FPInnovations
FERIC

Creating forest sector solutions

www.fpinnovations.ca

Improving the Dynamic Performance of Truck-Trailer Combinations

by James Sinnett, Seamus Parker & Larry Wulff

One vision
Global competitiveness

Outline

- Background
  - basic configuration information
  - Canadian regulatory environment
- Research Objectives
- Summary of Previous Work
  - presented last year
- Summary of New Work
  - design & manufacture of both hitches
  - testing regimen & results
- Next Steps
  - FPInnovations, Wolf Trailer Company, Governments
- Questions

Background

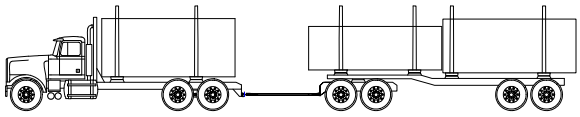
Wolf Trailer Company, Inc.

"The Safer-Trailer Company"

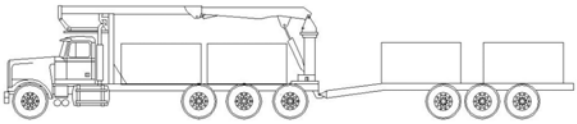
FPInnovations FERIC

Background

Truck/Full Trailer



Truck/Pony Trailer

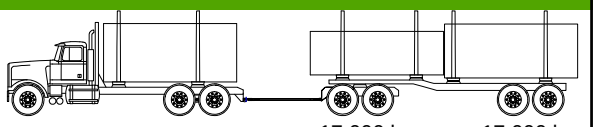


Truck-trailer configurations are:

- widely used in Western Canada & the world
- versatile & manoeuvrable
- less dynamically stable than a tractor/semi-trailer

Background

- Incorporated into MOU in 1991
- Weight limits based upon work by MTO
- Not all provinces fully apply the MOU
- BC will limit the quad-axle to MOU weights starting Jan 1, 2011



17 000 kg 17 000 kg

MOU 31 000 kg MAX

BC 34 000 kg MAX

MOU/BC 21 000 kg

OTHER TRIDEM GROUPS 24 000 kg

FPInnovations FERIC

Objectives

FPInnovations has been investigating improving dynamic performance of truck/full-trailers for a number of years.

Wolf Trailer Company has similarly been investigating truck/pony trailers.

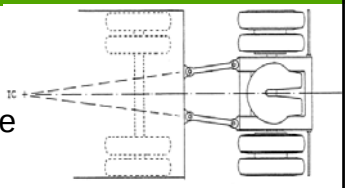
The goals have been:

- To improve configuration safety
  - meeting acceptable performance standards
- To allow full axle capacity

FPInnovations FERIC

Previous Feric Research

Review of Potential Solutions



- Vehicle parameter optimization
- Mechanical trailer dampening hardware
- Electronic dynamic controllers
- Roll-coupling hardware
  - This was the best solution, it:
    - ✓ will meet performance criteria under current dimensional allowances
    - ✓ will facilitate straightforward regulatory enforcement
    - ✓ Simulations showed significant improvement in LTR, meeting the TAC performance measure (LTR <0.60)

(Parker, 2004) (Parker, 2008)

FPInnovations FERIC

Previous Feric Research

Evaluate Hitch Torsional Capacity

- Evaluated full & pony trailer configurations using UMTRI modelling software
- Simulated standard (0.15 g 88 km/h) and extreme (0.20 g 100 km/h) lane change manoeuvres
- Concluded that:
  - Both full & pony trailer configurations experience similar levels of hitch torque to existing C-dollies
  - Hitch torsional stiffness requirements based upon existing C-dolly standards would be appropriate

(Parker, 2009)

