Transport Canada's Innovation Centre – On-Road RD&D 6x2 Drivetrains Testing & Evaluation

Task Force for Vehicle Weights and Dimensions Meeting

November 28, 2018

Brad Richard, P.Eng, PMP
Senior Engineer

RDIMS # 14752024

OVERVIEW

- TC Innovation Centre
- Background/Context
- Approach
- Track Testing
- Dynamic Simulation
- Infrastructure Impacts Analysis

Transport Canada's Innovation Centre

In January 2018, Transport Canada launched the Innovation Centre (IC) …

… a transportation innovation Research, Development & Deployment (RD&D) organization tasked with:

- driving an integrated departmental approach to transportation innovation;
- partnering in new ways with government, industry and academia; and
- leveraging emerging technologies for the benefit of all Canadians.

… with a vision: *"To enable bold and innovative transportation solutions that enhance the safety, security, accessibility, and environmental performance of transportation in Canada."*

On-Road RD&D (ecoTECHNOLOGY for Vehicles Program)

- tests, evaluates and provides expert technical information on advanced light-duty vehicle (LDV) and heavy-duty vehicle (HDV) technologies.

- testing and evaluation results:
  - guide the proactive development of codes, standards, and regulations;
  - support the development of non-regulatory industry codes and standards that anchor industry efforts to integrate new vehicle technologies.

- testing priorities are focused on addressing knowledge gaps, particularly where new innovations have potential environmental or safety implications.

- A few eTV projects related to assessing technologies for improving efficiency include:
  - Cooperative truck platooning systems
  - Vehicle-to-Vehicle Communication Testing (DSRC)
  - **6x2 Axles**

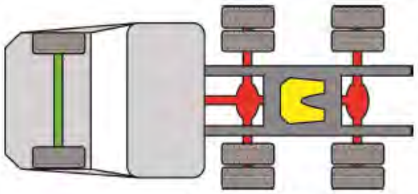
HDV 6x2 Axle Technology – Background Information

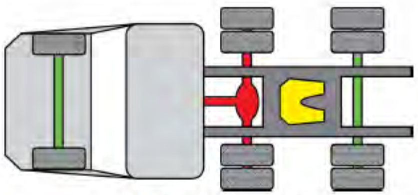
- Traditional highway tractors employ a 6x4 drive configuration which uses a non-powered steer axle and two powered rear axles.

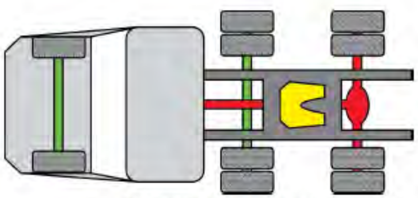
- Recent innovations have resulted in increased availability of 6x2 configurations in North America -- which employ only one powered rear axle in one of two configurations:
  - Tag – forward most drive axle is powered (Kenworth, Freightliner); and,
  - Pusher – rear most drive axle is powered (Volvo).

- OEMS can have different load shifting (biasing) strategies, for example:
  - During low speed operation load is transferred to the drive axle to gain traction
  - During high speed operation load is transferred to the dead (LRR) axle for fuel economy

- Increase in individual axle loads could have implications for:
  - Infrastructure (i.e. loading that is higher than the current allowable axle limits); and,
  - Vehicle dynamic stability (i.e. high speed maneuvering after load shifting has occurred).


6x4 arrangement


6x2 tag tandem 6x2 architecture


6x2 pusher tag 6x2 architecture

Potential Benefits	Potential Challenges
• fuel economy	• loading on infrastructure
• reduced emissions	• vehicle dynamic stability
• reduced maintenance	• tire wear
• mass reduction	• traction

