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Development of a Roll-Coupled Hitch for Truck/Trailers

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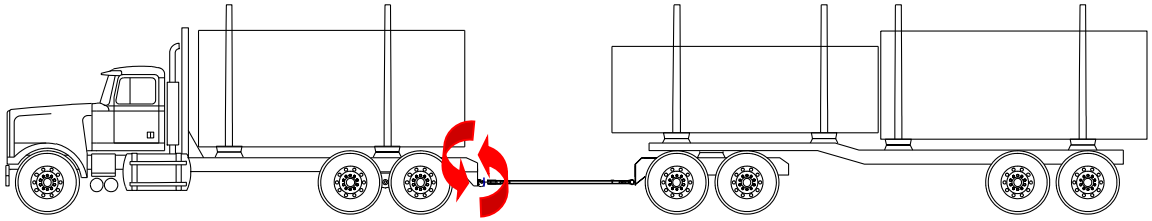
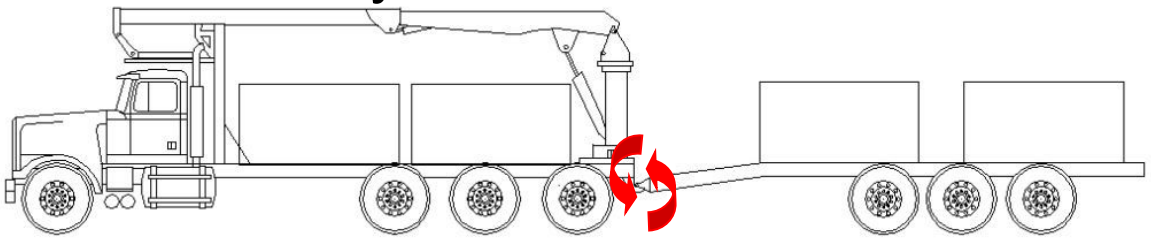
Background

- Truck/Full Trailer



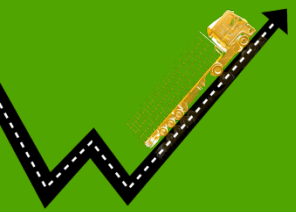
MOU 31 000 kg MAX

- Truck/Pony Trailer



MOU 21 000 kg MAX

- Truck-trailer configurations are:
  - widely used in Western Canada & the world
  - versatile & manoeuvrable
  - pintle hitch makes them less dynamically stable than a tractor/semi-trailer
    - leading to MOU weight restrictions

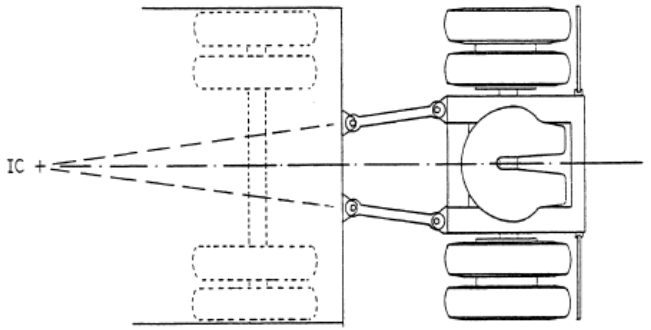


Objectives

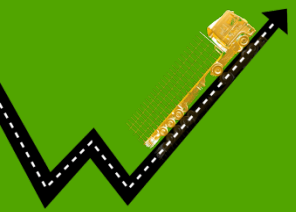
- To improve truck-trailer dynamic performance and thereby improve safety
- To improve configuration productivity by utilizing full axle load capacity
  - Reduction in fuel consumption and GHG emissions estimated to be:
    - ~5% (for truck / full-trailers), and
    - ~6% (for truck / pony trailers)

Research

- Many potential solutions evaluated
  - Optimization of vehicle dimensions
  - Mechanical trailer dampening hardware
  - Electronic dynamic controllers



- Roll coupling hardware deemed optimal solution to improve performance:
  - will meet performance criteria under current dimensional allowances
  - will facilitate straightforward regulatory enforcement
  - simulations showed significant improvement in Load Transfer Ratio (LTR), meeting the TAC performance measure (LTR <0.60)
    - LTR – the ratio of difference between sum of right wheel loads & left wheel loads to the sum of all wheel loads