FPInnovations FERIC

Previous Feric Research

Roll-Coupled Hitch Requirements

- (In Canada) no current regulations exist to govern requirements for this type of hitch.
- Proposed requirements were developed from existing C-dolly specifications (Transport Canada Standard 903).
  - modified to account for higher payloads.
- The proposed requirements specified:
  - Hitch axial strength
  - Hitch torsional strength
  - Hitch torsional stiffness

(Sinnett, 2008)

FPInnovations FERIC

Roll-Coupled Hitch Requirements

A Test Plan was developed

- proposed to Provinces at 2008 Task Force meeting in Toronto
- it included:
  - Hitch Torsional Testing
  - Configuration Stability Testing
  - Configuration Dynamic Testing (if required)
  - In-service evaluation

At this meeting, BC CVSE indicated it would:

- take the lead in overseeing this project
- report back to the Task Force with developments

CVSE recommended further testing:

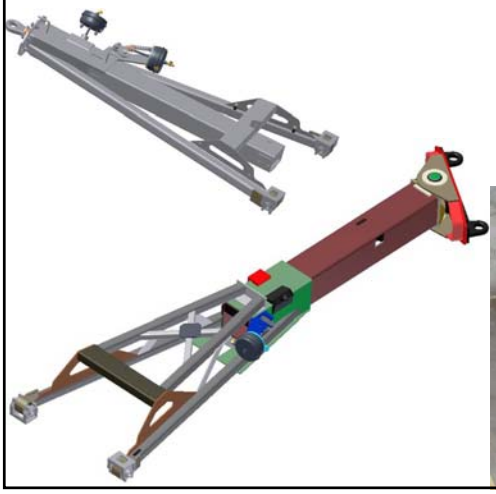
- Truck Frame Torsional Testing
- Full-Vehicle Torsional Testing (Pony Trailer only)

FPInnovations FERIC

Prototype Design – Truck-Full Trailer Hitch

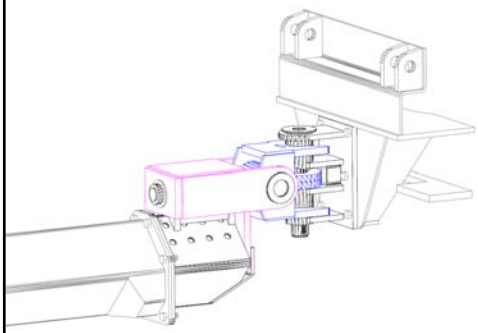
Feric worked with Arctic Trailers of Prince George to design & manufacture a prototype hitch to meet these requirements for the Full-Trailer

- used existing Arctic converter dollies as a starting point
- designed to meet strength requirements
- components analyzed using FEA



Prototype Design – Wolf Trailer Company Hitch

Larry Wulff (Wolf Trailer Company) designed & manufactured a prototype hitch to meet these requirements for the Pony Trailer