Test Vehicles: 6x2/6x4 Vehicle Pairs

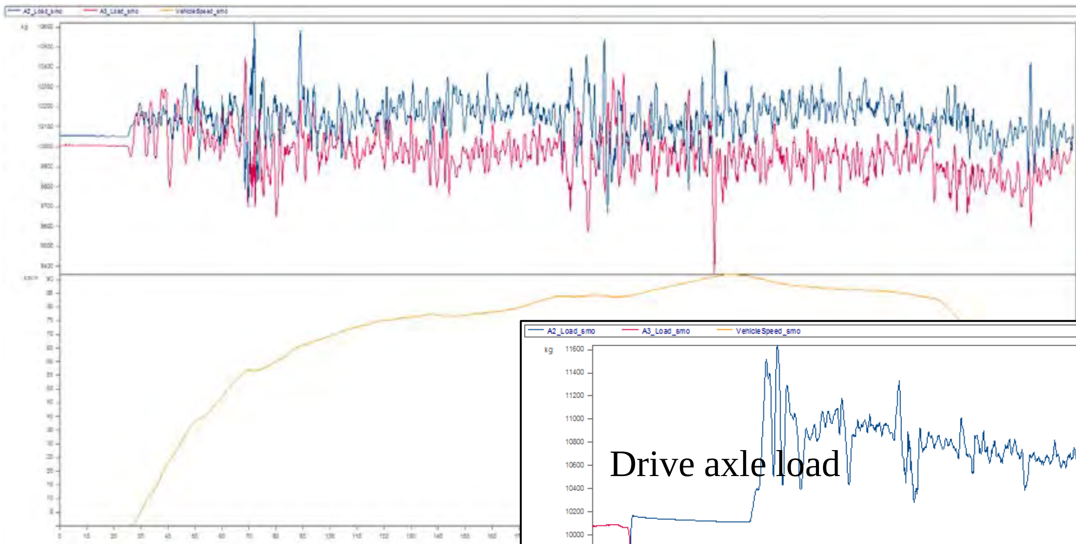
Kenworth T680 (provided by ECCC)	VNM62T 200 (provided by Volvo)	Freightliner Cascadia Evolution 125 (procured by TC)
		
PACCAR MX-13 HD, 12.9L 455 hp @1700 rpm, 1650 lb.-ft.@1000 rpm Governed RPM: 2,200 rpm Automated Eaton 10 spd **6x2: tandem tag** G.C.W, 80,000 lbs Fr Axle: 12,000 lbs Rr Axle: 6x4 40,000 lbs, 6x2 34,000 lbs Trailer Load (lbs): 40,000 Emission controls: LRRA, IRTE, ATS, TGR	Volvo D11 425V/1550, 11L 425 hp @ 1600 rpm 1550 lb-ft @1000 rpm Governed RPM: 2,200 rpm I-Shift ATO2612D, **6x2: tandem pusher** G.C.W, 80,000 lbs Volvo VF12 12,500 lbs Meritor RS23-160 23,000 lbs 40K; 20K Volvo Air Suspension, W 20K Liftable Aux Axle 50" Meritor ABS with VEST	Detroit DD15, 14.8L 400 hp @ 1,625 rpm, 1,750 lb-ft @1,075 rpm Governed RPM: 2,200 rpm DT12-OA-1550 automatic **6x2: tandem tag** GCW: 80,000 lbs (36,300 kg) 6x4: 40,000 lbs tandem 6x2: 20,000 lbs single 20,000 lbs tag 2.28 rear axle ratio ABA, ACC and LDW technologies * New acquisition

