The Horiba approach to on-board measurement

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The Horiba approach to on-board measurements

- **Why use on board measurements**
- **Past experiences with on board systems**
- **2002 system configuration**
- **Review of some of the data collected**
- **Where do we go from here ?**

Why use on board measurements

- Some vehicles are too large to fit in the test cells or are not practical for testing on a chassis dynamometer
- How does the engine behave on the road as opposed to a pre defined simulation cycle on a dynamometer, what effect does actual driving conditions (gear shift, braking etc) or weather, or with “in use” fuels
- Confirming simulated models of exhaust emissions migration, and actual emissions
- Comparing one mode of transportation with another with respect to exhaust emissions or looking at traffic flow improvements effect on exhaust emissions

Past experiences with on board systems

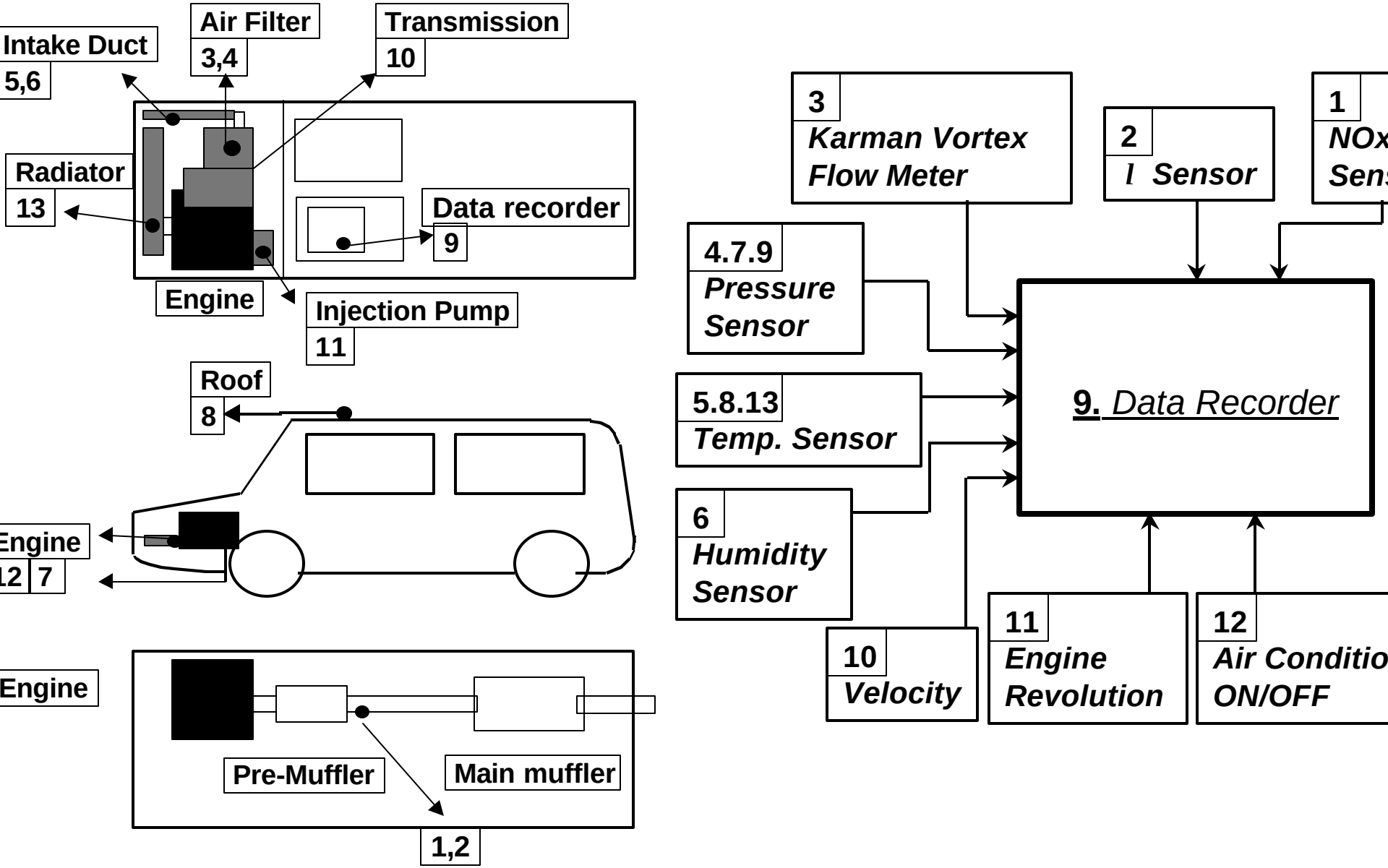
1998 Supplied on board dilution system for on board measurement of PM using TEOM on project with VITO (Belgium)

1999 The first on-board measurement system was developed using “off the shelf” λ and NOx sensors combined with other sensors and a data recorder. The system could measure NOx mass emission, fuel consumption and the power output of the engine during the on-road runs.

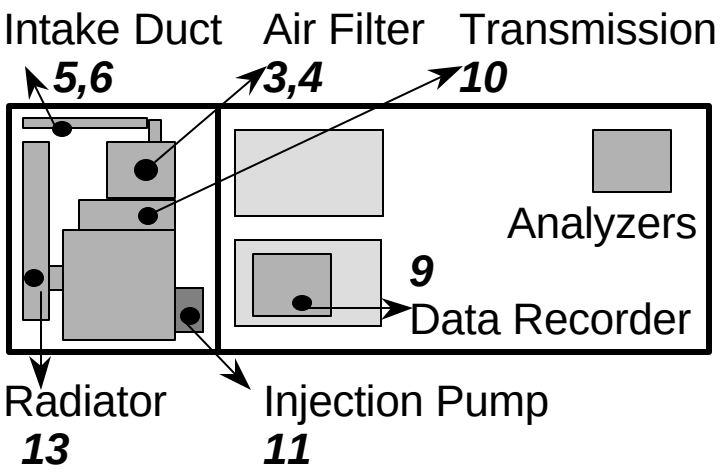
2000 System software was enhanced and considerable data was collected resulting in the SAE paper 2000-01-1141

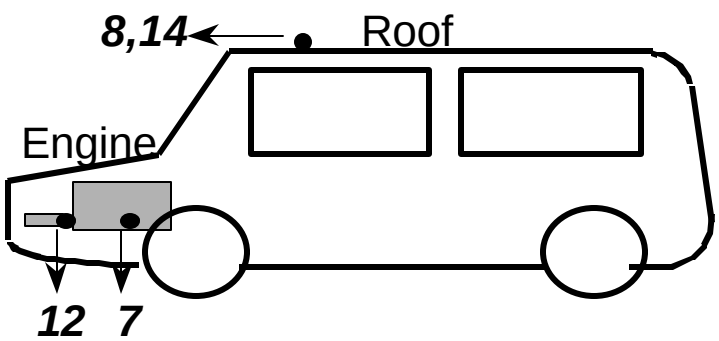
2001 HC and PM (smoke) measurement was added. Extensive tests on several exhaust flow measuring devices (Pitot tubes, Annubar etc..) compared to indirect exhaust flow measuring using the SAO technique

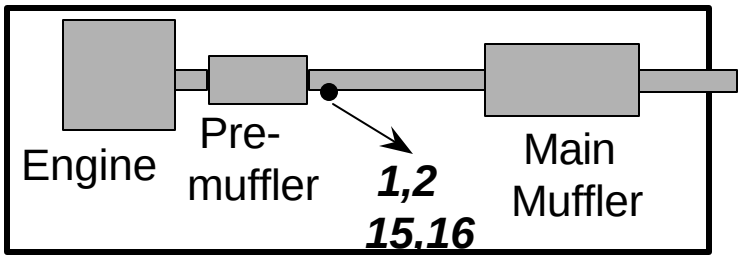
2000 System Configuration

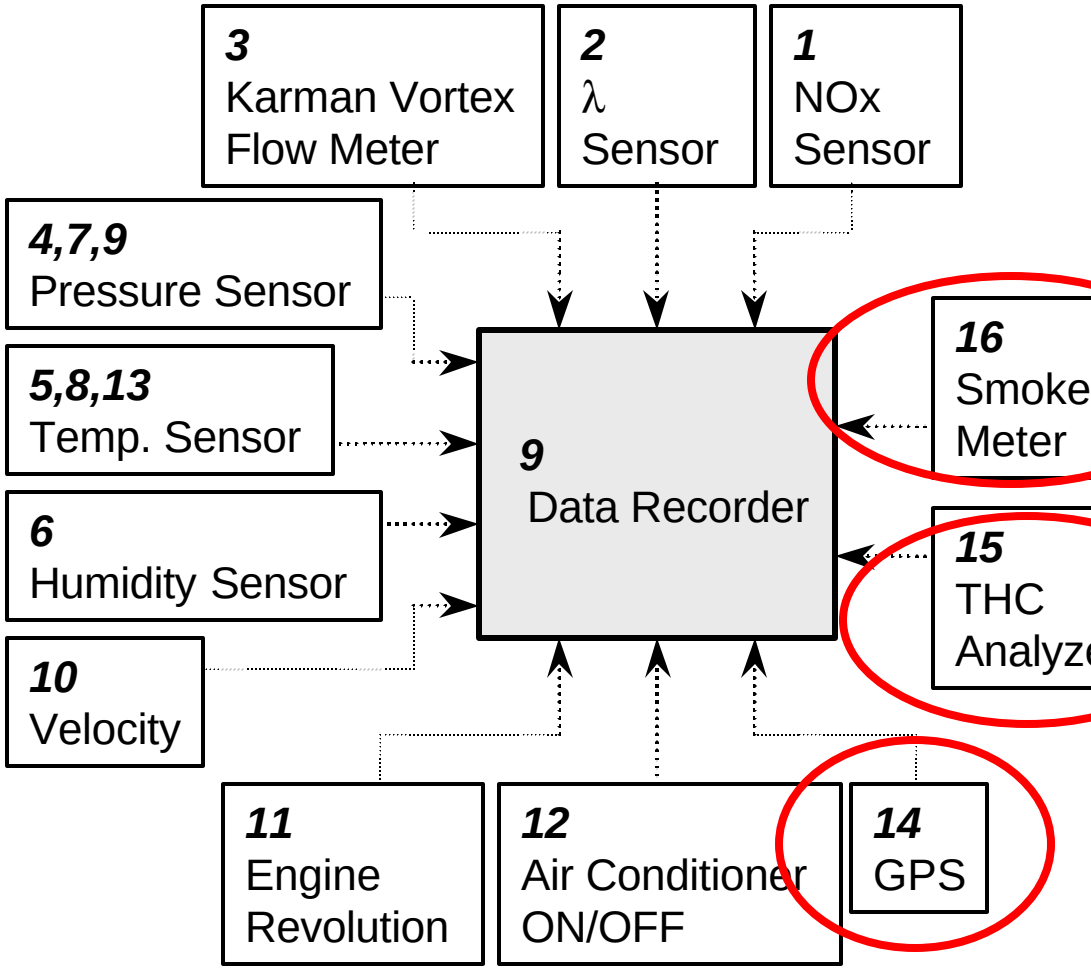


Updates for 2001

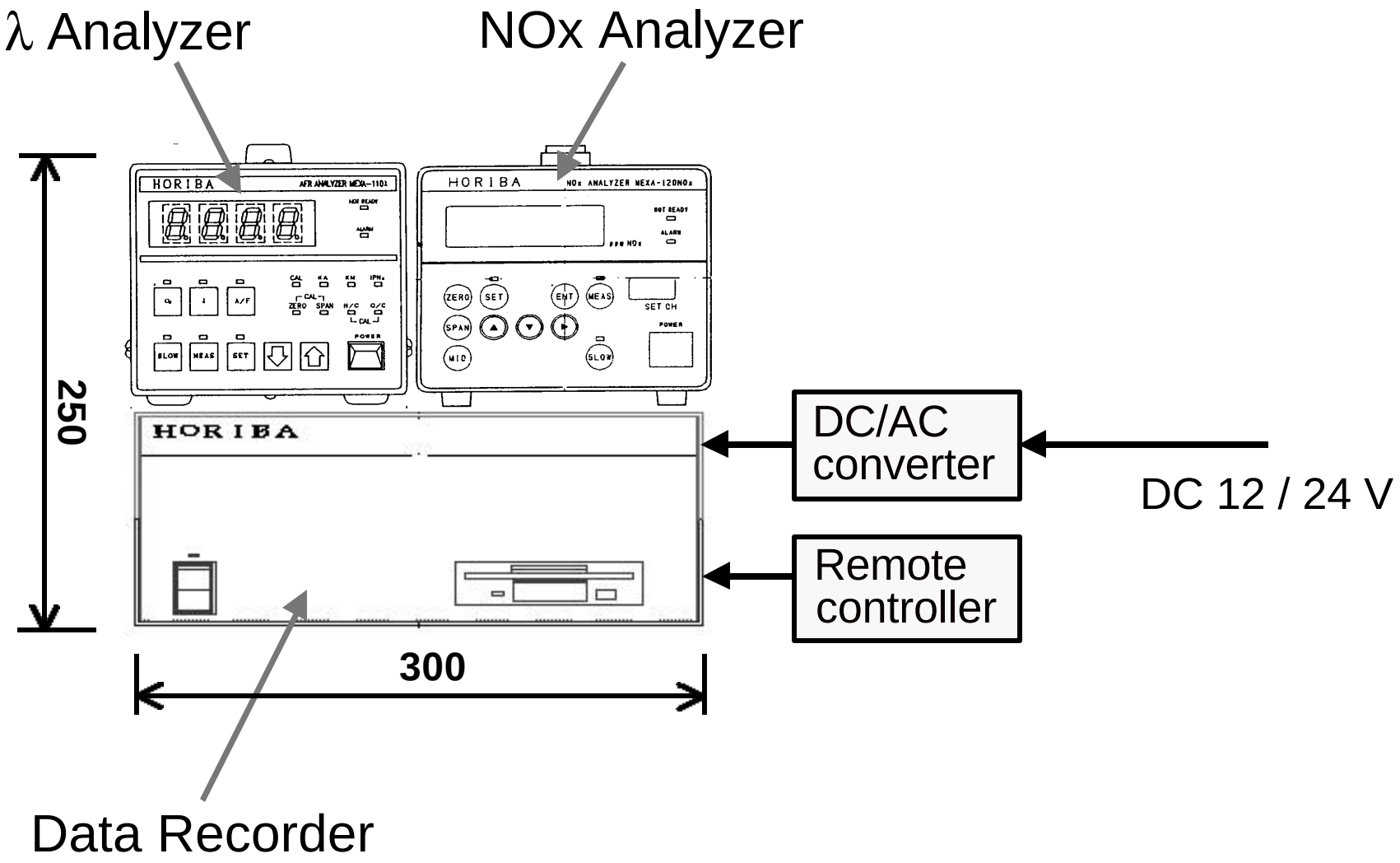




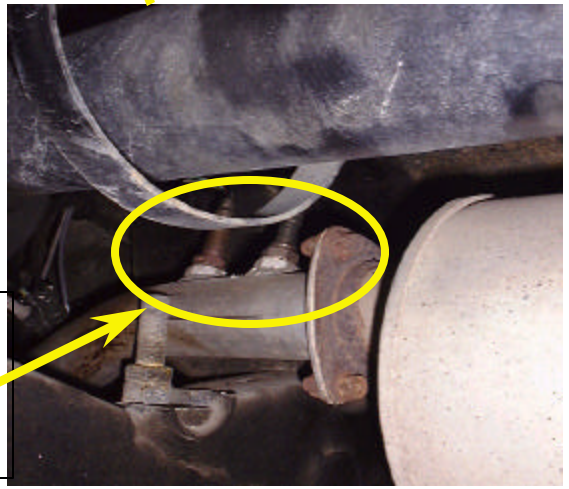




Analyzers and Data Recorder

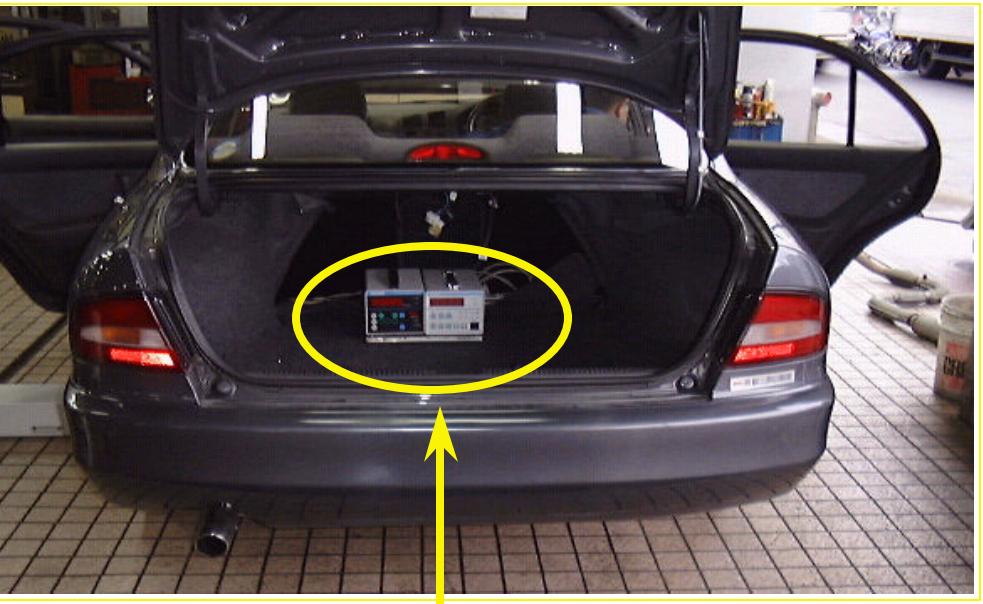


Installation



λ Sensor and
NOx Sensor

Installation to a Light Duty Vehicle

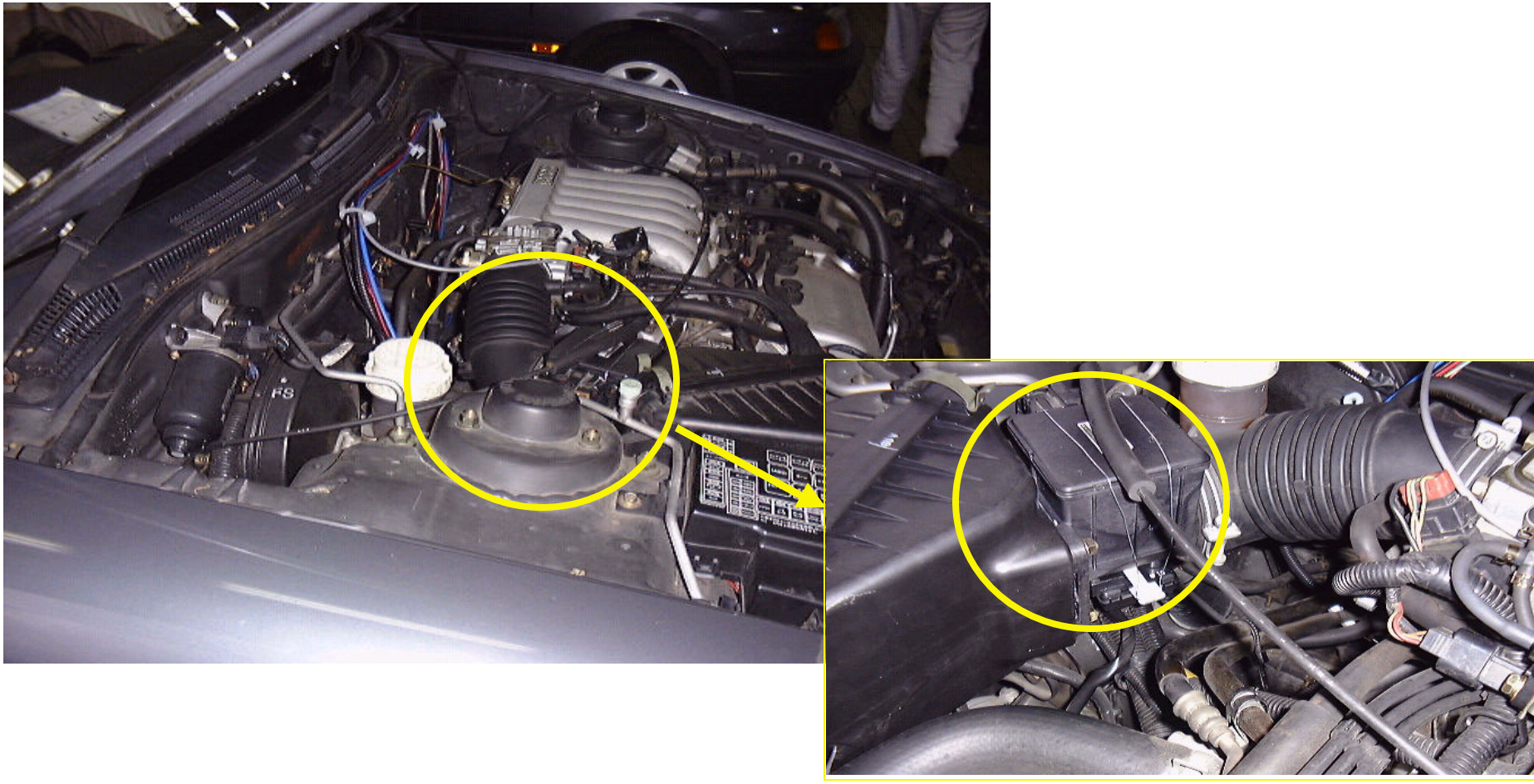


Control Units of
λ Analyzer and NOx Analyzer

Data Recorder

Remote Controller

Intake Air Flow Meter



Karman Vortex Flow Meter

Lambda and NOx Sensors

λ Sensor and
NOx Sensor

2002 system configuration

- CO, CO_2 and HC can be measured wet using a heated-NDIR(**MEXA-1170HNDIR**). Sample gas is introduced into the heated-NDIR without H_2O extraction, and H_2O interference can be corrected using special techniques (Patent pending).
- NOx and AFR can be also measured under wet conditions by using a ZrO_2 sensor(**MEXA-720NOx**). The ZrO_2 sensor is installed in the exhaust pipe directly. The NOx sensor has been improved and the AFR sensor is now part of the Nox sensor no longer requiring two independent units.
- Resulting in smaller size (no cooler), fewer mechanical parts and no need for wet/dry compensations
- Both the heated-NDIR(**MEXA-1170HNDIR**) and ZrO_2 sensor(**MEXA-720NOx**) need no operation gases. Resulting in smaller size (no bottles), safer operation, easier maintenance, and a low operating cost.
- New software, enhancing user interface and improving data presentation and export (labview)

2002 system configuration…a modular system

ehicle

elocity
evolution

Ambient Monitor
Temperature sensor
Humidity sensor
Pressure sensor

GPS
Longitude
Latitude
Altitude

Data Integration Unit

MEXA-1170HNDIR
CO, CO_2, HC

AC100V

NOx
AFR

MEXA-720NOx

Exhaust Attachment

PITOT flow meter
NOx/AFR sensor

2002 system specifications

MEXA-1170HNDIR

Item	Specification
Principal	Non-dispersive infrared absorptiometry
Measured gases	CO, CO_2, HC
Range	CO; 0-12vol%, CO_2; 0-20vol%, HC; 0-5000ppmC6
Response time(T90)	Within 1.5s
Linearity	Within ±1.0% of full scale
Drift	Within ±2.0% of full scale per 8 hours
Repeatability	Within ±1.0% of full scale
Outputs	Monitoring on LCD panel
	Analog output 0-1V/0-10V
	Digital in-outout (RS-232C)
Dimension	464(W) X 185(H) X 652(D) mm

MEXA-720NOx

Item	Specification
Principal	ZrO_2 type sensor
Measured gases	NOx, AFR
Range	NOx 0-3000ppm, AFR 9.5-200
Response time(T63)	NOx; within 0.5s, AFR; within 0.15s
Accuracy	NOx; ±30ppm or within ±3.0% of reading scale
	AFR; ±0.1 at stoich region
Outputs	Monitoring on LCD panel
	Analog output 0-5V
	Digital in-outout (RS-232C)
Dimension	130(W) X 75(H) X 170(D) mm

2002 system specifications

Data integration unit

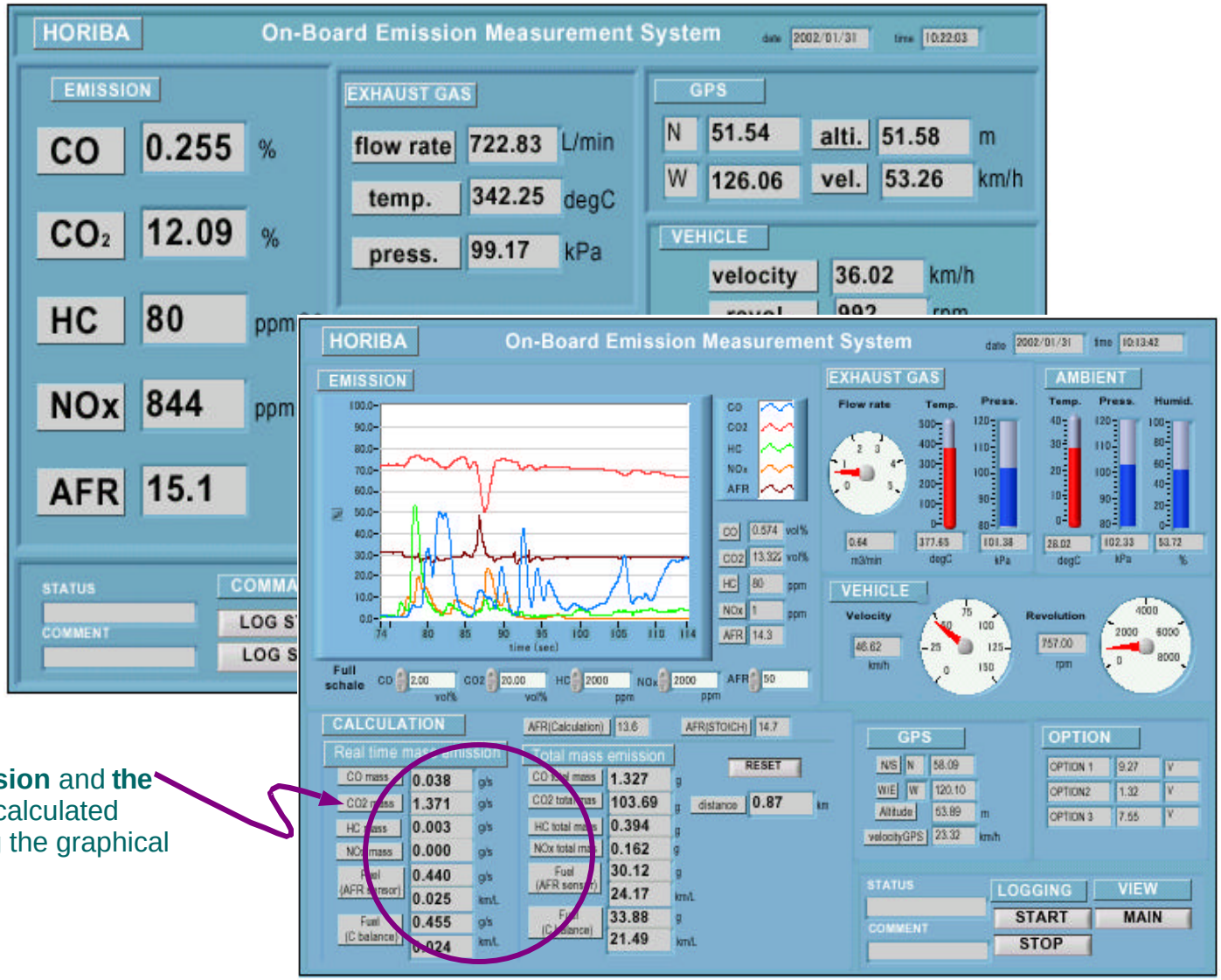
Item	Specification
Exhaust flow rate	0-6m^3/min, 0-15m^3/min, 0-30m^3/min.(3-type)
Exhaust pressure	0-160kPa(absolute) [±0.2%FS]
Exhaust temperature	0~350degC [±2%FS]
Ambient pressure	0-160kPa(absolute) [±0.2%FS]
Ambient temperature	-10~80degC [±0.5degC]
Ambient humidity	20~95%RH at 25degC [±3%RH]
Vehicle velocity	Analog input (0-10V)
	Pulse input (0-12V, open collector, open emitter)
Engine revolution	Analog input (0-10V)
	Pulse input (0-12V, open collector, open emitter)
GPS	Serial in-output (1Hz sampling)
Other input	CO, CO_2, HC (Analog input 0-10V from MEXA-1170HNDIR)
	NOx, AFR(Analog input 0-5V from MEXA-720NOx)
Optional input	Analog input (0-10V), 3ch
Dimension	464(W) X 140(H) X 652(D) mm

Power supply unit

Item	Specification
Battery	12V 100Ah x 2pc.
	170(W) X 244(H) X 412(D) mm 32kg X 2pc.
Inverter	Input DC-24V, Output AC-100V (1500W)
	275(W) X 103(H) X 390(D) mm 7kg
Charger	Input AC90~260V, Output DC24V (30A)
	290(W) X 110(H) X 385(D) mm 4.5kg
Operation time	More than 5 hours
	(opeate MEXA-1170HNDIR and Data integration unit)

Data logger Software

Main screen



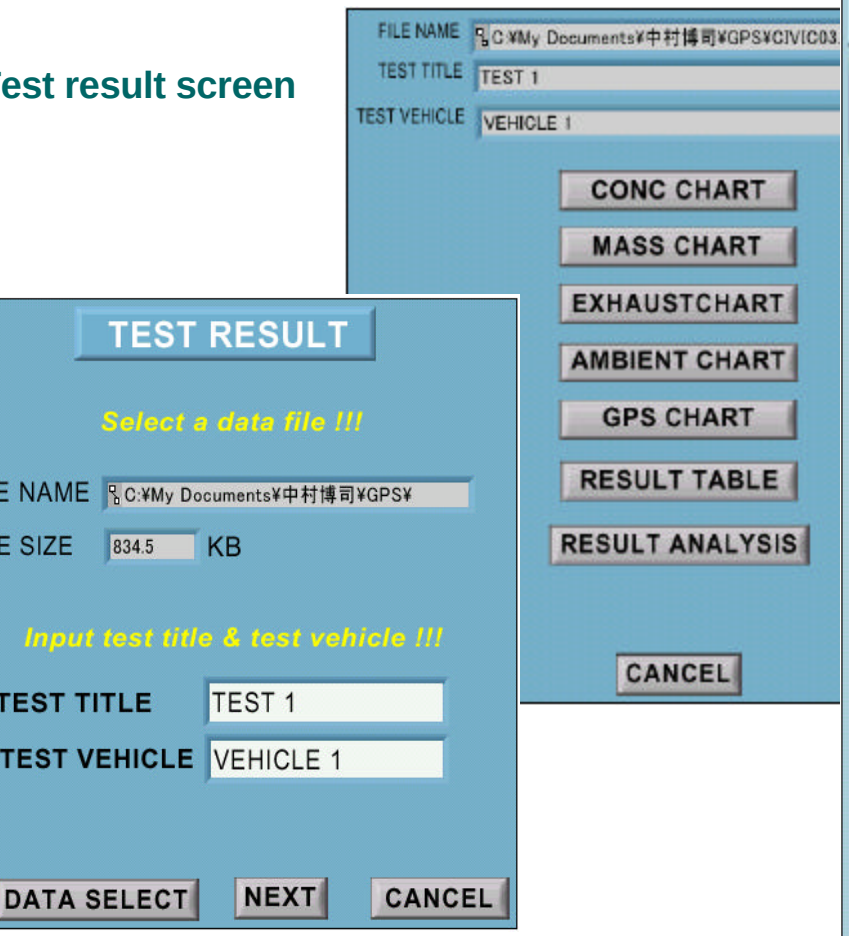
The real time mass emission and **the total mass emission** are calculated and can be indicated using the graphical screen in real time.

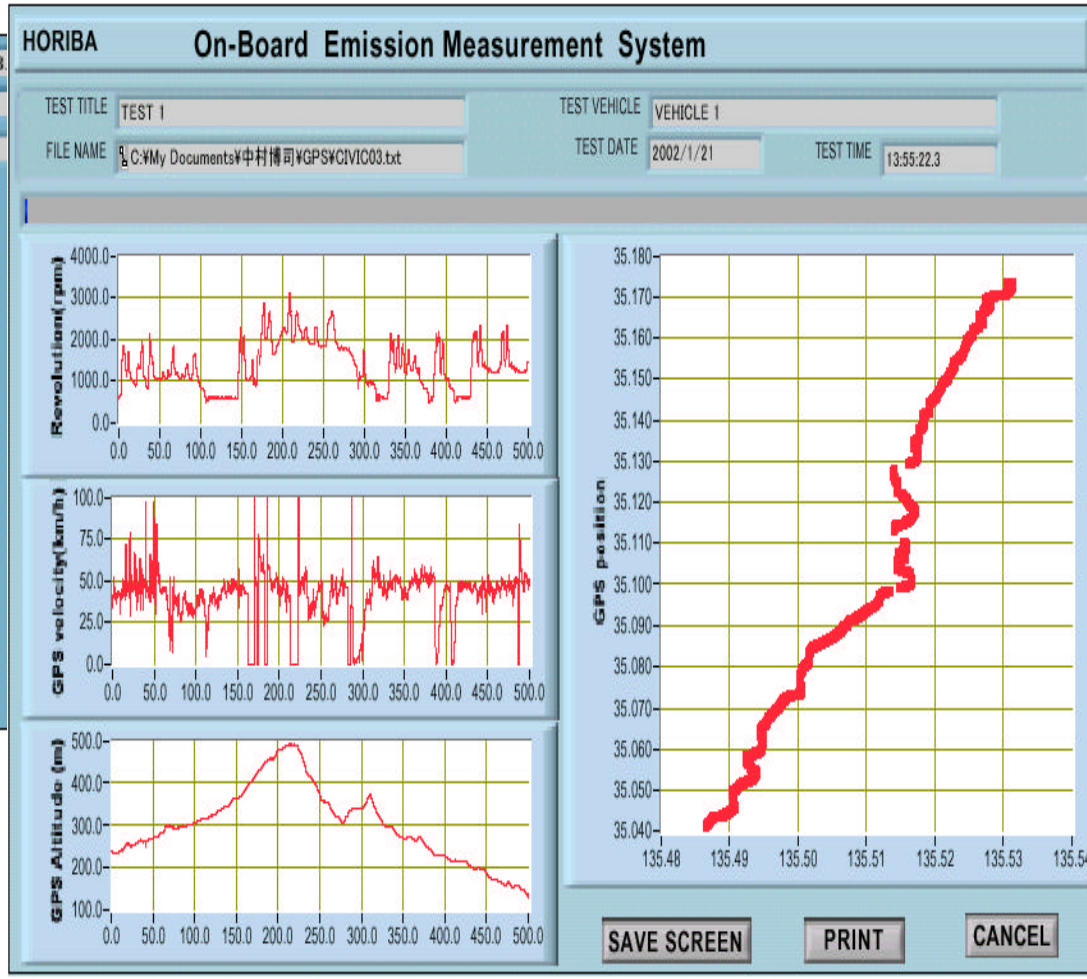
Graphical screen

Data logger Software

- All logged data can be checked and analyzed using the “Test result screen”. All these screens can be printed out using a optional printer, and or converted to “JPG- style” files.

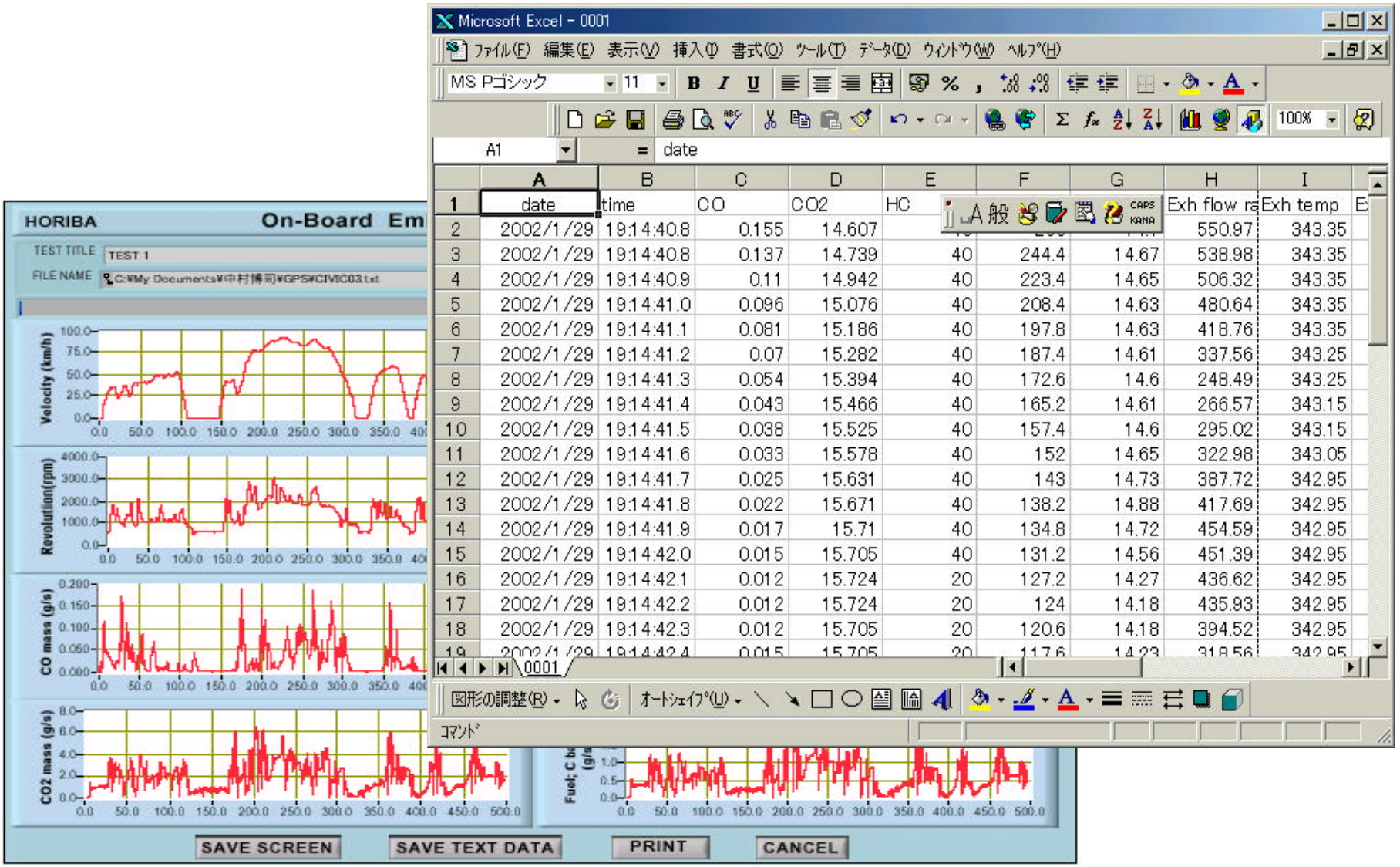
Test result screen





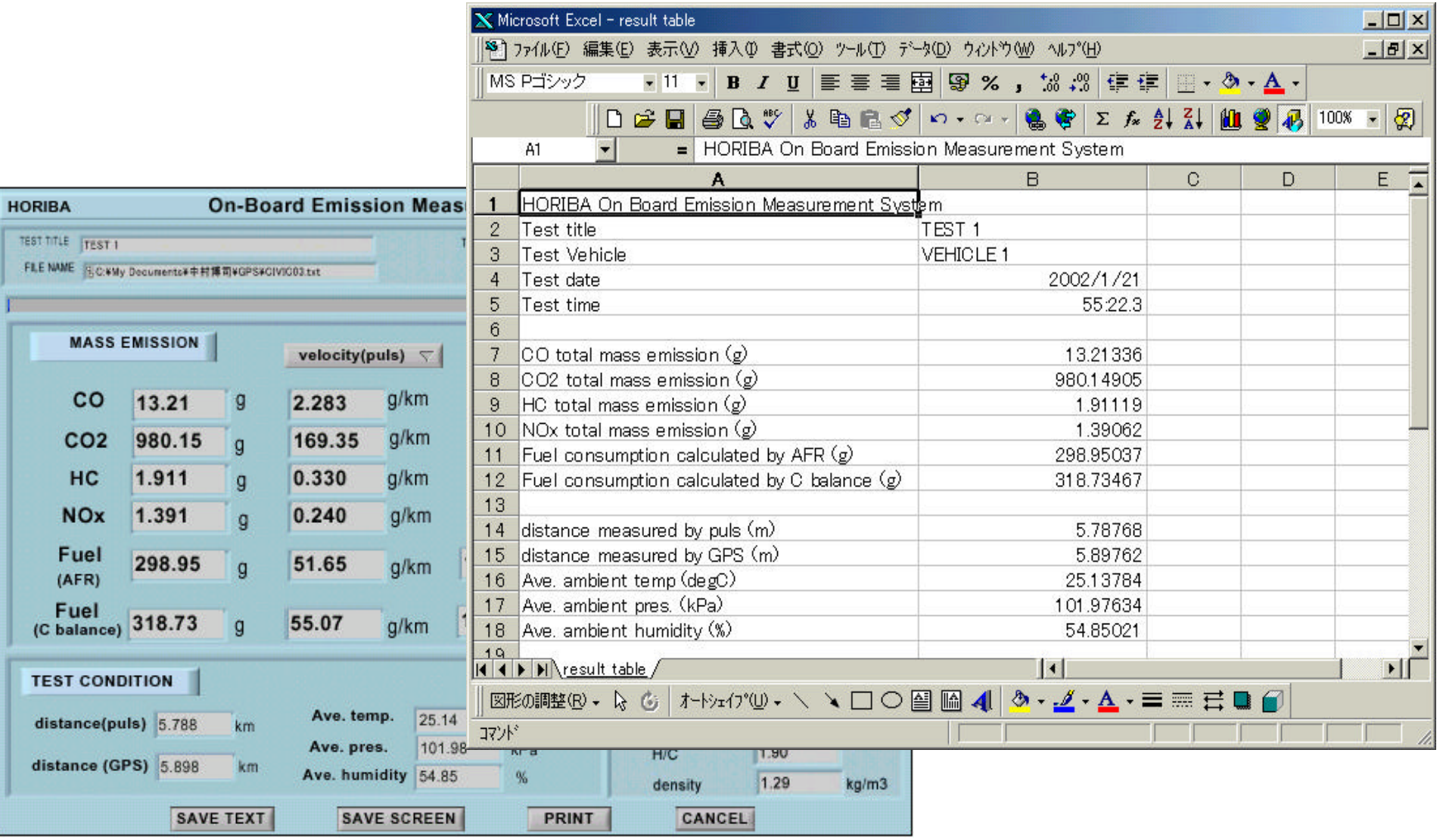
GPS CHART SCREEN

Data logger Software



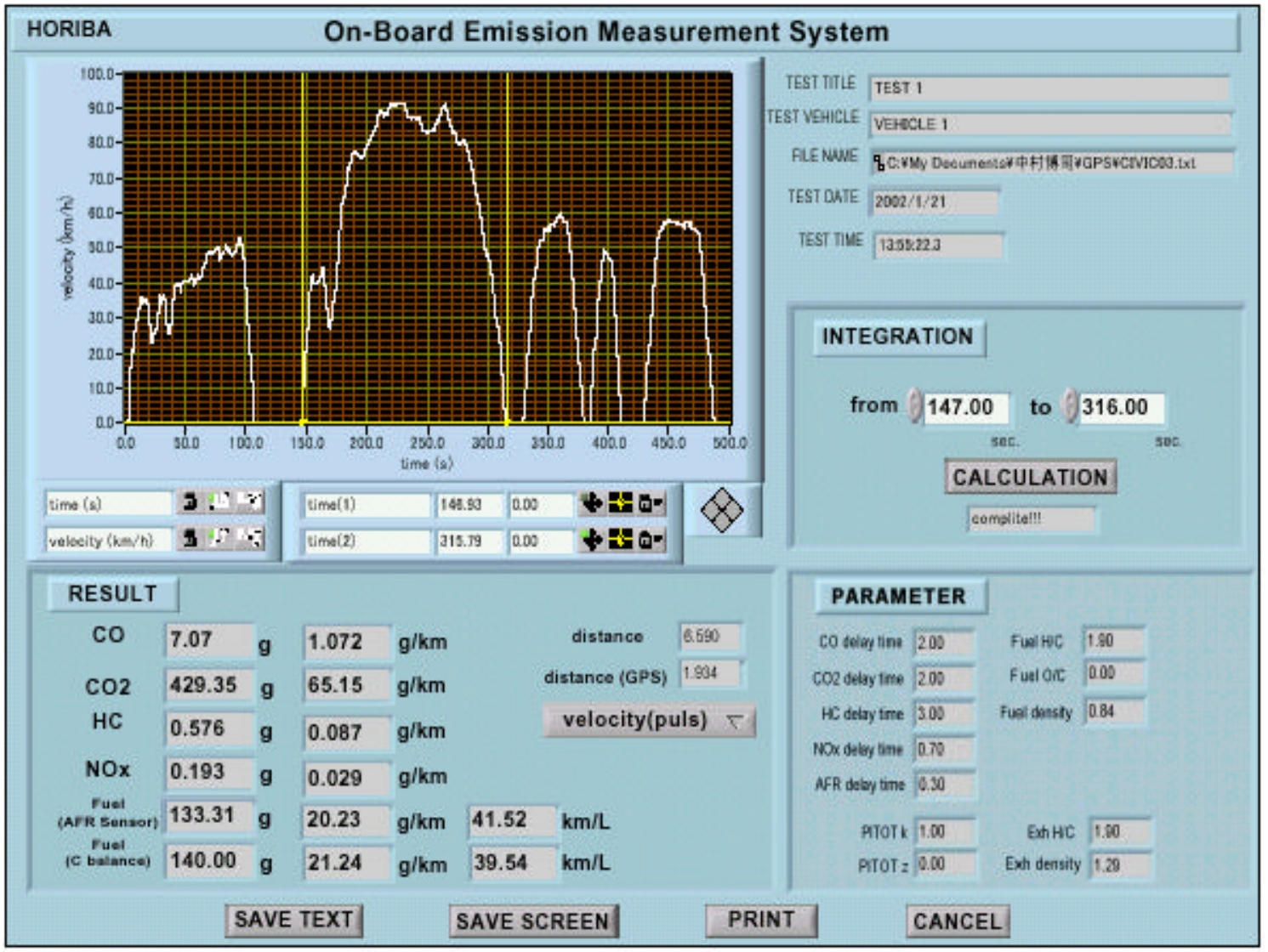
	A	B	C	D	E	F	G	H	I
1	date	time	CO	CO2	HC			Exh flow ra	Exh temp
2	2002/1/29	19:14:40.8	0.155	14.607				550.97	343.35
3	2002/1/29	19:14:40.8	0.137	14.739	40	244.4	14.67	538.98	343.35
4	2002/1/29	19:14:40.9	0.11	14.942	40	223.4	14.65	506.32	343.35
5	2002/1/29	19:14:41.0	0.096	15.076	40	208.4	14.63	480.64	343.35
6	2002/1/29	19:14:41.1	0.081	15.186	40	197.8	14.63	418.76	343.35
7	2002/1/29	19:14:41.2	0.07	15.282	40	187.4	14.61	337.56	343.25
8	2002/1/29	19:14:41.3	0.054	15.394	40	172.6	14.6	248.49	343.25
9	2002/1/29	19:14:41.4	0.043	15.466	40	165.2	14.61	266.57	343.15
10	2002/1/29	19:14:41.5	0.038	15.525	40	157.4	14.6	295.02	343.15
11	2002/1/29	19:14:41.6	0.033	15.578	40	152	14.65	322.98	343.05
12	2002/1/29	19:14:41.7	0.025	15.631	40	143	14.73	387.72	342.95
13	2002/1/29	19:14:41.8	0.022	15.671	40	138.2	14.88	417.69	342.95
14	2002/1/29	19:14:41.9	0.017	15.71	40	134.8	14.72	454.59	342.95
15	2002/1/29	19:14:42.0	0.015	15.705	40	131.2	14.56	451.39	342.95
16	2002/1/29	19:14:42.1	0.012	15.724	20	127.2	14.27	436.62	342.95
17	2002/1/29	19:14:42.2	0.012	15.724	20	124	14.18	435.93	342.95
18	2002/1/29	19:14:42.3	0.012	15.705	20	120.6	14.18	394.52	342.95
19	2002/1/29	19:14:42.4	0.015	15.705	20	117.6	14.23	318.56	342.95

Data logger Software



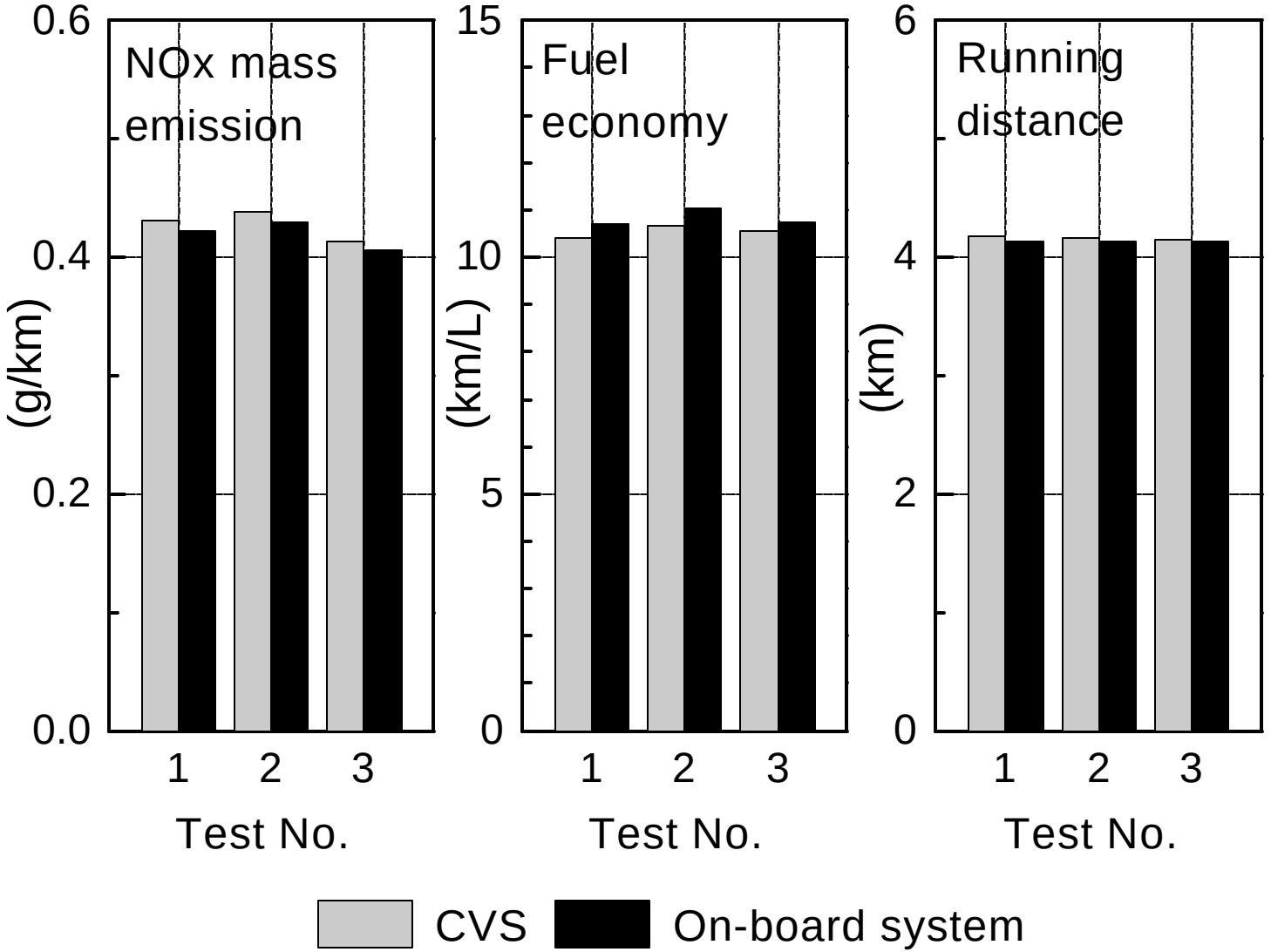
	A	B	C	D	E
1	HORIBA On Board Emission Measurement System				
2	Test title	TEST 1			
3	Test Vehicle	VEHICLE 1			
4	Test date	2002/1/21			
5	Test time	55:22.3			
6					
7	CO total mass emission (g)	13.21336			
8	CO2 total mass emission (g)	980.14905			
9	HC total mass emission (g)	1.91119			
10	NOx total mass emission (g)	1.39062			
11	Fuel consumption calculated by AFR (g)	298.95037			
12	Fuel consumption calculated by C balance (g)	318.73467			
13					
14	distance measured by puls (m)	5.78768			
15	distance measured by GPS (m)	5.89762			
16	Ave. ambient temp (degC)	25.13784			
17	Ave. ambient pres. (kPa)	101.97634			
18	Ave. ambient humidity (%)	54.85021			

Data logger Software



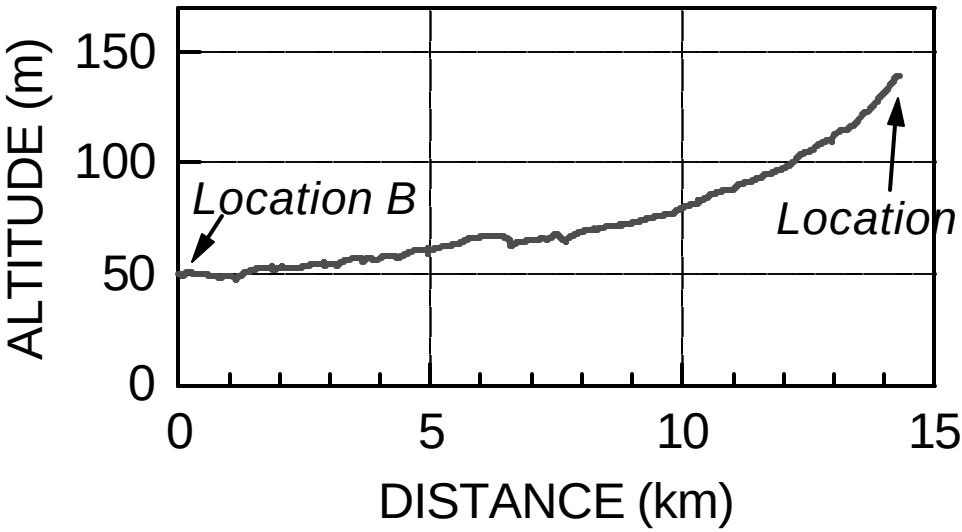
■Review of some of the data collected

Comparison with CVS-bag Measurement



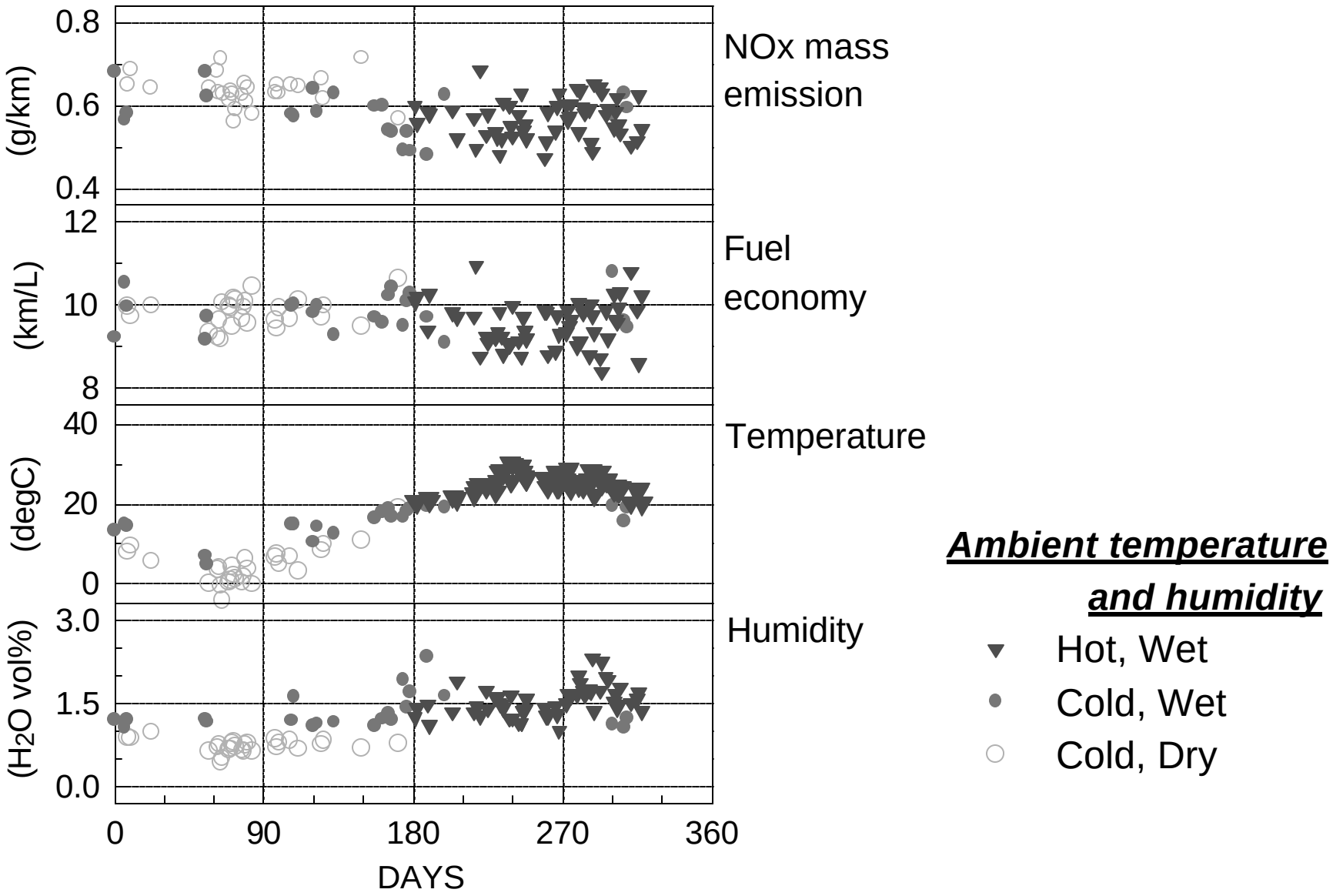
On-road Tests: Conditions

- Repeated tests through one year period.
- Commuting between two locations, A and B

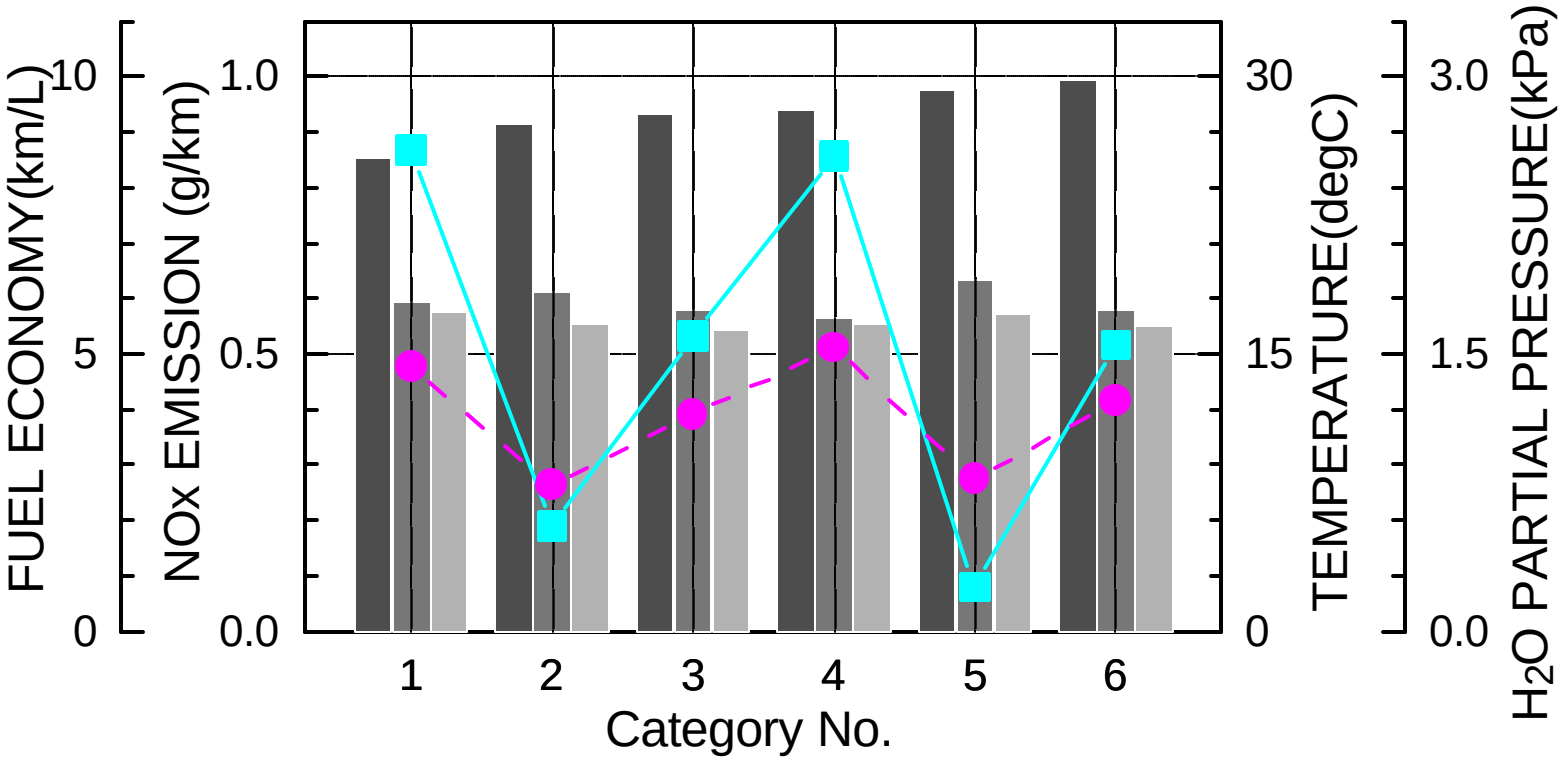


Items	*Station wagon*
Engine type	IDI diesel; with Inter-cooler and turbocharger
EGR	With
Gearshift	4 AT
Engine displacement	1.998 [L]
Vehicle weight	1500 [kg]
Product date	1994 [year]

Seasonal Change 1



Seasonal Change 2



1: Uphill,Summer; 2: Uphill,Winter; 3: Uphill,Spring & Autumn

4: Downhill,Summer; 5: Downhill,Winter; 6: Downhill,Spring & Autumn

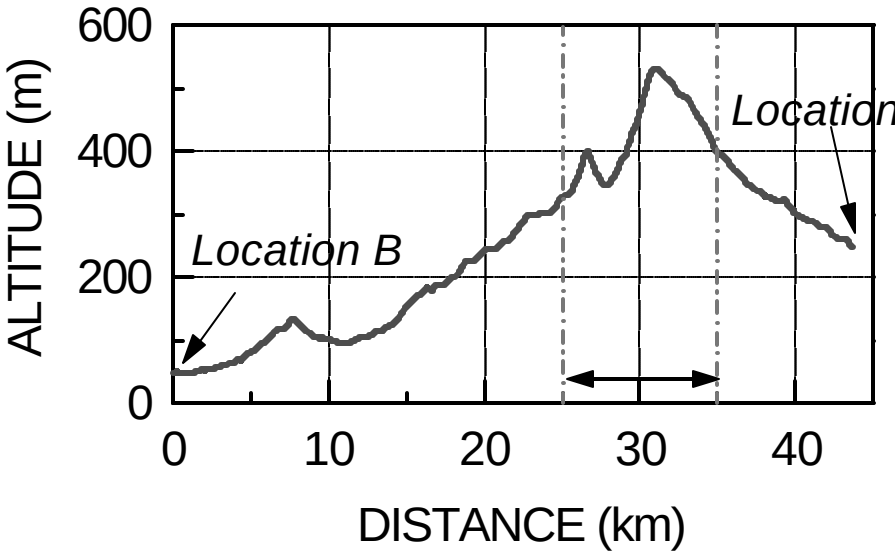
Fuel economy NOx NOx (corrected)

Temperature H_2O partial pressure

Comparison of two vehicles 1

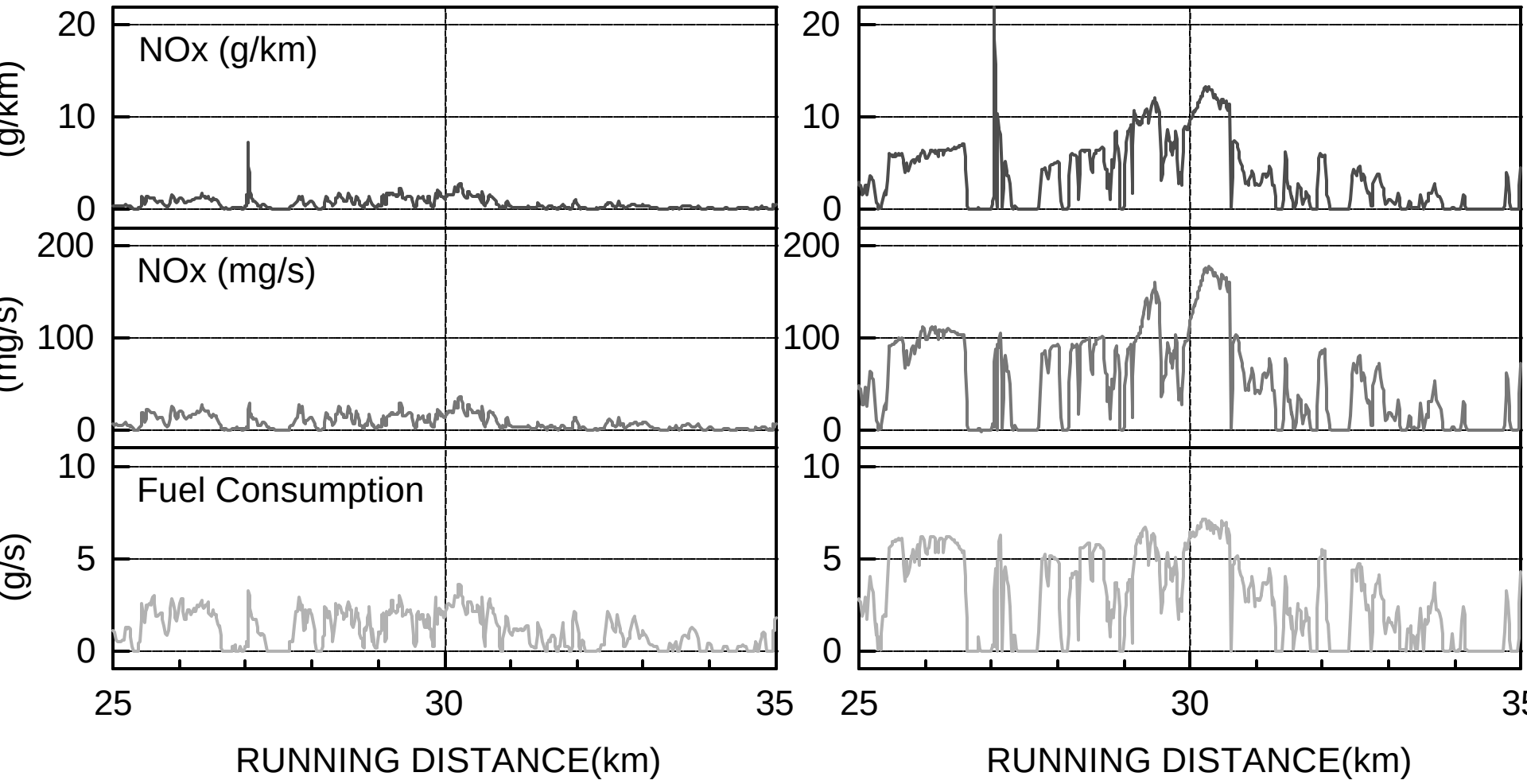
wo vehicles running at the same time

etween point B (south Kyoto) to point C
Kutsuki village)



Items	*Station wagon*	*Microbus*
Engine type	IDI diesel; with Inter-cooler and turbocharger	DI diesel; with Inter-cooler and turbocharger
EGR	With	Without
Gearshift	4 AT	6 MT
Engine displacement	1.998 [L]	3.907 [L]
Vehicle weight	1500 [kg]	3450[kg] (total 4970[kg])
Product date	1994 [year]	1990 [year]

Comparison of two vehicles 2

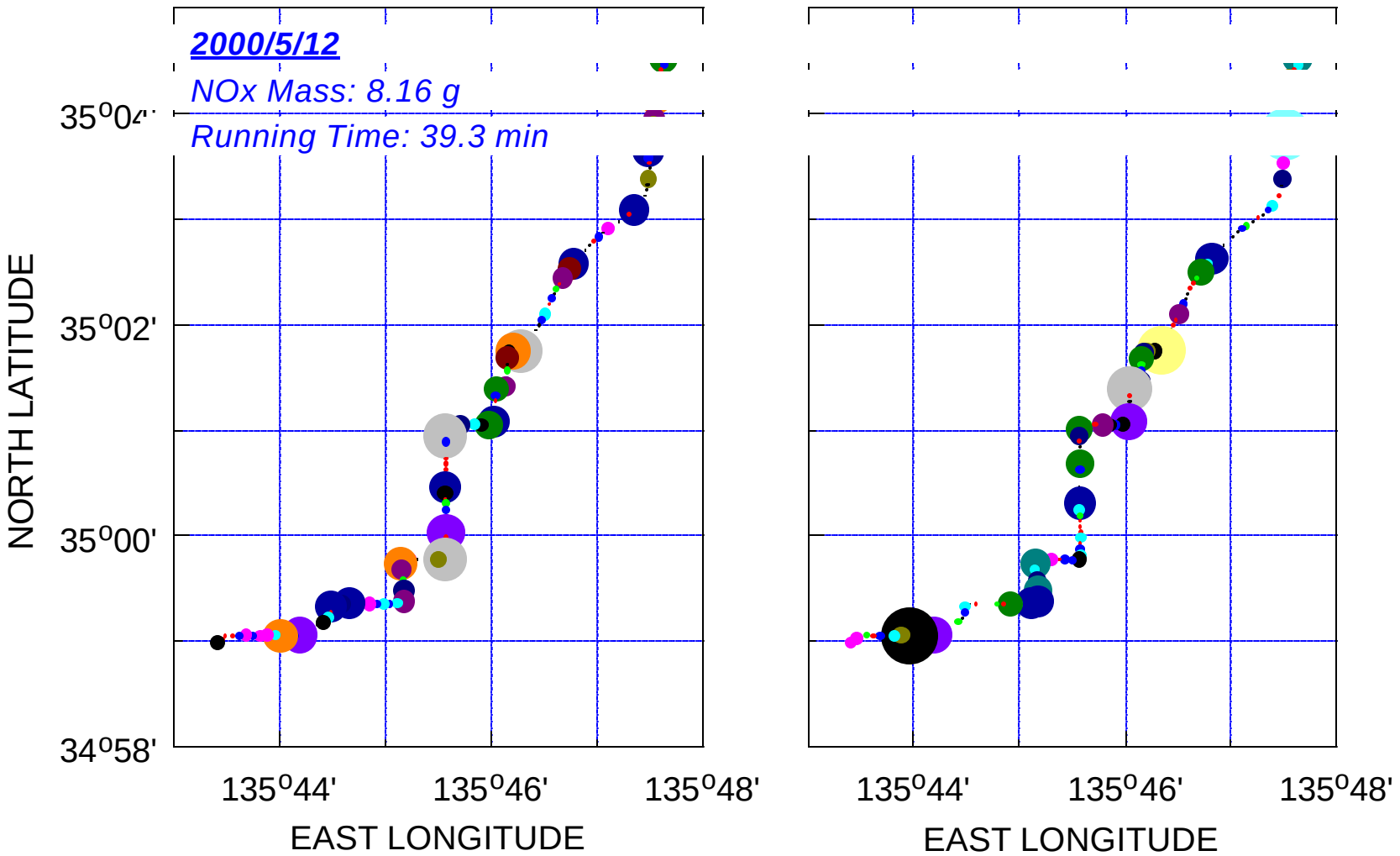


(A) Station Wagon

(B) Microbus

Utilization of GPS: Route

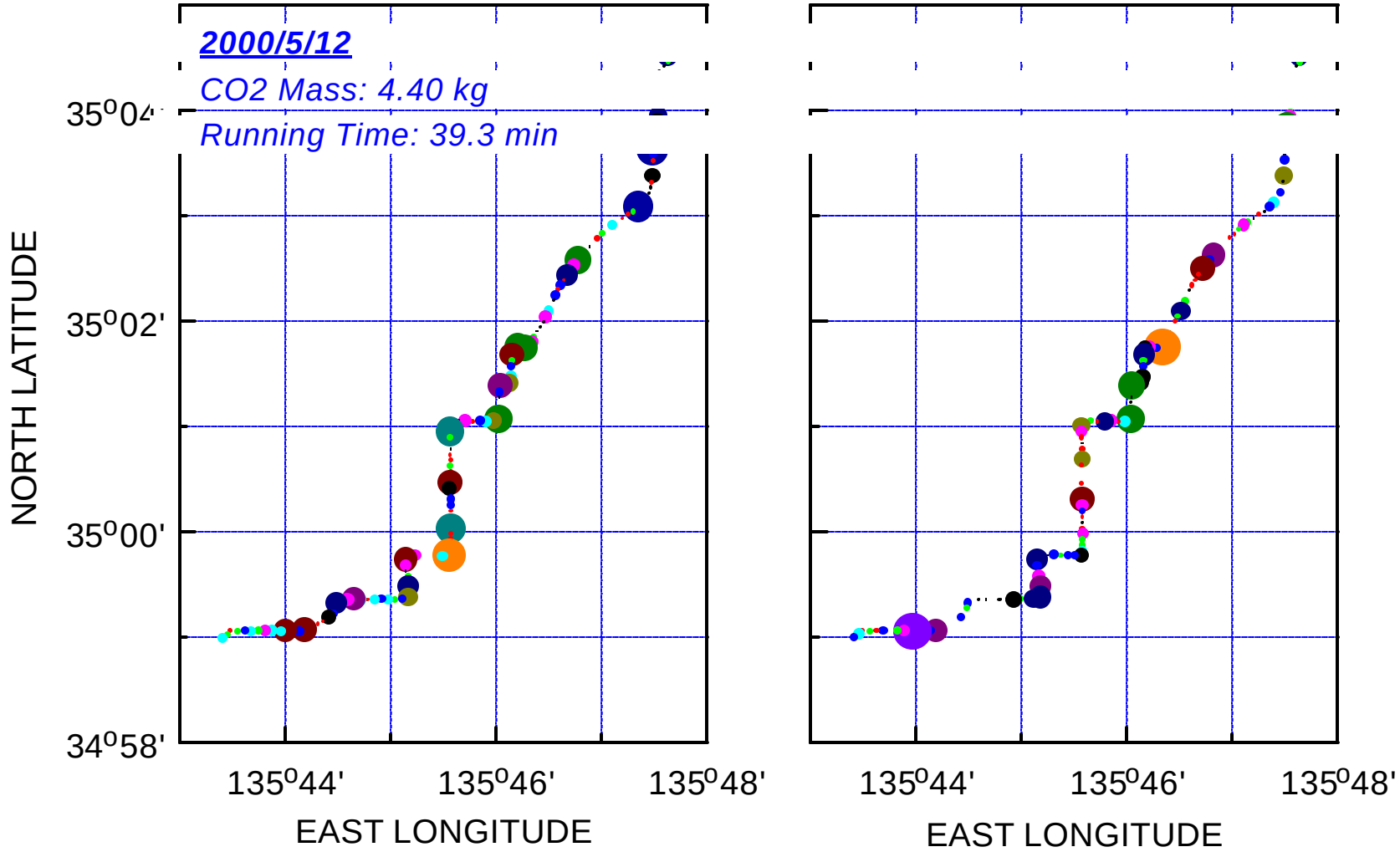
Utilization of GPS: NOx



NOx Mass Emission

Running Distance: 15.2 km

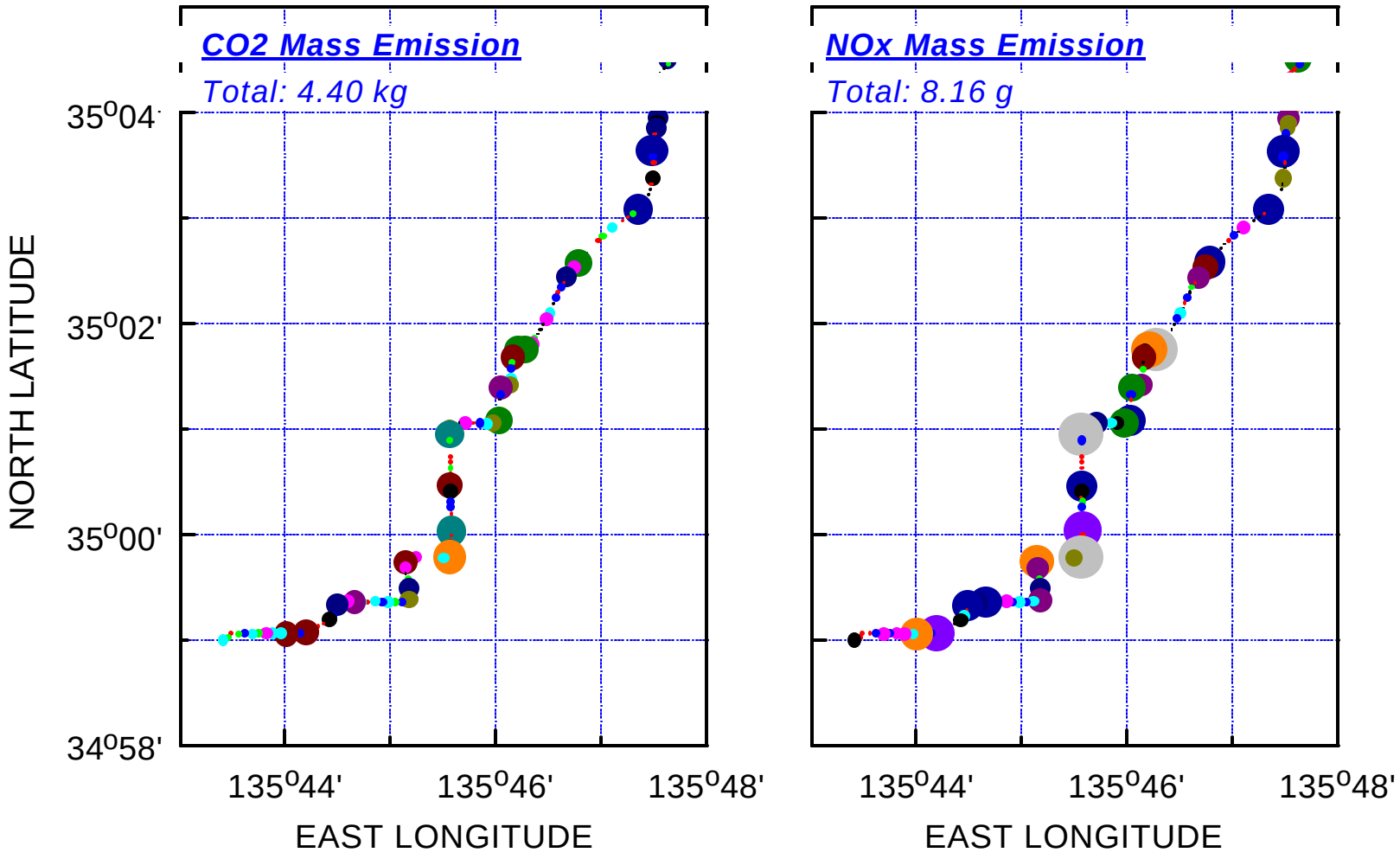
Utilization of GPS: CO2



CO2 Mass Emission

Running Distance: 15.2 km

Utilization of GPS: NOx and CO2



Date: 2000/5/12

Running Distance: 15.2 km, Running Time: 39.3 min

Where do we go from here ?

- Sell some systems ?
- Present SAE paper 2002-01-0612 (wet based NDIR)
- Continue work with

  EPA on potential CRADA or license

  MOE (Ministry of Environment) in Japan on a Japanese OBS

  Environment Canada on a OBS for agricultural farm implements
- Continue to improve sensors ? (HC and Nox)
- Continue to improve packaging and exhaust flow sensors depending on the specific application
- Continue to collect data