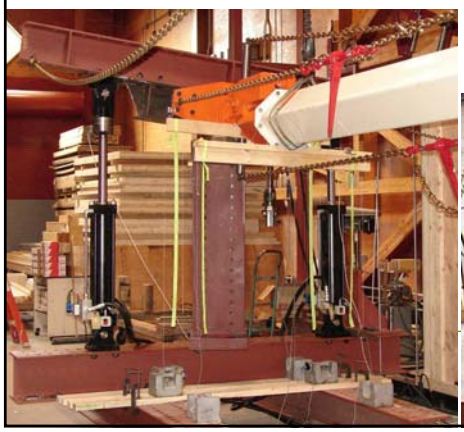
FPInnovations FERIC

Hitch Torsional Testing

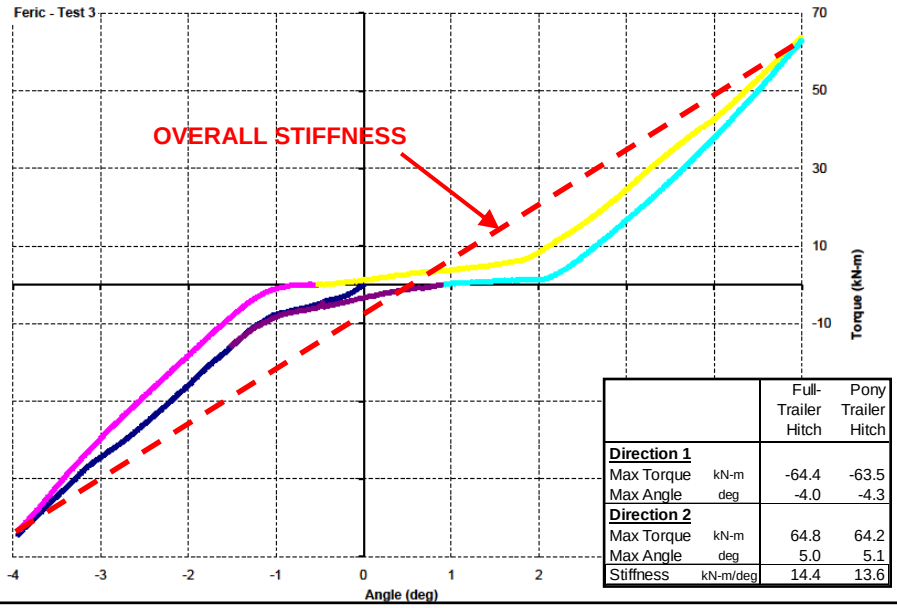
- Testing
  - conducted at FPInnovations – Forintek (Vancouver)
- Torsional requirements:
  - torsional strength of at least 60 kN•m
  - torsional stiffness of at least 4 kN•m/deg
- Procedure
  - Twisted both directions
  - multiple tests

FPInnovations FERIC

Hitch Torsional Testing



Hitch Torsional Testing - Results



		Full-Trailer Hitch	Pony Trailer Hitch
Direction 1			
Max Torque	kN-m	-64.4	-63.5
Max Angle	deg	-4.0	-4.3
Direction 2			
Max Torque	kN-m	64.8	64.2
Max Angle	deg	5.0	5.1
Stiffness	kN-m/deg	14.4	13.6

Hitch Torsional Testing - Conclusions

- **Torsional strength**
  - Both the full-trailer hitch & the pony trailer hitch were able to sustain over the 60 kN•m of torque required
- **Torsional stiffness**
  - Both the full-trailer hitch & the pony trailer hitch had a torsional stiffness over 3 times the required 4 kN•m/deg

(Sinnett, 2009)

FPInnovations FERIC

Truck Frame Torsional Testing

- Testing
  - as recommended by the BC CVSE
  - conducted by Innovative Vehicle Testing ltd. – an experienced vehicle testing engineering consulting firm
  - conducted at Mormak Equipment Ltd (gravel truck) and at Tolko – Armstrong Division (logging truck). Vernon, BC
- Torsional requirements:
  - ensure the truck frame can withstand the torsional forces from the trailer
- (Both) hitches were tested:
  - both loaded & unloaded
  - In both directions
  - 3 times for each condition

Truck Frame Torsional Testing

FPInnovations FERIC

Truck Frame Torsional Testing - Conclusions

- There was no indication of frame damage or permanent deformation during any of the test lifts.
- The truck frames were adequate to use in further on-road testing with the prototype roll coupling hitches.

