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## EXECUTIVE SUMMARY

HEAVEN (Healthier Environment through Abatement of Vehicle Emission and Noise) is a research project co-funded by the Information Society Technologies Programme of the European Union. In the project consortium, valuable expertise in the field of transport and environment of research institutes, the private sector (leading industry and supporting consultants), and the public sector is combined.

It is the high-level goal of the project to demonstrate a Decision Support System (DSS) which can evaluate the environmental effects (air quality and noise quality - both emissions and dispersion forecasting) of Transport Demand Management Strategies (TDMS) in large urban areas. The EU cities of Berlin, Leicester, Paris, Rome, and Rotterdam as well as the CEEC city of Prague serve as the demonstration sites of the project.

The demonstration in these cities provides a concrete sustainable development perspective and improves the quality of life in European cities by reducing transport-related noise and air pollutant emissions through the innovative combination of efficient TDMS and integrated environmental Information Society Technologies (IST).

Workpackage 8 is the demonstration phase of the HEAVEN project. Within this workpackage, the partner cities aim to work together to meet three key objectives: the demonstration of the DSS for evaluating the mobility related pollution in relation to implemented and planned TDMS; the demonstration of noise emission forecasting related to mobility strategies; and national-local pollution strategies in compliance with EU directives on air and noise pollution.

The present deliverable reports on the third year of the HEAVEN project in Paris. In this period, the Decision Support System and the local HEAVEN web site have been completed, put into operation, and evaluated.

The system has been applied to a set of radical traffic scenarios (global speed reduction, no heavy duty vehicles, no 2-wheelers, no traffic, emission standard Euro IV) in order to test the sensitivity of the modelling chain. The results are in accordance with tendencies obtained by earlier prospective studies, and show that very incisive measures will be required if the air quality objectives are to be respected in acute meteorological conditions.

Airparif has applied the system to two real-world cases : the evaluation of the impact of the new bus lanes in the City of Paris, and the Car-free day of September 2002. The bus lane results show a decrease by 2 to 10 % in street-level pollutant concentrations on the concerned axes, following a decrease in traffic flow accompanied by modifications in speed patterns and traffic composition. The car-free day results show that during the access restriction interval, emissions decrease by 10 to 16 % in the total city area and by 30 to 47 % in the areas with restricted access.

HEAVEN is rated as a success by all project partners from Paris. They will pursue the operation and further development of the system.

Chapter 1 gives a summary of the HEAVEN project. Chapter 2 presents Paris' HEAVEN system. Chapter 3 reports on the completion of the system and its verification. The sensitivity tests are presented in chapter 4, the bus lane study and the final HEAVEN public information

web site are presented in chapter 5. The evaluation results are reported in deliverable D3.2, common to all six HEAVEN cities.

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**ANNEX: SCENARIO ANALYSIS**

# 1 INTRODUCTION

## 1.1 Guide to the reader

Demonstration of Paris' HEAVEN *Decision Support System* has run from April 2002 to January 2003. During demonstration :

- the HEAVEN DSS has been completed, then operated and evaluated
- it has been applied to test scenarios and to a real transport management measure (the City of Paris' new bus lanes)
- the information produced by the HEAVEN DSS has been spread to professional and general public through the local HEAVEN web site.

The Parisian partners of HEAVEN report herewith on the results of the demonstration phase, excepted the evaluation results, which are the subject matter of HEAVEN deliverable D3.2.

Chapter 1 recalls the objective of HEAVEN. Chapter 2 presents Paris' HEAVEN DSS in its presently operational form. Chapter 3 reports on the verification activities, pertaining to workpackage 7, which have been completed during demonstration. Two particular aspects of evaluation are reported in chapter 4, since they have constituted two major activities during the demonstration phase : calibration of the street level pollution model, and the set of radical scenarios that have been modelled in order to test the sensitivity of the HEAVEN DSS. Chapter 5 reports on the three central aspects of demonstration : system operation, information platform, and the results of the application of the HEAVEN DSS to the new bus lanes in Paris and to the car-free day on 22<sup>nd</sup> of September 2002.

## 1.2 Objectives

The project objectives can be considered on varying scales - on a HEAVEN basis, on a workpackage basis and on a site basis and each of these will now be discussed briefly.

### 1.2.1 By project

The project's high-level goal is to demonstrate a decision support system (DSS) which can evaluate the environmental effects (air quality and noise quality - both emissions and dispersion forecasting) of Transportation Demand Management Strategies (TDMS) in large urban areas.

This goal has been translated into a concise set of high-level project objectives:

- Improve the basis for decision-making through integrated and real time information on key pollution factors;
- Inform key actors (including the public) on the state of air and noise pollution levels and their effects on health;
- Investigate the data needs of health experts and the implementation of a valid data exchange platform with health authorities;
- Identify the concrete benefits of these measures for sustainable urban development and the quality of life in cities;
- Generate commercial value out of the project;
- Draw conclusions for the implementation of local noise and air action plans.

### 1.2.2 By workpackage

In WP8, the main objectives are as follows:

- To demonstrate the DSS for evaluating the mobility related pollution in relation to implemented and planned TDMS;
- To demonstrate noise emission forecasting related to mobility strategies;
- To aid in the compliance with EU directives on air [and noise] pollution, national-local pollution strategies.

### 1.2.3 By site

In HEAVEN, Paris wants to integrate a chain going from real-time traffic data to a quasi real-time modelling of the complete regional traffic situation, to the modelling of pollutant emissions from traffic and other sources, and finally to regional pollutant dispersion modelling and street level pollutant concentration modelling. This means a strong improvement in the description of the current air quality situation in the Ile-de -France

region. At the same time, the modelling chain is adapted to off-line scenario modelling, thus increasing strongly the capacity of evaluating the impact of TDMS measures.

In particular, the objective of the Paris partners is to offer an improved decision support for TDMS measures, and to provide a means to citizens as well as professional users to understand and assess the impact of traffic and TDMS measures on the air quality situation.

Paris does not handle noise emissions in Heaven.

### **1.3 Summary of WPs**

#### **WP1: Project Management**

The project management consists of the continuous co-ordination and monitoring of the project's progress, paying attention both to end goals and interim goals. Because of the complexity of the project, the management is divided into administrative management and technical co-ordination.

#### **WP2: Dissemination**

The goal is to disseminate the outcomes of the project and form consensus on the approach used in HEAVEN. The major milestones are an interim technical workshop and a final conference both to be organised at the European level. Contribution to Key events organised by the Commission and to European and World conferences dealing with the HEAVEN research will be ensured. The outcomes of the project are also made available through a project website. The feasibility of organising a temporary web site for user group consultation and discussion is examined.

#### **WP3: Validation Co-ordination**

WP3 assists both the verification and the demonstration stages of the project. Firstly, a draft validation plan has been developed, in close co-operation with the local evaluation managers, who are responsible for performing the actual evaluation in WP7 and WP8. Secondly, the local evaluation work, both for the verification and the demonstration phase, is to be guided through advice and direct assistance. Verification of systems has been done in WP7, evaluation of the demonstration's impacts in WP8. WP3 is

responsible for co-ordinating the results from the verification and demonstration phases and for incorporating them into a Final Evaluation Report.

#### **WP4: User Requirements and Implementation Framework**

This WP has focused on a detailed analysis of the needs of the different DSS and Information system users: decision makers, system operators and end-users. The draft user requirements have formed an input to WP5 for the design of the DSS and Information system and to WP3 for the preparation of the draft validation plan.

#### **WP5: Functional Specifications/System architecture**

WP5 has developed the specifications for DSS and Information systems on the basis of the requirements captured by WP4. The work has been performed in each site according to local particularities and constraints, and following a common and structured approach, which helps to identify commonalities between sites. The underlying purpose of this work package is to design the functions and architectures suitable to support tasks presented above.