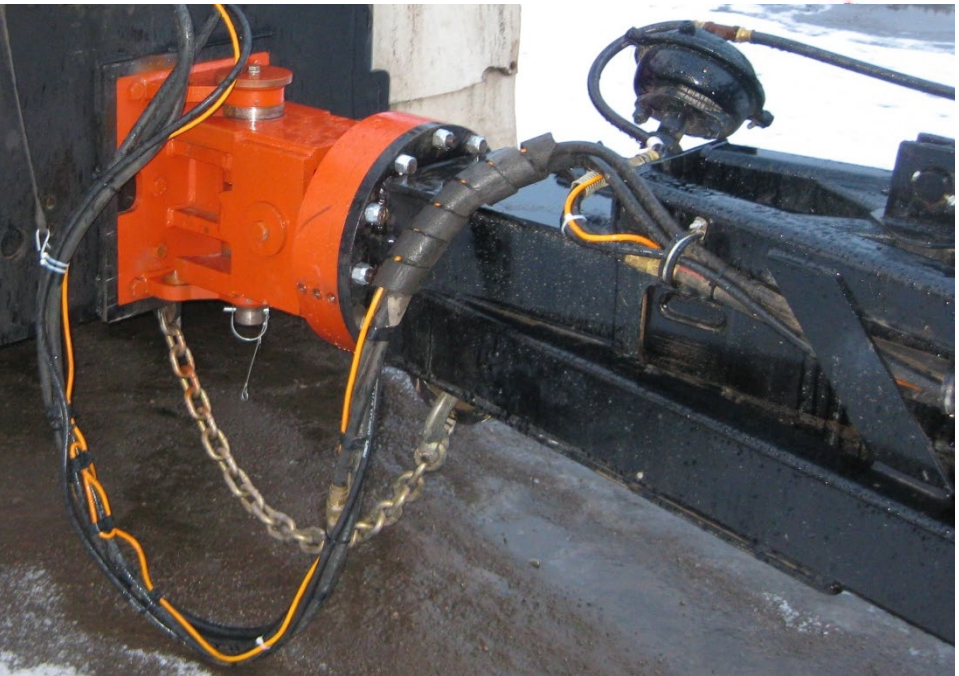


Research

- Proposed strength requirements were developed from existing C-dolly specifications (Transport Canada Standard 903).
  - Increased for higher payloads
- The proposed requirements specified:
  - Hitch axial strength (400 kN pull; 130 kN vertical; 40 kN lateral)
  - Hitch torsional strength (60 kN-m)
  - Hitch torsional stiffness (4 kN-m/deg)

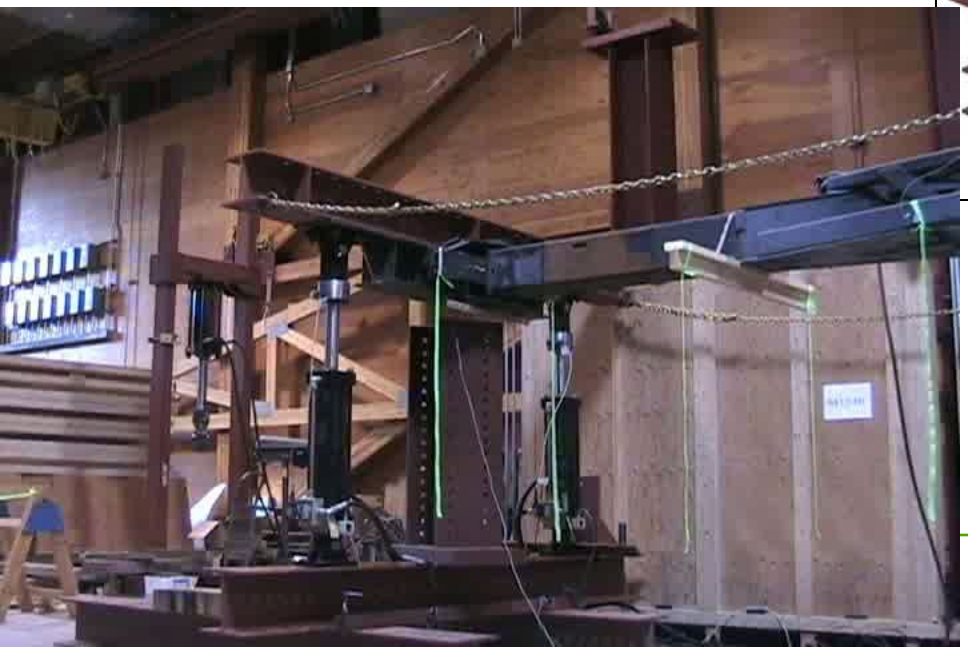
Prototype Development

- Prototype hitches were developed and built to meet these requirements
  - FPInnovations & Arctic Trailers design & build a full-trailer hitch
  - Larry Wulff (Wolf Trailer Company) design & build a pony trailer hitch
    - Included selective roll-coupling & self-alignment
  - FPInnovations hitch modified to incorporate Wolf Trailer design

