

Manufacturer Perspective for Improving Efficiency and Reducing GHG Emissions from Heavy Duty Vehicles

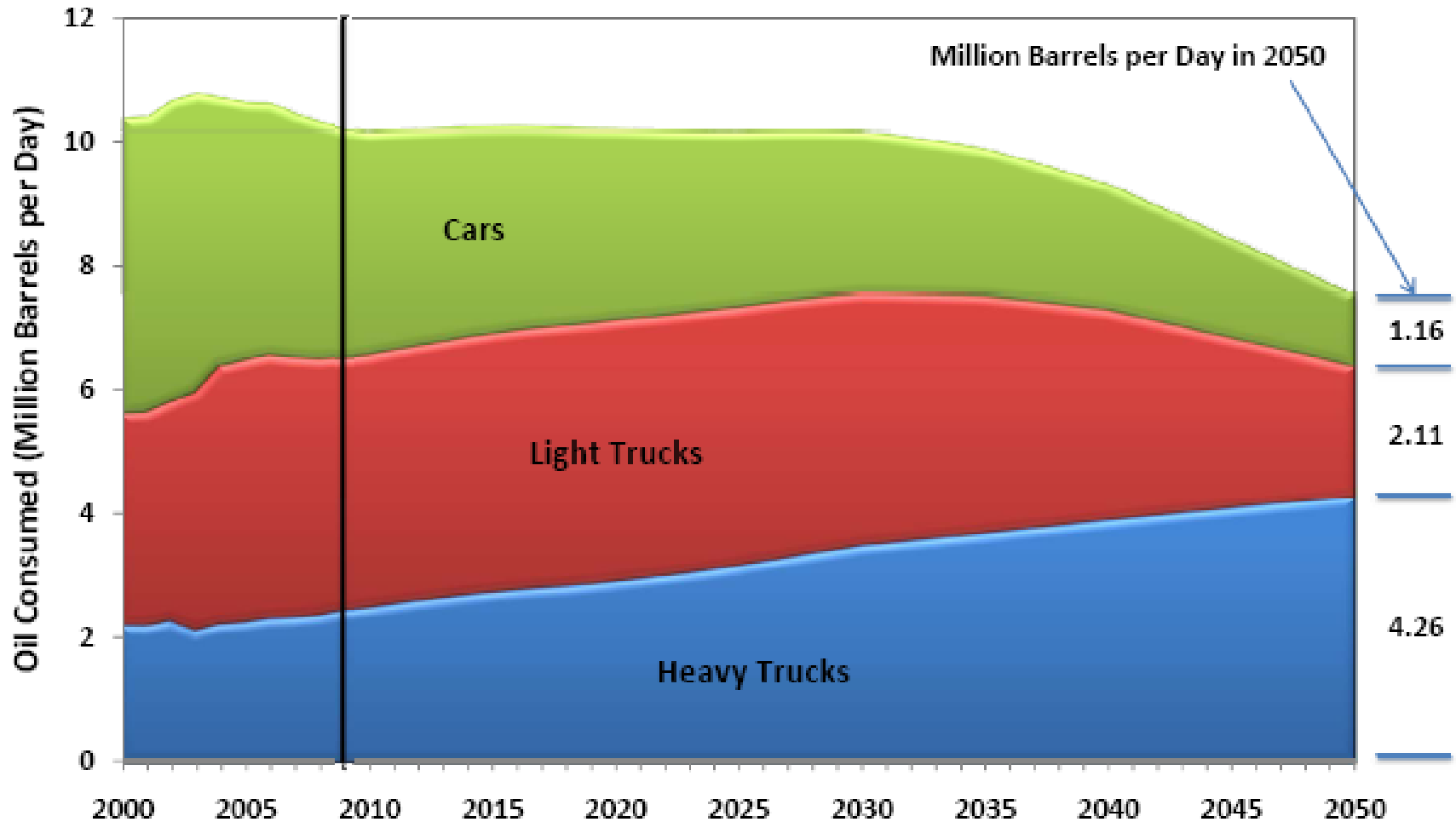


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Volvo Powertrain



Projection – Provided by US DOE in 2009

*Projection Oil Consumption by Vehicle Type
Presuming 75% Reduction in Light-Duty Oil Consumption**



*Light duty oil consumption reduction from AEO 2007 reference case modeled via increased fuel economy and shifts to flex-fuel, hybrid-electric, and plug-in hybrid-electric vehicles.