#### **WP6: Build Integrated Systems**

Starting from the functional architectures and the systems design provided by WP5 and based on the actual existing implementations, WP6 has identified the set of components and actions to be undertaken in order to grant the implementation of the DSS and Information System. WP6 includes the identification of the components required to fulfil the specifications provided by WP5; the selection, validation and improvement of the environmental models; and the detailed specification of the central Decision Support System (DSS).

#### **WP7: System Verification**

At first, the operating performance of the system has been assessed by focussing on indicators like number of breakdowns, log-files and speed of the system.

Secondly the acceptance by users interviewed in the context of WP3. Users have been asked if the system meets their requirements and if the information supplied is clear.

Thirdly, a user panel consisting of a small group of citizens has given its opinion on the information provided to the general public.

In this stage, some changes to be made to the systems before the large-scale demonstration within work package 8 could be indicated.

## **WP8: Large Scale Demonstration**

The on-site implementation and real-life operation of the systems of both the DSS and the information platforms occurs in Workpackage 8. All the system component integration also occurs (traffic monitoring, environmental monitoring, emissions and dispersion models, etc.). The demonstration will reflect modifications made in response to the verification phase (WP7), both in terms of technical performance and in terms of the outputs (content and form). Additional minor adjustments will proceed during the demonstration period, according to the milestone schedule. Once the system is in operation, the DSS will be used to evaluate a host of TDMS strategies implemented and/or planned for the different sites, including road pricing initiatives, express roads, traffic calming measures, etc. During this stage, the evaluation of the system performance and impacts will occur.

## **WP9: Exploitation and Business Planning**

This workpackage assesses the added value and the exploitation possibilities of the suite of HEAVEN end products, in particular the DSS for evaluating TDM strategies, the information integration platform, and any of the refined models incorporated into these end products. This workpackage will provide a detailed Exploitation and Business Plan for the industrial partners, identifying what market possibilities they identify for the developments completed in this project.

The following diagram displays how each work package inter-relates with the others.

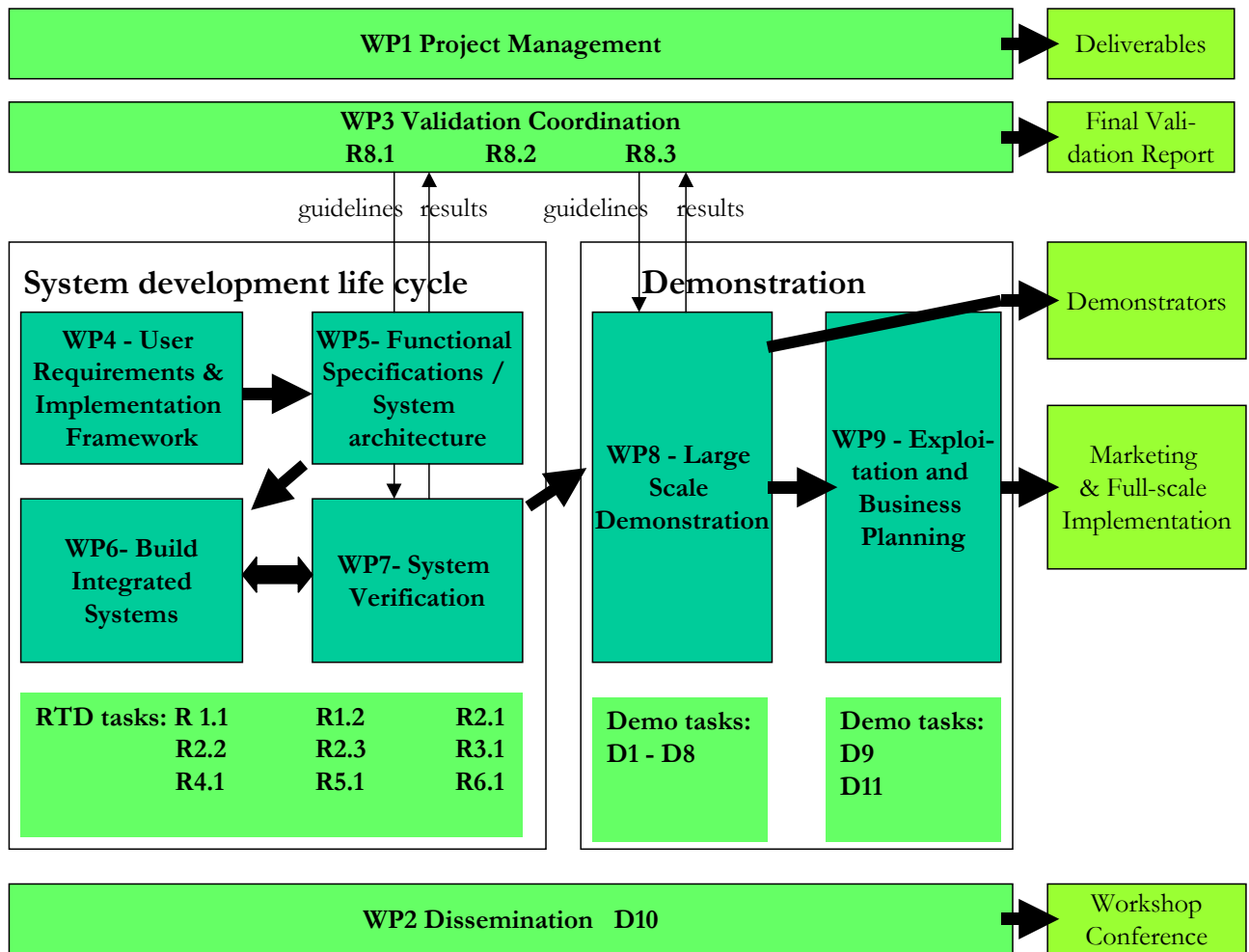


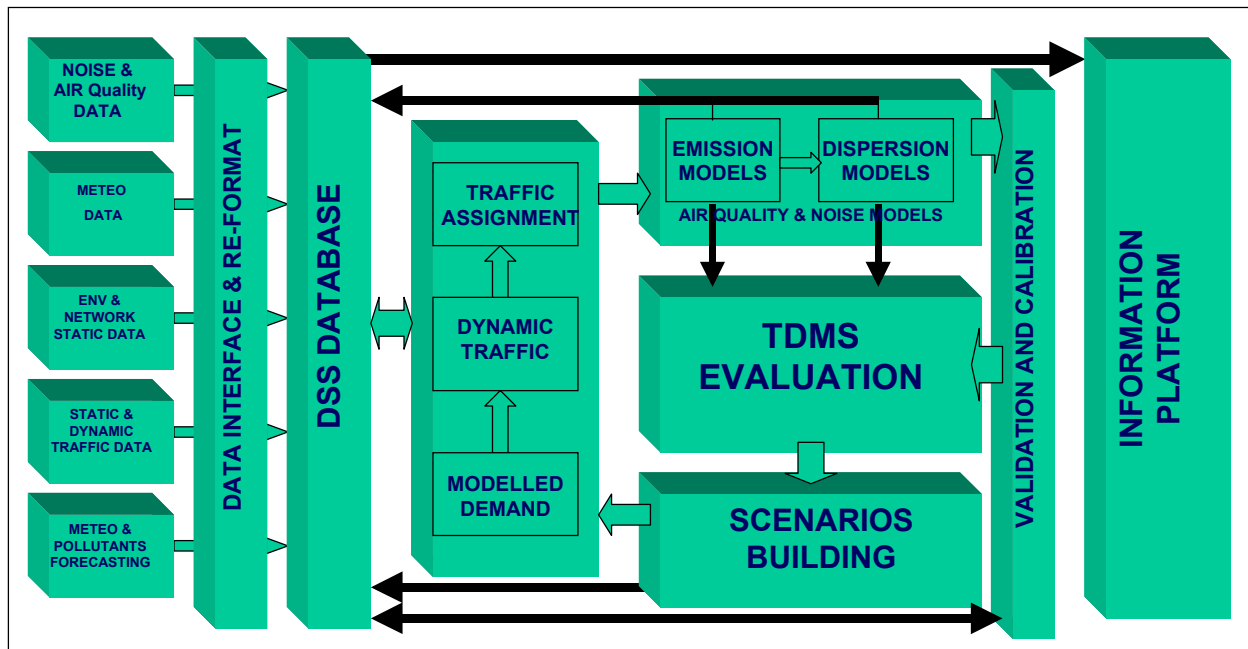
Figure 1 : Interrelations between workpackages and RTD and demonstration tasks

### 1.4 HEAVEN System Concept

The HEAVEN DSS combines near real-time traffic flow information into emission models so as to analyse the contribution of mobile sources to air quality and noise. In order to estimate emissions based on current traffic levels and on planned demand management scenarios, the system can operate on-line, based on current traffic and environmental information, and off-line, based on planned traffic and environmental conditions and pre-defined TDMS.