(Macnabb, 2009a; Macnabb, 2009b)

FPInnovations FERIC

Vehicle Torsional Testing – Pony Trailer

FPInnovations FERIC

Vehicle Stability Testing

- **Vehicle stability testing undertaken to quantify the effect of roll-coupling**
- **Tilt-table testing to measure SRT and LTR**

Configuration Stability Testing

	Drawbar Type	Pony trailer loads (kg)	Full-trailer loads (kg)
1a	standard	21 000	31 000
1b	standard	24 000	34 000
2a	roll-coupled	21 000	31 000
2b	roll-coupled	24 000	34 000

Truck fixed to tilt table to demonstrate influence of "roll-coupling"

FPInnovations FERIC

Configuration Stability - Requirements

Static Rollover Threshold (SRT)

***Definition*: the maximum lateral acceleration (in g's) a vehicle can sustain without rolling over.**

Load Transfer Ratio (LTR)

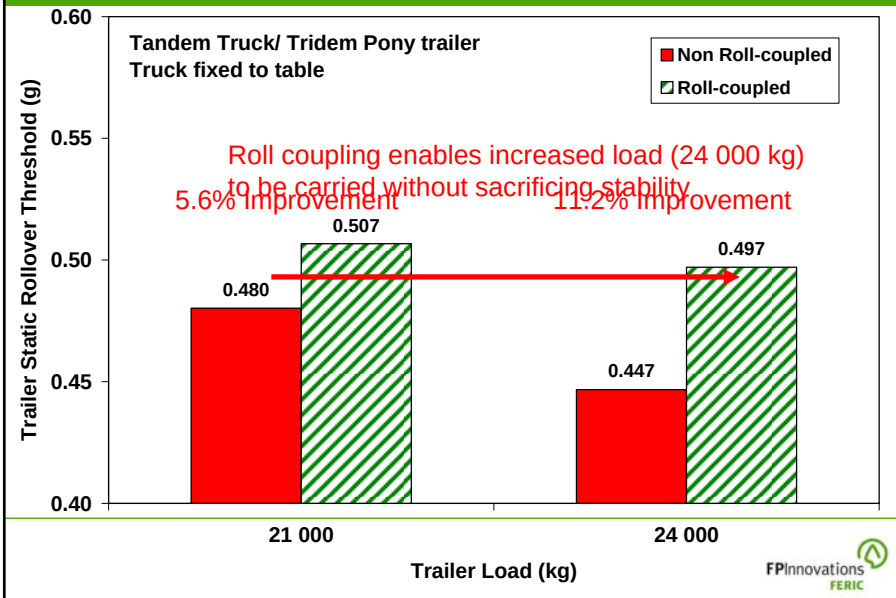
***Definition*: ratio of difference between sum of right wheel loads & left wheel loads to the sum of all wheel loads**