Major Contributors to Long Haul Truck Freight Efficiency

Engine Technology

Technology

- Diesel Combustion Efficiency
- Waste Heat Recovery
- Nox aftertreatment improvements
- Engine friction reduction
- Engine Auxiliaries (water/oil pump)
- Other New Technology Developments

Truck Technology

- Transmission & Driveline Efficiency
- Powertrain integration (includes engine)
- Cooling optimization
- Vehicle Auxiliaries (Air comp, PS pump, Air Cond, Fan, Alternator)
- Aerodynamics (tractor)
- Weight
- All Tractor Tires
- Trailer Gap or vortex stabilizer
- Smart Navigation
- Mild long-haul hybrid (add to no-idle)
- Full Hybrid

Fleet Operations

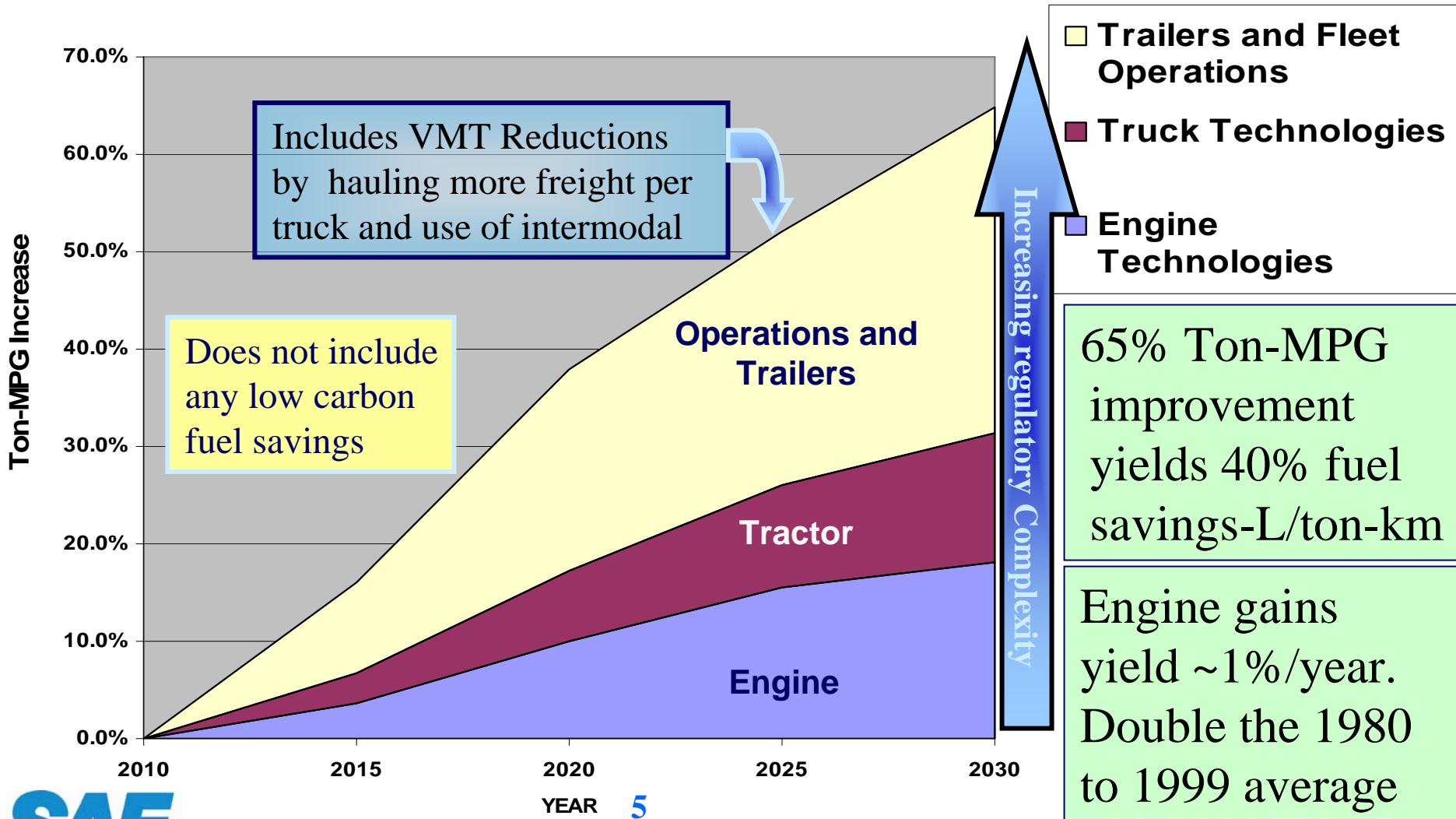
- Logistics
- Trailers -Tires, Aero, Weight
- Longer Combinations & increased weight (assuming consistent state regulations)
- Intermodal (rail)
- Driver Training
- Trailer gap control (add to truck design)
- Idle Elimination
- Road speed reduce 7 MPH