The diagram in Figure XXX shows the dynamic data processing and modelling chain that supports the on-line operation of the system. The near real-time input information

concerning traffic, air quality, noise and meteorological conditions is processed and archived for use during off-line operation.



**Figure 2 : The dynamic Data Processing and Modelling Chain of the HEAVEN DSS**

*The main operational characteristics of the HEAVEN DSS emerge from the processes drawn in the diagram above.*

i. Data exchange from external sources to the DSS models

*The input data for the DSS come from several external sources:*

- Near real-time dynamic Traffic, Air Quality, Noise and Meteorological data come from specific infrastructures and monitoring systems. Type of data, spatial and time resolution, accuracy, etc, depend on the features of the monitoring systems. The data exchange is performed on-line to ensure near real-time data processing.
- Static and infrequently updated data - such as data representing the traffic network, the land use, the built environment, statistics and forecasts concerning traffic, pollution and meteorological conditions, the model configuration parameters, etc – are provided by specialised institutions, bodies and data bases. This data exchange is performed off-line.

In general, specific interfaces are required to interact with the different data sources and to hide the possible complexity of the on-line connection with the monitoring systems. The storage of data in the HEAVEN data base is normally performed after manipulation, pre-processing and reformatting of raw data. Dynamic data are fed into the DSS modelling chain only after validation.

ii. Dynamic traffic data processing

- *The (validated) dynamic traffic information is employed to update in near real-time the traffic status in the monitored network and to improve the traffic demand model. Traffic assignment in the whole network represents the last element of the traffic models chain.*
- Also the output of the traffic models undergo validation procedures both to ensure consistency of the information for the subsequent models chain, and to contribute to the traffic models calibration and tuning.
- Near real-time and modelled traffic data are then fed into the environmental models for emissions estimation.
- Finally, the monitored traffic conditions contribute to the evaluation of the impact of the TDMS under analysis and constitutes one component of the TDMS application scenario.

iii. Dynamic Air Quality and Noise data processing

- *The (validated) dynamic air quality, noise and meteo data are employed to compute the traffic related emissions in near real-time, and so to feed the pollutant dispersion estimation and the noise levels computation. Concentration of pollutants and noise levels are then computed for key points and areas in the network taking care of background dispersions possibly modelled through specific models.*
- Also the output of the Air Quality and Noise models undergo validation procedures both to ensure consistency of the information produced, and to contribute to the environmental models calibration and tuning.

- Finally, modelled emissions and measured and modelled Air Quality and Noise levels are the main information for the evaluation of the impact of the TDMS under analysis.
- iv. Information exchange between the DSS Data Base and the Information Platform
- All the input information and DSS model results are stored in the system data-base. The entire or a part of this set of information can be transferred to the Common Information Platform and disseminated according to user related access restrictions.
  - Dissemination is performed through several format (tables, maps, etc)
- v. Scenarios building
- Through the scenarios building, the operator can define the context for the off-line evaluation of new TDMS in the view of optimising the environmental impact of the traffic.
  - Scenarios are also built by the system automatically by recording the contextual conditions where the TDMS is currently actuated.
- vi. TDMS Evaluation
- *The evaluation of the performance of a TDMS in the context of a planned or actual scenario is made through the comparison between the traffic, emissions, air quality and noise modelled output based on this scenario and the traffic, emissions, air quality and noise modelled output based on a reference situation.*
  - This process bases on automatic and manual procedures for data collection, selection and computation but the system operator plays a key role to set the operational conditions to perform the evaluation. The system operator steers the evaluation process through a specific Operator Interface.

*These processes are asynchronous and each of them is driven by the frequency of the input information updating and by the expected updating frequency of the output.*

The characteristics of the site DSS' reflect the general characteristics of the HEAVEN DSS, although duly customised according to the peculiarities of the site (availability and type of the data sources external to the system, models adopted, operational constraints, etc).

## 2 DECISION SUPPORT SYSTEM IN PARIS

### 2.1 System architecture

The Paris HEAVEN system is constituted of many modules : interfaces, traffic modelling module, emissions and pollution modelling modules, Web site. They participate to three main processes : data collection, input processing and modelling, information and dissemination of the results (figure 3). A brief description of each module is made here, an explicit description having been done earlier in the D6.1 and D6.2.