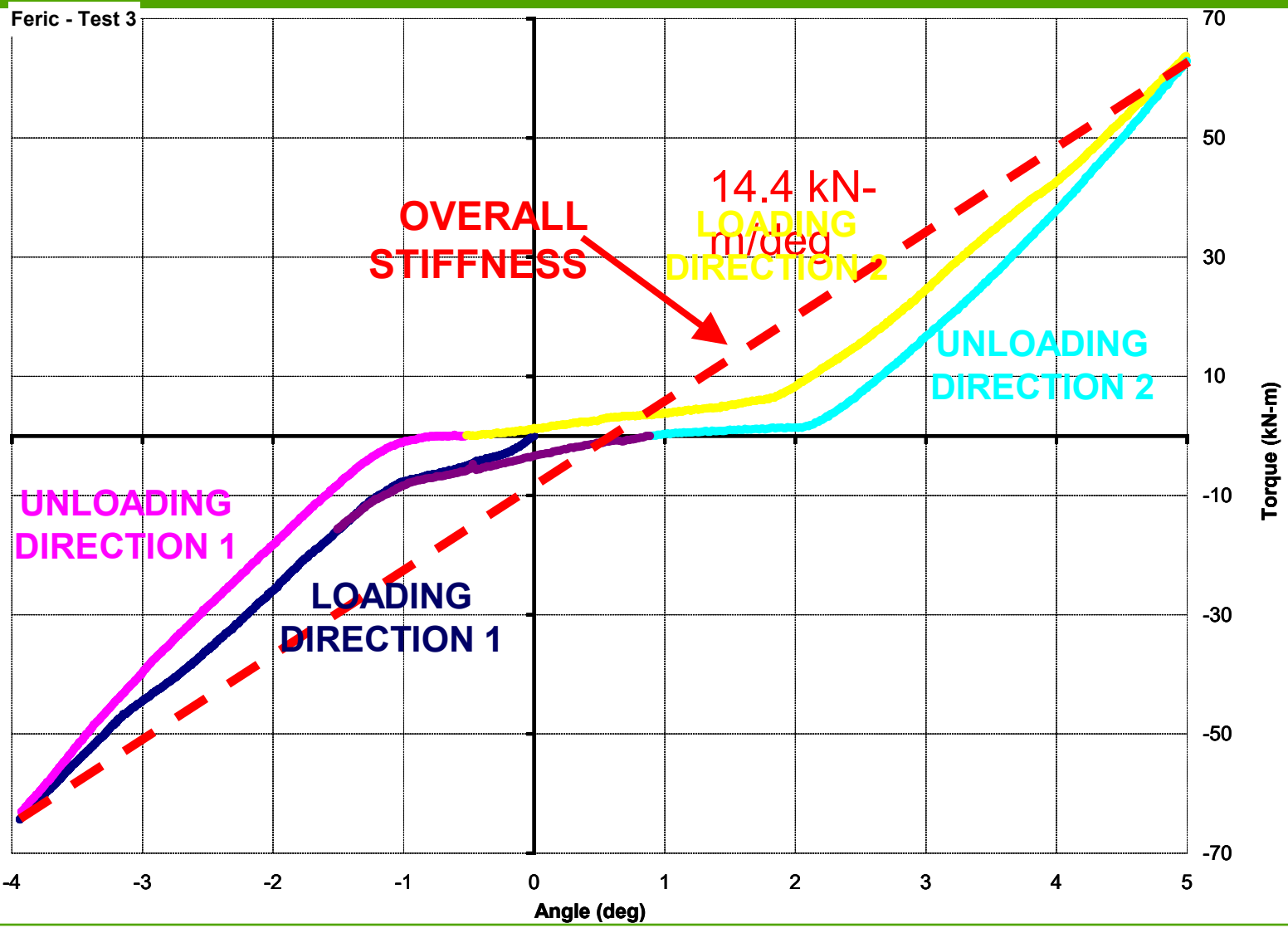


Hitch/drawbar Torsional Testing

- Do drawbars meet torsional strength requirements?
  - Requirements derived from C-dolly standard
  - Torsional strength of at least 60 kN•m
  - Torsional stiffness of at least 4 kN•m/deg



Torsional Testing - Results



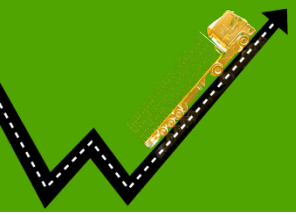
Hitch/drawbar Torsional Testing

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

Vehicle Stability Testing

- Vehicle stability (tilt-table) testing undertaken to quantify the effect of roll-coupling
- Evaluating LTR & Static Rollover Threshold (SRT)
  - SRT - the maximum lateral acceleration (in g's) a vehicle can sustain without rolling over



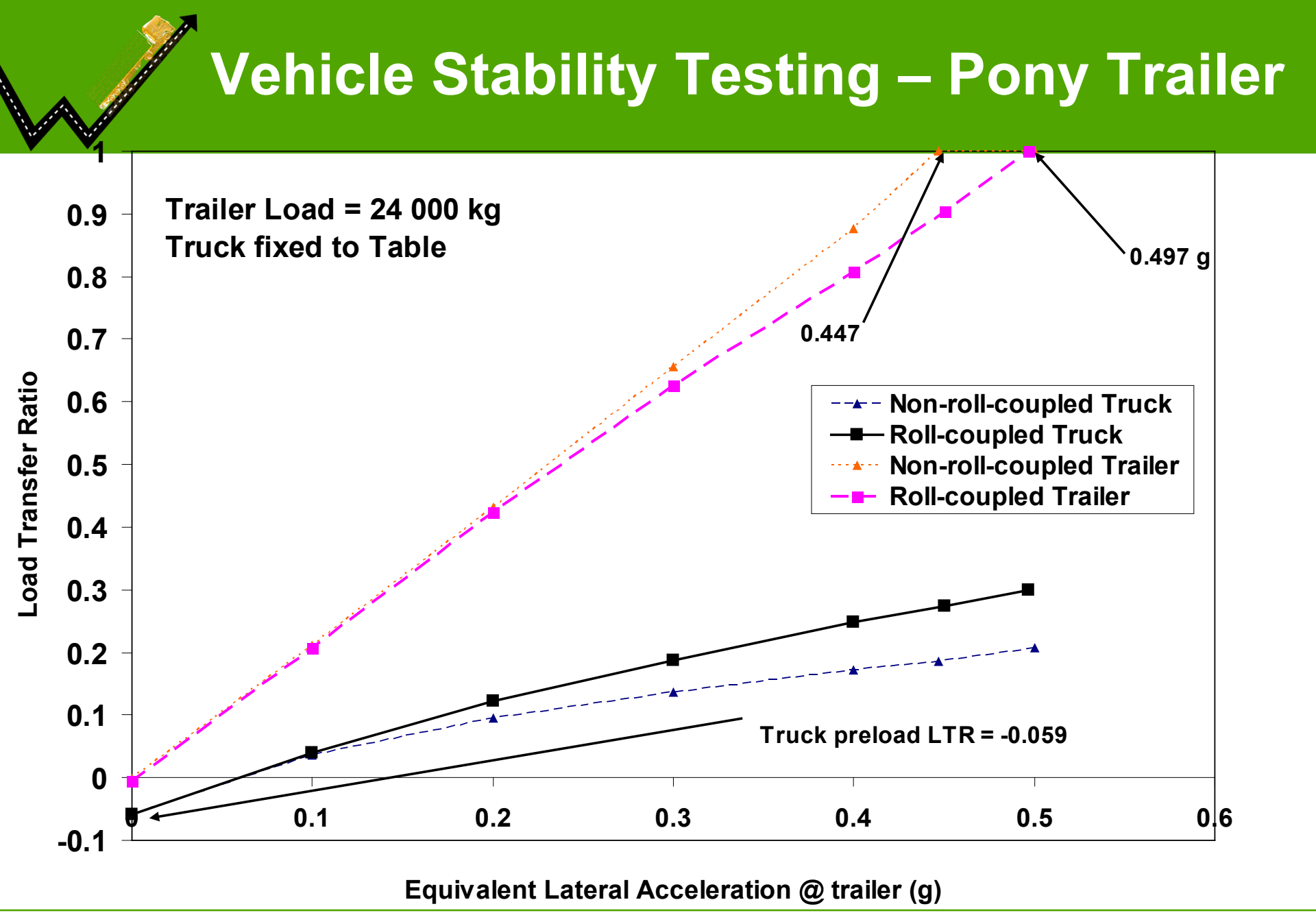
Vehicle Stability Testing

	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

- Two conditions evaluated:
  - Truck free to roll : steady state stability
  - Truck fixed to table : dynamic stability (phase shift)

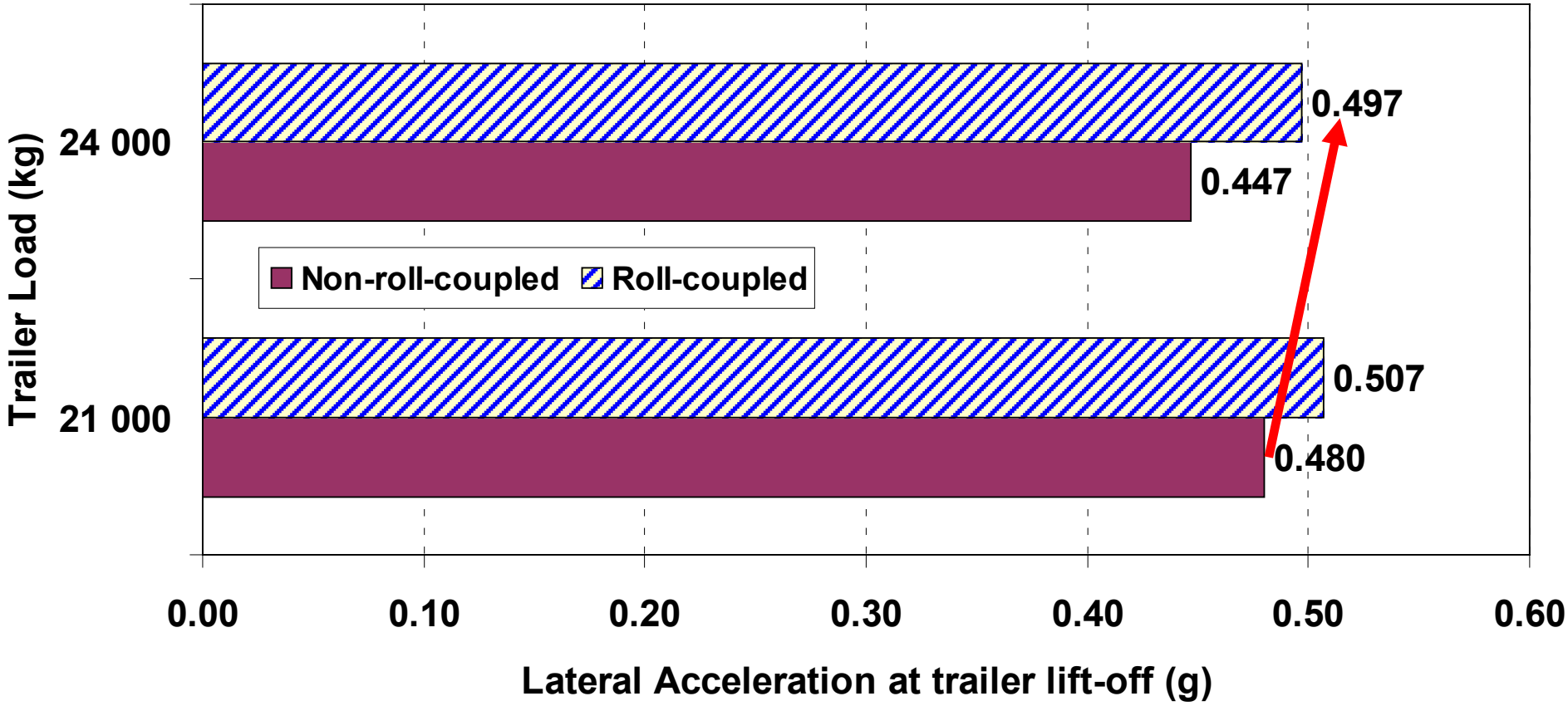
Vehicle Stability Testing

Vehicle Stability Testing – Pony Trailer



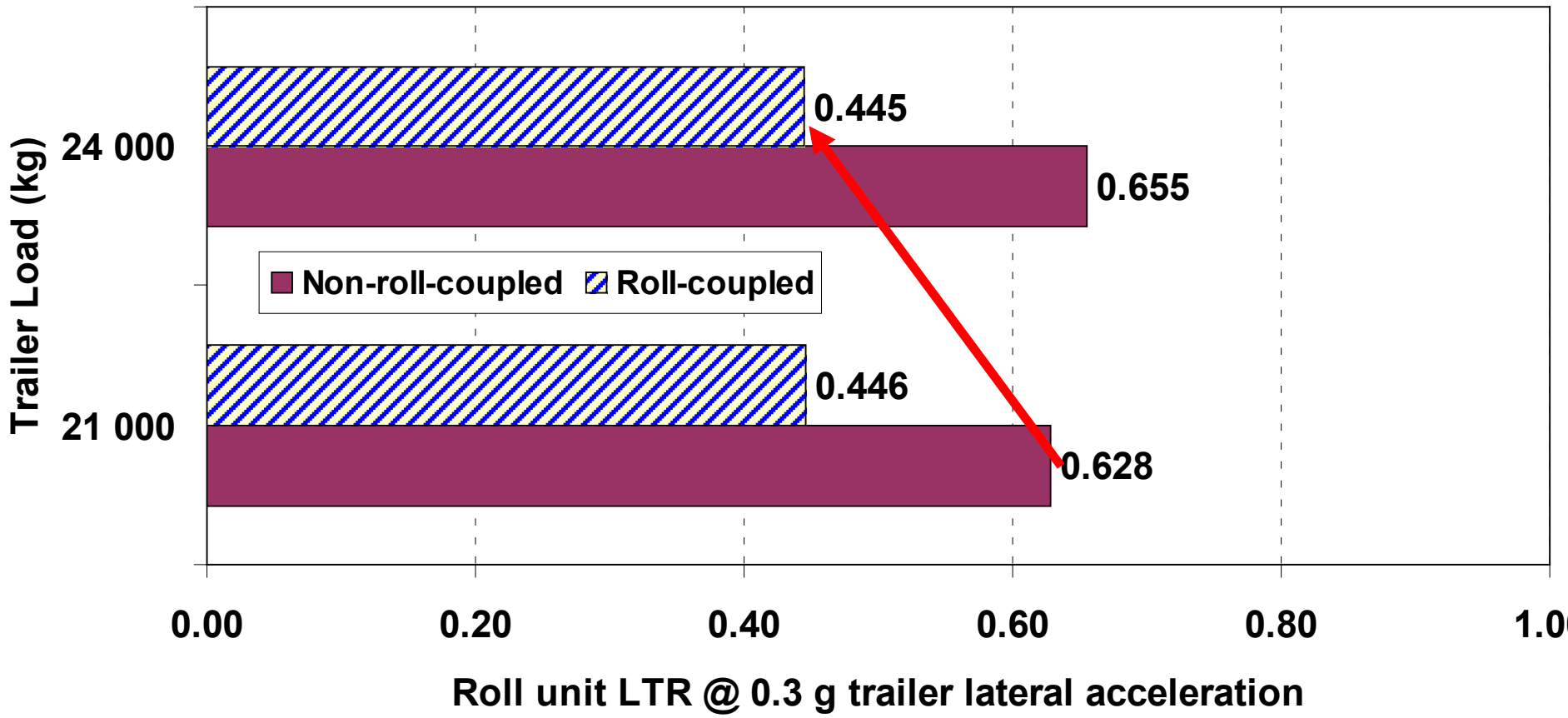
Vehicle Stability Testing – Pony Trailer

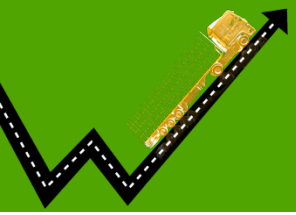
