



6x2 Forward Liftable Tandem

November 26th, 2014

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Agenda

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- **Forward Liftable Tandem 6x2**
- **Government Regulations**
- **OPTIMAAX Overview**
- **OPTIMAAX ECU**
 - Safety Interlocks
 - ECU Data Logging
 - Configuration Tool
- **Validation Testing**
 - Fuel Economy
 - Mobility
- **Conclusion**

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What is a Forward Liftable Tandem?

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- **Forward Liftable Tandem**
 - 6x2 with non-driven front axle
 - Drop center axle for driveline clearance
- **Commonly called a pusher axle**
- **Controls may be automated or manual**
- **Key differences**
 - Pusher (auxiliary) axles typically installed in addition to drive tandem
 - ♦ Infrastructure laws vary by state and province
 - Forward liftable tandem suspensions engineered to comply with tandem infrastructure laws



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Why no Liftable Tag?

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- **Liftable Tag Advantages**
 - Shorter driveline
 - Lighter weight
 - Lower cost
- **Disadvantages**
 - Only safe to lift in bobtail or with light unloaded trailer
 - ♦ 5th wheel position behind driven axle creates oversteer
 - ♦ Oversteer leads to vehicle instability, poor handling
 - Unable to be lifted as much as liftable forward axle due to reduced vehicle handling
- **Forward liftable tandems provide**
 - More flexibility for fleets
 - Increased opportunity to lift axles
 - Superior vehicle handling vs. liftable tags



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Government Regulations

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- **48 Contiguous states – Legal operation**
 - Legal in all states except Utah
 - Utah currently requires lift axles be steerable
 - ♦ Hendrickson has proposed revised language which Utah has agreed to implement
 - Tire Chains
 - ♦ Regulations vary by state – Apply to drive tires only
- **Canada – Restricted operation**
 - Varying Provincial
 - ♦ Ontario SPIF
 - ♦ Must not exceed 1000 kg weight shift for load bias
 - Canadian trucking industry interested in learning more
- **Hendrickson to maintain compliance link on website**

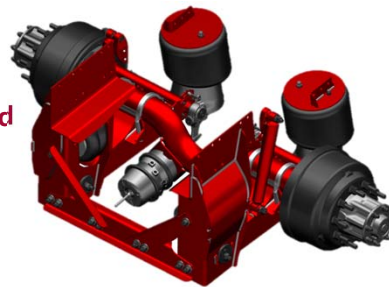


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- **Based on existing Hendrickson technology**
 - Similar to HLM suspension currently in production as a vocational lift axle
- **Compatible with existing bolt-on brake options**
- **R or P Spindles**
- **6" drop axle to clear driveline in lifted position**
- **350 lb savings vs. 6x4**
- **Load equalization with drive suspension at same pressure**
- **Torque reactivity**
 - Matches trailing arm air suspensions to ensure optimum braking performance
 - Meets FMVSS 121



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Optimize Capacity

- Senses lighter load conditions and lifts the non-drive axle



- Senses heavier load conditions and lowers the non-drive axle



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OPTIMAAX® ECU Overview

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Fully Automated Controls

- No driver intervention
- Proprietary program logic for deploying lift axle
- Designed to equalize tandem loads with common air
- Automatic load transfer to driven axle during wheel slip
- Safety interlocks – Automatically lowers axle
 - ♦ Parking brake
 - ♦ Ignition off
 - ♦ System fault detected
 - ♦ System unplugged (Service Mode)
- User friendly software interface to allow reprogramming if vehicle configuration is modified

OPTIMAAX ECU

OPTIMAAX Manifold



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ECU Data Logging

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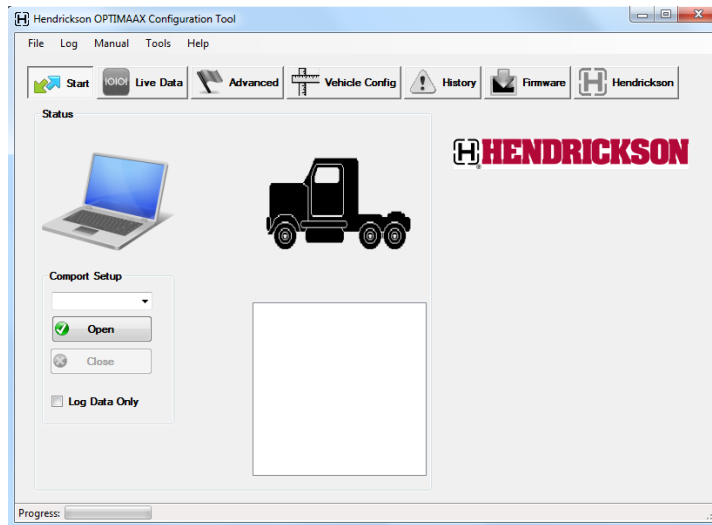
- **Stored in Internal Memory**
 - Total miles traveled
 - Miles traveled with aux axle deployed
 - Total time
 - Time with aux axle deployed
 - Number of deploy/retract cycles
 - Number of ATC events
 - Number of overload events