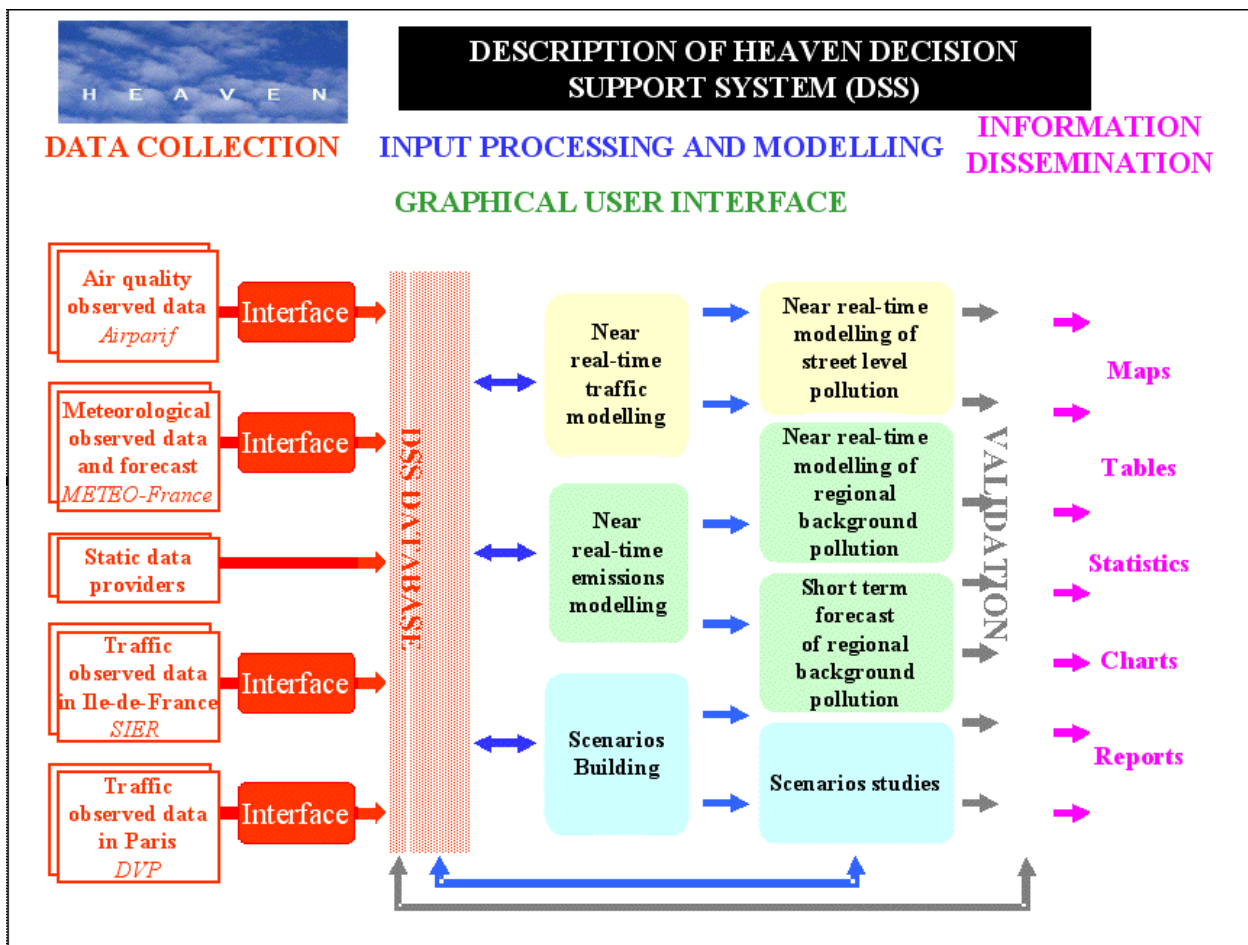


Figure 3 : Structure of Heaven DSS. The modules (interfaces, traffic modelling, emissions and pollution modelling, web site) participate to the three main processes : data collection, input processing and modelling, information and dissemination of results.

## 2.2 Interface to air quality data sources

The HEAVEN DSS is connected to the air quality database of Airparif using the local area network by the way of SQL requests. It acquires observed hourly air quality data of NO, NO<sub>2</sub>, O<sub>3</sub> corresponding to background monitoring sites and observed data of CO, NO, NO<sub>2</sub>, PM10, C<sub>6</sub>H<sub>6</sub> corresponding to traffic sites for the previous hours. The connection is established six times per day.

## 2.3 Interface to meteorological data sources (Météo-France)

The HEAVEN DSS is interfacing with two different servers from the French Meteorological Office (Météo-France).

From the first server (<ftp.meteo.fr>), the HEAVEN DSS acquires hourly meteorological observations for the previous day coming from some twenty monitoring sites located in Ile-de-France region. This acquisition is achieved every day at 11:15 a.m. (local time) using a ftp protocol.

From the second server (SIRIUS1), the HEAVEN DSS acquires meteorological analyses and forecasts coming from the ARPEGE model. The connection is achieved once a day at 06h45 a.m. by using a ftp protocol.

## 2.4 Static data providers

The HEAVEN DSS also uses static data provided by :

- - IGN : topographical data
- - IFEN: land-use data
- - INSEE : social and economical statistics
- - IAURIF : streets typologies (“canyon”, “open”...)
- - EEA : MEET / Copert III methodology
- - INRETS/ADEME : national fleet data
- - DRIRE : annual emissions for industrial sources
- - ADP : annual emissions for aircraft traffic (below 900 m)
- - CITEPA : annual emissions for area sources.

## 2.5 Interface to observed traffic data in Ile-de-France

Ile de France traffic data (SIER) originate from two different systems named SIREDO and SIRIUS. SIRIUS and SIREDO are concentrated on a different MI2 node of the Ministry of Transport, and made available to Airparif through the national traffic information access node located at CETE Bordeaux. The MI2 node provides traffic flows, occupancy rates and speeds measured by electromagnetic sensors on the highway and national road network of the Ile-de-France region (238 selected inductive loop). The sensors provide 6-minute data, which are averaged to 1-hour values before the transmission to the Heaven DSS.

## 2.6 Interface to observed traffic data in Paris

Paris centre traffic data originate from the information SGI server. Dedicated wires were installed between Airparif and City of Paris TCC for the traffic data acquisition. On line traffic data from 421 selected inductive loops are then continuously sent to Airparif for near real-time traffic modelling. (The SGI server provides 3-minute data, which are averaged by the Heaven DSS to 1-hour values.)

## 2.7 DSS database

Air quality data, meteorological data, traffic data are stored in oracle databases.

## 2.8 Traffic modelling module

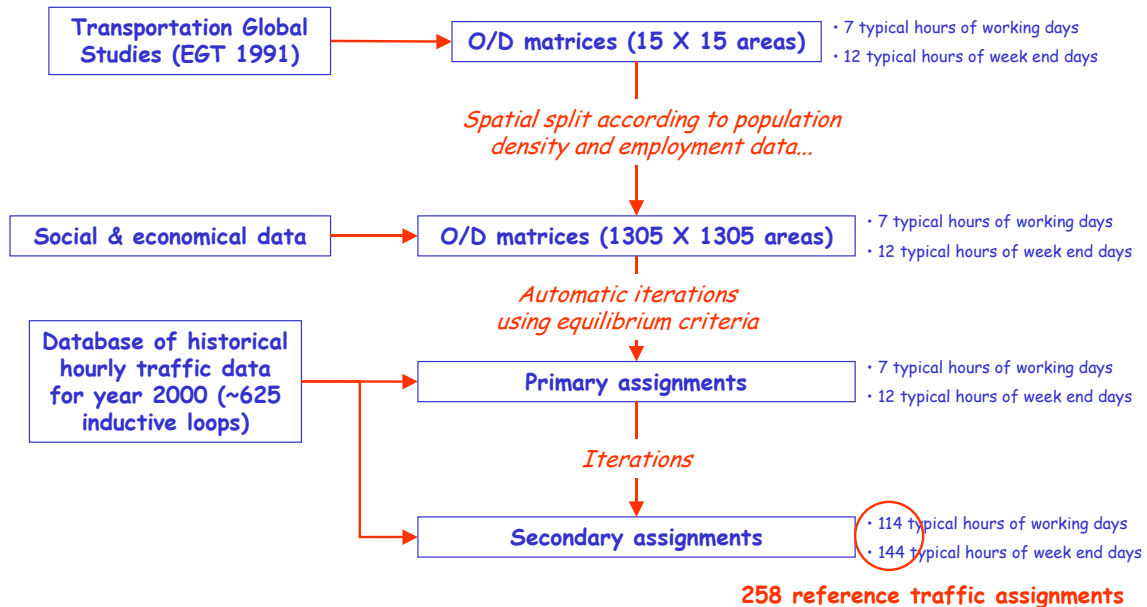
The traffic modelling module is a new and innovative development that is specifically realised in the HEAVEN project. The module simulates a traffic status on an extended network.

The approach (Extended DAVIS model) consists in optimizing a traffic status between two border conditions :

- A reference traffic assignment, obtained from an origin/destination matrix for the type and time of day in question, through refinement of a primary reference assignment and comparison to historically observed traffic data (see figure 4).

- A sample of pinpoint measurements of the real traffic status.