Roll coupling enables increased load (24 000 kg)
to be carried without sacrificing stability



Vehicle Stability Testing – Pony Trailer

Roll coupling reduces roll unit LTR





Vehicle Stability Testing – Pony Trailer

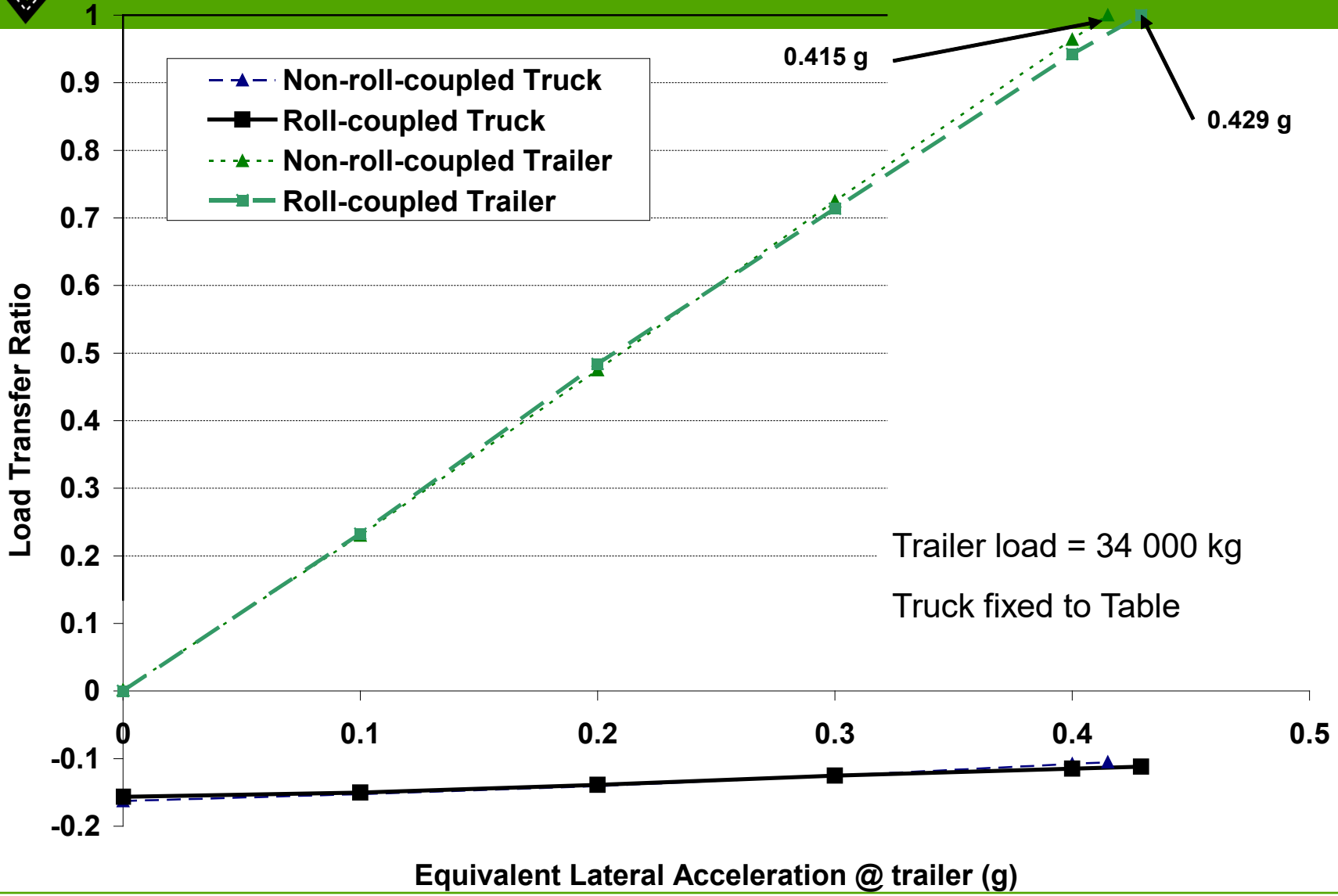
Conclusions:

- Roll-coupling demonstrated improved stability for truck/pony trailer
- A roll-coupled pony trailer with 24 000 kg load showed improved stability relative to a non-roll coupled unit with 21 000 kg trailer load

Recommendations:

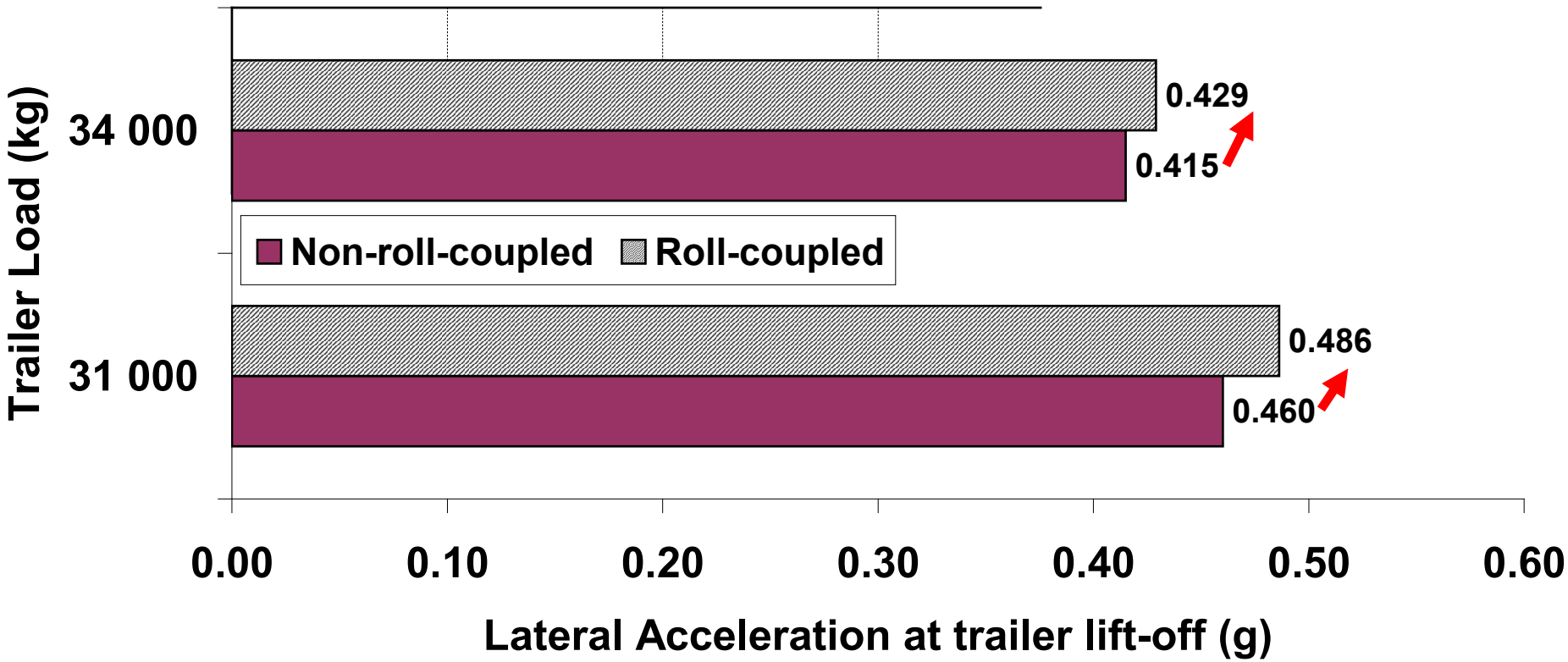
- Allow full axle weight allowances for roll-coupled pony trailers

Vehicle Stability Testing – Full Trailer



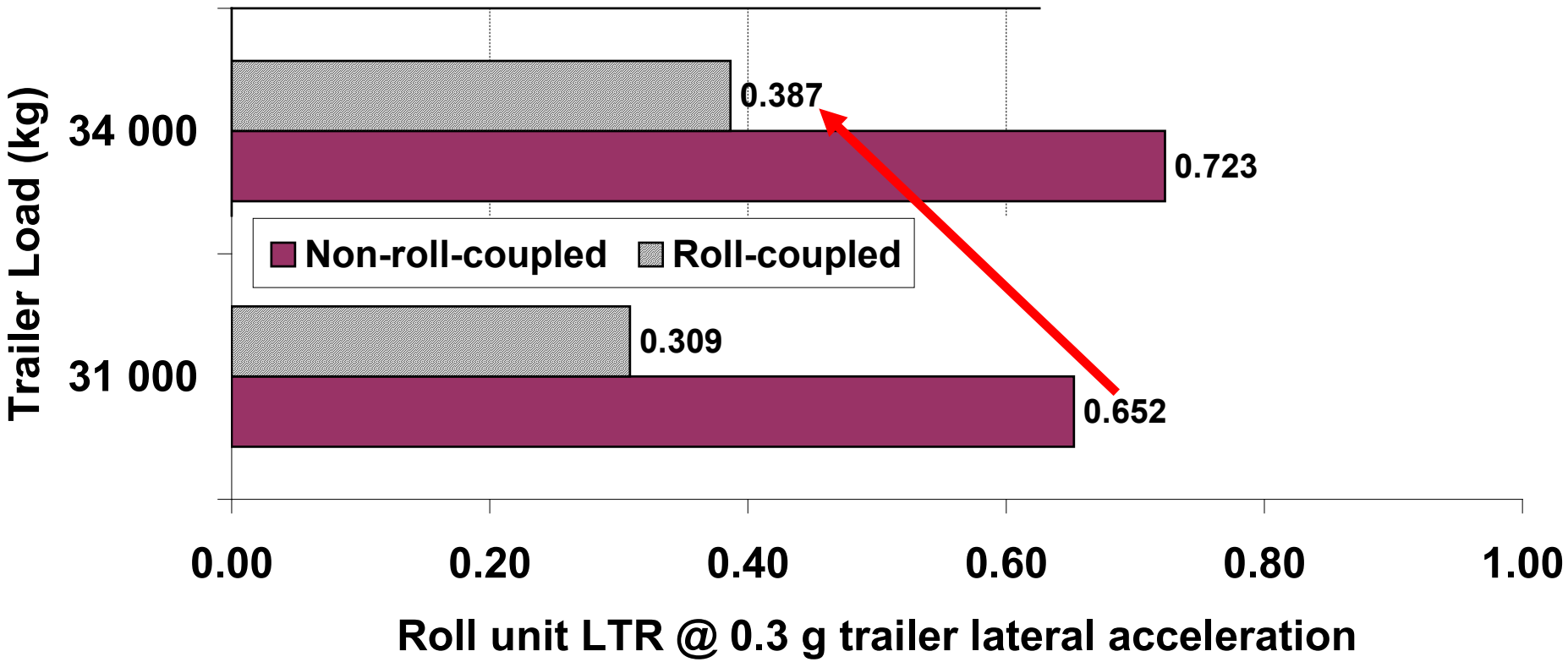
Vehicle Stability Testing – Full Trailer

Roll coupling (somewhat) improves static stability at both payloads



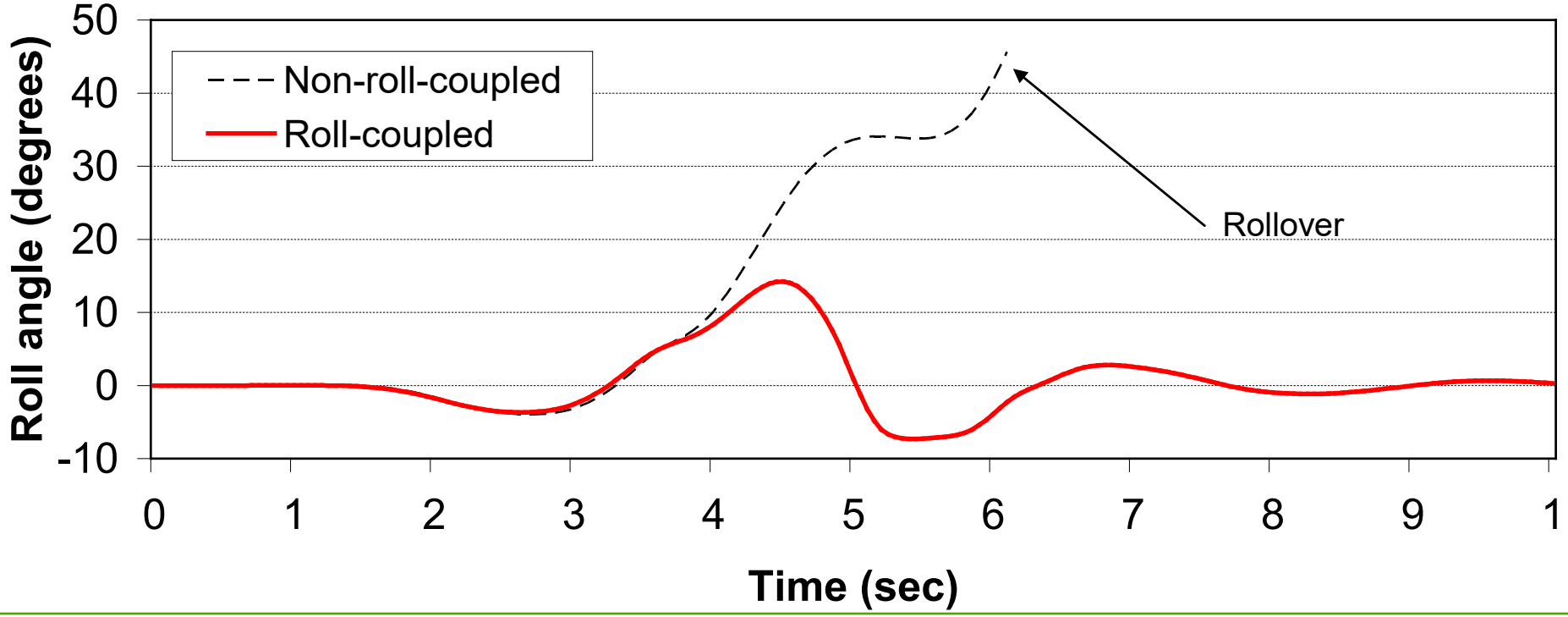
Vehicle Stability Testing – Full Trailer

Roll coupling reduces roll unit LTR



Vehicle Stability Testing – Full Trailer

- Dynamic benefits of roll-coupling expected to be higher than shown statically
  - Even after lift-off roll-coupling would resist trailer roll-over
  - Further dynamic modelling was conducted



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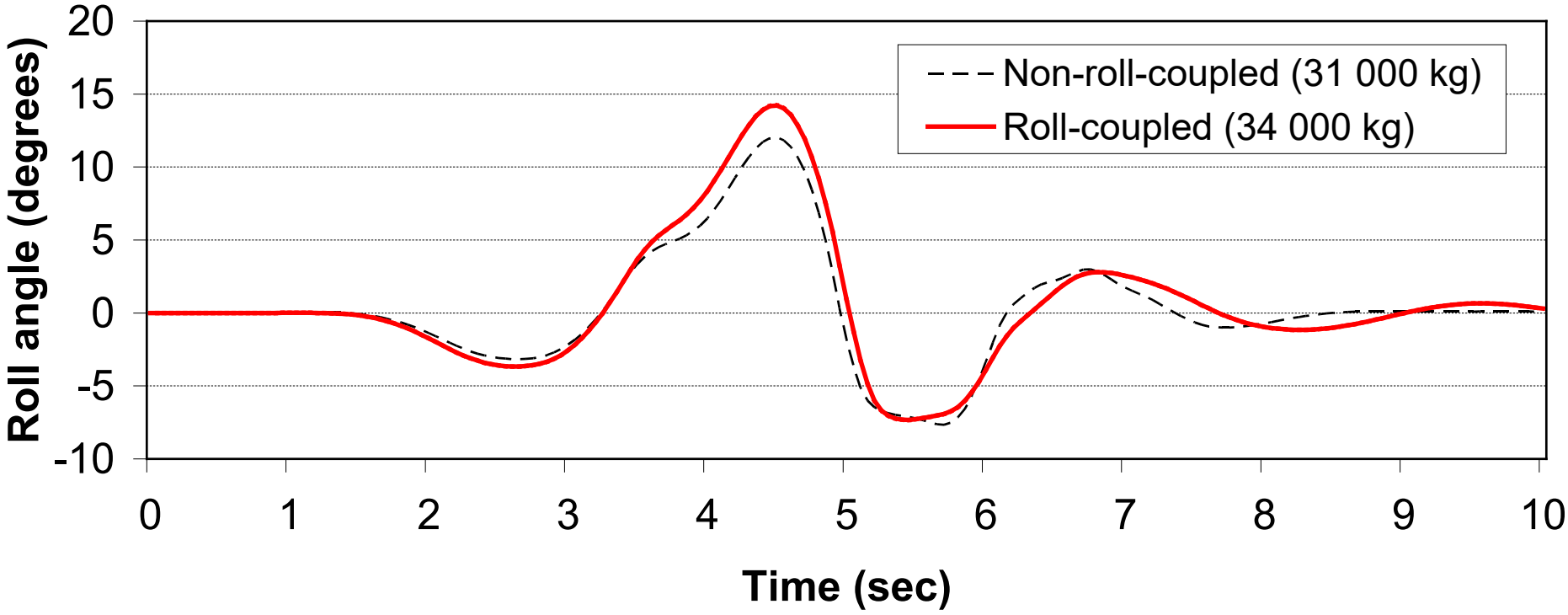
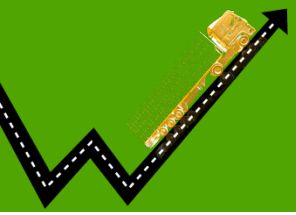


Vehicle Stability Testing – Full Trailer

Conclusions:

- Roll-coupling demonstrated improved stability for truck/full trailer
- Effects of roll-coupling greater at higher lateral accelerations (more severe manoeuvres)
  - Due to high levels of compliance in vehicle
- Roll-coupled full trailer with 34 000 kg load performed similar (dynamically) to a non-roll coupled unit with 31 000 kg trailer load



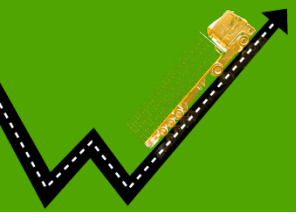
Vehicle Stability Testing – Full Trailer

Recommendations:

- Allow full axle weight allowances for roll-coupled full trailers
- Roll-coupled full trailer manufacturers should reduce compliance in the vehicle
  - Reduce turntable lash
  - Stiffen the drawbar / dolly connection
  - Stiffen the trailer frame

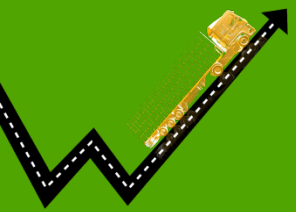
In-Service Evaluations

- Field trials conducted on both logging & pony trailers. Both:
  - Were easy to connect / Dis-connect
  - Felt to be much more stable on the road
  - Provided driver with feedback from trailer
  - Had a tighter hitch connection with less “jarring” impacts
  - Handled more like a 5th wheel hitch than a pintle hitch
- No operational or maintenance issues were found



Follow-up

- BC is now (as of July 15th) allowing full axle weight allowances for roll-coupled pony trailers
  - On a permit basis
- Roll-coupled hitch requirements (and certification):
  - Minimum roll torque capacity of 60 kN-m
  - Minimum roll stiffness of 4 kN-m per degree
- BC is reviewing the testing results for the full-trailer and is expected to make a decision soon.



Next Steps

- Other Jurisdictions in Canada are looking at following BC's lead in allowing roll-coupled trailers
  - Initially expected to require In-Service Evaluations
    - Conducted by FPInnovations
  - Followed by operational Permits
    - Similar to BC

Acknowledgements & Questions

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