TRACK TESTING

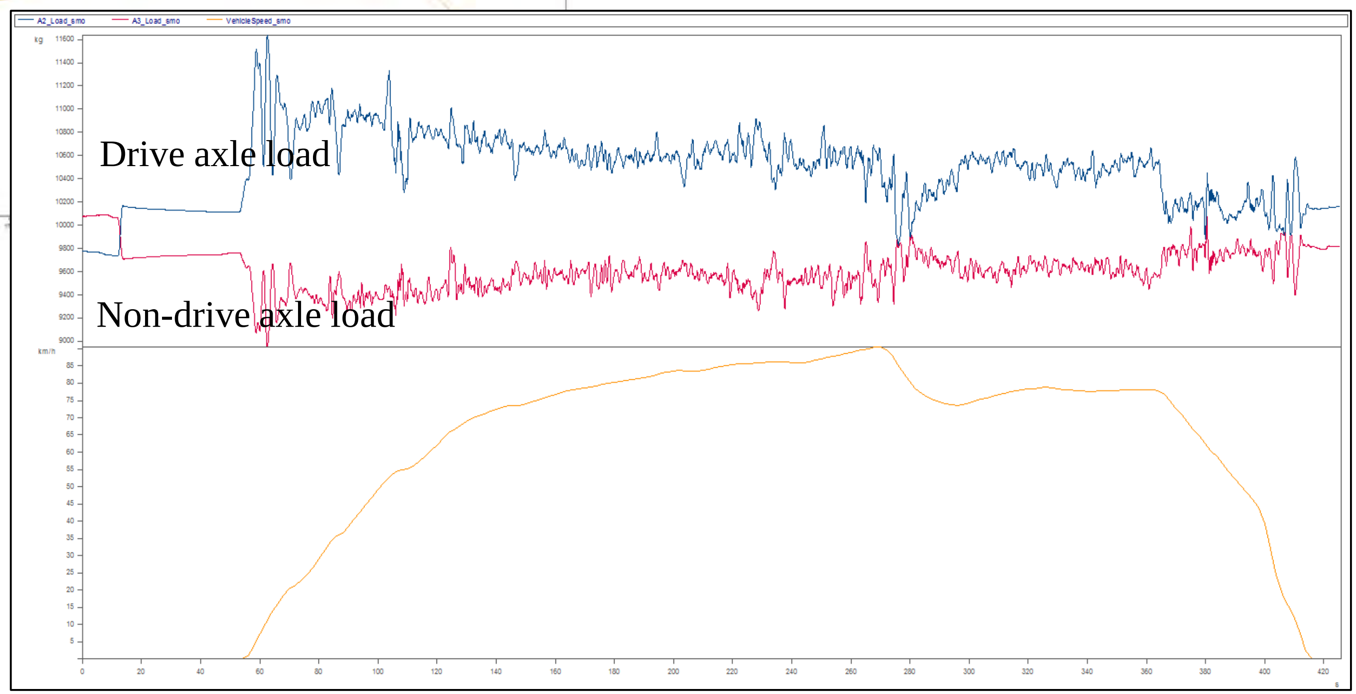
- Testing at TC Motor Vehicle Test Centre on an ice surface (NRC)
- Determine tractive capability of each tractor (startability, acceleration)
- Open deck trailer with range of ballast amounts and distributions
- Evaluating the effects of the traction control system, and the magnitude and duration of load shifting events
- Results can be used for dynamic simulation and infrastructure impacts analysis

TRACK TESTING – EXAMPLE RESULTS

(Preliminary – from draft report on winter 2018 testing)



← Freightliner 6x4



Freightliner 6x2 →

PROVINCIAL INPUT

Feedback received from the provinces/territories has included:

- *More challenging traction conditions (low friction, grade, with and without tire chains)*
- *Comparison of 6x2 vs. 6x4 stability during an emergency lane-change maneuver*
- *Vehicle response during a load biasing event while at speed, accelerating, and decelerating, cornering along a curved down slope*
- *Use of single wide based tires vs standard dual configuration*

… challenging to test full range of scenarios on a test track!

HDV 6x2 Axle Technology – Project Approach

The eTV Program technical assessment has three planned phases.

Phase 1 – Technical Literature Review – Completed August 2016

- Review available OEM technical documents, peer-reviewed publications, consult OEMs and suppliers, and other available material to characterize different 6x2 architectures and performance.
- Posted to TC's website (http://www.tc.gc.ca/eTV).

Phase 2A –Test Plan Development – Completed September 2016

- Development of track testing procedure to measure how much load is transferred to the drive axles in various loading configurations.

Phase 2B – Winter Track Testing (Two vehicle pairs) – Completed February 2017

- Equip the vehicles with wheel force transducers to measure the loads and moments at each wheel Complete track testing at TC's Motor Vehicle Test Center (MVTC) to measure axle loads and moments during accelerations from a dead stop on a low μ (ice) surface.

Phase 2C – Winter Track Testing (all vehicle pairs) – Completed February 2018

- Similar to Phase 2B, but including a third vehicle pair, transitions to higher speeds, and lighter loads.

This Year

Phase 2D – Dynamic Simulation – Planned March 2019

- Use empirical data from testing to simulate dynamic performance in various scenarios.

Phase 3A – Infrastructure Analysis – Planned March 2019

- Susan Tighe, Ph.D., Centre for Pavement and Transportation Technology (University of Waterloo) developing a proposal for analyzing potential pavement impacts of 6x2 powertrains.

DYNAMIC MODELING AND SIMULATION

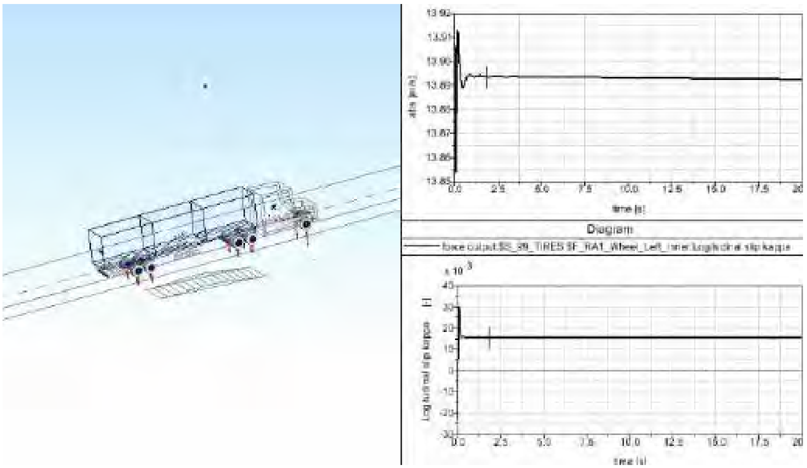
- NRC for drivetrain dynamic simulation will be signed in the coming weeks. The SoW includes 2 main tasks.

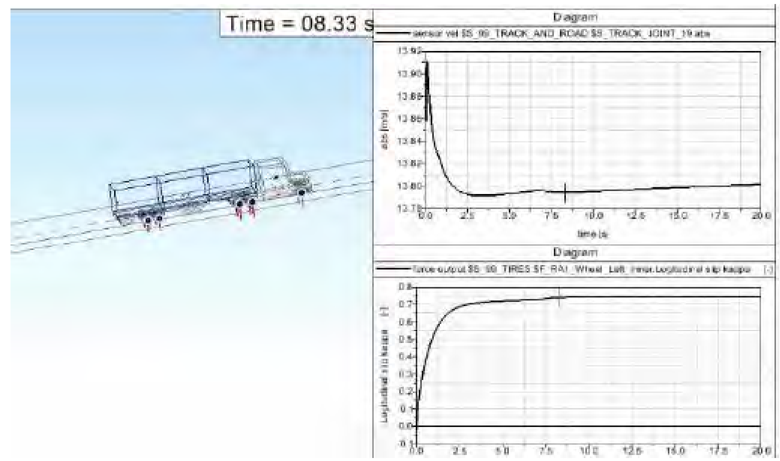
- **Task 1.1: Development of a 6x2/6x4 model**
  - Simulate different lift-able axle positions and load biasing scenarios
  - 6X2 vs. 6X4 comparison
  - Tire/road interaction
  - Aerodynamic drag forces and wind velocity effects
  - Model control:
    - Closed loop: predefined vehicle speed profiles
    - Open Loop: The user will define the pedal and steering wheel inputs

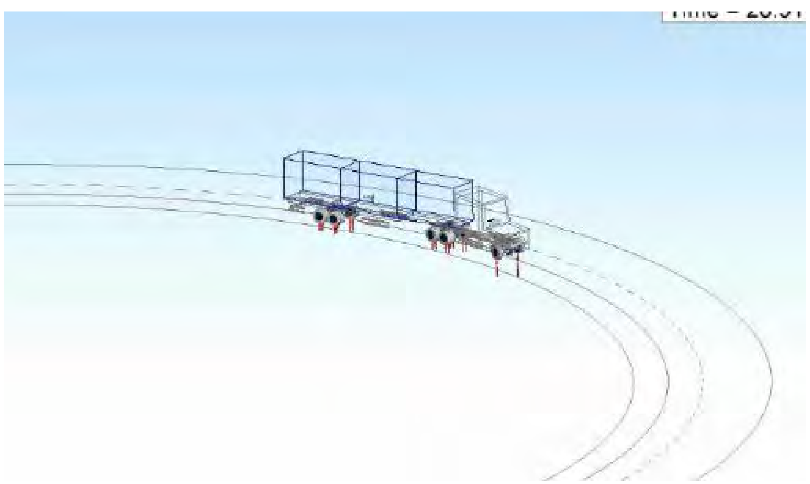
- **Task 1.2: 6x2/6x4 Simulations**
  - More challenging traction conditions, emergency maneuvers, slopes, tires