Biggest opportunities

SCR Impact on Petroleum and CO₂

- **SCR, used to reach 2010 emission level, results in significant reduction in use of petroleum and green house gas emissions while reducing operating cost.**
 - **Compared to 2009 Emissions Engine:**
 - Each gallon of DEF reduces diesel use by ~1.5 gallons
 - Each gallon of DEF eliminates ~15 KG CO₂ (equal to 1.3 gallons diesel)
 - Equivalent to natural gas displacing 4% petroleum use
 - DEF (Urea) is made from natural gas
 - **Compared to EGR only solution for EPA 2010 (Assuming 2-3% Fuel Efficiency Loss vs. 2007):**
 - Each gallon of DEF reduces diesel use by ~3 gallons
 - Each gallon of DEF eliminates ~33 KG CO₂ (equal to 2.8 gallons diesel)

Class 8 Ton-MPG - A Prospective Scenario Via Vehicle Efficiency Gains and VMT Reductions



HD Vehicle Market has Huge Variety Size, Shape, Duty Cycle

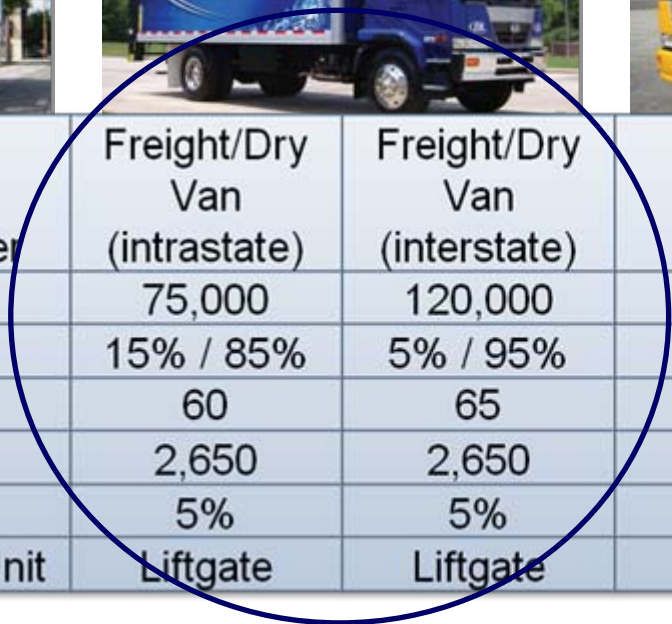


Volvo Class 8 Variety





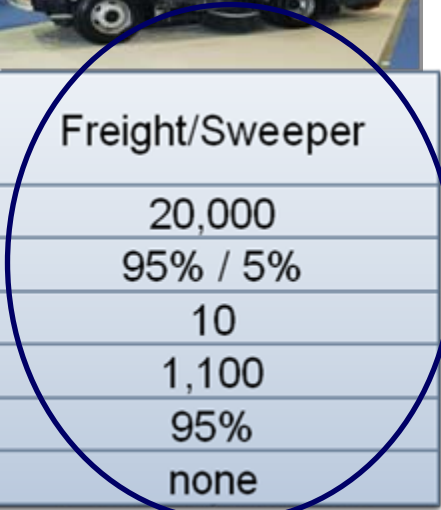
Vocation/Body Type	Provisions/Refrigerated	Freight/Dry Van (intrastate)	Freight/Dry Van (interstate)	Tow/Roll Back
Est. Annual Miles	52,000	75,000	120,000	40 – 45,000
City / Highway Use	60% / 40%	15% / 85%	5% / 95%	50% / 50%
Est. Ave. Speed	45	60	65	45
Est. Ave. Eng. RPM	2,000	2,650	2,650	1,800
Est. Idle & PTO Time	25%	5%	5%	20%
Aux. Equipment	Engine Driven Unit	Liftgate	Liftgate	PTO / Hoist



