



Improving the Dynamic Performance of Truck/Full-Trailers

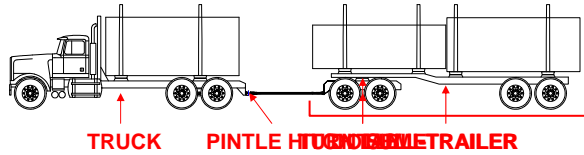
by James Sinnett

One vision
Global competitiveness

Outline

- Background
- Feric research
 - **Project Objective**
 - **Phase 1 (completed)**
 - **Phase 2 (in progress)**
 - Proposed test procedures
 - Work to date
 - Next steps
- Questions

Background



The truck/full-trailer configuration

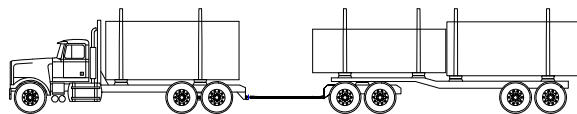
is:

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



FPInnovations
FERIC

Background



FOR A QUAD-AXLE

MOU	17 000 kg	17 000 kg	31 000 kg MAX
BC	17 000 kg	17 000 kg	34 000 kg MAX

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

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Feric Research - Objective

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

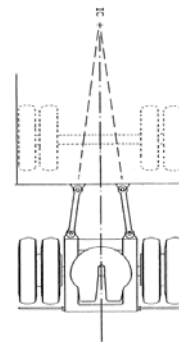
The goals have been:

- To improve configuration safety
- To allow full axle capacity

Feric Research - Phase 1 (completed)

Potential Methods

- Vehicle parameter optimization
- Mechanical trailer dampening hardware
- Electronic dynamic controllers
- Roll-coupling hardware



Feric Research - Phase 1 (completed)

The Feric research concluded that the best solution was roll-coupling.

- UMTRI research improved train performance with roll-coupling, the same principle can be applied to truck/full-trailers
- ✓ Feric simulations showed significant improvement in LTR, meeting the TAC performance measure (LTR <0.60)

Rollcoupling:

- ✓ will meet performance criteria under current dimensional allowances
- ✓ will facilitate straightforward regulatory enforcement
- ✓ has been successfully trialed in Australia
- ✓ is the focus of Phase 2 of Feric's research



Feric Research - Phase 2

Phase Objectives:

- To design & fabricate a suitable roll-coupling device for a truck/full-trailer.
- To evaluate the device against Key Performance Requirements:
 - device strength (Torque, Torsional Stiffness)
 - vehicle stability (Static Rollover Threshold, Load Transfer Ratio)



Device Strength - Requirements

No current regulations exist to govern torsional strength requirements for this type of device.

Proposed requirements were developed from existing C-dolly specifications (Transport Canada Standard 903).

- modified to account for higher payloads.

The proposed requirements state that the device (dolly reach) shall:

- have a torsional stiffness of at least 4 000 N-m/degree (longitudinally)
- be capable of sustaining a torque of at least 60 000 N-m in either direction with less than 0.5 degree residual deformation

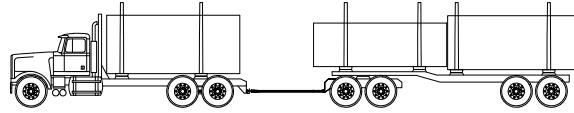
Device Strength - Test

The test has been adapted from Transport Canada TM 903

1. clamp the device to the test rig.
 - one end fixed in place, the other end attached for torsional input
 - drawbar extended to its limit
2. subject it to an increasing torque
 - about longitudinal axis
 - until 60 000 N-m is reached
3. measure initial angular displacement due to slack; rotation (degrees) & torque (N-M) measured continuously through the test
4. remove load & measure residual angular displacement
5. repeat in the opposite direction

Vehicle Performance – Test Configurations

Tandem drive truck / quad-axle trailer configuration.



7,300 kg

17,000 kg

	Drawbar Type	Trailer Load (kg)
1a	standard	31,000
1b	standard	34,000
2a	roll-coupled	31,000
2b	roll-coupled	34,000

Prior to each test, data recorded will include:

- configuration dimensions
- axle loads
- component specifications

Configuration Stability - Requirements

Static Rollover Threshold (SRT)

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

Performance Standard: must be greater than 0.35 g's

Load Transfer Ratio (LTR)

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

Performance Standard: must be less than 0.6

Configuration Stability - Test

SRT & LTR will be assessed through tilt-table testing, similar to SAE J2180

1. restrain configuration to prevent rollover
2. raise tilt-table until full wheel lift-off achieved
3. measure the rotation angles of the tilt table, truck frame, trailer frame, drawbar; & wheel loads
4. wheel loads used to measure load transfer progression



Other Testing?

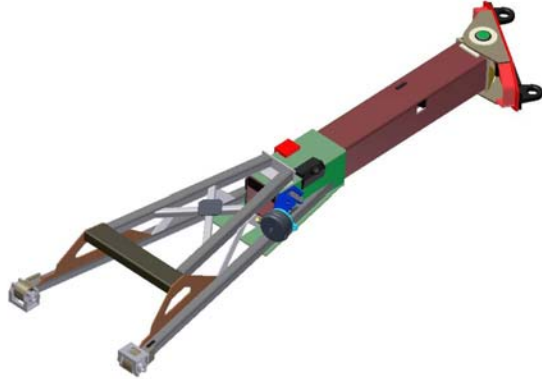
Dynamic Testing

- Single Lane Change Manoeuvre
- J-turn Manoeuvre



Prototype Design

Feric has worked in conjunction with Arctic Trailers of Prince George to design a prototype hitch to meet these requirements.



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



Prototype

- Arctic Trailers has built the prototype.
- It is now awaiting the next stage of the project...

TESTING!!



Next Steps

- **Receive feedback**
- **Fully develop the testing procedure**
- **Proceed with testing**
- **Report findings**

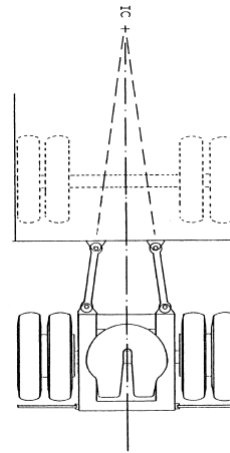
- **Questions?**

Auxiliary Slides

Feric Research - Phase 1 (completed)

Potential Methods:

- Vehicle parameter optimization
 - Increased wheelbase, or drawbar length
 - Decreased hitch offset or load height
 - ✗ Difficult to enforce; reduced productivity
- Mechanical trailer dampening hardware
 - UMTRI researched modified dollies for A-trains, some potential solutions for truck/full-trailers
 - Feric selected the trapezoidal dolly selected for further study
 - ✗ Dampened trailer motion; did not improve truck performance



Feric Research - Phase 1 (completed)

Potential Methods:

- Electronic dynamic controllers
 - Dynamic control through selective application of wheel brakes
 - Both RSC & ESC systems are on the market
 - ✗ Difficult for regulators to distinguish vehicles equipped with these devices & if they are operational; lack of a fail-safe
- Roll-coupling hardware
 - UMTRI research improved train performance with roll-coupling, the same principle can be applied to truck/full-trailers
 - ✓ Feric simulations showed significant improvement in LTR, meeting the TAC performance measure (LTR <0.60)

Dynamic Performance - Requirements

Rearward Amplification (RA)

Definition: ratio of peak lateral acceleration at C.G. of rearmost trailer to that at the truck steer axle

Performance Standard: must be less than 2.0

Dynamic Performance - Test

RA assessed through the Single Lane Change Manoeuvre in ISO 14791

- conducted at 90 km/h
- target input lateral acceleration of 0.15g (at steering axle)
- conducted at frequencies of 0.3, 0.4, & 0.5 Hz.
- 3 successful runs required at each frequency
- additional runs at 80 km/h & 100 km/h to determine speed sensitivity