### Construction of the reference traffic assignments database



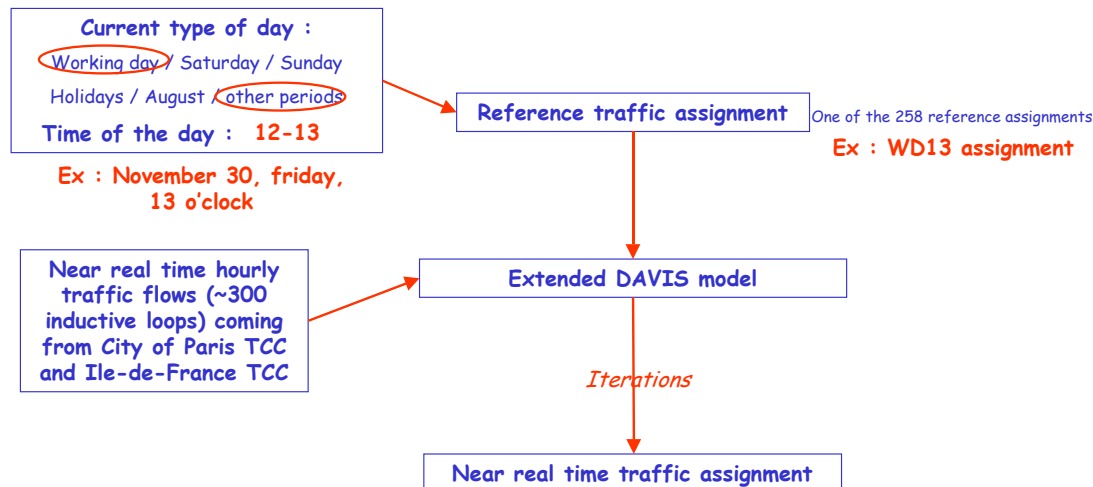
**Figure 4 : The reference traffic assignments have been obtained from an origin/destination matrix for the type and time of day in question, through refinement of a primary reference assignment and comparison to historically observed traffic data.**

The module takes as input :

- the traffic flows at 659 points obtained each hour through the interfaces to SIER and City of Paris
- the description of the road network (~39000 oriented links)
- 258 traffic assignment matrices.

The module produces a traffic assignment matrix that indicates traffic flow, speed and cold-vehicle percentage for 39000 oriented links of the road network of the Paris region. The simulation runs each hour, starting from the measurements taken during the recent hour and the typical O/D matrix corresponding to that hour. A run lasts 20 minutes.

## Near real time traffic assignment



**Figure 5 : The traffic model produces a near-real-time traffic status through combination of a reference traffic assignment and a sample of pinpoint measurements of real traffic flow.**

## 2.9 Emissions modelling module

This module called DSS\_EMI provides pollutants emissions for the Ile-de-France and surrounding area. Emissions are calculated each hour, with a linear resolution for the traffic, and spatial resolution of 1 square kilometre for total emissions. Following substances : carbon monoxide (CO), sulphur dioxide (SO<sub>2</sub>), nitrogen oxide (NO<sub>x</sub>), non-methane volatile organic compounds (NMVOC), carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>) are concerned. For traffic, particulate matter emissions are as well calculated. This module covers three main sub-modules :

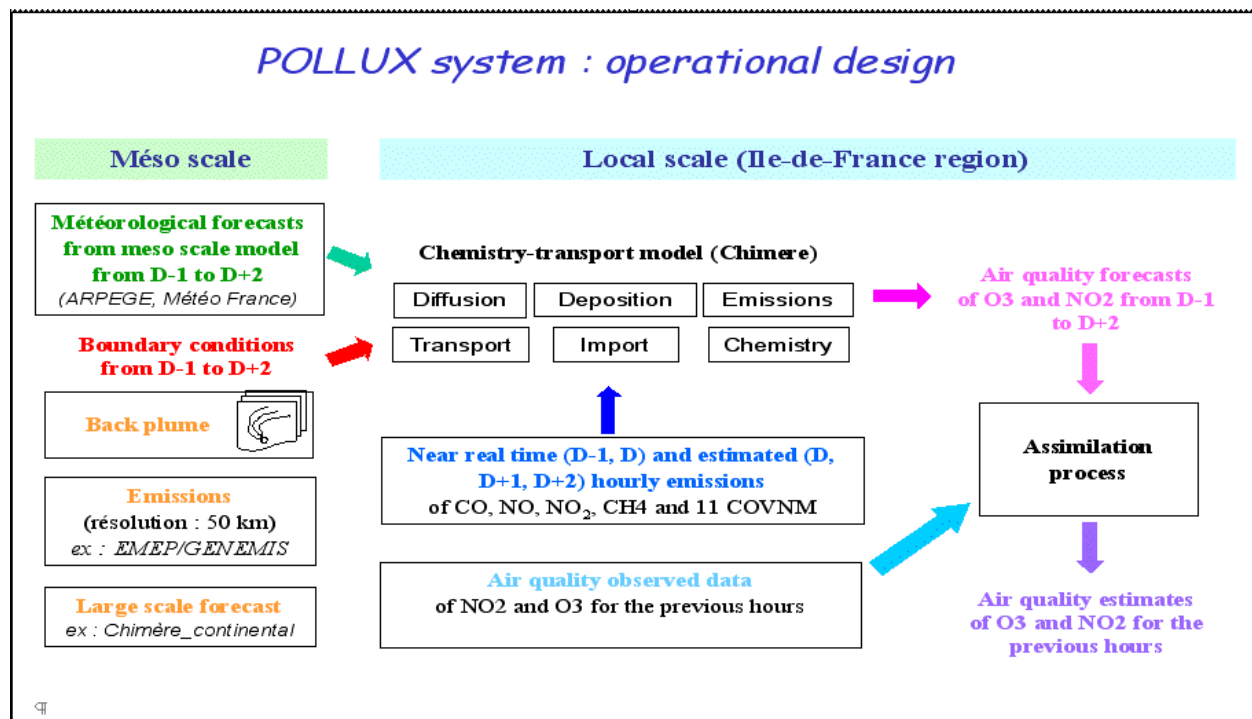
- traffic related emissions modelling module: This module is devoted to the calculation of the linear then grid square traffic emissions based on the Traffic Modelling Module outputs (traffic flow and speed for example), the fleet distribution and the emission factors coming from the Copert III methodology,
- other sources emission modelling module: This module is devoted to the calculation of the grid square emissions related to other sources (industries, airports, diffuse sources like domestic heating or biogenic emissions).
- merging module: This module is devoted to assemble both emissions.

## 2.10 Street level pollution modelling module

Evaluation of street-level annual mean concentrations for each link of the whole reference network (~ 34'000 links) is made at AIRPARIF by using the "Street" V.4 software. The objectives in framework of the Heaven project has been to be able to go down from an annual evaluation to a hourly evaluation based on the near real-time traffic, meteorological and background concentration data. A first approach consisting in adapting the Street software has been abandoned. An alternative model ("Sirane") has been investigated (see section 3.1).

## 2.11 Background pollution modelling module

The system called POLLUX\_HEAVEN is the system that provides the regional background dispersion modelling and forecast (figure 6). It is based on a deterministic chemistry-transport model called Chimere.



**Figure 6 : The chemistry-transport model Chimère computes the concentration fields of O3 and NO2. The results are forecasts for the days D - 1 to D + 2. For D - 1 and D, the concentrations fields undergo an assimilation process to observed air quality data.**

The system is designed to be as simple as possible in order to fit the real-time constraints, i.e. it delivers O<sub>3</sub> and NO<sub>2</sub> quasi real-time evaluations and O<sub>3</sub> and NO<sub>2</sub> forecasts in the early morning up to two days ahead. In order to satisfy this constraint, a major simplification is made. This simplification is based on the geographical character of the Paris area that allows us to assume that the meteorological variables can reasonably be represented by a large-scale meteorological model. This enables the use of operational forecasts issued in the main weather forecasting centres. We use here the ARPEGE weather forecasts from Météo-France.

The background pollution imported into the model domain can be modelled using either a set of back trajectories (called the back plume) or output from a large-scale forecast. The system uses estimated emissions generated by the emissions module for the hours of the previous days and estimated emissions for days D, D+1 and D+2.

Using the emissions, meteorological variables and lateral boundary conditions, the chemistry-transport model CHIMERE calculates the concentrations fields of O<sub>3</sub> and NO<sub>2</sub> on a 6km x 6km grid over a domain of 180km x 180km that will cover the Ile-de-France area or on a 3km x 3km grid over a 90km x 90km domain that constitutes a zoom on the dense urban area of the Ile-de-France region.

Chemical mechanism describes the chemical behaviour of about 80 gaseous species, through almost 200 reactions. The hydrocarbon degradation scheme is very similar to the EMEP gas phase chemical mechanism.

The execution time of the complete simulation process is about two hours on an IBM RS6000 platform. The assimilation process takes only few minutes. The outputs are delivered in the form of graphics and tables to the DSS information platform, every hour.

## 2.12 Scenario building and studies

Scenario building consists in selecting a set of data comprising a day of meteo data and traffic data in a free combination. The data are extracted from the database (corresponding then to a real historical case, e.g. car-free day) or generated for a particular hypothesis (e.g. general reduction of traffic). Scenario modelling consists in off-line operation of the modelling chain.



### 3 VERIFICATION

In the HEAVEN project, workpackage 7 (WP7) was responsible for the verification procedure and concentrates on the physical functioning of the system and the preliminary user acceptance proving that the integration of models works and meets the requirements of the end users. In addition, the workpackage dealt with the calibration of models aiming to give an indication about the adequacy of the models keeping in mind that full verification of environmental models is out of the scope of the IST project HEAVEN. WP7 has developed a common verification concept, co-ordinated detailed local verification planning, analysed local results across sites, and made recommendations on system modifications before the start of the demonstration stage. HEAVEN verification is based on a common verification concept necessitating that indicators are measured in the same way, or at least yield comparable results across the sites. In close co-operation with Workpackage 5 “Functional Specifications/System Architecture” and Workpackage 6 “Build Integrated Systems”, a list of common verification indicators has been defined, which taking into account the main processes, data flows and data stores. The indicators have been grouped into the three main themes of verification:

- Testing physical functioning of the system,
- Preliminary user acceptance
- Accuracy of roadside modelling and monitoring

The approach and methodologies applied in WP7 have been closely tuned with the overall evaluation process (WP3) to avoid disproportional overlap between the Evaluation and Verification. The WP3 Evaluation Indicator 1.3 Accuracy of Roadside Description is in operation as part of the verification process. All other indicators in the verification stage are specific for verification.

The tests on the *physical functioning of the system* showed that in general the different components are functioned very well. No inadequate level of system failures occurred and the systems were over 95% operational. In general the interfaces to external

systems and data sources work properly and the operational speed of the system is high enough to make the necessary updates on an hourly basis.

The investigations on the *preliminary user acceptance* were in general very positive. The users are satisfied, very supportive and enthusiastic. Recommendations for changes were made and are incorporated in the design where possible.

Within verification the results for *accuracy of modelling and monitoring for roadside description* in the cities were also very positive. The results showed that the different models used at the sites had been carefully selected and adjusted sufficiently for the specific situation at each site.

Results of the verification phase on the project level are reported in the “Final Verification Report” (D7.1). In this chapter outstanding verification issues not included in the Final Verification Report are reported. In Paris, all verification indicators had been completed except the verification of roadside concentration modelling and the verification of preliminary user acceptance by the general public. Verification of preliminary user acceptance by professional users had resulted in recommendations for the completion of the information platform, which was unfinished at the time of verification.

### **3.1 Further Investigation of Roadside Concentration Modelling**

In the framework of Heaven, the objective in terms of street level pollution modelling is to go down from estimates of annual mean concentrations to hourly estimates. At present, the annual mean concentrations are obtained with the Street v.4 software. Airparif has conducted a feasibility study with the aim of adapting this software for obtaining hourly estimates. The results have been insufficient, as reported in deliverable D7.

Airparif is investigating an alternative approach using a 3D model called Sirane which has been developed by the Ecole Centrale de Lyon.

The approach is currently tested on a 3x3 km domain located in the east of Paris. The configuration of the field test is summarized in the following table.

#### **Test of SIRANE model**

<b>Test period</b>	4 - 18 November 2002
<b>Domain</b>	3X3 km area in eastern city of Paris
<b>Measurements</b>	2 laboratory vans with automatic analysers Diffusion filter tubes
<b>Modelling</b>	Heaven DSS with Sirane model (off-line)
<b>Expected results</b>	Comparison of modelled and measured concentrations, available at end of December 2002

The investigation is not concluded at present time. First results on model calibration are reported in section 4.1.

### **3.2 Completion of Information Platform**

The information platform has been completed in November 2002. Along with this development, the actions planned at the issue of verification have been performed : introduction of a bulletin with a limited amount of information for quick access, and addition of map features for easier localisation.

The bulletin gives access to today's and yesterday's situation. It contains one page for each step of the Heaven modelling: meteorology, traffic, emissions, street level concentrations, background concentrations.

For traffic and emissions, bars have been introduced. They indicate the relative situation of the present day with respect to an average. For the emissions of NO<sub>2</sub>, CO<sub>2</sub>, CO and VOC the bulletin indicates the part of traffic in the total emissions. The user can access the relative emission intensities for individual road links.



**Figure 8 : The bulletin pages contain bars which show the relative intensity of traffic or emissions with respect to an average day.**

The pages on pollutant concentrations show the values of the day along with the table of legal reference values. As a fallback solution for the modelled street level concentrations (which are not available yet), the measured street level concentrations are shown.

All maps now show the contours of *départements* or *arrondissements*, and two or three town names per département. This eases the lecture of the maps.

### 3.3 Verification of User Acceptance by the General Public

Verification of user acceptance by the general public has been conducted by Airparif on the occasion of the exhibition "L'air dans ma ville". The exhibition took place in the Paris City Hall between 14<sup>th</sup> and 27<sup>th</sup> November 2002 and was organised by the Société Météorologique Française. Airparif was present with an exhibition booth.

Airparif presented the Paris Heaven web site to 3 small groups of persons picked among the exhibition visitors, and collected their spontaneous comments. In majority they were non-specialists, while two persons were students in environment-related fields. The most important feedbacks were the following.

- The test persons were uncertain on how to interpret the traffic maps. Their spontaneous interpretation was that color represents congestion, as on the usual traffic status maps. In fact, on the Heaven maps color represents flow.
- They appreciated to have traffic emissions per road link.
- The test persons criticised the synthetic indicators (graphical bars with relative scale) on the traffic emissions, which show relative numbers and not absolute numbers. They felt that something might be hidden by the absence of absolute numbers.

- They wished to be able to visualise the average day.
- Some test persons wished to have the possibility of making requests (e.g. sundays in August).
- The test persons appreciated the bulletin for its quick access.
- There weren't any negative comments on user-friendliness.

In summary, the test gave positive results. As consequences of the test, the presentation of the traffic maps has been clarified, and absolute values for emission have been added. Further adaptations and developments (specific requests, average days) will be taken into consideration after more complete evaluation.

## 4 EVALUATION

The HEAVEN project has considered evaluation as a very important horizontal activity throughout the whole project lifetime. The evaluation was geared to establish the benefits which all stakeholders, i.e. internal and external users, operators, and content providers can gain from the developed system. In order to determine and quantify the impacts, the project performed evaluation in a rigorous and systematic way. To do so, a formal evaluation process has been established. In the first year of the project lifetime, the evaluation has been carefully planned. A comprehensive validation plan (Deliverable 3.1) and a toolbox, which further defines the expected impacts, related indicators, reference cases, success criteria and the methods for measuring the indicators, has been developed. During the second year, the ex-ante evaluation has been performed and in the third year the ex-post evaluation took place. Despite the fact that the HEAVEN Decision Support System (DSS) was implemented and applied at six different European cities, its evaluation process is based on commonality. The challenge to reach commonality lies in the range of technical and institutional framework conditions, in the variety of existing methods and statistical considerations, as well as in the formulation of different reference cases and success criteria across the sites.

The impacts of HEAVEN are:

- Impact 1: Enhanced description of current environmental situation
- Impact 2: Enhanced environmental scenario analysis
- Impact 3: Improved access and quality of environmental information for professional users and for public users
- Impact 4: Improved institutional co-operation
- Impact 5: Increased support of urban planning on an environmental basis

For each impact, clear assessment objectives and a series of operational indicators have been identified and described. Throughout these exercises, an effort was made to reach the highest degree of commonality in defining these key elements of evaluation.

State-of-the-art evaluation ensured that the project was able to establish the extent that HEAVEN has met its objectives, what impacts it has generated on the city level and what its European added value is. The results from the evaluation process provided important input to the definition of the business case, exploitation and marketing plans and will therefore be instrumental for decisions on the direction of any future investments of the final product. The final evaluation report (Deliverable 3.2) describes the results of the evaluation in details and clearly outlines the lessons learnt and results gained by using IST to contribute environmental protection in the area of advanced transport strategies.

This chapter concentrates on the work undertaken and results gained on the field of calibration and model sensitivity.

#### **4.1 Calibration of Street Level Pollution Model**

The test and calibration work on the street level pollution model SIRANE is still ongoing. A measurement campaign has been performed in November 2002, as described in section 3.1.

The measures have been obtained by diffusion tubes on 48 measurement sites. Two sites have been equipped by laboratory vans allowing hourly measures.

The two following figures show that comparison of model results and measured values is unsatisfying at present time. For 2-week average  $\text{NO}_x$  concentrations, several model results lie far outside the error interval of the measurements (figure 9). For hourly  $\text{NO}_x$  concentrations on one of the measurement sites, the modelled results obtained with two plausible sets of meteorological data are too low (figure 10).

Comparison between observed data (blue) and sirane results (pink) for the 2 weeks period average values in the different roads

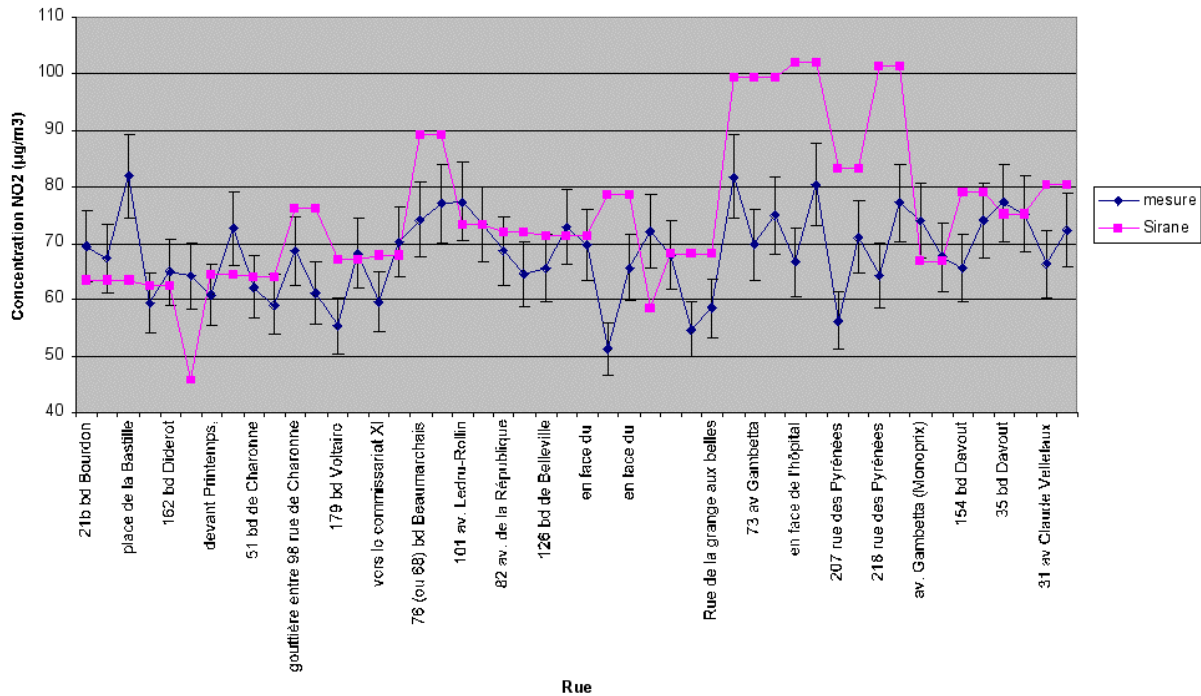
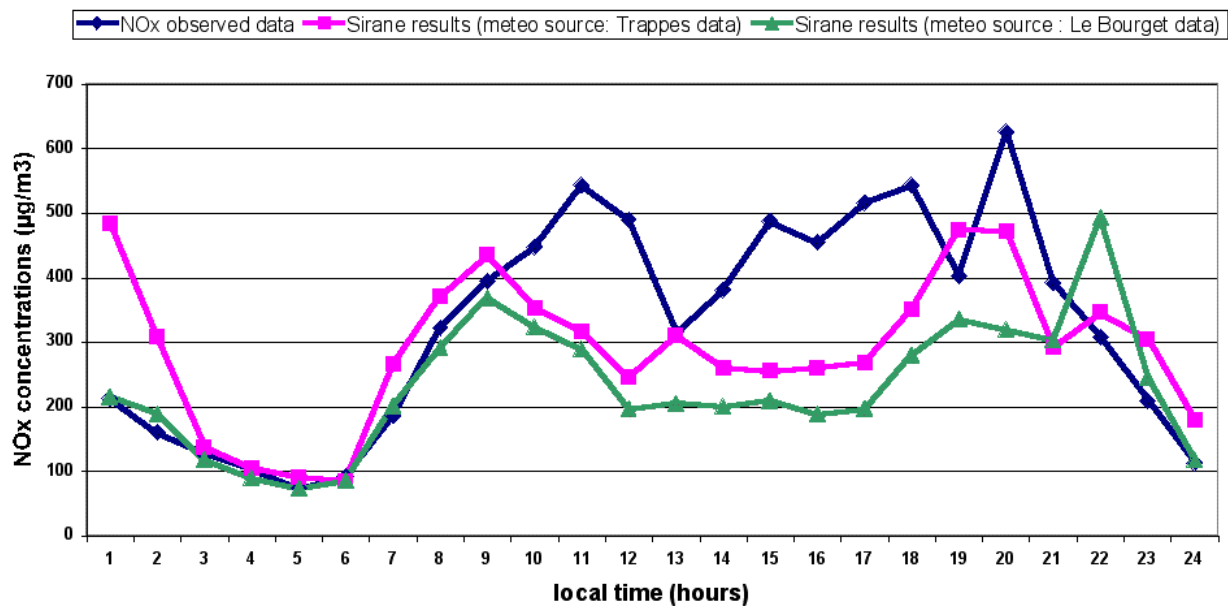


Figure 9 : Comparison of average street level NO<sub>2</sub> concentrations for a 2-week period in November 2002, measured and modelled. At present time, the comparison is unsatisfying, several model results lying far outside the error interval of the measurements. Calibration of the model is ongoing.

**Comparison between observed data and modelling results  
Ledru Rollin street, November 6th, 2002**



**Figure 10 : Comparison of hourly street level NO<sub>x</sub> concentrations, measured and modelled with two different set of meteorological data. At present time, the model produces far lower concentrations than measured. Calibration of the model is ongoing.**

The analysis of the differences between modelled and measured values has revealed three factors of error :

- The type of street profile (street width and building height) for each link of the road network had been extracted via an automatic procedure from a land use database. The resulting set of data reveals to be inaccurate in several cases. The street profiles are now being updated manually from a detailed topographic database.
- There is a bias in benzene emission values which are generally overestimated. The bias has been corrected by 1) a refinement and update of the decomposition of the 2-wheeler fleet., and 2) a correction of the VOC speciation profiles, where the Copert values have been substituted by more recent values provided by the University of Stuttgart.
- Two different fleet decompositions are now applied for main urban axes and for secondary urban streets, respectively.

Re-computation of the measured time series with the SIRANE model and with these modified calibrations is still outstanding.

