SAE 2010

Government/Industry Meeting

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Challenges, Opportunities and a Possible Framework for Regulation of GHGs from Commercial Vehicles

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CHANGING THE CLIMATE
ON CLIMATE CHANGE

Improving Efficiency / Reducing CO_2 Footprint

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Idle Reduction

Hybrids

CO_2 = Energy Efficiency

High Efficiency Clean Combustion

Waste Energy Recovery

Low Temp Aftertreatment

CO_2 Regulation will Drive Technology

- NAS: Technology Study
- EPA: “Technology Forcing” CO2 regulation
- Defined test protocol
- Ensure compliance verification
- Align with business model
- Adequate lead-time

Regulatory framework must align with technology development, product application and business structure to be effective

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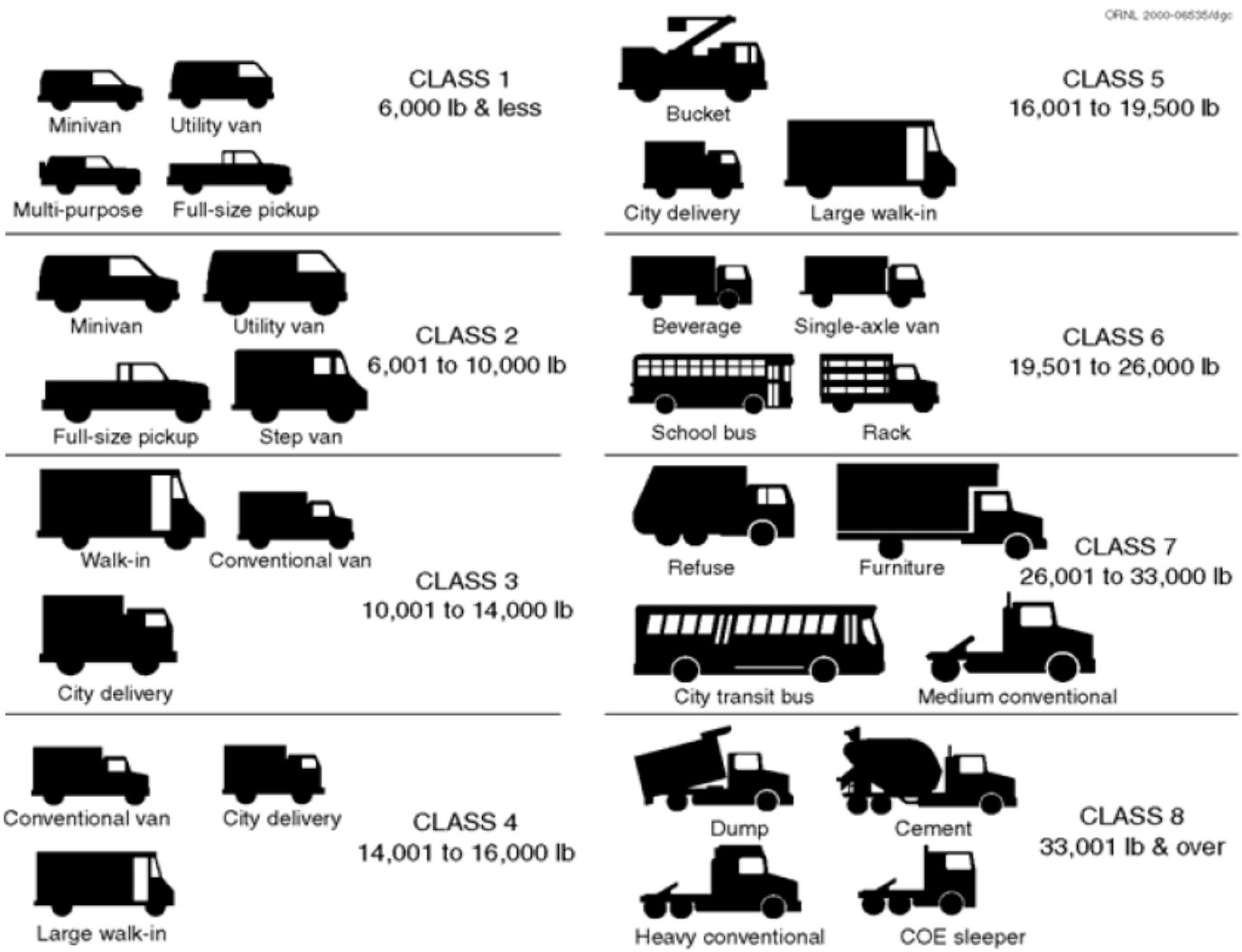
Many *Class 8* configurations and measures of useful work

Vehicle and Application Complexity

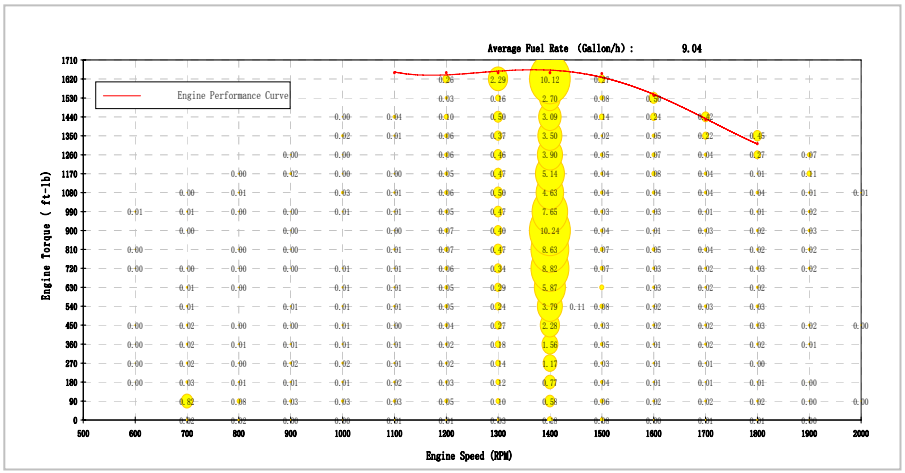


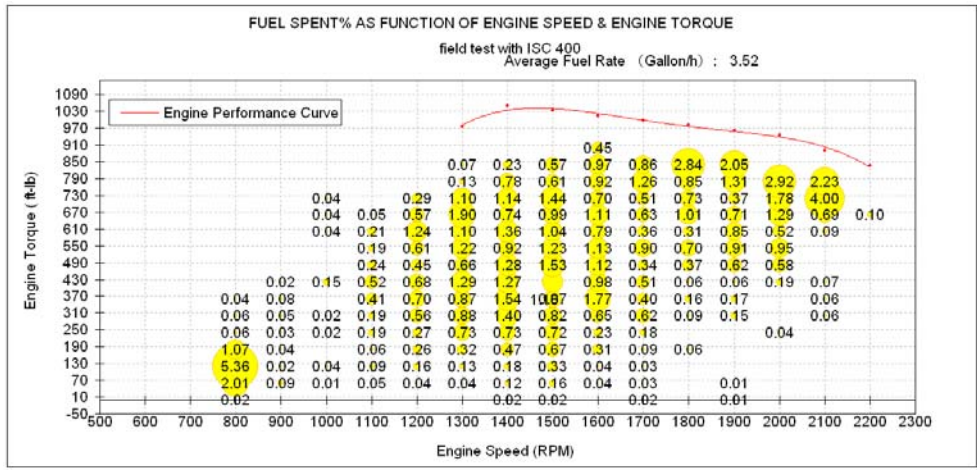
Guiding Principles

Simplicity	Right Balance
Speed	Ability to implement near-term
Incentives	Encourage early adoption
Technology	Drive uniformly
Fairness	Avoid unintended consequences
Compliance	Verifiable
Feasibility	Best available technology
Flexibility	Use current flexibility
Phase-In	Progressive approach

Natural Separation

Line Haul and Vocational





Line Haul
Flat – Dallas to San Antonio

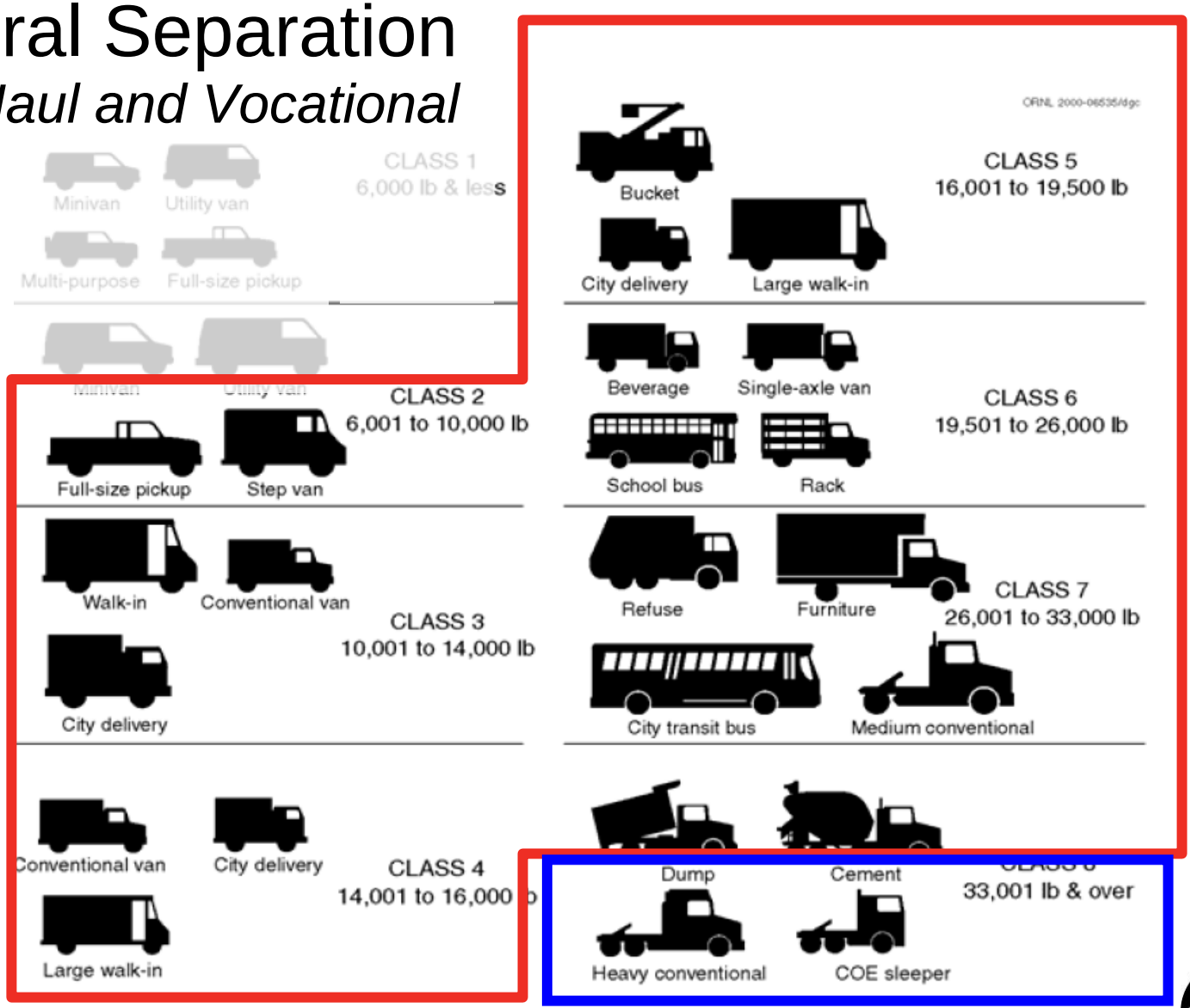
Vocational / Work Truck
ISC School Bus

Natural Separation
Line Haul and Vocational

Parameter	Line Haul	Vocational
Average Speed	**40 - 55 MPH**	**20 - 40 MPH**
Cruise Speed	60 - 70 MPH	-
Idle Time	5 - 35 %	30 - 55 %
Annual Mileage	**100 - 225k**	**15 - 6 0k**
Average GVW	50 - 80k LBS	20 - 4 0k LBS
No. of Wheels	18 - 26	4 – 1 6
Accessory Loads	Sleeper, HVAC	PTO , HVAC
Cruise Power	180 - 250 HP	-
Ave Duty - Cycle Power	**100 - 200 HP**	**20 - 125 HP**
Peak Power	400 - 5 00 HP	200 - 500 HP

Natural Separation

Line Haul and Vocational



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Fuel Consumption Factors

Tractor aerodynamics
Trailer aerodynamics
Trailer Gap & Height
Power & Torque Rating
Electronic Features: Smart Torque…
Fuel Carbon Intensity
Engine Performance
Engine Efficiency
Transmission, Rear Axle Ratio
Wheels & Tires, Pressure, Condition

Emissions Level
Emissions Technology
Measurement Protocol
Payload configuration
Duty-Cycle
GVW
Route – Flat, Hilly, Traffic…
Highway Conditions
Ambient Conditions
Driver Performance
Accessories, Hotel Load

Partitioning the System

Power Demand
"Passive"

- **Fuels**
  Reduced carbon intensity
  Bio Diesel, CNG, LNG
- **Engines**
  Efficiency improvements
  Reduced Carbon Fuels
  Hybrids / Waste Heat Recovery
- **Vehicles**
  Transmissions / Axles / Tires
  Aerodynamics
  Tractor & Trailer - Smartway
- **Fleets / Operators**
  Incentives for low GHG vehicles
  Logistics, Driver training & aids
- **Highways / Infrastructure**
  Highway Construction / Congestion
  Speed limits
  GVW

Power Supply
"Active"

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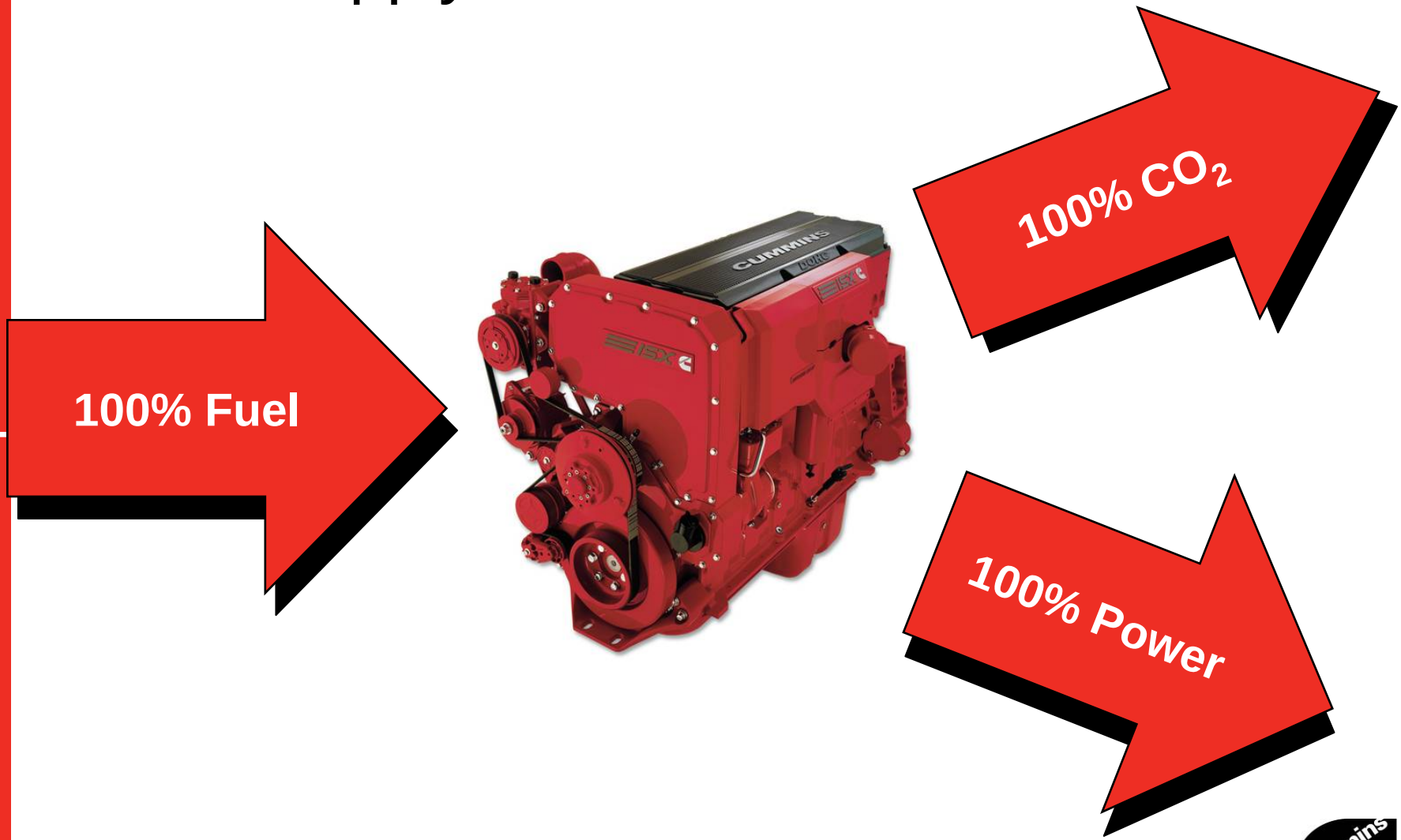
Power Supply



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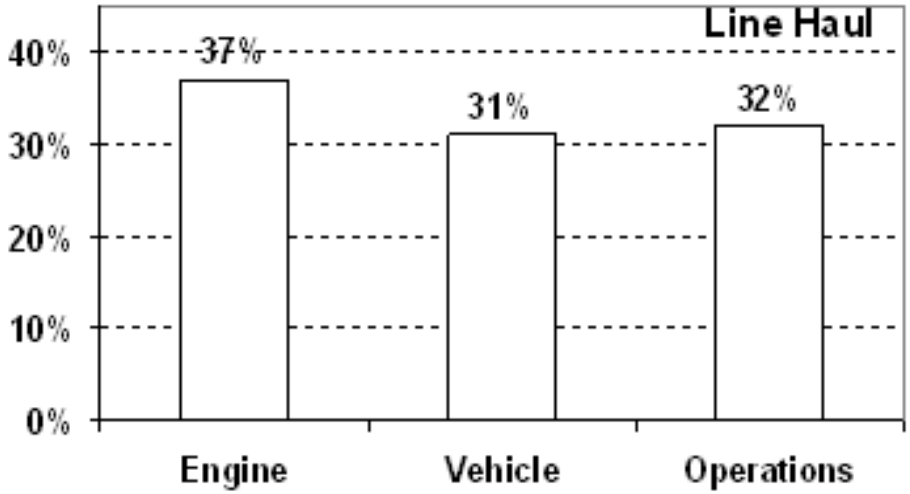
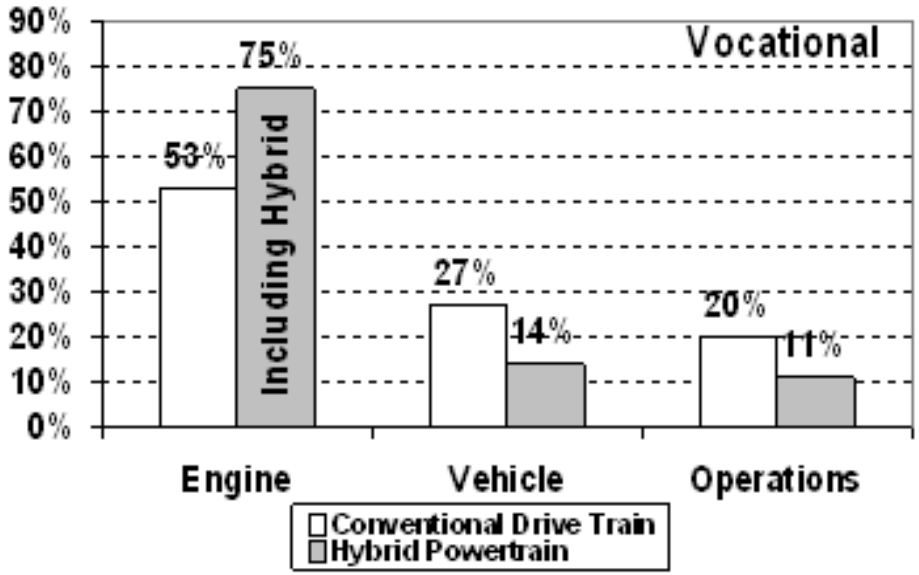
Potential CO_2 Reductions

LINE HAUL



VOCATIONAL



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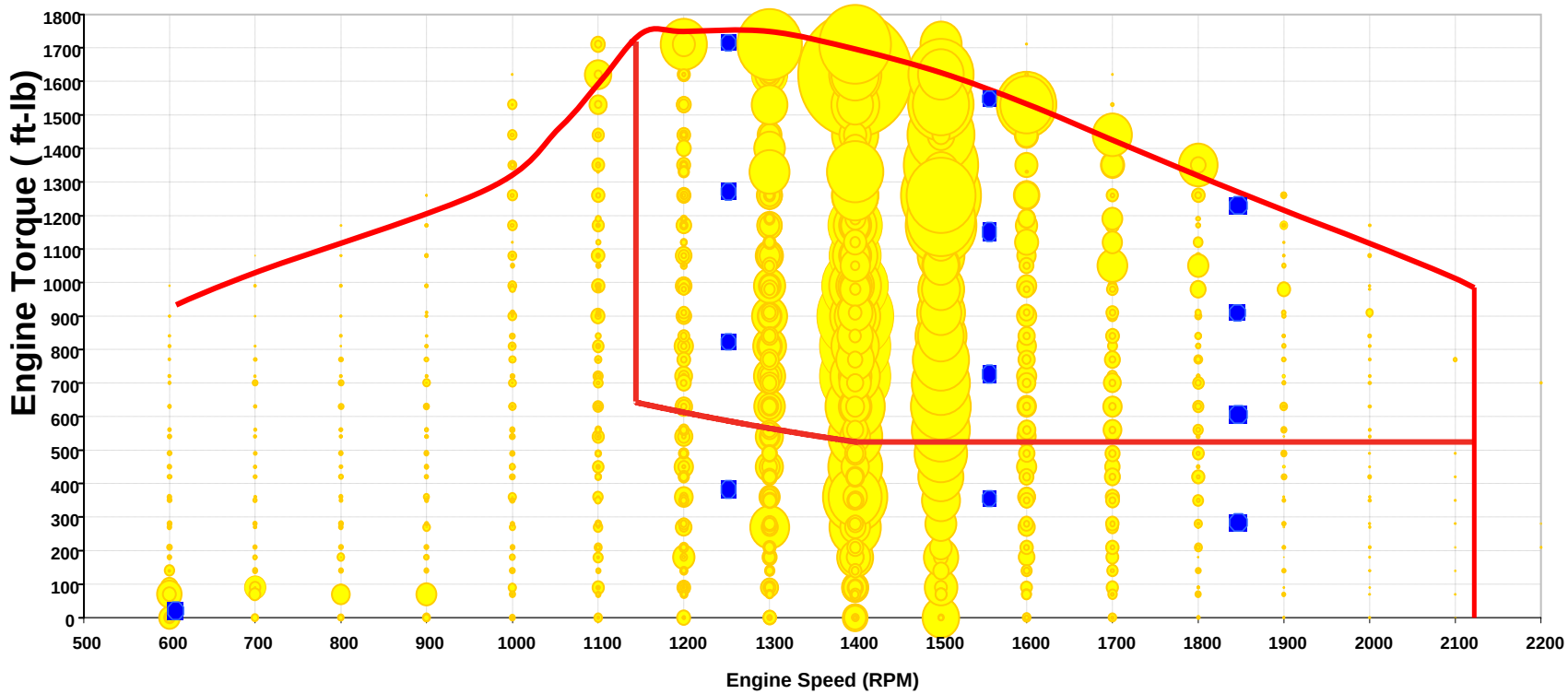
Line-Haul Duty Cycle Analysis

- 8 line-haul duty cycles overlaid with SET points and NTE
  - Based on fuel burned at mode, as opposed to time at mode
  - Very little fuel spent outside of 13 mode “surface” and NTE Zone
  - Line-Haul maps well to the 13 SET modes



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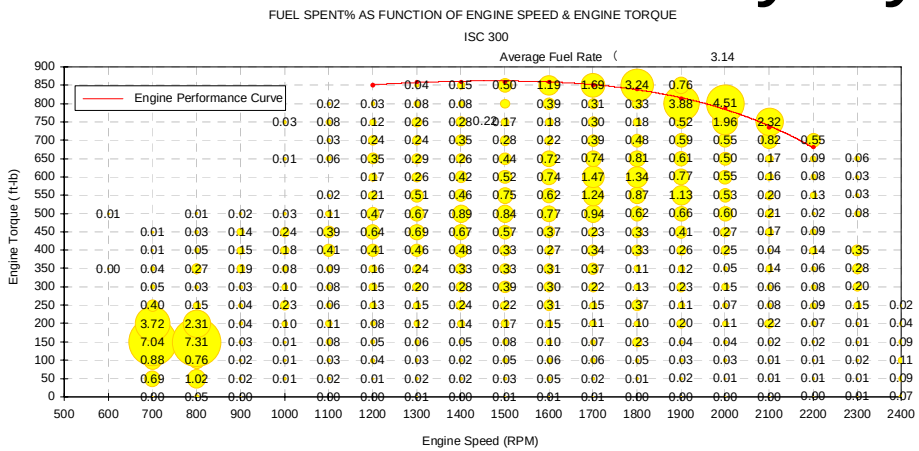
SET as a Model for Line Haul

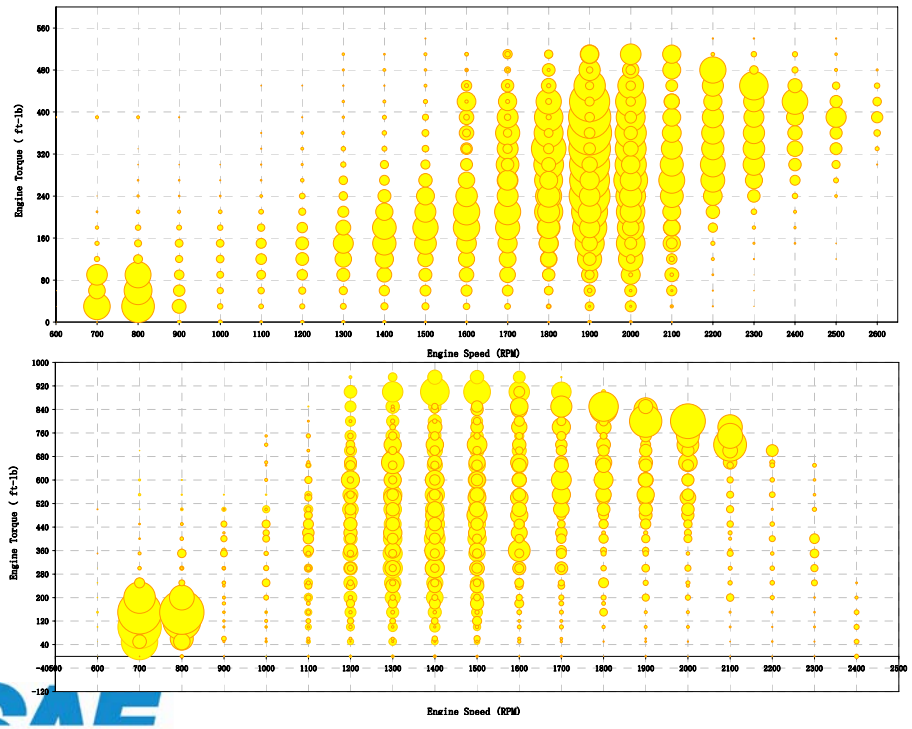
- Compare SET results from emissions certification test cell with results from the field
- 11L and 15L engines – field data from all 8 data sets
- 13 mode test cell data from independent emissions test

CO_2 Predicted from SET Test v. Actual Field Data

SET Model	Difference
Full 13 Mode SET Emissions Results with ESC Weighting Factors	**3.7%**

Vocational Duty Cycle Analysis





ISM Refuse Truck with PTO

ISC School Bus, Refuse

ISB P&D x 2

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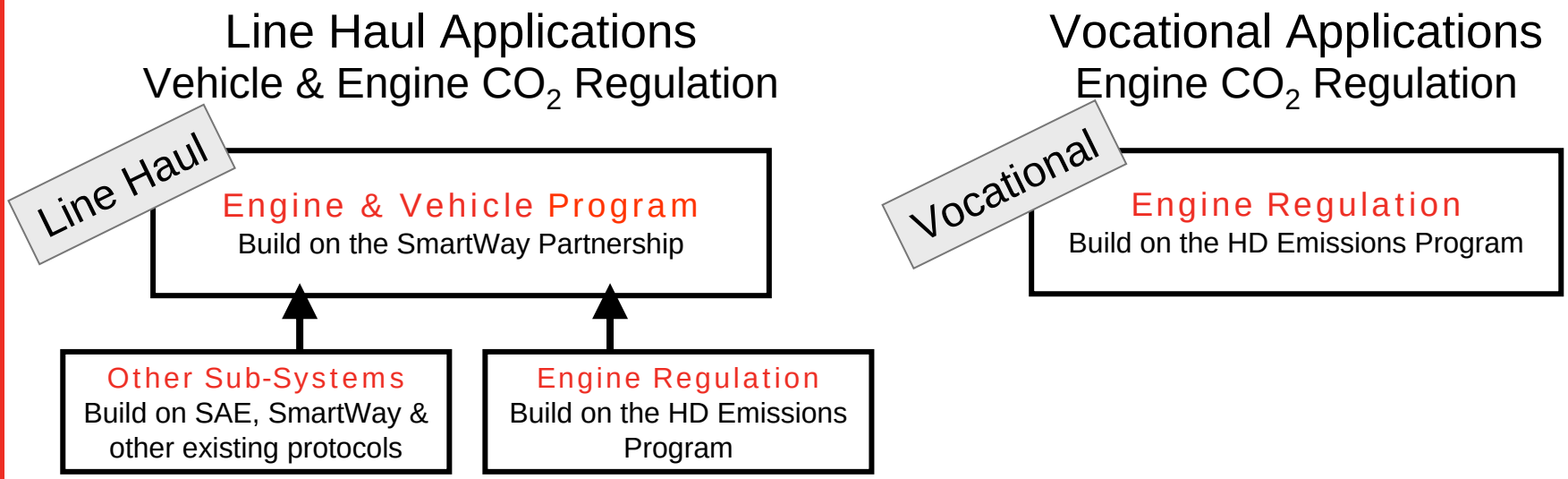
FTP as a Model for Vocational

- Compare FTP results from emissions certification test cell with results from the field
- 6.7L, 8.3L & 11L engines – field data from 9 data sets

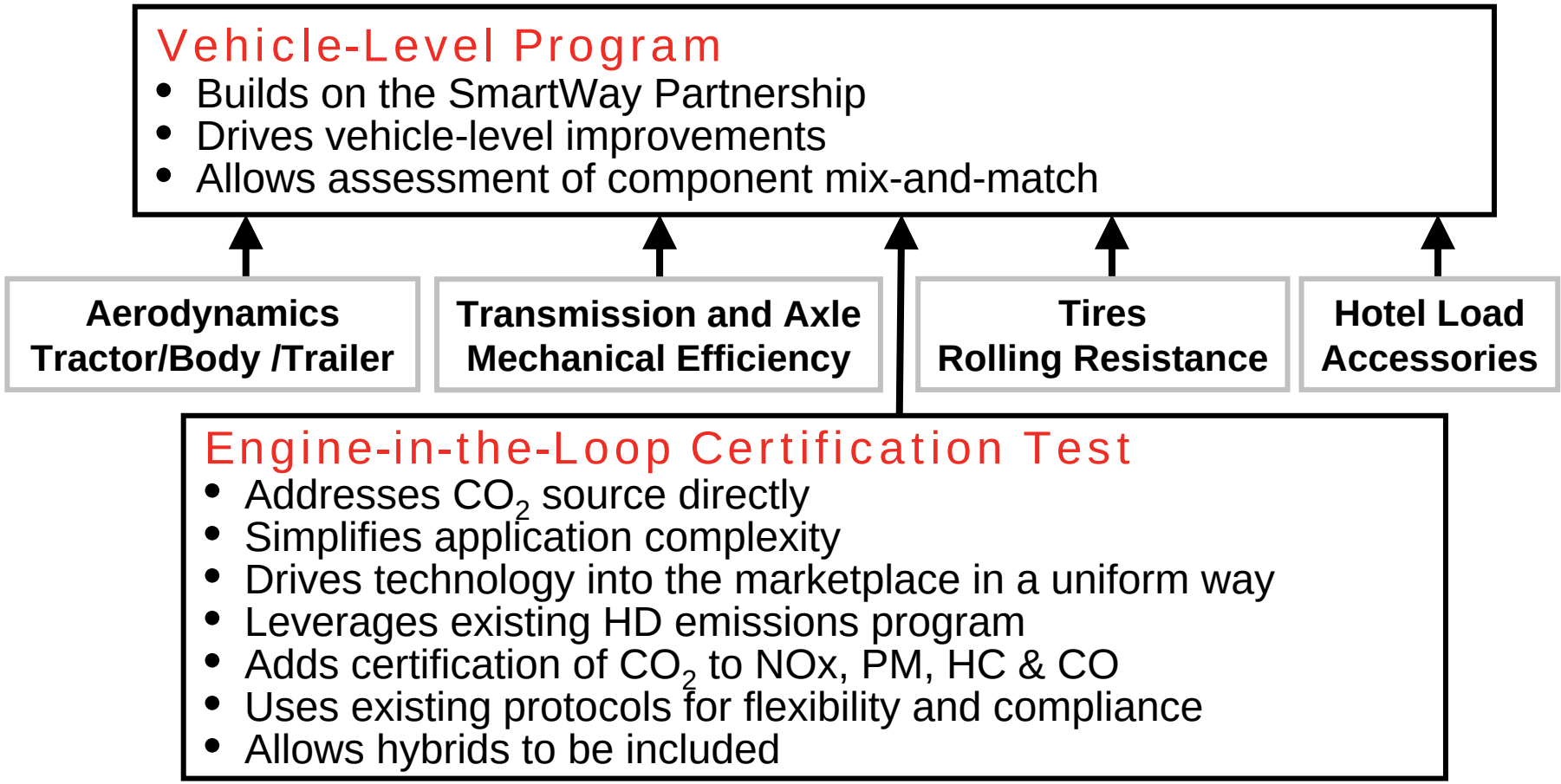
CO_2 Predicted from FTP Test v. Actual Field Data

FTP Model	Difference
Full FTP Cold & Hot Cycle Composite	**4.0%**

Overall Framework

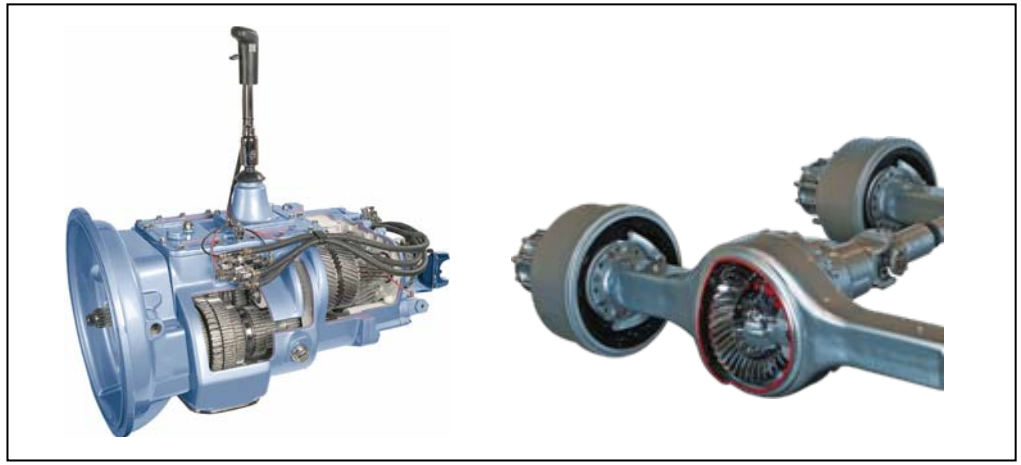


Line Haul Framework



Concept for Phase 1 – Line Haul

Engine - Certification / CO_2 Standards



Drivetrain – Customer specified, reduced parasitics / losses

Tractor – focus on aero, tires and accessories

- Tractor certification model or Look-up table approach
- Sleeper cab / 53’ Box Van application
- Key inputs:
  - Aero characteristics
  - Tires / wheels, axle loads
  - Accessories / APU
  - Drive cycle – Vehicle speed route profile, idle time, GVW …
- Engine map not required – model should focus on the effectiveness of tractor features
- Key outputs: CO_2 [g/ton-mile]
- Family approach
- Type approval / certification
- Flexibility at a tractor level

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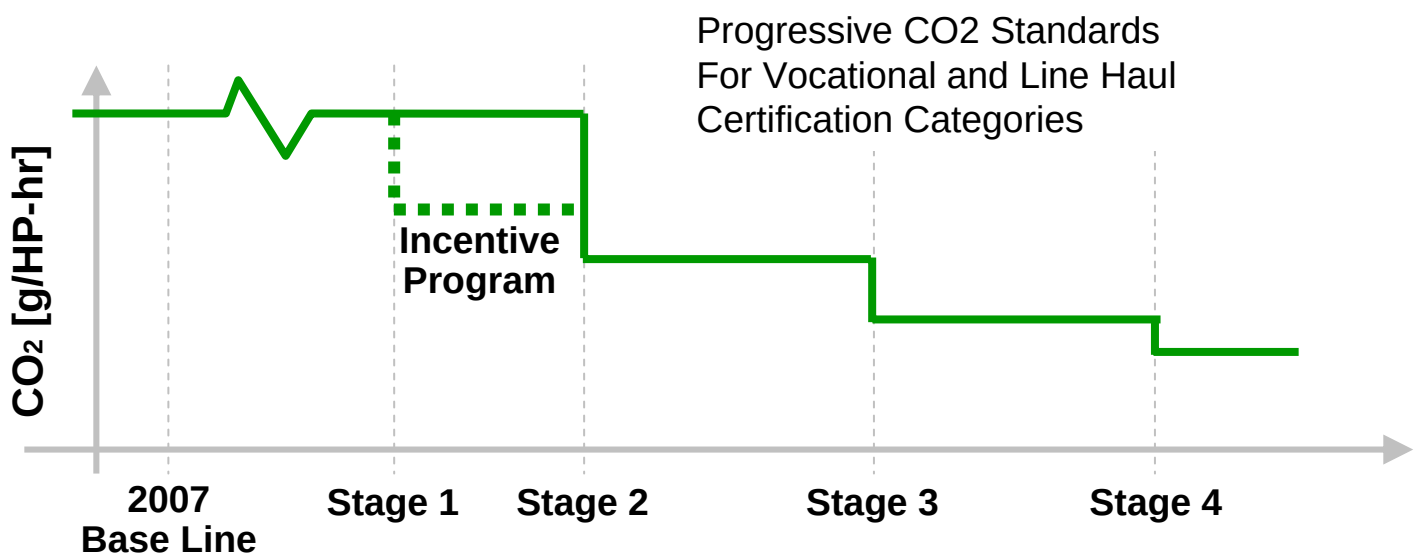
CO2 Reduction Phase-In



Executive Summary

- CO2 / Fuel Effiency regulations will drive technology development for vehicles, engines and critical sub-systems
- The broad range of vehicles and applications create significant and practical challenges for effective regulation
- Regulatory framework must align with technology development, product application and business structure to be effective
- Existing, well established test protocols for criteria emissions provides a sound basis to apply CO2 regulation for engines.
- Application of existing test protocols will enable faster implementation of regulations for reduced CO2 emissions