TPCS ? Why now?

Driving forces for industry

- Need for more traction with increasing trailer size and payloads.
- Need for enhanced mobility and reduced rutting for summer operations; combined with poor drainage, lack of gravel, heavy payloads.
- Drive to reduce inventories (especially in spring).
- Government initiatives of road-friendly trucks.
- Need for more stable wood flows.
- Need to access timber in sensitive habitat areas.

Additional benefits

- Reduced flats and tire damage, and downtime.
- Longer tire life and improved recapping success.
- Fewer stuck trucks and related recovery costs.
- Less vibration-related damage to driver and truck.
- Increased truck productivity and revenue.
- Better working conditions and driver retention.

Fuel efficiency – FPInnovations (2005)

	Laden	Unladen
Class 1&2 gravel road	+2%	+7%
Class 1&2 gravel road	+2%	+5%
Soft in-block roads	+30%	+14%

** Measured with formal SAE test procedure*

Implementation strategies are keys to success

- All stakeholders can benefit:
  - vehicle owners/ contractors/ drivers
  - forestry companies
  - traveling public and road regulators
- Strategies and tools have been created to assist with successful implementation.
- Develop champions and address stakeholder resistance, optimise TPCS use, build a business case, change operations and policies to capitalize on new abilities.

Recap

- Contact footprint, contact stresses and sidewall stiffness (i.e., traction, mobility, ride performance) are optimized to the haul.
- TPCS allow operational use of VTP; some allow monitoring for compliance.
- Reduced road impacts – especially on weak, lower standard roads and when traffic is light.
- Regulators in Canada recognize the beneficial impact of reduced tire pressures in current and anticipated initiatives.
- Industry is turning to TPCS to solve wood supply issues and reduce transport costs.

An opportunity exists

- Proven, dependable TPCS systems are now being introduced into the Scottish forest industry.
- An opportunity exists for the industry to coordinate research and/or implementation efforts within their own operations, and with other road user groups (e.g., Roading Authorities).

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Thank you

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