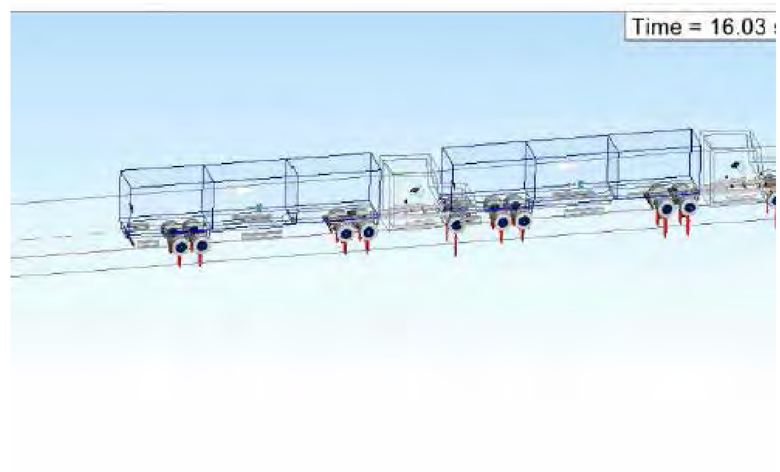
- **Task 2: Report – March 2019**

DYNAMIC MODELING AND SIMULATION









DYNAMIC MODELING AND SIMULATION

Inputs from track testing:

- Weights and dimensions of trucks
- Axle loads for each of the axles before and after load transfer
- Relationship between load transfer and slip

Inputs from provinces and territories:

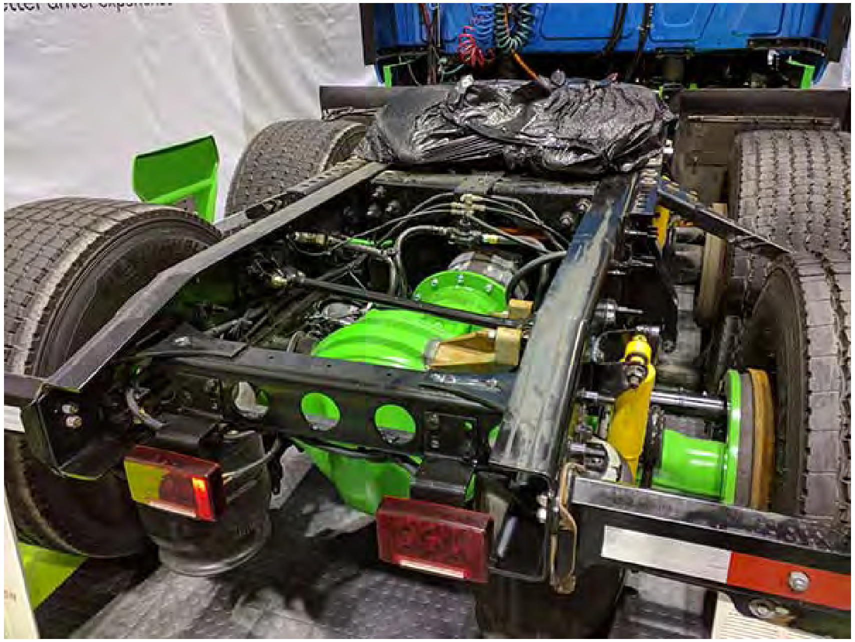
- Road friction
- Radius of curvature
- Slope
- Super elevation
- Speed profile

INFRASTRUCTURE IMPACTS ANALYSIS

- Contract with Infratech Solutions Inc. (Susan Tighe, University of Waterloo Centre for Pavement and Transportation Technology).
- **Task 1: Planning and Stakeholder List**
  - Each jurisdiction should be represented by someone active on:
    - Council of Ministers Task Force for Vehicle Weights and Dimensions; or,
    - Transportation Association of Canada
  - Stakeholders should have expertise in road design in each P/T
- **Task 2: Gather data on operational performance and provincial road networks**
  - Track test results from NRC/TC
  - Specific road infrastructure that would be most impacted by 6x2 vehicles
  - Technical specifications (elastic modulus, allowable load repetitions for fatigue/rutting, base layer, subgrade, seasonal data)
  - Average annual daily traffic
- **Task 3: Conduct Infrastructure Damage Analysis**
  - Calculate Truck Factors (TF) and Equivalent Single Axle Load (ESAL)
  - Damage ratios for each vehicle configuration
  - Gather stakeholder feedback on preliminary analysis and incorporate in final report
- **Task 4: Final Report and Webinar – March 2019**

ON OUR RADAR….
HYBRID ELECTRIC TANDEM DRIVE AXLES

- Regenerative braking captures power when slowing down, then electric power is applied when necessary to keep diesel engines at their most efficient RPM, delivering hybrid fuel savings.
- Using battery electric and cooling system to deliver power to the APU unit for several hours on a single charge



Hyliion 6X4HE Hybrid Electric System for Class 8 trucks

Thank you.

Brad Richard
Senior Engineer, Transport Canada
brad.richard@tc.gc.ca

Jeff Patten
Chief, Road RD&D, Transport Canada
jeff.patten@tc.gc.ca