HEAVY-DUTY TRUCK EMISSIONS AND FUEL CONSUMPTION SIMULATING REAL-WORLD DRIVING IN LABORATORY CONDITIONS

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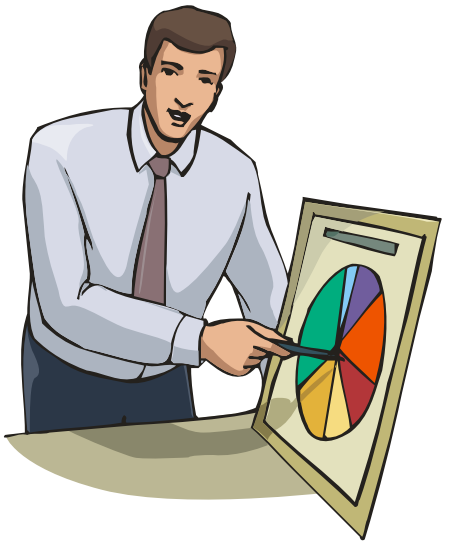
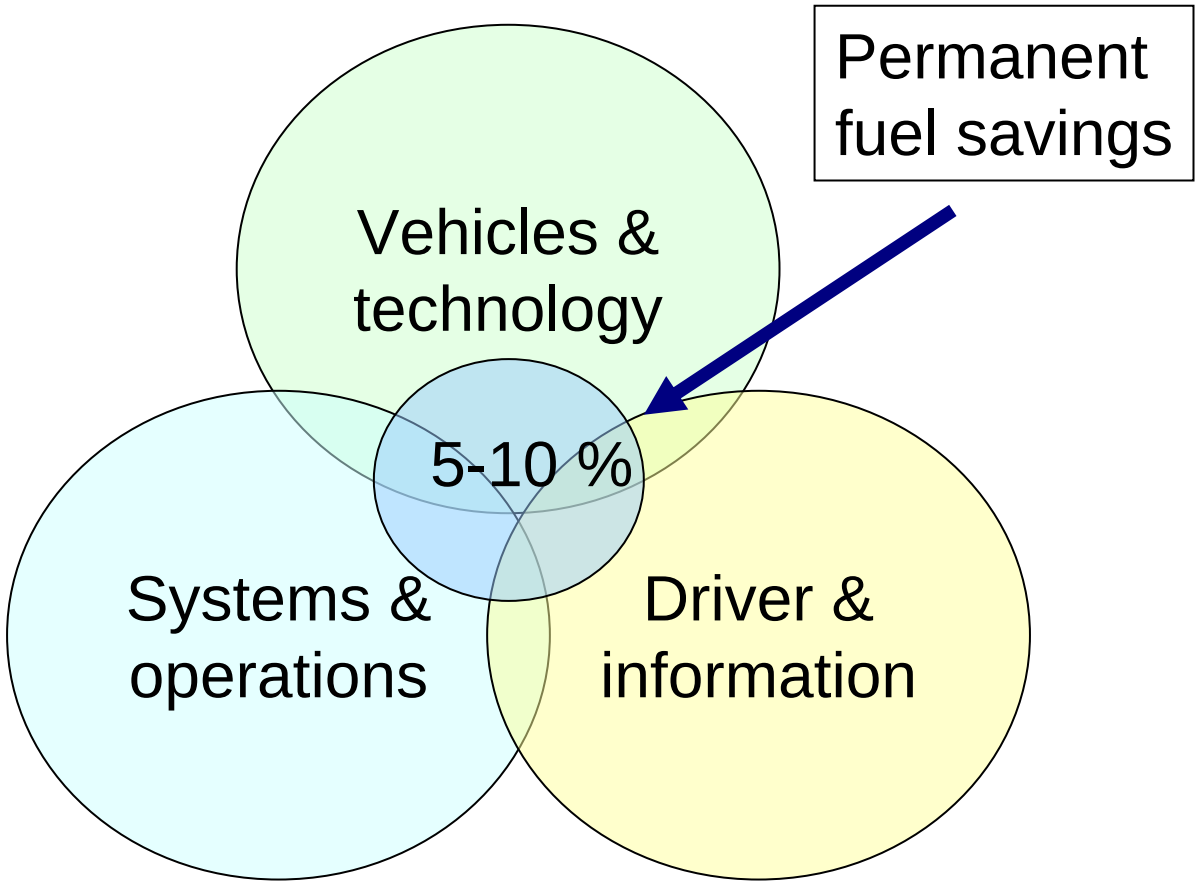


RESEARCH INTEGRATE ON HEAVY-DUTY VEHICLES

- Finland, like many other countries is highly dependent on road transports
- Some 75 % of the goods within the borders of Finland are transported on rubber wheels
- VTT initiated a three-year (2003-2005) multi-client research project to seek fuel savings for heavy-duty vehicles
  - 6 research institutes and some 20 sponsors from government, industry and transport companies cooperating

www.motiva.fi/raskaskalusto (in Finnish)

THE GOAL OF THE PROJECT
- in a 5-year perspective



EMISSION CERTIFICATION

- For light-duty vehicles, certification is done running complete vehicles
  - both emissions and fuel consumption are reported

- Both for the US and Europe, HD emission certification is done using stand-alone engines
  - the outcome is specific emission values (g/hph or g/kWh) for the engine itself tested over a certain duty cycle
  - the testing does not in any way reflect the properties of the vehicle itself (weight, aerodynamic drag, design of the driveline etc.)
  - no requirements to report fuel economy

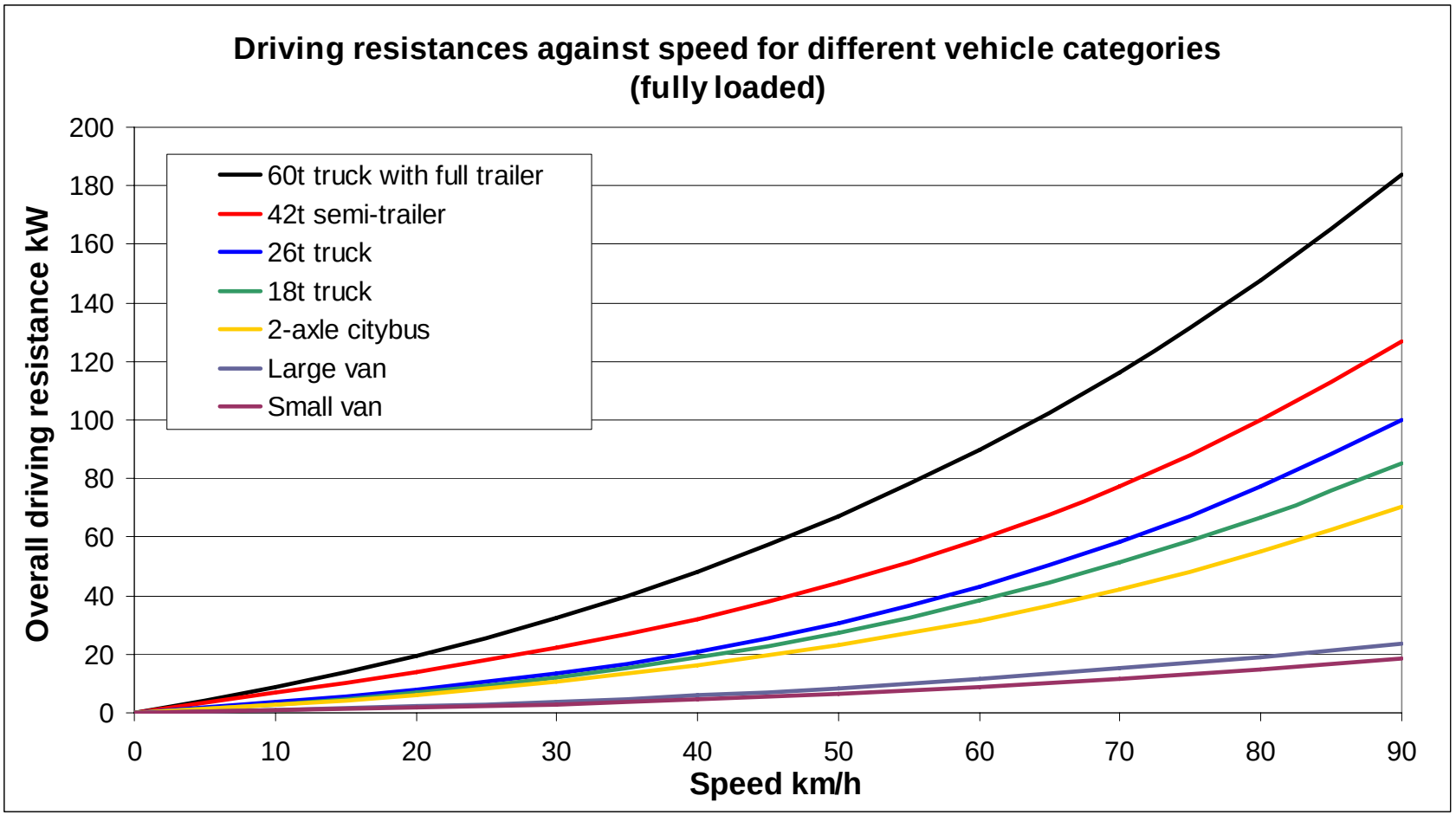
WHY TEST COMPLETE HD VEHICLES?

- There is a clear need to generate emission and fuel consumption figures that take into account the properties of the complete vehicle:
  - generating truthful distance based emission and fuel consumption figures
  - effects of load and driving cycle
  - comparison of vehicles
  - chassis dyno testing also enables checking of in-use vehicles
- Within VTT's research project, both the authorities and the transport companies are very interested in comparable (vehicle to vehicle) emission and fuel consumption figures for various HD vehicles
  - fuel economy is extremely important for the operators

DEVELOPMENT OF TEST METHODOLOGY

- Together with one of the biggest transport companies in Finland (Transpoint) VTT developed a methodology for chassis dynamometer measurement of heavy-duty trucks
- The key elements in the methodology are
  - transient type testing on dyno with 2,5 m diameter rollers
  - using truthful vehicle loading and speed profiles
  - also taking into account road gradient
  - determination of accurate rolling and draq resistance by conducting coast-down measurements
- The speed and road gradient profiles were recorded from actual routes served by Transpoint
- Varying speed and taking into account the road gradient creates highly transient loading

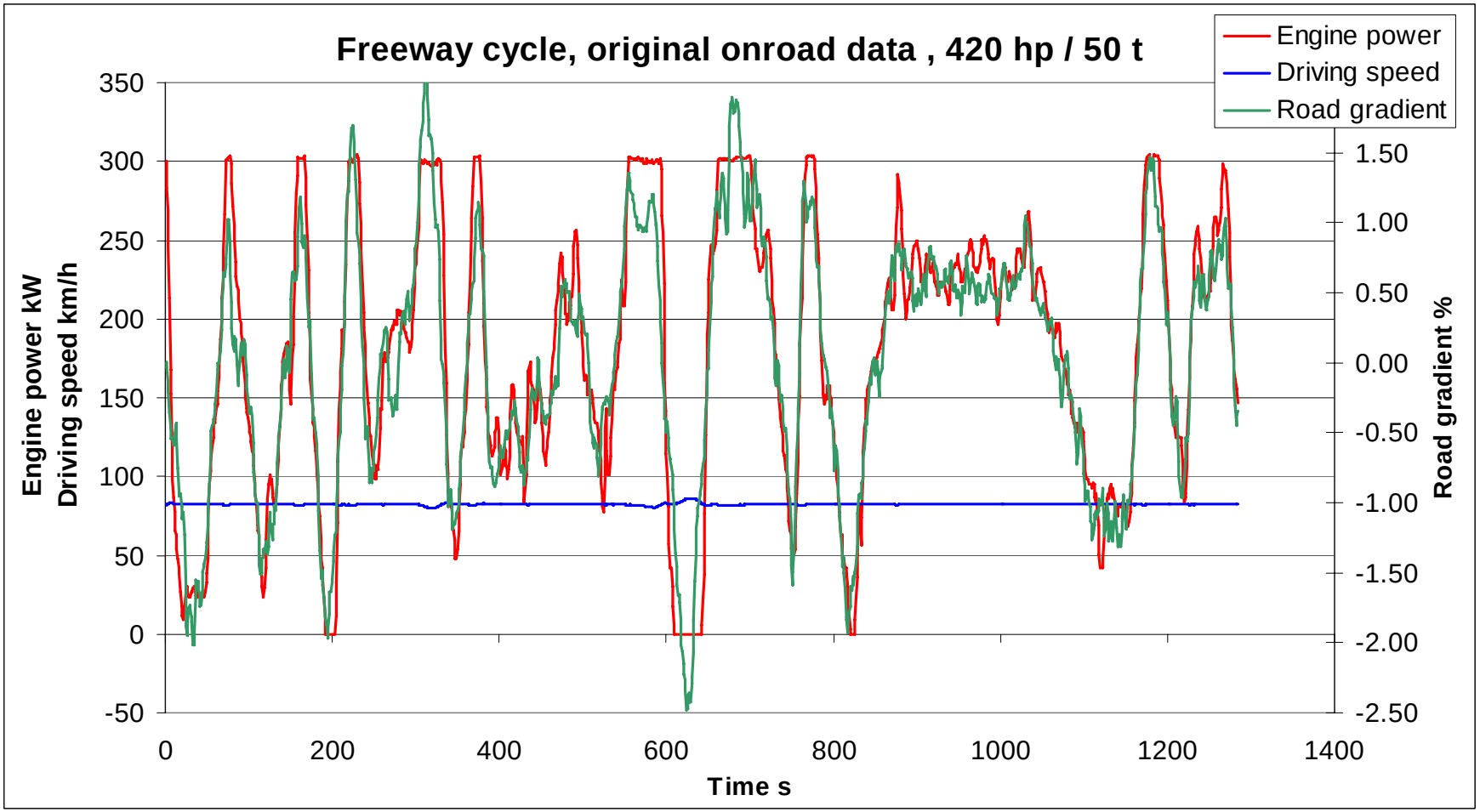
TEST METHODOLOGY – POWER VS. SPEED



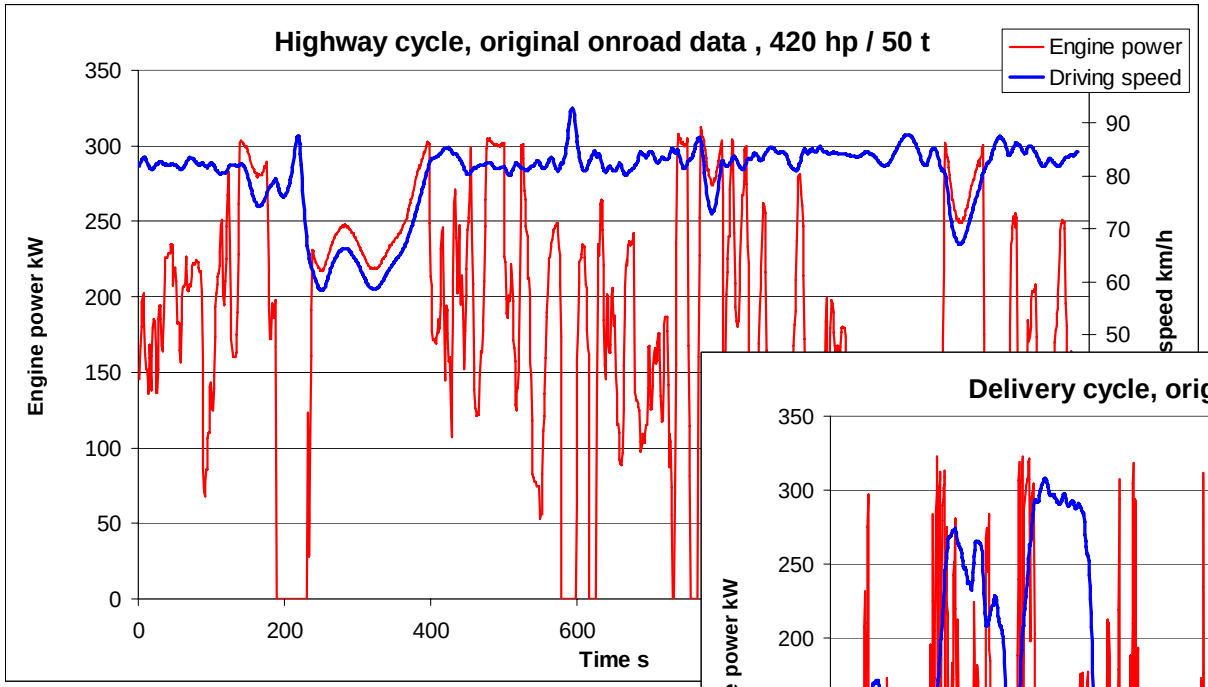
TEST METHODOLOGY – CYCLE DEVELOPMENT

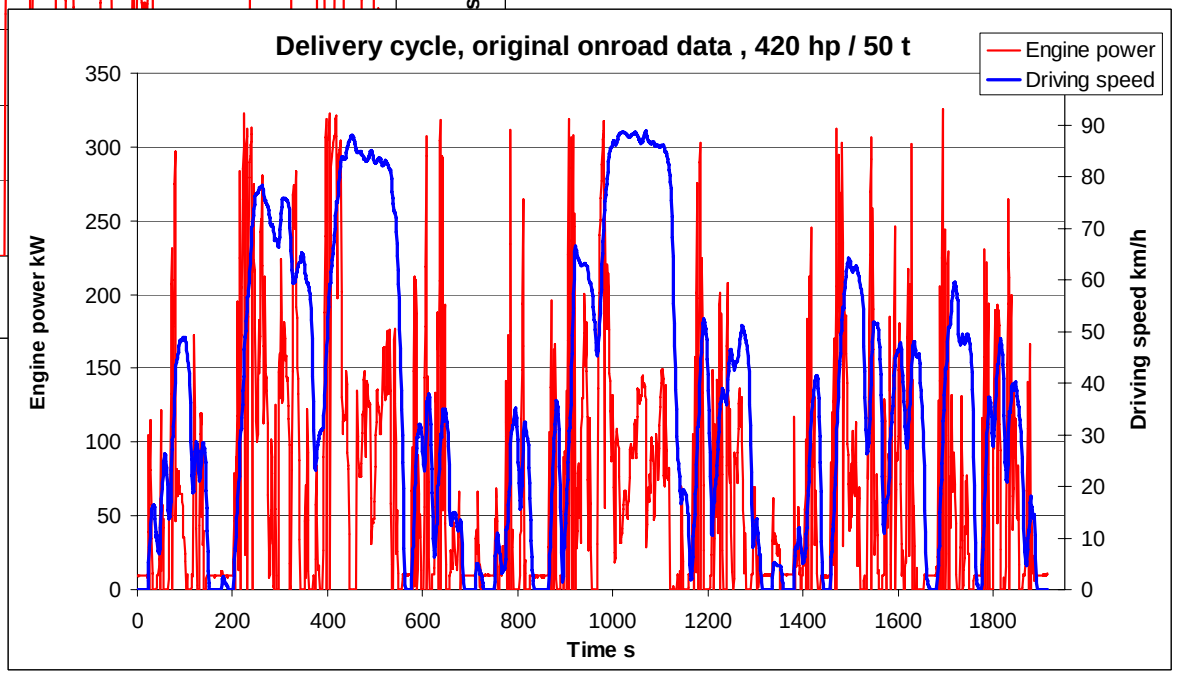
- **Freeway cycle** for a 60 t truck with full trailer
  - 420 hp truck + 4-axle trailer
  - total weight 49 050 kg
  - cruise control active
- **Highway cycle** for a 60 t truck with full trailer
  - 420 hp truck + 4-axle trailer
  - total weight 49 050 kg
  - driver controls speed
- **Delivery cycle** for a 26 t truck
  - 26 t truck, 420 hp
  - vehicle weight 21 700 kg
  - ”normal” style of driving

TEST METHODOLOGY

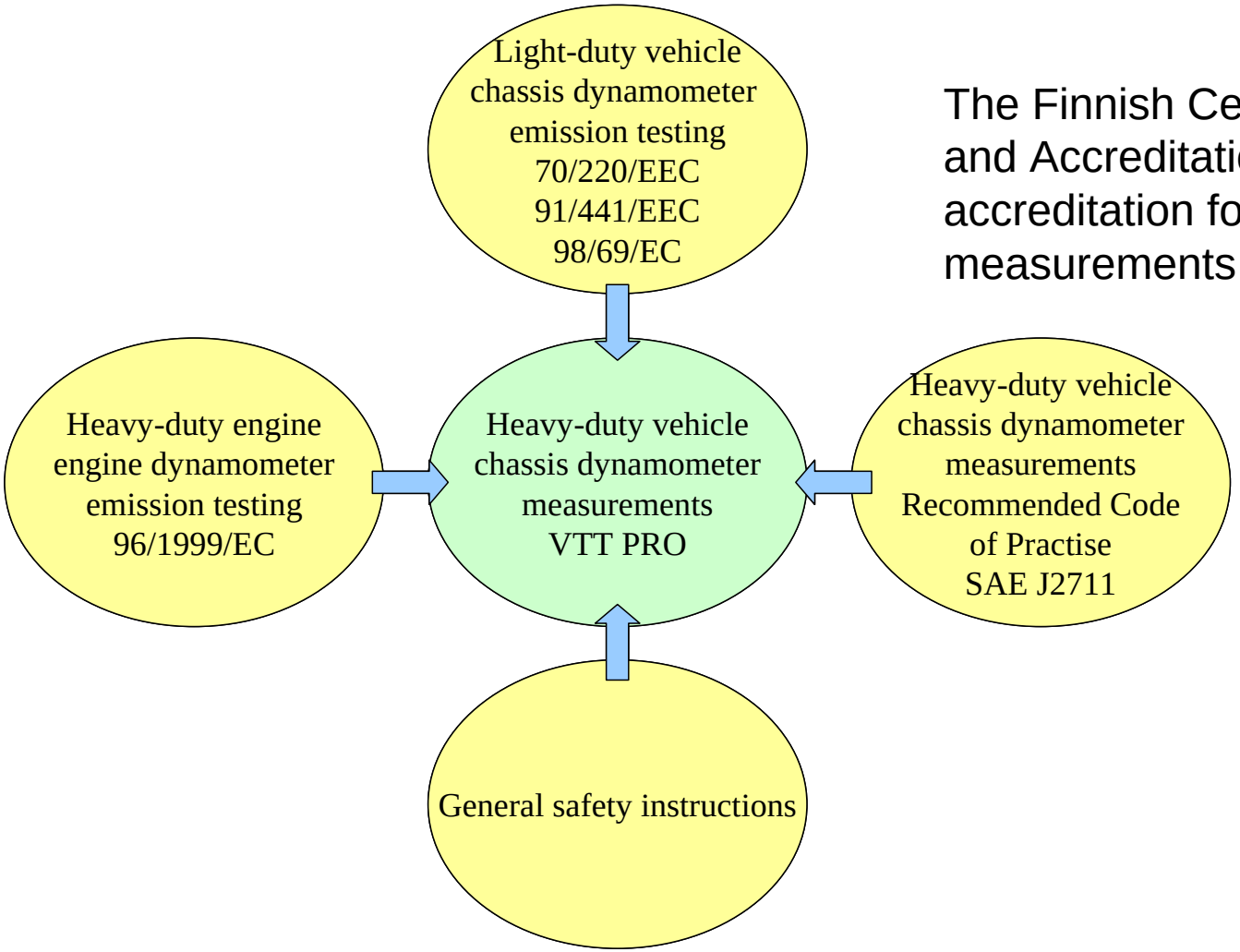


TEST METHODOLOGY





TEST METHODOLOGY - ACCREDITATION



The Finnish Centre for Metrology and Accreditation granted accreditation for VTT's measurements in 2003

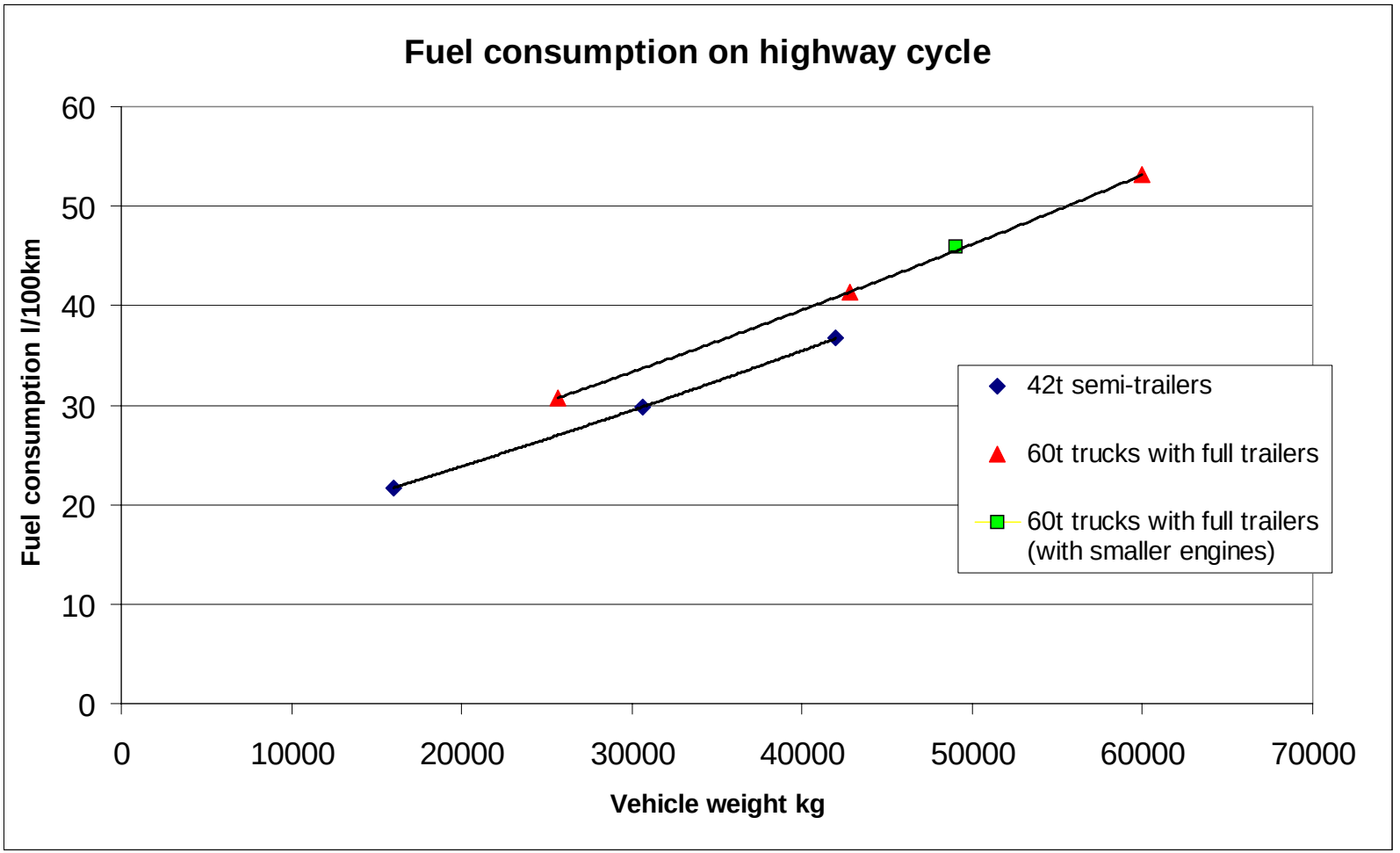
SUBPROJECT TRUCK 2004:

Exhaust emissions and fuel consumption of Euro 3 certified trucks

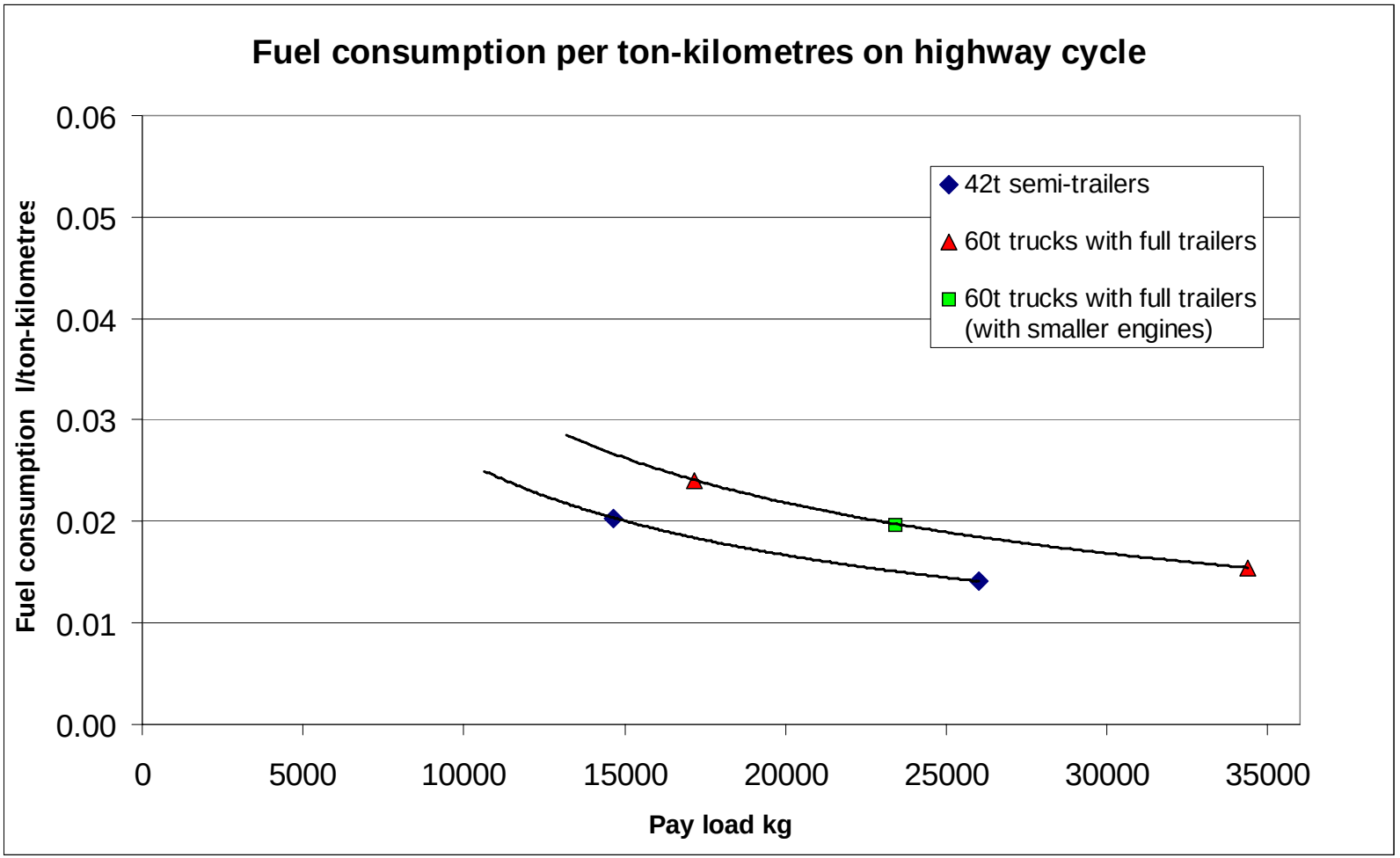
TEST MATRIX 2004

- The measurements were done running dynamic load cycles including simulation of road gradient (three cycles: freeway, highway and delivery)
- Measurements were conducted in four weight classes:
  - 18 t delivery trucks: 0, 1/3, 2/3 and 1/1 load (four load levels)
  - 26 t delivery trucks: 0, 1/2 and 1/1 (three load levels)
  - 42 t semi-trailers: 0, 1/2 and 1/1 (three load levels)
  - 60 t trucks with full trailers: 0, 1/2 and 1/1 (three load levels)
- Vehicles of different makes were tested in parallel:
  - 18 t: three brands
  - 26/60 t: four brands
  - 42 t: three brands
- 13 different vehicles were measured, and the number of combinations (vehicle/load/cycle) was 63
  - including repetitive tests, more than 130 tests were done

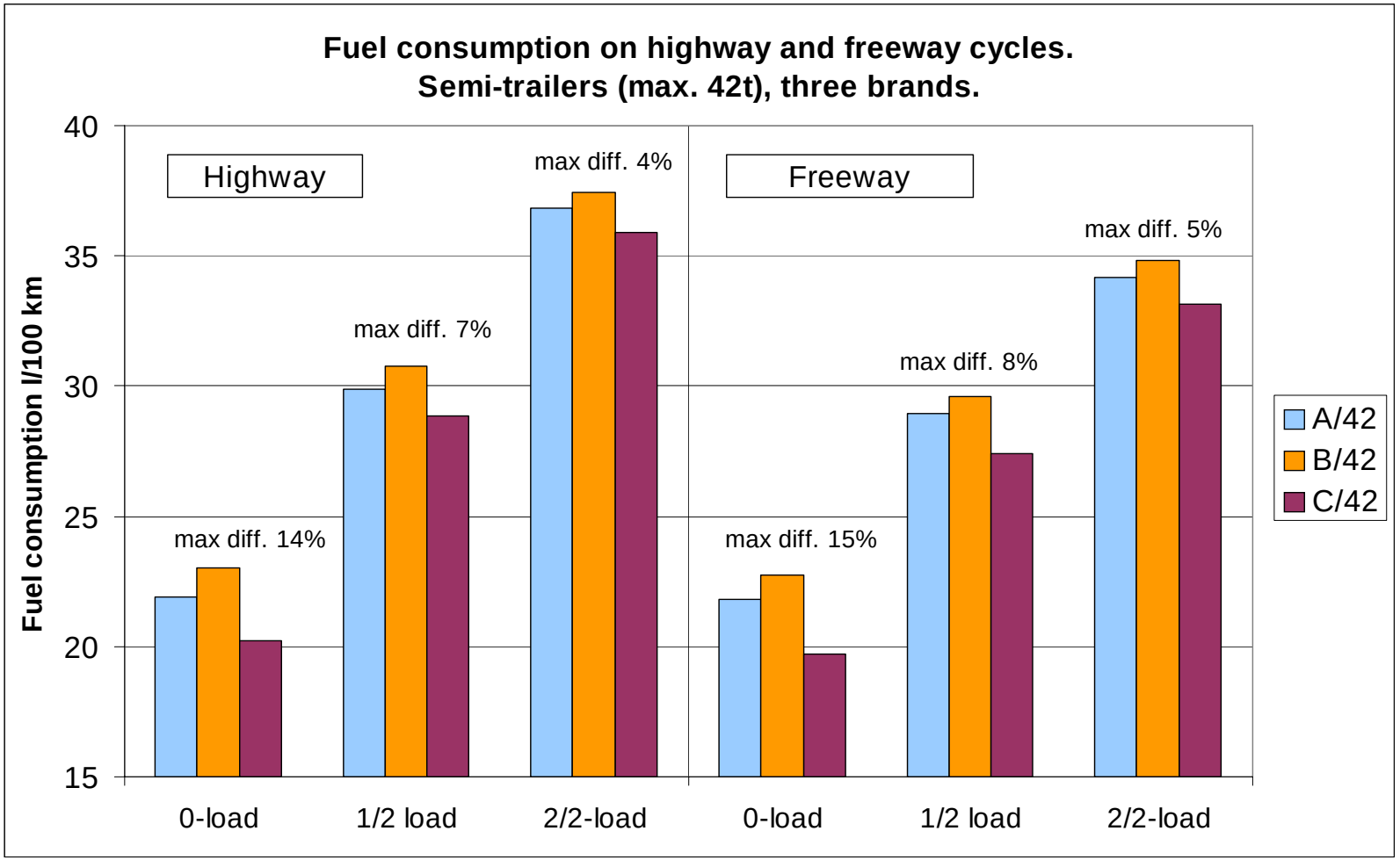
INFLUENCE OF VEHICLE MASS



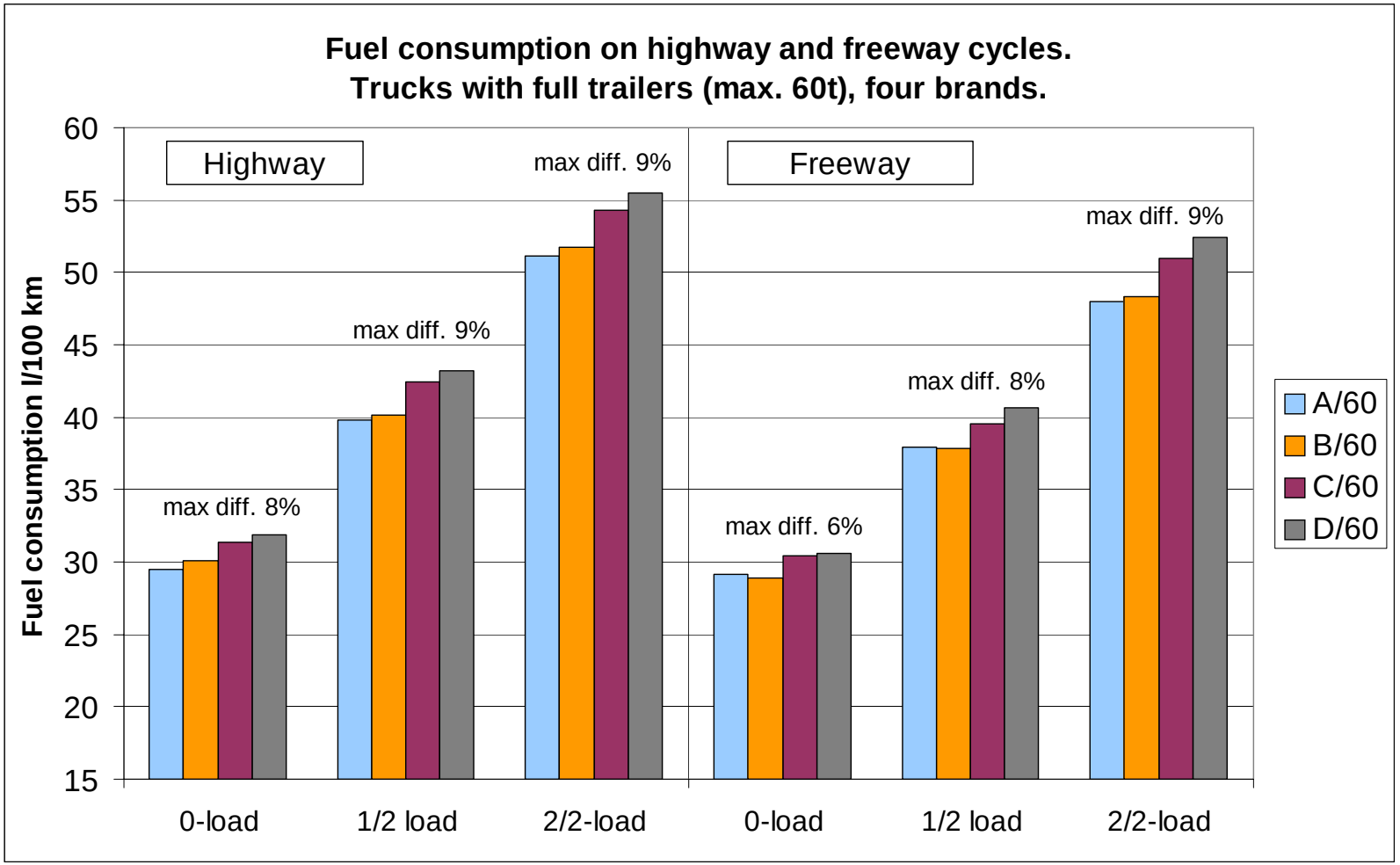
INFLUENCE OF LOAD



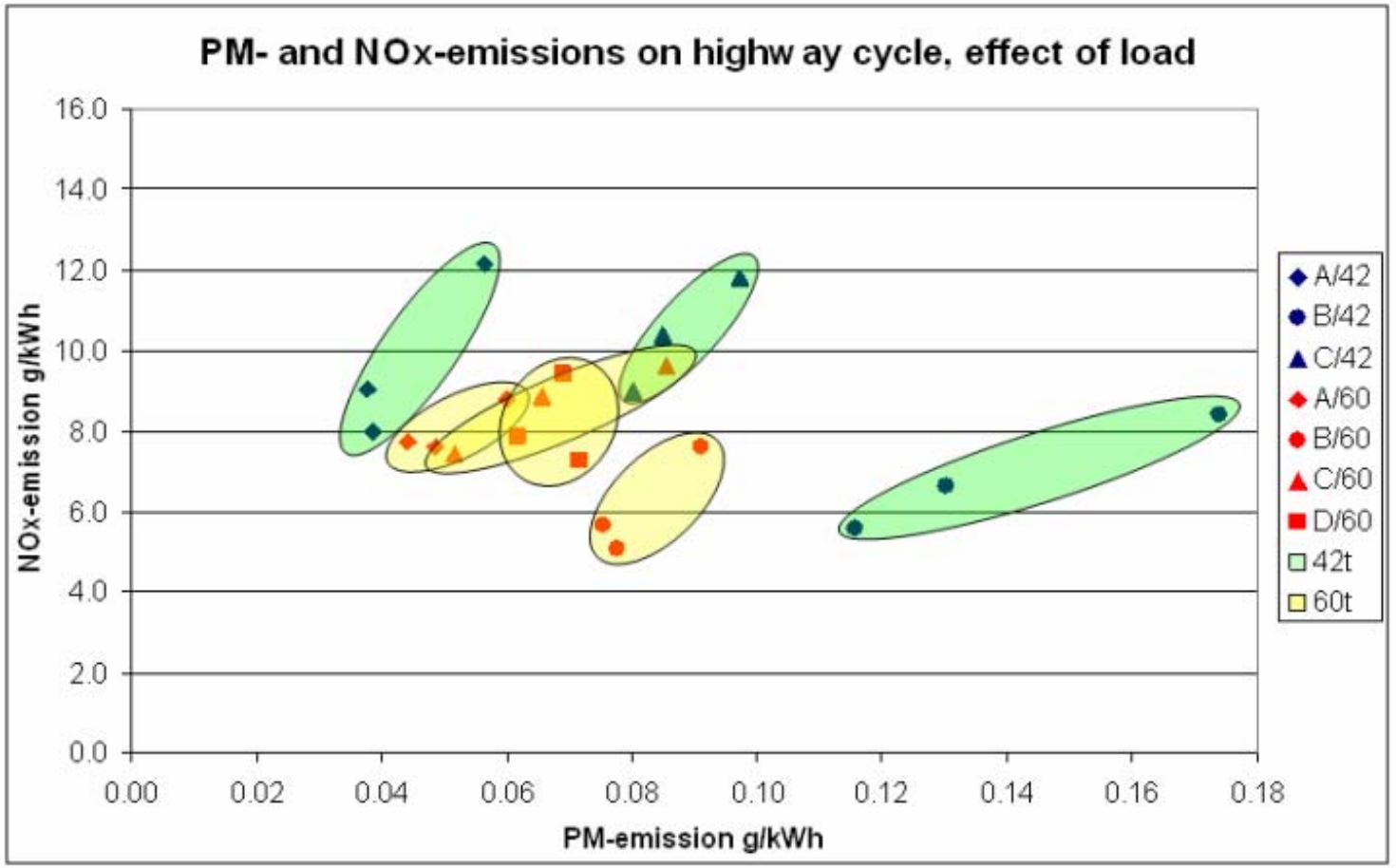
FUEL CONSUMPTION BY VEHICLE MAKE



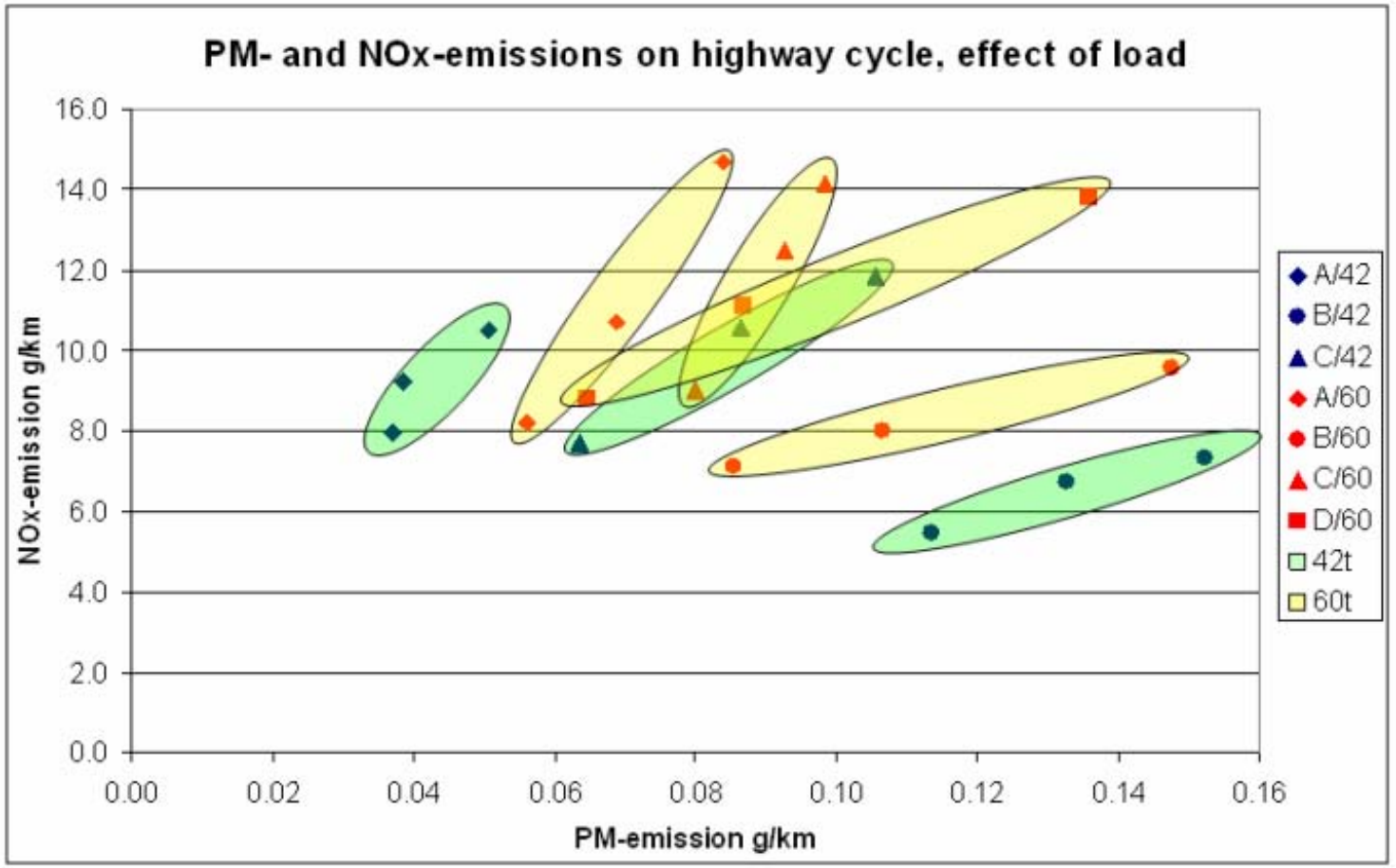
FUEL CONSUMPTION BY VEHICLE MAKE



EMISSIONS (g/kWh at the driving wheels)



EMISSIONS (g/km)



SUMMARY..

- VTT has now got measurement methods which make vehicle to vehicle comparisons, for emissions and fuel consumption, possible
- The methodology is based on transient-type chassis dynamometer measurements simulating realistic speed profiles, vehicle loads and also road gradient
- In 2004, a matrix of 13 new heavy-duty trucks in prime condition were measured for emissions and fuel consumption

..SUMMARY..

- Fuel consumption is primarily dependent on vehicle mass:
  - for delivery-type service fuel consumption is 25 – 42 l/100 km
  - for highway and freeway-type driving the fuel consumption of 42 t and 60 t vehicle combinations is 22 – 53 l/100 km depending on the weight of the combination
- The minimum specific fuel consumption was 0.04 l/ton-km over the delivery cycle and 0.015 l/ton-km over the highway cycle
  - transient-type driving increases fuel consumption significantly
- The variations in fuel consumption between vehicles within the same weight class are surprisingly big
  - the variation from vehicle to vehicle within the same category is 0 – 16 %

..SUMMARY

- The variations in exhaust emissions (NOx, PM) are even bigger
  - for 42 and 60 t vehicles on highway NO_x varies by a factor of some 2.5 and PM by a factor of some 4
  - the differences in emissions are so big that the influence of load and even vehicle category is obscured
  - some manufacturers have succeeded in combining low emissions and low fuel consumption
- So far the vehicle makes have not been published
  - there is, however, an increasing demand for vehicle specific figures to guide vehicle procurements
- Euro 4 vehicles with either EGR + DPF or SCR will be introduced in Europe starting 2005
  - this might increase differences in both emissions and fuel economy in real-life service