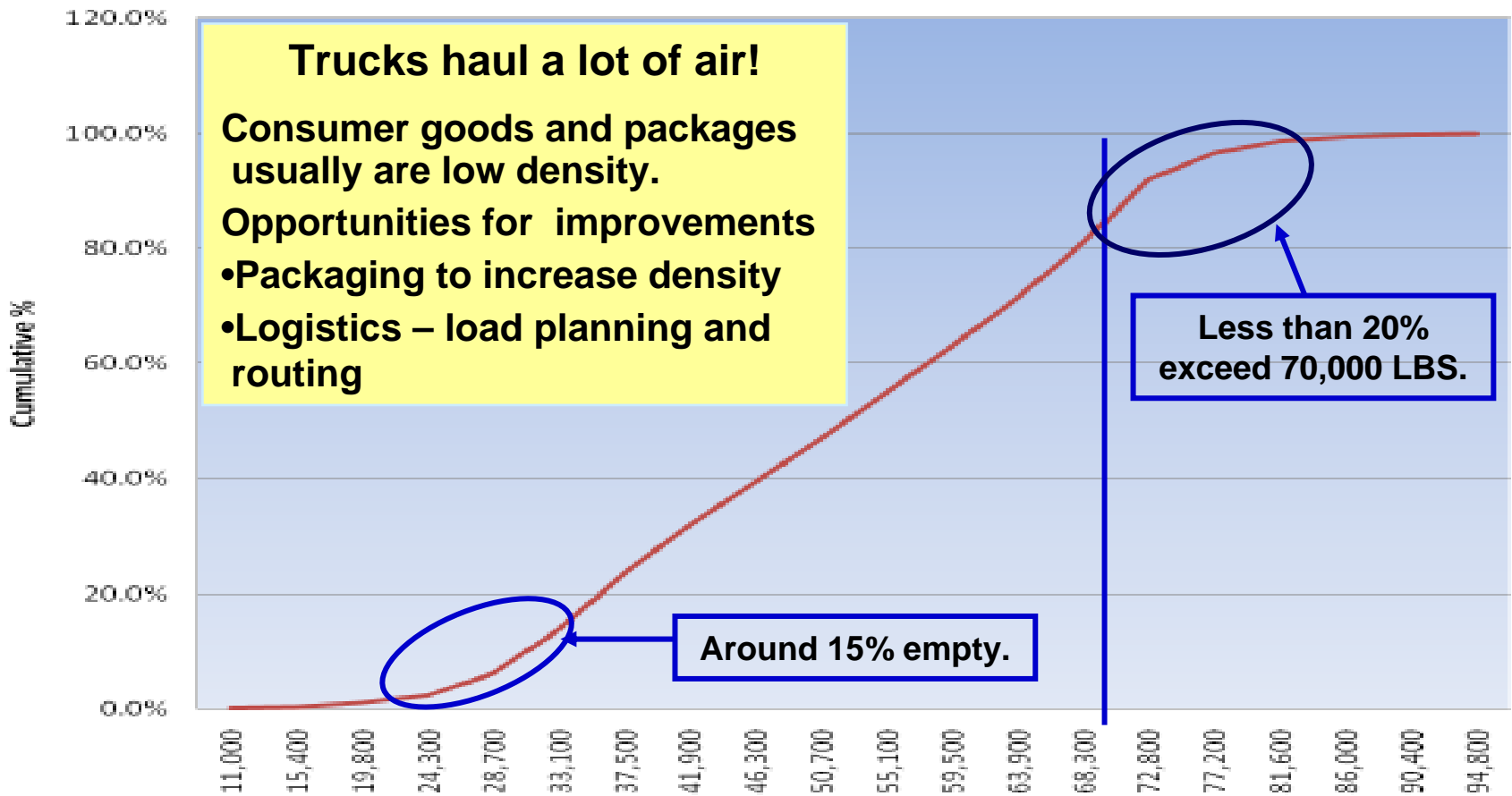
All mounted on same chassis delivered to body builder



Vocation/Body Type	Refuse/Rear Loader	Construction/Mixer	Freight/Sweeper
Est. Annual Miles	30,000	30,000	20,000
City / Highway Use	90% / 10%	70% / 30%	95% / 5%
Est. Ave. Speed	30	40	10
Est. Ave. Eng. RPM	1,600	1,900	1,100
Est. Idle & PTO Time	60%	40%	95%
Aux. Equipment	PTO / Hydraulics	PTO / Hydraulics	none

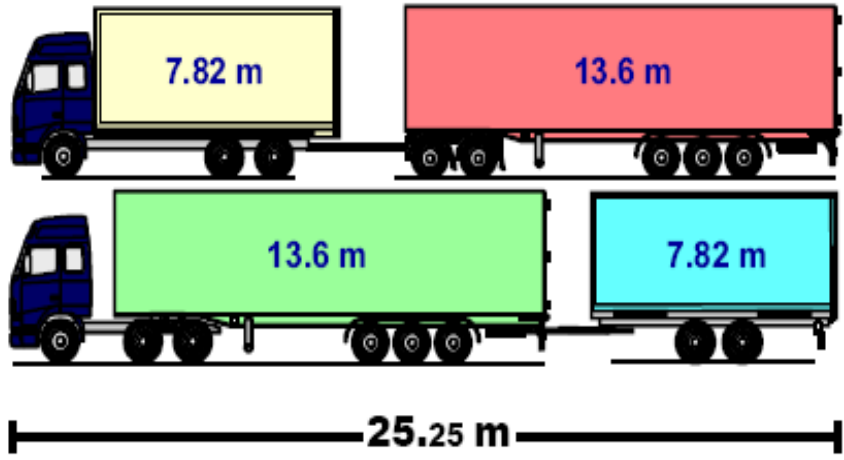


Cumulative Percentage of 5-Axle Tractor Trailer Combination Vehicles by Gross Vehicle Weight as Reported by VTRIS for Fifteen States (CA, CT, FL, GA, HI, IA, MN, MO, MT, NC, MN, OR, PA, SD, TX, & WA) in 2008



Longer Combination Trucks

Single Biggest Potential Efficiency Gain via Lower VMT



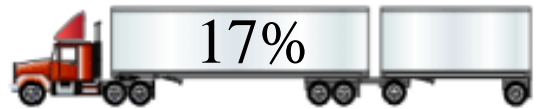
Sweden and Finland allowing rigs up to 25.25 m vs 18.75 m in rest of EU (14-20% less fuel)

Quote – Ontario, Canada Ministry of Transport

LCVs are a win-win-win. They are good for the economy, good for the environment and improve highway safety. They can move goods at a lower cost and with fewer greenhouse gas emissions than single-trailer trucks and, under carefully controlled conditions, more safely.

Fuel saving for longer US combinations (with volume limited freight- per ATRI study)

6-axle Tractor-Semitrailer



Rocky Mountain Double (RMD)



Triple Trailer Combination (TRPL)



Turnpike Double (TPD)



CO2 Reduction through Bio-fuels

Seven trucks running on renewable fuels



Issues & Opportunities

Trailer economics do not easily support efficiency improvements

- ⌘ 3-4 trailers per tractor drives up cost vs fuel savings
- ⌘ Difficult to manage proper trailer match to tractors
- ⌘ Very long trailer life – slow turnover

Shipper's area of influence

- ⌘ Manufacturing and distribution systems are based on low cost freight transportation. (Just-in-Time)
- ⌘ Packaging impact on freight density and volume
- ⌘ Warehousing and distribution patterns

Infrastructure

- ⌘ Highway infrastructure
- ⌘ Truck stops (Availability and Electrification)
- ⌘ Congestion mitigation
- ⌘ Intermodal facilities

