International Seminar
on
Engine System Combustion Process @ Doshisha University
May 28, 2004

Recent Topics in Engine Emission Measurement

Horiba Ltd.
Engine Measurement Division

Contents

- Super Ultra Low Emission Measurement
- Particulate Matter Measurement
- GRPE Particulate Matter Measurement
- On Board Emissions Measurement

Explore the future HORIBA

Super Ultra Low Emission Measurement

The Challenges of ULEV and SULEV Measurement

- **Very low emissions from modern vehicles.**
  - **Essentially zero emissions in hot stabilized phase.**
  - **Ever decreasing emissions in transient phases.**

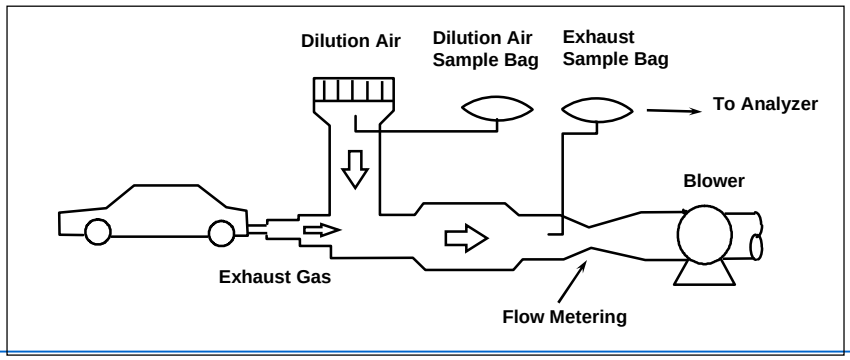
Vehicle Category		THC limit g/mile
LE	Low Emission Vehicle	0.400
ULEV	Ultra Low Emission Vehicle	0.040
SULEV	Super Ultra Low Emission Vehicle	0.020

Concentration is lower than ambient air

Measurements of Mass Emission and CVS Method

■ **Mass Emission** (g)
= Gas Concentration (%, ppm) x Gas Density (g / m^3)
x Exhaust Volume (m^3)

■ **CVS Method** => Dilute exhaust and obtain known flow rate.

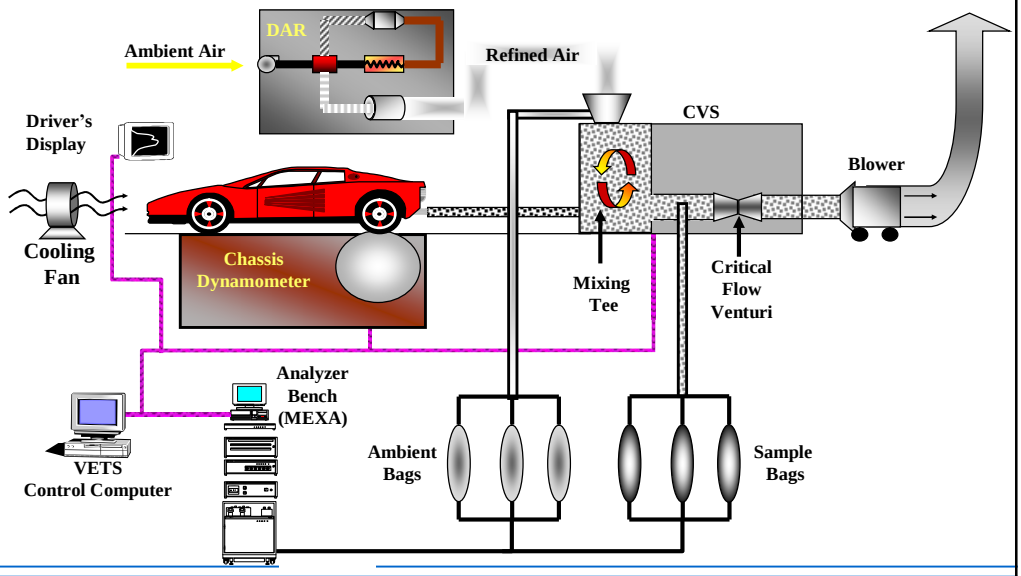


How to measure the emissions that are cleaner than the ambient air ?

Japan / ASIA

- **Conventional CVS and analyzers with "Dilution Air Refiner" system.**
- **Conventional CVS and analyzers – both heated.**

Complete Test Cell DAR-CVS



Dilution Air Refiner (DAR)

Uses oxidation catalyst and NOx absorber to reduce CVS dilution air concentrations.

THC < 0.1 ppm C
CO < 0.1 ppm
NOx < 0.1 ppm
Maximum flow rate : 22 m3/min

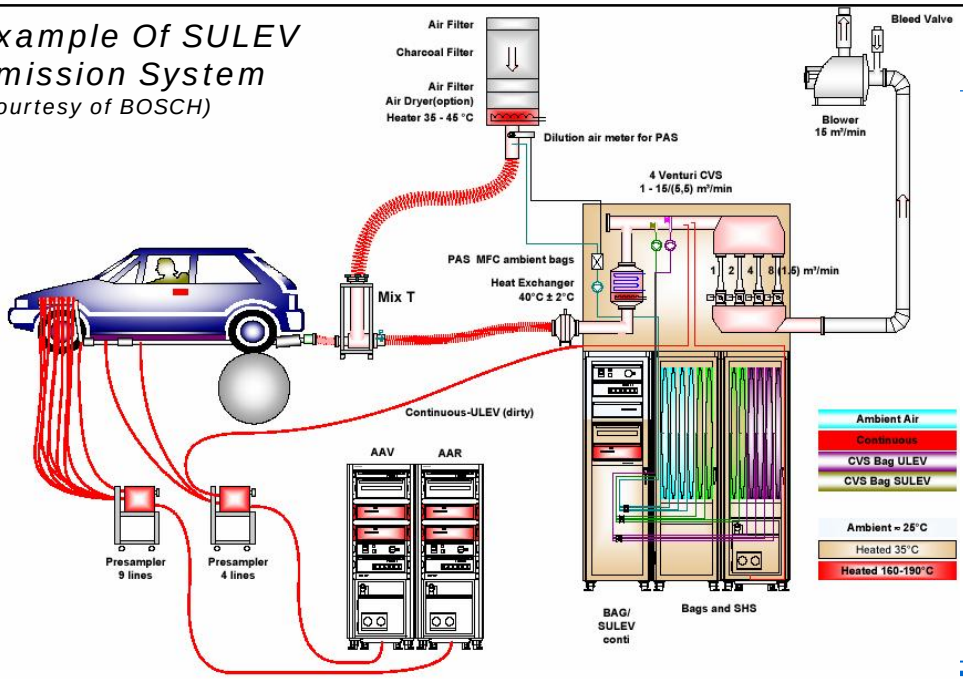
Stabilises the THC levels and also minimises DF error by creating zero concentration in dilution air bag

Europe

- Conventional CVS and Analyzers all heated using a large charcoal filter.

Example Of SULEV Emission System

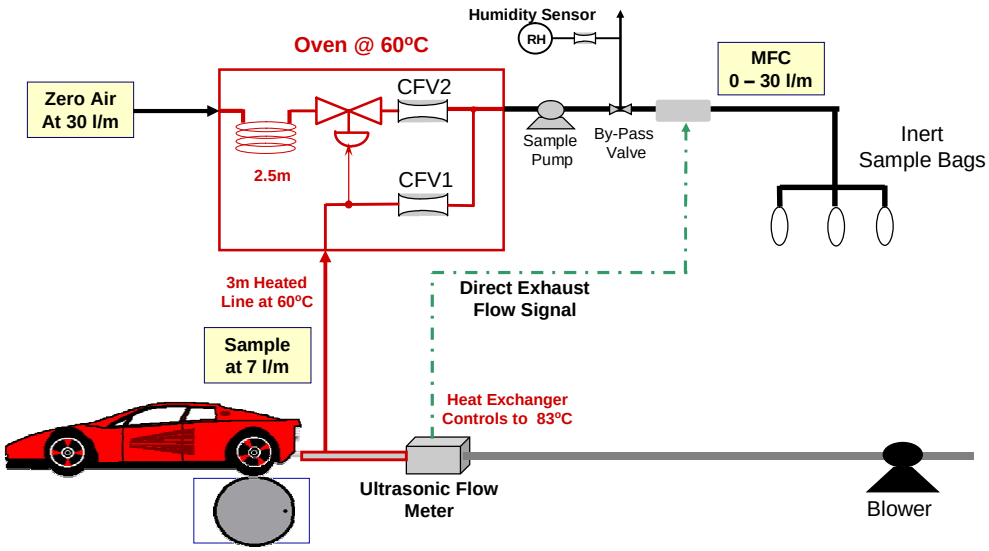
(Courtesy of BOSCH)



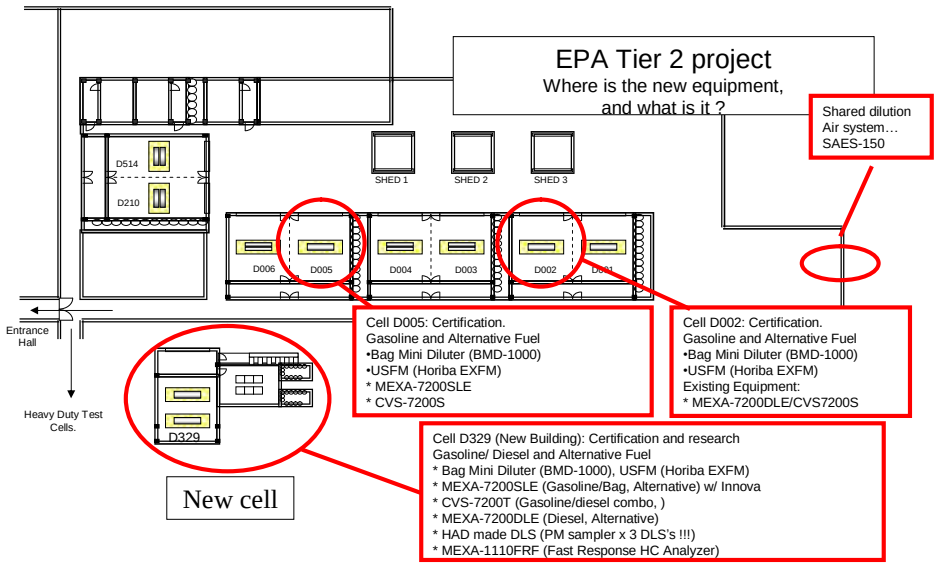
North America

- BMD and analyzers With/without Conventional CVS
- Conventional CVS and analyzers with DAR system.

Bag Mini-Diluter



EPA Tier II Projects 2004-2005

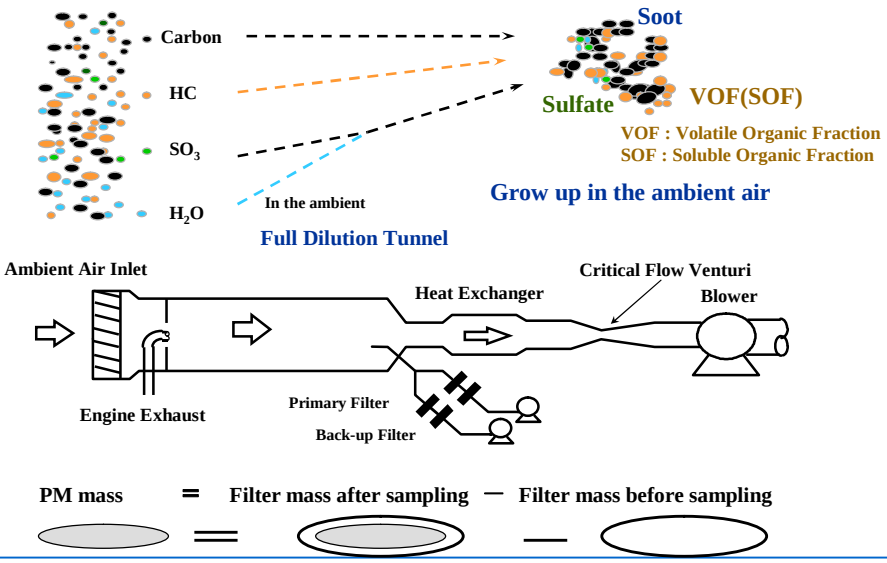


What is the solution for SULEV measurement ?

Sorry…. Currently there is no single global answer

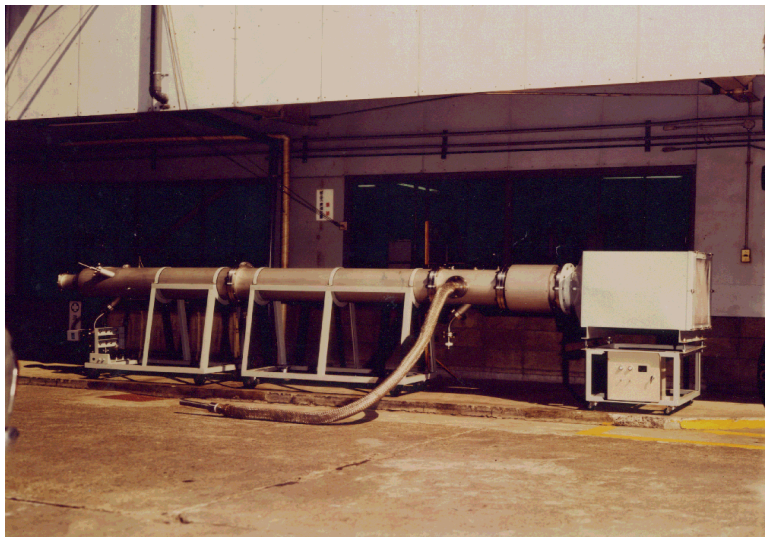
Particulate Matter Measurement

Gravimetric Technique

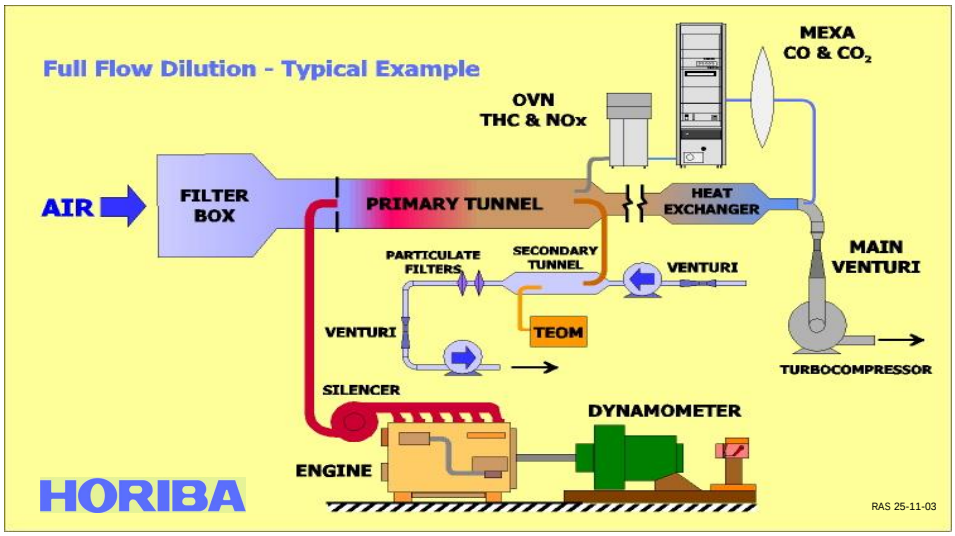


PM mass = Filter mass after sampling − Filter mass before sampling

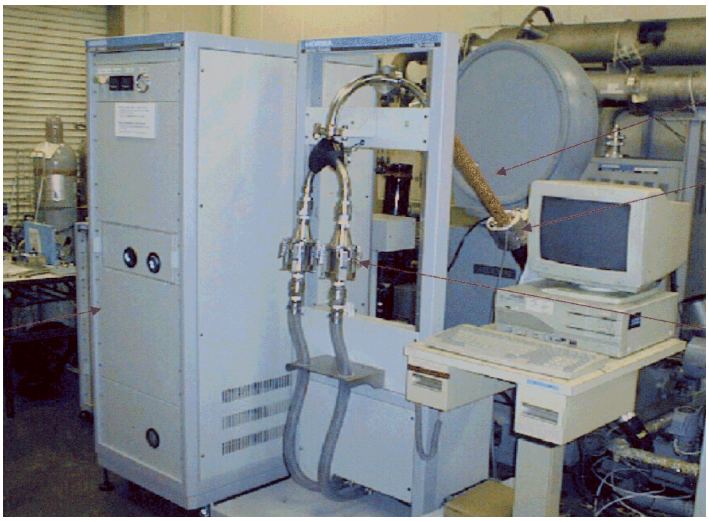
Full Dilution Tunnel



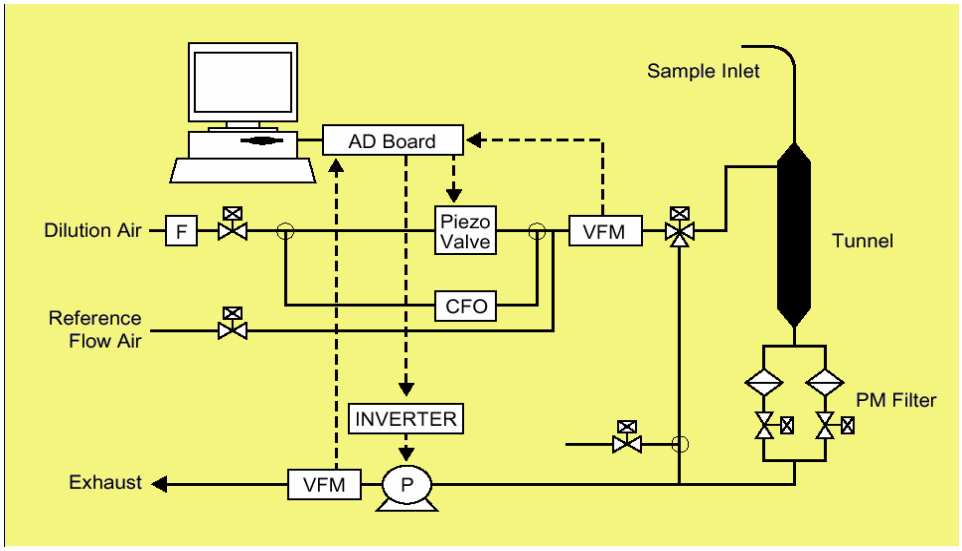
Full Flow Dilution System



Micro Tunnel



Partial Flow Dilution System



GRPE
Particle Measurement Program (PMP)

Update - March 2004

Introduction

- PM emissions remain a concern for health
  - New vehicles are producing lower mass but continue to emit “nano-particles” that may be harmful (a recent report showed small particles in the bloodstream five minutes after inhalation) but the mechanism for such, still debatable, health affects remains unknown
  - PM emissions from new engine/vehicle technologies are said to be reaching the limit of the existing legislative gravimetric measurement technique.
- It was considered necessary to review the available PM measurement principles and instrumentation for possible future legislation

GRPE - Particulate Measurement Program

- The PMP program is organised under the UNECE WP29/GRPE Group
  - Aim is to develop a new system of PM measurement (instrument, sampling and procedures) to complement or replace the existing gravimetric method
  - PMP is open to governments or industry who are members of GRPE.
  - Each contributor funds their own research
  - All results are shared and will be published during and at the end of the two year program

Instruments Considered In Phase 1

CPC/CNC - Condensation Particle Counter
DCS - Diffusion Charging Sensor
EDB - Electrical Diffusion Battery
PASS - Photo Acoustic Soot Sensor
ELPI - Electrical Low Pressure Impactor
LII - Laser Induced Incandescence
PAS - Photoelectric Aerosol Sensor
TEOM - Tapered Element Oscillating Microbalance
QCM - Quartz Crystal Microbalance
DMS - Differential Mobility Spectrometry
MEXA - HORIBA 1370PM : PM mass by gas analysis
EPA-2007 “style” GRAVIMETRIC as a reference method

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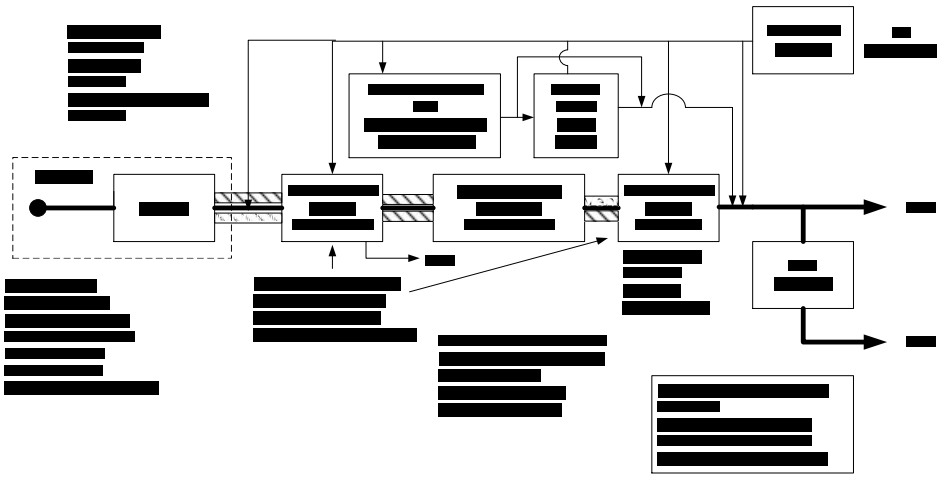
Explore the future HORIBA

Phase 3 : Use On Advanced Technology

- The recommended test systems from Phase 2 will be used to measure PM from advanced engine/vehicle technologies
  - using diesel engines/vehicles with DPF or equivalent emission control technologies
  - testing on light duty direct injection gasoline engines will also be included
- "Round Robin" exercise during 2004 (organised by JRC)
- Emission standards will be established for expected emission levels beyond 2005/2008

Overall GRPE-PMP Actual Schematic ?



Switzerland Draft Regulation Issued

- Applicable from 1st January 2006, the Swiss regulation supplements Directive 70/220/EEC and ECE Reg 83 until the EU introduces a EURO 5 limit for PM mass and number emissions
- Applies to all vehicles in Category M_1 vehicles up to 3.5 tonnes. All measurements must be tested on a system certified by a recognised Swiss technical service
- Maximum emission : 10^{11} particles/km

Swiss Specification (Not Same GRPE-PMP)

- Separate sampling probe from PM mass
- Optional adsorber (HC removal ?) after the evaporator tube
- No dilution after the Evaporator Tube
- Different specifications for CPC
- Modified check procedures for Evaporator Tube
- Use of reference CPC for all tests unless traceable certified particle number generator is used

Overall Schematic For Swiss TPN ?

On Board Emission Measurements

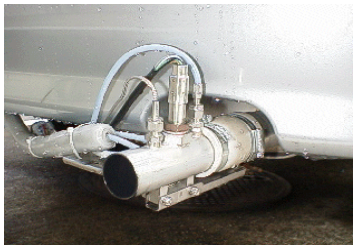
Why use on board measurements

- How does the engine behave on the road as opposed to a pre defined simulation cycle on a dynamometer, both US and most recent, EU regulatory movement !
- Could replace current in use testing facilities !
- Some vehicles are too large to fit in the test cells or are not practical for testing on a chassis dynamometer, like HDD trucks and buses
- Confirming simulated models of exhaust emissions migration, and actual emissions
- Comparing one mode of transportation with another with respect to exhaust emissions, car ferries vs highways..

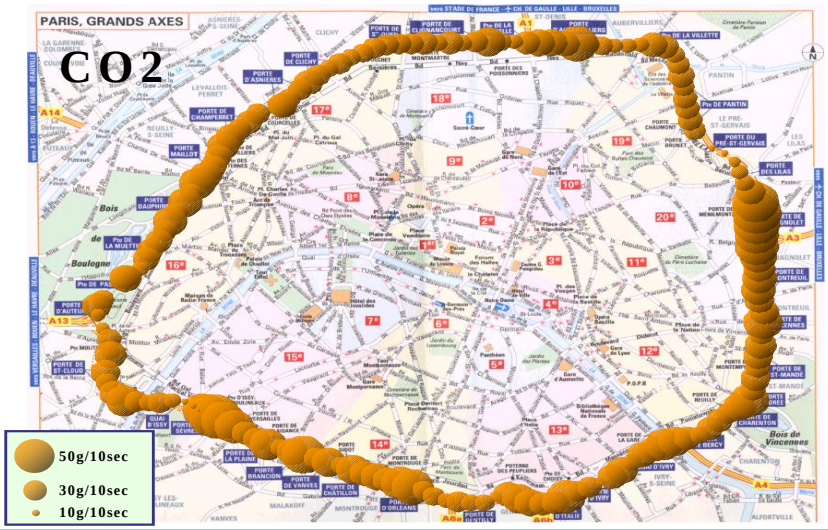
OBS-1000 Installation

Remote control from driver seat

Analyzers installed in the trunk



Fuel Consumption Measurement : Paris Downtown



HC and NOx from Biwako to Kyoto