FPInnovations FERIC

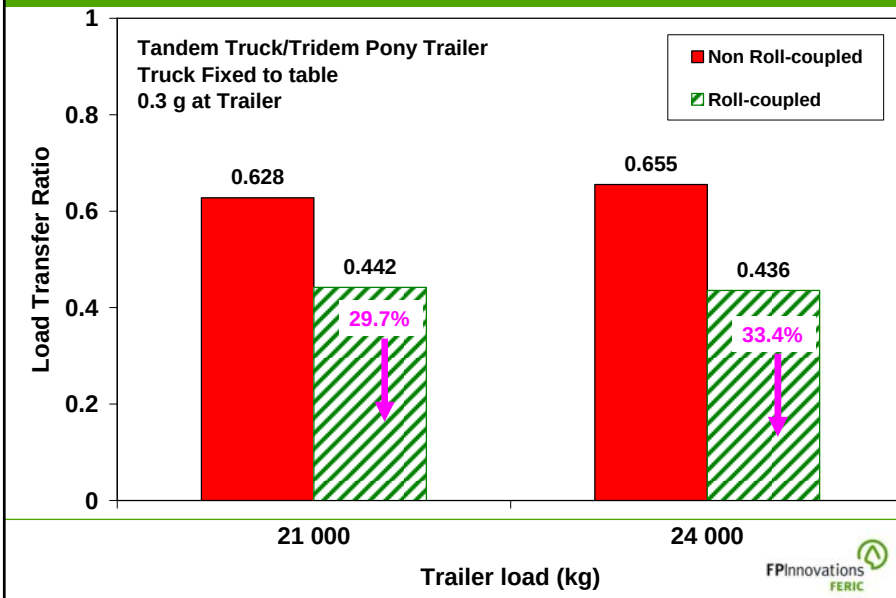
Configuration Stability Testing

FPInnovations FERIC

Configuration Stability Testing



Configuration Stability Testing



Configuration Stability Testing

Conclusions

- Roll-coupling demonstrated improved stability for the truck/pony trailer
- A roll-coupled Pony trailer with 24 000 kg load showed improved stability relative to the non-roll coupled unit with 21 000 kg load
- Full-trailer analysis to be completed – supplementary testing may be required

FPInnovations FERIC

Next Steps – Truck/Pony Trailer

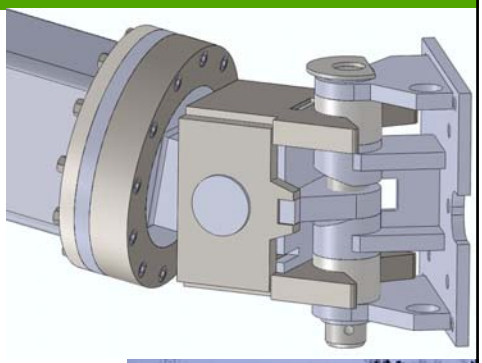
- **The benefits of roll-coupling for pony trailers has been proven**
- **We recommend allowing full axle group weights for roll-coupled pony trailers. This could be accomplished by:**
  - an amendment to the MOU (preferred)
  - a province based permit system (alternative, or interim)
- **With a "Roll-Coupled" hitch defined as:**

  A hitch capable of resisting vehicle roll, from one unit to another. The hitch must be able to resist (a minimum of) 60 kN-m of roll torque in (no more than) 15 degrees of (combined) lash and twist, in both directions.

FPInnovations FERIC

Next Steps – Truck/Full Trailer

- **Tilt-table testing**
  - analysis of results still ongoing
  - test report
- **In-service evaluation**
  - through winter haul season
- **Hitch modification**
  - Addition of roll-relief
- **Further testing**
  - may be required (based upon tilt-table results)
    - dynamic testing
    - additional tilt-table testing



Next Steps

- **Draft Final Report and present to BC CVSE**
  - also to national steering committee on vehicle weights & dimensions (TAC)
- **Final BC CVSE approval leading to:**
  - increased payload allowances (in BC)
- **TAC to evaluate results for potential adoption in other provincial jurisdictions**

FPInnovations FERIC

References

Macnabb, M. 2009a. *Truck frame torsional capability with respect to a prototype roll coupling device – Wolf Trailer Truck Frame Test.* Vernon, B.C. 17pp.

Macnabb, M. 2009b. *Truck frame torsional capability with respect to a prototype roll coupling device – Feric Truck Frame Test.* Vernon, B.C. 16pp.

Parker, S.P.S. 2004. *Improving the dynamic performance of truck/full trailers.* FERIC, Vancouver, B.C. For Western Provinces Task Force on Vehicle Weights and Dimensions Policy. 10pp.

Parker, S.P.S. 2008. *Investigation of the influence of roll-coupling on the dynamic performance of pony trailers.* FERIC, Vancouver, B.C. 3pp.

Parker, S.P.S. 2009. *Investigation of hitch torsional strength capacity required for the roll-coupling of truck/trailer combinations.* FERIC, Vancouver, B.C. 3pp.

Sinnett, J. 2008. *Evaluation Improving the Dynamic Performance Of Truck/Full Trailer Configurations – (Proposed) Test Plan.* FERIC, Vancouver, B.C. 8pp.

Sinnett, J. 2009. *Evaluation of the Torsional Strength Characteristics of Two Prototype Roll-Coupled Hitches.* FERIC, Vancouver, B.C. 16pp.

FPInnovations FERIC

Questions?

We would like to acknowledge the following people & organizations for their assistance in this project: