EUROPEAN PROJECT ON PORTABLE EMISSIONS MEASUREMENT SYSTEMS: "PEMS" PROJECT

PROJECT PLAN 2005

March 2005
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Introduction:
The contribution of transport to air pollution is of major concern in Europe. The member states of the European Union need efficient policy monitoring tools to check the in-use conformity of road vehicles with the emissions standards. The extraction of engines from heavy-duty vehicles or heavy non-road machinery to compare pollutant emissions against legislative limits is for several reasons impractical. A new approach to in-use conformity checking is needed. Therefore, the European Commission, through DG ENTR, is proposing to develop a protocol for in-use conformity checking (IUC) of heavy-duty vehicles based on the use of Portable Emissions Measuring Systems (PEMS). A similar approach is followed by the US-Environmental Protection Agency (US-EPA) who initiated a research into the use of portable systems as a tool for in-use conformity checking of vehicles and engines. Their proposed method for IUC shall be applicable to 2007 and later model years (heavy-duty and non-road) engines.

Background: Policy making in Europe
The European Commission is intending to make a proposal setting out the general framework for IUC. This objective has already been formalised by DG ENTR in their recent paper [R1] on in-use compliance checking for heavy-duty vehicles and in the Commission proposal COM (2003)/522 [R6] prepared for the amendment of the heavy-duty Directive 88/1999/779/EEC, as amended by Directive 1999/96/EC [R7]: "Further adaptations to the technical annexes of the adopted Directive are foreseen to include, for example, the specifications for PEMS equipment and the associated test protocols, when these are developed and validated. The work being completed by the US EPA will provide a solid platform for the development of a test protocol for use in the EU. It also provides a means of attaining world harmonisation in this subject area." (...) "When appropriate, this would be contained in a Commission proposal setting out the general framework for IUC (based on that of light-duty vehicles) accompanied by a proposal for a simplified NTE approach that reflects on international work through the UN-ECE."

Commission proposal COM (522) 2003 was recently agreed by the European Parliament and the Council and we now await the formal publication of the new Directive in the Official Journal of the European Union. However, amongst 12 amendments agreed by the institutions, two amendments to the Commission’s proposal that are relevant to IUC were agreed by the institutions:

A new recital was added that states:
“Under all randomly selected load conditions within a defined operating range, the limit values may not be exceeded by more than an appropriate percentage.”

And a new Article was added that states:
“For compression-ignition or gas engines that must comply with the limit values set out in section 6.2.1 of Annex I under the type-approval system, the following
shall apply: under all randomly selected load conditions, belonging to a definite control area and with the exception of specified engine operating conditions which are not subject to such a provision, the emissions sampled during a time duration as small as 30 seconds shall not exceed by more than 100% the limit values in rows B2 and C of the tables in section 6.2.1 of Annex I. The control area to which the percentage not to be exceeded shall apply, the excluded engine operating conditions and other appropriate conditions shall be defined in accordance with the procedure referred to in Article 6.”

These amendments may not represent the ideal application of a “Not to Exceed” concept for IUC (they are the same amendments that both institutions accepted in the case of the Directive on non-road mobile machinery). However, they allow the Commission flexibility in preparing a future proposal in this area.

Therefore, the Commission’s proposal to use PEMS in the future for IUC of heavy-duty vehicles is accepted by the Member States and the European Parliament.

Now, DG ENTR is preparing a proposal on heavy-duty vehicles which, amongst other issues, will include a proposal on IUC to establish a legal framework in the Directive. The Commission is aiming to adopt this proposal in the late autumn of this year. However, the possibility to conduct confirmatory tests on heavy-duty vehicles remains a problem still to be solved for the short term.

Therefore, the Commission regards this PEMS project as an extremely important initiative. It will provide the basis on which to conduct tests on heavy-duty vehicles in real-life operations that are far more representative than tests in the laboratory and will be capable of monitoring how heavy-duty engines vehicles actually perform outside the limitations of today’s regulatory tests.
Project objectives
The European Commission through DG ENTR in co-operation with DG JRC has decided to launch a co-operative research programme to study the feasibility of portable emission measurement systems in view of their application in Europe for IUC of heavy-duty vehicles. Given this policy-making road map\(^1\), the main objectives of the PEMS project are:

- To assess and validate the application and performance of portable instrumentation relative to each other, and in comparison with alternative options for IUC testing;
- To define a test protocol for the use of portable instrumentation within the IUC of heavy-duty vehicles;
- To evaluate the US ‘Not To Exceed’ (NTE) approach and possibly develop a simplified method\(^2\) in order to propose IUC pass/fail criteria;
- To address the need of the European industry, authorities and test houses to go through a learning process.

At the end of this project, the resulting test protocol including its data evaluation tools will then be used for a pilot program. Additionally, the verification of the robustness of the test protocol for future engine and after-treatment technologies (SCR catalyst, particulate traps...) should be addressed at this stage.

Status of portable instrumentation
Though many portable instruments are able to provide and record information about the gaseous components present in the exhaust from motor vehicles in general, very few meet the requirements that are needed for IUC purposes. Basically, these systems have to deliver the same information as advanced and costly laboratory systems in terms of mass of the different regulated pollutants, be easy to install and lightweight as well.

Work performed in USA starting from the mid 90s has been documented by Gautam [R8], who discusses the experience for three methodologies to determine the in-use emissions: in-field measurements, on-board measurements, and recent commercial developments. His review includes an extensive discussion of on-board instruments, including those developed by a number of engine manufacturers and research institutes. Other recent reviews by Weaver [R9], Thompson [R10], Reading [R11], Gezelle [R12], Spears [R13], and Ensfield [R14] draw similar conclusions. Finally, the US-EPA developed a generic verification protocol for on-board vehicle emission monitors as part of their Environmental Technology Verification Program (ETV).

The PEMS project presented in this document specifically concerns the latest technological improvements ("State of the art" and commercially available on-board systems) in the frame of the specific European boundary conditions. The

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1 A complementary pilot program will be started within 2005 by the European heavy-duty industry
2 Which could also be applicable to other types of motor vehicles and validated according to the European needs
instrumentation evaluation in the European context concerns the characterisation of gaseous and PM emissions. Given the fact that some portable instruments do not include the characterisation of PM yet and in order to not delay the progress of work (given the tight timetable), the evaluation exercise will for now include the portable instruments too that only implement the gaseous emissions characterisation.
Detailed Project Plan

Overview
Following the prime objectives, the project will be structured into three main tasks.

- Task 1: Instrumentation inter-comparison and validation;
- Task 2: Vehicle road testing with on-board instrumentation;
- Task 3: Data reduction and evaluation.

Task 1 and Task 2 will provide the information needed in terms of instrumentation definition. Task 2 will also address the issues of calibration and provide the modus operandi whereas Task 3 encompasses all data analysis and calculations. As the project foresees the development of a test protocol, the following key issues need to be addressed:

- To specify the equipment and the measurement instruments to be used for testing;
- To define the calibration and performance checks for the above equipment and instruments;
- To prescribe how a test must be run, i.e. how to prepare the vehicle, run the equipment and instruments and collect the data.

A meeting is anticipated between DG JRC, the instrument providers and the OEMs at the end of Task 1 and after the first two trucks are tested to review how the work and plan are matching so that changes can be made as needed in terms of test protocol or data to be collected.

The following diagram shows the structure of the tasks and related sub-tasks.

Data quality
A number of steps will be taken within the project to evaluate the data quality:

- The follow-up of the testing activity by a single organisation (DG JRC) to ensure the continuity of the project and the consistency of the data;
- The documentation of the capabilities of the instruments in terms of accuracy, repeatability, noise, reproducibility and comparison to agreed standards;
- The development of data reporting tools.