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Configuration Tool

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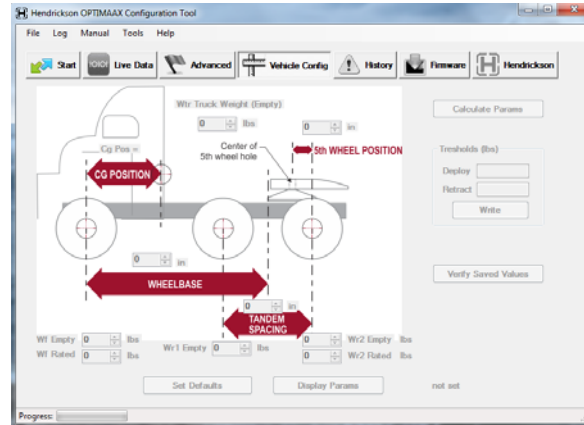


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Lift Threshold Setpoint Calculator

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- **Used when**
 - Aftermarket equipment added
 - 5th wheel relocated

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Tractor Fuel Economy Test

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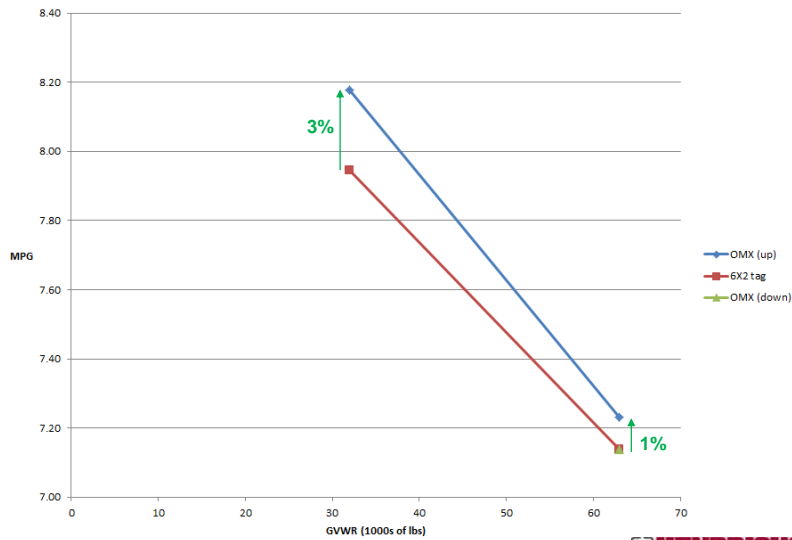
- **Test Method**
 - TMC/SAE In-Service Fuel Consumption Test Procedure – Type II
 - Test accuracy $\pm 1\%$
 - Kenworth 6X4 used as control
 - Volvo 6X2 tractor with loaded trailer used as baseline
- **Location**
 - Texas Proving Ground, Ft. Stockton, TX
 - 7.712 mile oval track
- **Test speed: 60 mph**
- **Test weight:**
 - 32,000 lbs GVW for empty trailer tests
 - 62,000 lbs GVW for loaded trailer tests
- **Fuel consumption measurement**
 - Removable fuel cells
 - Measurement: 0.005 lbs. (US)

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Normalized Fuel Economy

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Mobility Improvements

- **Weight of lifted axle improves traction on driven axle**
- **Tire scrub reduced in low speed turns**
 - Also reduces drive torque (fuel) required to complete low speed maneuver
- **Tractor trailing beam suspensions are torque reactive**
 - Tag solutions transfer load away from driven axle during reverse driving

6x2 Tag

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6x2 Forward Liftable Tandem



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Improved Traction



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Flexible Tire Strategies

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- **Drive tires in all positions**
 - Rotate often
- **Trailer tires on lift axle**
 - Lighter weight
 - Lower cost
 - Better fuel economy
- **New drive tires on drive axle, cycle used drive tires on lift axle**
- **Duals and singles are both currently used**

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Future developments

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- **Deeper drop axles**
 - Shortened tandem spacing – maximize axle up position
 - Accommodate large diameter lightweight drivelines
 - Eliminate occasional 3 pc driveline configuration
- **Additional weight reduction**
- **ADB compatible**
- **OEM Integration**
- **Trailer style spindle/hub options**
 - Truck R spindle hub heavier to support drive torque
 - ◆ Standard equipment at truck OEM
 - Trailer P (parallel) spindles capable of offset wheels
 - Trailer N (tapered) spindles most cost/weight efficient

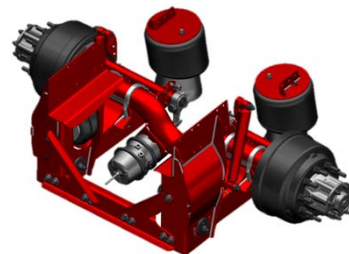
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Conclusions

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- **Enabling technology to improve acceptance of 6x2's**
- **Green solution providing improved:**
 - **Fuel savings**
 - ◆ Minimum 2% fuel economy improvement over non-liftable 6x2
 - ◆ Lower emissions
 - **Unloaded maneuverability – reduced tire scrub**
 - ◆ Improves tire life
 - ◆ Road friendly – less tires on the road and only when needed
 - **Weight reduction**
 - ◆ Increase payloads
 - ◆ Less mass, less horsepower, less fuel and emissions
 - **Traction**
 - **Toll saver**
- **Continue to work with various task forces in the US and CAN**



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