Lack of Long-Term Vision

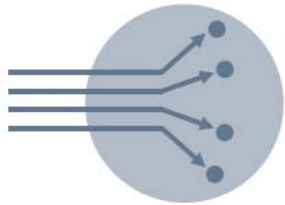
Long-Term Infrastructure Vision Needed

Long Haul

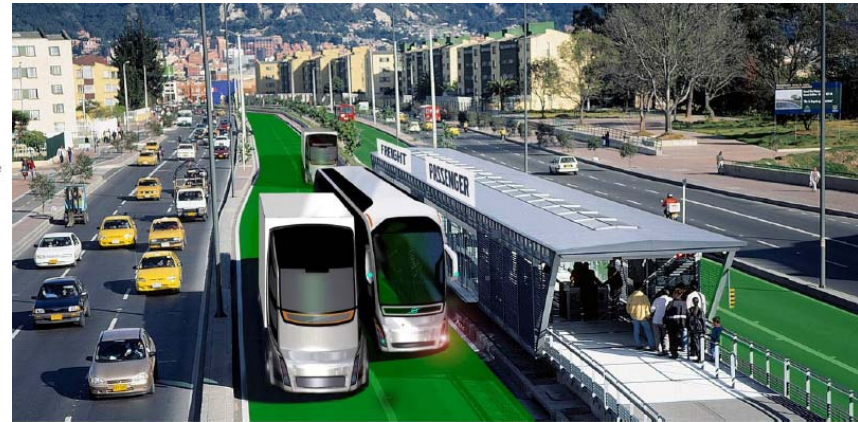
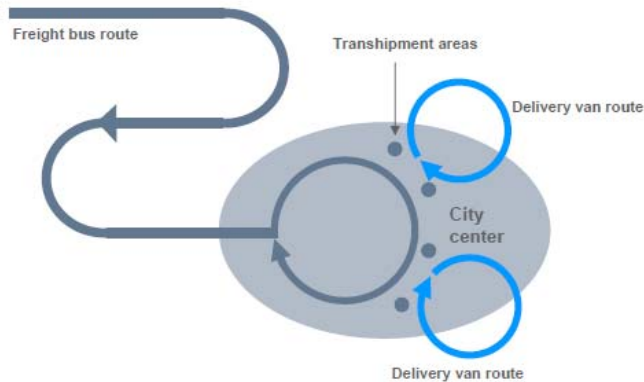
Truck only lanes
Autonomous operation
Lower speeds
Warehousing and Distribution
Road trains Packaging
Intermodal

•Urban

Today



Tomorrow - The logistic hub



Public Policies to Promote Road Freight Efficiency

Establish fuel or carbon tax policy to increase overall cost of fossil fuel or set a long-term escalating floor price for fossil fuel.

- ▶ Establishes a target value for alternate fuel development.
- ▶ Establishes market value for fuel efficient vehicle technology development.
- ▶ Incentivizes freight efficiency by carriers and shippers.

Establish uniform vehicle size and weight limits at the highest possible levels with supporting highway infrastructure.

Replace new vehicle taxes (12% excise) with increased fuel tax to promote fleet roll-over to lower emissions vehicles.

⌘ 24% shift in value of technology

Support technology development of efficient trucks, alternate fuels, and fuel infrastructure.

Set mandatory hard-programmed road speed limits as is already done in Europe and most countries.

Public Policies to Promote Road Freight Efficiency

Develop infrastructure for efficient rail and intermodal shipment between rail and truck.

Develop Highway Infrastructure and Intelligent Vehicle Management

- ⌘ Mitigation of congestion
- ⌘ Ample truck stops to avoid idling (electrification)
- ⌘ Truck lanes in congested areas to support longer combinations and avoid conflict with higher speed cars.
- ⌘ Intelligent systems to manage vehicle flow

Revise vehicle regulations that inhibit efficiency

- ⌘ Allow cameras to replace mirrors
- ⌘ Allow extra length for aerodynamic features (trailer boat-tail)
- ⌘ Allow extra weight for emissions and fuel efficiency technologies to avoid displacing freight.

Create trailer standards to integrate with tractors and support full vehicle aerodynamic optimization.

Public Policies to Promote Road Freight Efficiency

Truck Efficiency Regulation?

- ⌘ Variation in truck size, work performed, and duty cycle makes such regulation very difficult.
- ⌘ Impossible to regulate all significant impacts on freight efficiency

Vehicles

Trailers

Combinations

Freight logistics

Driver management

Route planning

Smart Vehicle Management

Warehousing and distribution

Mode shifting

Packaging

Still Good Reasons to Consider Regulation

- ⌘ Establish firm dates for technology introduction
- ⌘ Remove market barriers to new technology
- ⌘ Set targets and lead time

But also need to drive demand and efficiency in all areas via market mechanisms through carbon tax or cap & trade.

MPG is not an appropriate efficiency measure



Possible Regulatory Options

Start with focus on long-haul and regional tractors.

Use vehicle modeling to simulate specification variants to deal with diversity in freight trucks

Vocational applications even more difficult. Initial focus on small number of areas (engine, tires...)

Establish target efficiency levels based on available or expected technologies.

Metric based on truck freight capacity – volume and weight

Very difficult to account for vehicle and driver management technologies.

Drive trailer efficiencies and proper tractor trailer matching

- ⌘ Education and incentive to carriers
- ⌘ Could have trailer regulations
- ⌘ Still need to address VMT growth.
- ⌘ Logistics, Packaging, Routing

All options require a difficult compromise between effectiveness and complexity.

Conclusion:

On the way to climate neutral transportation

Significant gains in freight efficiency are possible, but efforts by governments, vehicle manufacturers, trailer manufacturers, carriers, and shippers is required.