It is evident that the data analysis proposed for this project depends strongly on the data quality. The methodologies suggested in Task 3 for data analysis will be re-examined once the data quality has been established.
Sub-Task 1.1: PEMS validation in Laboratory
To compare each candidate PEMS and laboratory grade analyzers

Sub-Task 1.2: PEMS inter-comparison
Sub-Task 1.3: PEMS chassis dyno testing
Sub-task 1.4: Validation of EF meas. Technique

Sub-Task 3.1: Analysis of the comparative performance of on-board systems
To analyze data obtained in Tasks 1.1 to 1.4 and study the performance of portable systems under controlled conditions.

Task 2 Vehicle road testing with PEMS
To obtain on-road emissions and PM data for different engines and applications, possibly using trips selected in Sub-Task 3.2

Sub-Task 3.2: On-road evaluation of portable systems
To analyze and document the measured emissions and their variation due to real-world varying conditions (engine, ambient or other factors)

Accepted? NO

SUB-TASK 3.3: Evaluation of NTE approach and alternative methods

Actions TBD

YES
Task 1: Instrumentation inter-comparison and validation

Task 1 regards the evaluation and inter-comparison of the on-board measurement systems under controlled conditions. This testing activity will identify the instruments to be used for the road tests. The tests will be performed on a dynamic heavy-duty engine test bench. Simultaneous testing of two or more portable systems and the laboratory equipment will be carried out.

The main instrumentation requirements, defined in the preparatory stages of the project, should serve IUC purposes and can be detailed as below:

- To be small, lightweight and easy to install;
- To work with a low power consumption (So that only a small (maximum 3kW) power generator is required and tests of at least three hours can be run);
- To measure and record the concentrations of NO\textsubscript{x}, CO, CO\textsubscript{2}, THC, gases in the exhaust;
- To record the relevant parameters\(^1\) (engine data from the ECU, vehicle position from the GPS, weather data, ) on an included data logger.

Additionally, the portable systems should provide sufficient accuracy, repeatability and data logging capabilities for IUC applications, as specified in the Draft Technical Support Document: In-Use Testing for Heavy-Duty Diesel Engines and Vehicles issued by US-EPA[R15]. The main elements to be included in a complete PEMS for IUC are:

1. Exhaust gas analysers
2. Power supply unit
3. Heated sampling line + Filtering unit
4. Exhaust flow meter
5. Fuel flow meter\(^2\)
6. Global Positioning System (GPS)
7. Computer for test management and data logging

The aforementioned requirements also apply to the PM instrumentation and the systems developed for the measurement of gaseous emissions should include as soon as possible:

8. PM Sampling unit (Proportional sampling)
9. Filter unit or QCM\(^3\) or TEOM\(^4\).

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\(^1\) Details to be found in "Road Tests with On-board instrumentation: Test parameters, test reports" [W2]
\(^2\) Backup of exhaust flow, see sub-task 1.4
\(^3\) Quartz Cristal Microbalance
\(^4\) Tapered Element Oscillation Microbalance
**Sub Task 1.1 PEMS Pre-validation**

**Objectives:**
In this task, the instrumentation providers will conduct a preliminary verification of their systems (analysers, flow sensors, diluters...) at their sites or at any other test site under the testing protocol defined in the European legislation. At the end of the sub-task, they supply the related data for the project reporting.

**Technical approach:**
The test program includes engine dynamometer tests. Simultaneous use of the portable and the laboratory equipment is foreseen, to check for instance:

- The portable analysers against laboratory grade analysers;
- The portable exhaust flow measurement device against the laboratory method (CVS\(^1\) venturi coupled with a SAO\(^2\), or equivalent);
- The portable diluter against a validated laboratory diluter working along the same principle.

The engine to be used for these tests should be of a type complying with the limit values shown in either row A or row B1 of table 2 in section 6.2.1 of Annex I to Directive 1999/96/EC [R7] for the ETC cycle.

**Sub-Task 1.2 PEMS Inter-comparison**

**Objectives:**
Under Sub-Task 1.2, the scope of Sub Task 1.1 will be enlarged by testing the candidate portable systems for other engines and a wider range of operating conditions in terms of driving cycles and operating conditions. Emissions tests will be conducted in a heavy-duty dynamic test facility to evaluate the performance of the different candidate portable systems. The goal is to check how the portable systems compare with the high quality lab systems for emissions and PM measurement and against each other. In this task, the laboratory systems will be considered as reference.

**Technical approach:**
The detailed work programme will be prepared jointly by the involved laboratories, in close co-operation with the OEMs and the instrument providers. The test cycles shall be selected to cover a wide range of engine responses and emission patterns (ESC, ETC and other cycles to be decided). Simultaneous tests with two or more portable systems will be carried out.

**Sub Task 1.3 PEMS Chassis dynamometer evaluation**
Sub-task 1.3 could also involve vehicle testing in case of availability heavy-duty chassis dynamometer testing. This activity could provide further information to establish the potential differences between emissions measured during on-road tests.

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\(^1\) Constant Volume Sampler

\(^2\) Smooth Approach Orifice
testing and the emissions generated in the laboratory under controlled conditions. Additionally, as vehicle chassis dynamometer testing is one of the alternatives to on-road measurement with portable systems, the exercise could provide further data on the feasibility of IUC with a chassis dynamometer and its cost-effectiveness with respect to other solutions.

Sub-Task 1.4 Validation of exhaust flow measurement techniques
One of the key technical issues is the measurement on-road of the exhaust flow rate: it is needed both to derive mass emissions and to control PM proportional sampling systems. Finding a proper technique or device to measure the instantaneous vehicle exhaust flow has been a long lasting issue. Recent progress was made using ultrasonic devices ("E-flow") or "hot-wire" anemometers and these techniques have proven to be reliable mostly in laboratory conditions on light-duty vehicles. The accuracy and the reliability of such sensors throughout the whole range of conditions encountered in real-world vehicle testing still have to be demonstrated. Therefore a specific evaluation of the exhaust flow sensors and some alternative measurement techniques (fuel flow + intake air) to be used for on-road testing will be conducted in the laboratory, in parallel to sub-task 1.2.

Task 2: Vehicle road testing
The on-road evaluation of the candidate systems will be conducted on several heavy-duty diesel trucks (one from each participating European manufacturer). This evaluation will be based on collected "real-world" emissions data at different locations and for a panel of engines typical for the various engine families and technologies currently existing on the European market.

Technical approach:
The main direction of Task 2 is to evaluate the response of the portable systems on the road, i.e. to proceed from the engine mounted on the dynamometer and tested under controlled laboratory conditions to the vehicle driven on the road and therefore to introduce other sources of variability that could affect the response of the portable instrumentation.
The on-board systems will be configured and installed according to instrument provider's specifications and recommendations. Whenever possible, two or more on-board systems shall be installed for simultaneous data collection.
Seven vehicles complying at least with the EURO3 requirements will be used. These vehicles are shown in the table below. If available, the plan will include tests with a city bus and at a later stage two or more vehicles equipped with modern engine and after-treatment technologies and meeting the EURO4 or 5 emissions requirements.

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1 Even though, it is evident that there are fundamental differences that cannot be reproduced, the results of these tests will lead to a better understanding of the influencing parameters of emission variability.
<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Vehicle / Engine type</th>
<th>Engine capacity</th>
<th>Rated Power</th>
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<tr>
<td>DAF TRUCKS</td>
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<tr>
<td>DAIMLER CHRYSLER</td>
<td>OM 501LA</td>
<td>12 l</td>
<td>300 kW</td>
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<td>IVECO</td>
<td>CURSOR 10</td>
<td>10 l</td>
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<tr>
<td>MAN</td>
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<td>6.8 l</td>
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<tr>
<td>RENAULT VI POWERTRAIN</td>
<td>MIDLUM / DCi4</td>
<td>4 l</td>
<td>128 kW</td>
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<td>SCANIA</td>
<td>R 124</td>
<td>12 l</td>
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<tr>
<td>VOLVO POWERTRAIN</td>
<td>FH 12 / D12D</td>
<td>12.1 l</td>
<td></td>
</tr>
</tbody>
</table>

These road tests with on-board instrumentation will be conducted at or close to the premises of heavy-duty manufacturers. Engaged in a variety of typical on-road missions, the driving routes should represent typical urban, suburban (mixed), and highway driving, including also hill climbs where possible in order to make a proficient evaluation of the PEMS instruments’ performance. They should also include segments with cruising at constant speed and segments that are highly transient in their character. The trips should be defined at different altitudes where possible. The candidate routes shall be of sufficient length (30 Minutes). The road trip will be driven in both directions (outbound and return). In-use testing should entail multiple shorter-length tests, rather than fewer extended length tests in order to prevent voiding tests due to component failures or operator errors. The trip should be run with unloaded and loaded vehicle. Ambient conditions as function of the seasonal variety could be included. Finally, three to five tests per driving condition should be performed.

The proposed road trips should be evaluated prior to any emission test in order to ensure a more reliable start of Task 2. Analysing the data when the actual PEMS tests are performed could lead to the necessity of a repetition of modified road tests, which again could mean more cost or delay.

**Task 3: Data analysis;**

Task 3 concerns the analysis of the data collected during the measurement campaigns defined in task 1 and task 2. This work is performed by DG-JRC with the contribution and support of the experts of all participating parties. Workflow based written documents should be supplied by all involved experts regarding the analysis as following from the objectives. This way some of the analysis will be done in different ways in parallel, allowing thus to establish the most suitable approach. Certain methodologies (for the analysis) will be applied because they improve the understanding of underlying variability of and dependency between parameters without any implication of including these methodologies later into the resulting protocols.

Task 3 is subdivided into three subtasks. This division is of chronological character, i.e. sub-task 3.1 feeds into 3.2 etc. They are not independent tasks.
Sub-Task 3.1: Analysis of the comparative performance of on-board systems

The data analysis for the validation and inter-comparison of the on-board systems will include the comparison between:

- The laboratory instruments and their portable equivalent (analyser, flow sensor, diluter...);
- The portable instruments themselves, i.e. two different portable sensing technologies (for instance two analysers technologies and/or two flow sensors).

Furthermore, the selected systems/instruments will be evaluated for the variation of parameters such as temperature and humidity and if possible their sensitivity to disturbances such as vibrations.

The report of subtask 3.1 will contain the results of these tests, but it will also highlight the portable systems’ performance.

Sub-Task 3.2: On-road evaluation of portable systems

The scope of sub-task 3.2 is to analyse and document the measured emissions and their variation due to real-world varying conditions (engine, ambient or other factors). The combination of the results from sub-tasks 3.1 and 3.2 will provide information on the portable instruments reliability and a multi parameter variability envelop of on-vehicle systems when they are used on road. These information will be fed into the evaluation of the US-NTE concept or other equivalent approaches, included under sub-task 3.3.

Several methodologies will be derived, based on proposals by all the participating experts (The first JRC discussion paper [W1] to was issued in June 2004). As data available from test sites might not be homogeneous and the methodologies need to be adapted to the data quality that will be finally available, the sub-group on data analysis will develop a minimum platform through the data reporting protocol. The baseline data evaluation will be conducted with the aforementioned platform whereas more detailed analysis could be performed for some OEMs and test sites on a voluntary basis.

Sub-Task 3.3: Evaluation of NTE approach and alternative methods

Using the data collected under task 2 and evaluated in subtasks 3.1 and 3.2, the US-NTE approach and possible simplified approaches will be evaluated. This work addresses the last issue regarding the development of a test protocol. Several methodologies will be derived, based on proposals by all experts (JRC discussion paper to be issued within July 2004).

Horizontal tasks

Further details on the following tasks A, B and C can be found under the chapter "Project organisation and management".
A. Project preparation and management
This task regards the evaluation of objectives, the preparation of test plan, the co-ordination and the follow-up of the project and will be conducted by DG JRC with the support of the other participants.

B. Preparation of the candidate portable systems
Under this task, the instrument providers prepare and assemble the instruments into ready-to-use systems to be sent out to the different test sites throughout Europe. These systems are delivered to DG JRC Ispra site. This task includes also the training of DG JRC staff and the definition of packing and shipping instructions.

C. Documentation
This task regards the drafting, distribution and filing of project documents.
Project organisation and management

Resources:
So far, the following bodies and companies have reached an agreement to join their efforts, perform the experiments and conduct the related activities. The main contributions till now are as such:

- The European Commission through DG JRC acting in close cooperation with DG ENTR will prepare and co-ordinate the programme.
- ACEA\(^1\) (with its members DAF, MAN, Iveco, Daimler, Volvo, Scania, RVI) will provide the test vehicles and co-operate with DG JRC to perform the on-road tests;
- Sensors Inc, Horiba, AVL and Control Sistem will supply the portable systems and provide training and product support;
- National laboratories (TNO, RWTÜV, IDIADA) involved in type approval and in-IUC will provide their expertise based on their IUC testing experience;
- TNO will provide the analysis to compare portable systems with alternative options for IUC;
- DG JRC will follow-up on the engine in-field tests;
- DG JRC will make available its heavy-duty testing facilities (Vehicle and Engines Emissions Laboratories at DG JRC Ispra);
- DG JRC will plan the tests and the statistical analysis required to examine the test results together with the relevant experts of the participating organisations;

Planning group
The planning group was open to companies or organisations willing to contribute to the activity, as stated in the call for interest published by DG ENTR: "On behalf of the European Commission, DG ENTR welcomes participation from others parties (e.g. manufacturers of heavy-duty vehicles, manufacturers of portable instrumentation) who can add value to the project (i.e. provide portable instrumentation for evaluation and testing, provide heavy-duty vehicles and engines for testing, provide chassis dynamometer facilities etc)."
This invitation closed on the 15th of June 2004. The planning group has been established only for the preparation of the activity and is be replaced by the Steering Group once the project has started.

Project Steering Group
The project will be managed by a Project Steering Group (PSG). The members of the PSG will belong to the companies or institutions invited by the Commission and sponsoring or contributing to the project. The PSG will be co-chaired by EC-DG ENTR and EC-DG JRC.

\(^1\) Association des Constructeurs Européens d'Automobiles
The sub-groups of the PSG will be:

- The Technical Task Forces (TTF): On a voluntary basis, small groups will conduct activities on key technical issues identified by the PSG;
- The Test protocol drafting committee.

The PSG will report on a bi-annual basis to companies or organisations appointed by the Member States, for instance in the Motor Vehicle Emissions Group of DG ENTR or one of its sub-groups.

**Dissemination of information and confidentiality:**

All data sent to the European Commission (ENTR or JRC) by any of the PSG members will remain confidential under the conditions of the *Regulation No. 1049/2001 of the European Parliament and the Council of 30 May 2001*. Article 4(2) of that Regulation notes that "The institutions shall refuse access to a document where the disclose would undermine the protection of...commercial interests."\(^1\) This confidentiality agreement will apply to engine test data for instance.

In addition to the above statement:

With respect to all information concerning the data and information declared as confidential by one of the participants: (whether in oral, written or computerised form),

Within the project, the data declared as confidential by one of the parties shall:
- Only be used for the development of the European heavy-duty in-use compliance procedure;
- Be processed, analysed and reported with a methodology and within a time frame approved by the said party.

Any publications making use of the data, i.e. objectives, content and text will be agreed in advance.

The above confidentiality agreement will be applicable for instance to all the test data collected by EC-DG JRC in co-operation with the different European heavy-duty manufacturers (for the road tests) and with the instrument providers (for some specific laboratory tests).

**Planned Deliverables**

DG JRC will manage the project documentation: all documents will be jointly reviewed and be adopted by the majority of experts.

* Experimental programme on Heavy Duty vehicles portable emission measurement systems

\(^1\) From Euro5 questionnaire issued by DG ENTR
* Test protocols: The "Preliminary" protocol to be used during the testing campaign to be carried out in 2004 and early 2005, then a "Final" protocol that should be the basis for the manufacturers pilot programme to be started from mid 2005.
* Reporting to the stakeholders the progress at least two times per year during the Motor Vehicle Emissions Group meetings at DG ENTR.
* Reporting the progress at least four times per year to the "Working" or "Steering" Groups.
* Technical reports

**International links**

As the success of the programme requires a deep experience in the field, and as harmonization of standards is also envisaged by the EC, other bodies and companies able to bring a substantial contribution will be encouraged to participate in this effort. For instance:

- EU Member States through their authorised ministries, type approval bodies or national reference laboratories;
- US-EPA and also CARB\(^1\) that start a programme to be considered as a worldwide reference on the subject;
- The Japanese Ministry of Environment;
- Representatives from EUROMOT, EMA, (US Engine Manufacturers Association) and LEMA, (Japanese Engine Manufacturers Association);
- Manufacturers of portable instruments for measuring emissions with the assistance of their technicians and engineers.

In that respect, DG ENTR has launched a call for interest\(^2\) in participating in the collaborative project.

The project being set-up will be strongly connected to on-going international activities such as:

- The United Nations GRPE\(^3\) off-cycle working group;
- The United Nations GRPE working group on non-road mobile machinery coordinated by DG JRC, who has adopted as base procedure the new US Part 1065;
- The Memorandum of Understanding (MoU) signed by EC-JRC with US-EPA (NVFEL\(^4\)), Japan (NTSEL\(^5\)) and China (SEPA-VECC\(^6\));
- National projects having used portable systems as a tool to obtain real-world emission factors for different vehicles (Projects by EMPA in Switzerland and BASi in Germany).

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\(^1\) California Air Resource Board
\(^2\) [http://europa.eu.int/comm/enterprise/automotive/pages/background/pems_project.htm](http://europa.eu.int/comm/enterprise/automotive/pages/background/pems_project.htm)
\(^3\) World Forum for Harmonization of Vehicle Regulations (WP.29) - Working Party on Pollution and Energy (GRPE)
\(^4\) National Vehicle and Fuels Emissions Laboratories
\(^5\) National Traffic Safety and Environment Laboratory
\(^6\) State Environment Protection Administration, Vehicle Emissions Control Center
### Planning 2004:

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### TASK 1. INSTRUMENTATION INTER-COMPARISON

**1.1 PEMS pre-validation Laboratory**

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**1.2 PEMS inter-comparison in Laboratory**

| Engine1, System 182 (Gaseous Emissions) | DG, JRC, INECO, SENSORS, HORiba |  |  |  |  |  |  |  |  |  |  |  |
| Engine2, System 182 (PM+Gaseous Emissions) | DG, JRC, DC, SENSORS, HORiba |  |  |  |  |  |  |  |  |  |  |  |

**1.3 PEMS chassis dynamometer evaluation**

| TO BE DEFINED |  |  |  |  |  |  |  |  |  |  |  |  |

**1.4 Validation of exhaust flow measurement techniques**

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### TASK 2: VEHICLE ROAD TESTING

| IVGO | DG, JRC, INECO |  |  |  |  |  |  |  |  |  |  |  |
| VOLVO | DG, JRC, VOLVO |  |  |  |  |  |  |  |  |  |  |  |
| DC | DG, JRC, DC |  |  |  |  |  |  |  |  |  |  |  |
| MAN | DG, JRC, MAN |  |  |  |  |  |  |  |  |  |  |  |
| SCANIA | DG, JRC, SCANIA |  |  |  |  |  |  |  |  |  |  |  |
| DAF | DG, JRC, DAF |  |  |  |  |  |  |  |  |  |  |  |
| RENAULT | DG, JRC, RENAULT |  |  |  |  |  |  |  |  |  |  |  |

### TASK 3. DATA REDUCTION AND EVALUATION

**3.1: Comparative performance of on-board systems**

| Engine 1 | DG, JRC |  |  |  |  |  |  |  |  |  |  |  |
| Engine 2 | DG, JRC |  |  |  |  |  |  |  |  |  |  |  |

**3.2 Analysis of test trip data**

| Data set 1 | DG, JRC |  |  |  |  |  |  |  |  |  |  |  |
| Data set 2 | DG, JRC |  |  |  |  |  |  |  |  |  |  |  |

**3.3 Analysis of emissions and PM on-road data**

| IVGO | DG, JRC |  |  |  |  |  |  |  |  |  |  |  |
| VOLVO | DG, JRC |  |  |  |  |  |  |  |  |  |  |  |
| DC | DG, JRC |  |  |  |  |  |  |  |  |  |  |  |
| MAN | DG, JRC |  |  |  |  |  |  |  |  |  |  |  |
| SCANIA | DG, JRC |  |  |  |  |  |  |  |  |  |  |  |
| DAF | DG, JRC |  |  |  |  |  |  |  |  |  |  |  |
| RENAULT | DG, JRC |  |  |  |  |  |  |  |  |  |  |  |

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### TASK 1: INSTRUMENTATION INTER-COMPARISON

**1.1 PEMS pre-validation laboratory**
- System 1: SENSORS
- System 2: HOBRA

**1.2 PEMS inter-comparison In laboratory**
- Engine 1, Systems 1 & 2 (Gas emissions): DG, JRC, Iveco, SENSORS, HOBRA
- Engine 2, Systems 1 & 2 (PM+Gas emissions): DG, JRC, Iveco, SENSORS, HOBRA

**1.3 PEMS chassis dynamometer evaluation**
- TO BE DEFINED

**1.4 Validation of exhaust flow measurement techniques**
- System 1: DG, JRC
- System 2: DG, JRC

### TASK 2: VEHICLE ROAD TESTING

- IVECO: DG, JRC, Iveco
- VOLVO: DG, JRC, VOLVO
- MAN: DG, JRC, MAN
- SCANDIA: DG, JRC, SCANDIA
- DAFF: DG, JRC, DAFF
- RENAULT: DG, JRC, RENAULT

### TASK 3: DATA REDUCTION AND EVALUATION

**3.1 Comparative performance of on-board systems**
- Engine 1: DG, JRC
- Engine 2: DG, JRC

**3.2 Analysis of test trip data**
- Data set 1: DG, JRC
- Data set 2: DG, JRC

**3.3 Analysis of emissions and PM on-road data**
- IVECO: DG, JRC
- VOLVO: DG, JRC
- MAN: DG, JRC
- SCANDIA: DG, JRC
- DAFF: DG, JRC
- RENAULT: DG, JRC

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References


R2. Alf Ekermo (Volvo) - In-use US testing experience, presentation at the 2nd meeting of the PEMS planning group, Brussels, 22nd of January 2004.


R4. Draft EPA Regulation Part 1065 Test Procedures - Subpart J "Field Testing"

R5. Protocol for in-use on-vehicle testing - Draft protocol prepared by Analytical Engineering Inc. for US-EPA.


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W1. PEMS: Definition and evaluation of road trips - R. Hummel, P. Bonnel - May 2004
W2. Road Tests with On-board instrumentation: Test parameters, test reports - P. Bonnel, R. Hummel - June 2004
W3. Guide for the preparation and the execution of the road tests (First draft version) – March 2005
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1 Observers or organisations having sent a notification of interest following the call published by DG ENTR at: http://europa.eu.int/comm/enterprise/automotive/pagesbackground/pems_project.htm