## 4.2 Sensitivity Tests

In the framework of WP3 Evaluation the HEAVEN project agreed to run a number of scenarios which are common to all project cities. These scenarios are quite simple “black and white” scenarios involving some basic crucial parameters with no direct link to the specific situation at each site. These scenarios have the aim to investigate the sensitivity of the applied model chain towards parameters such as fleet composition, emission standards, traffic volume and speed and can give decision makers an indication about the bandwidth of possible emission reductions. In addition the scenarios are used to quantify the time which is needed to run scenarios before and after HEAVEN.

### 4.2.1 Scenarios

Airparif has used the HEAVEN DSS for modelling 5 scenarios as "sensitivity tests". These scenarios use radical assumptions, which represent drastic extrapolations of possible policy measures.

- **20 % speed reduction** : A homogeneous speed reduction of 20 % for the whole running fleet (passenger cars, light duty vehicles, heavy duty vehicles, buses, mopeds, motorcycles) is applied to the output of the traffic module, and the impact of this measure on emissions and air quality is evaluated.
- **No heavy duty vehicles** : The scenario consists in setting to zero the emissions related to Heavy Duty Vehicles (>3.5 t).
- **No two-wheelers** : Consists in setting to zero the emissions related to two-wheelers.
- **No traffic** : Consists in setting to zero all traffic-related emissions.
- **Euro IV legislation** : The scenario consists in anticipating for each type of vehicle fleet (passenger cars, light duty vehicles etc.) the implementation of one of the most advanced legislations (Euro IV) related to the emission factors.

Each assumption has been tested in two sets of meteorological conditions. The first set, called "winter episode" specifies acute conditions which lead to high levels of NO<sub>2</sub> in winter. The second, called "summer episode", specifies acute conditions which lead to high levels of Ozone in summer. Both sets represent real cases : 21-Feb-2000 for winter and 27-July-2001 for summer. In winter conditions, the scenarios observe the NO<sub>2</sub> concentrations. In summer conditions, they observe the O<sub>3</sub> concentrations.

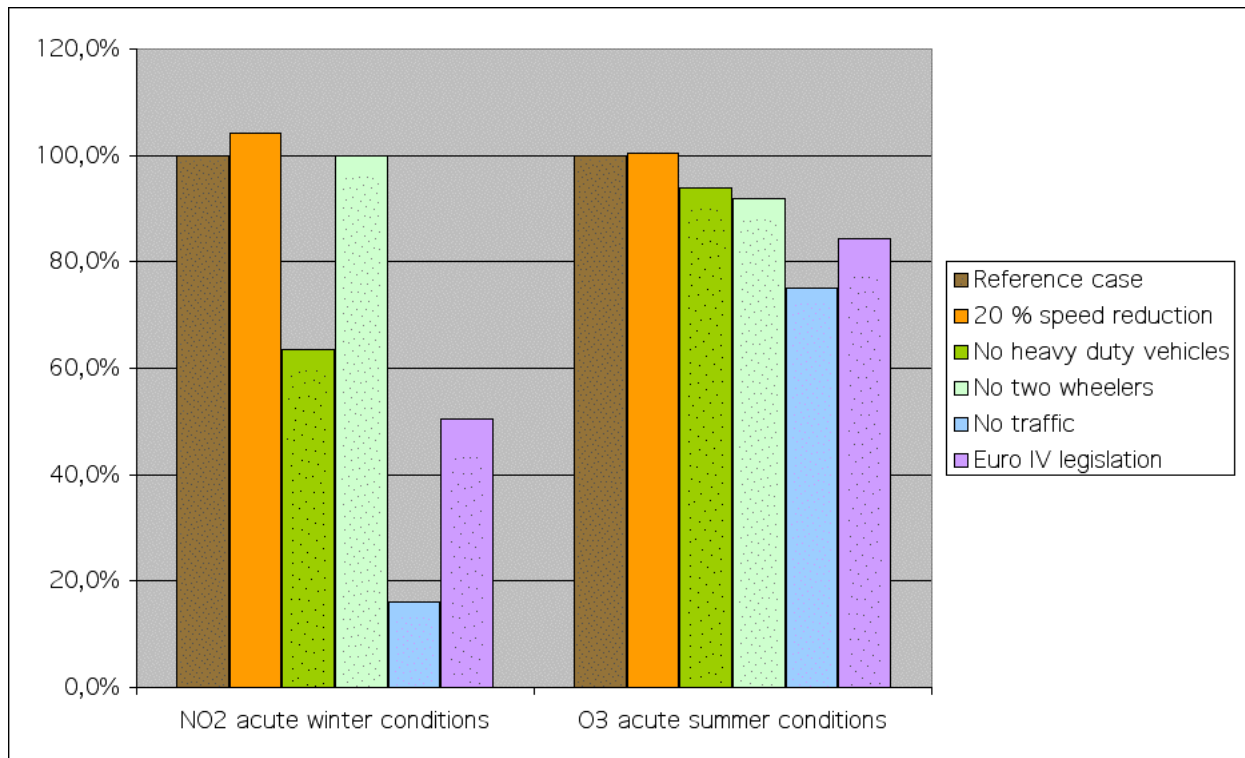
#### 4.2.2 Results

The results of these sensitivity tests, expressed in terms of maximum concentrations, are summarized below. They are described in detail in the annex (impact of each measure on emissions, spatial distribution of concentrations, spatial distribution of difference between reference case and scenario).

Scenario	NO <sub>2</sub>		O <sub>3</sub>	
	acute winter conditions		acute summer conditions	
Reference case	307 µg/m <sup>3</sup>		250 µg/m <sup>3</sup>	
20 % speed reduction	320 µg/m <sup>3</sup>	+4,2 %	251 µg/m <sup>3</sup>	+0,4 %
No heavy duty vehicles	195 µg/m <sup>3</sup>	<b>-36,5 %</b>	235 µg/m <sup>3</sup>	-6,0 %
No two-wheelers	306,5 µg/m <sup>3</sup>	0,0 %	230 µg/m <sup>3</sup>	-8,0 %
No traffic	49 µg/m <sup>3</sup>	<b>-84,0 %</b>	187 µg/m <sup>3</sup>	<b>-25,0 %</b>
Euro IV legislation	155 µg/m <sup>3</sup>	<b>-49,5 %</b>	211 µg/m <sup>3</sup>	<b>-15,6 %</b>

**Table 1 : Results of sensitivity tests. The scenarios use assumptions which are drastic extrapolations of possible policy measures. The assumptions are tested in acute meteorological conditions which have led to high concentrations of NO<sub>2</sub> and O<sub>3</sub> in reality. The results are expressed in terms of maximum concentrations.**

The scenario of speed reduction slightly increases the concentration levels. This is due to an increase of NO<sub>x</sub> emissions in dense areas where speeds are inferior to 40 km/h, while the global level of emissions remains almost constant.



**Figure 11 : Results of sensitivity tests, shown in relative height of maximum concentrations.**

Elimination of Heavy Duty Vehicles has a large positive impact on NO<sub>2</sub> concentrations in acute winter conditions, resulting from a comparable diminution of NO<sub>2</sub> emissions. The scenario has a positive impact on ozone in acute summer concentrations. Taking into account that a constant amount (146 µg/m<sup>3</sup>) of imported ozone has been considered in all scenarios, the *local* production of ozone due to the emissions of the Ile-de-France region decreases by -14,5 %, going from 104 to 89 µg/m<sup>3</sup>.

Elimination of two-wheelers reduces emissions of CO and NMVOC primarily, remaining without impact on NO<sub>2</sub> in the acute winter conditions but bringing significant reduction of O<sub>3</sub> levels in the summer episode.

The drastic scenario "no traffic" has a very important impact on NO<sub>2</sub> levels and on O<sub>3</sub> levels. Taking into account the constant amount of imported ozone, the production due to emissions in the Ile-de-France region decreases by 60 %.

Finally, the Euro IV scenario has also a very important impact on NO<sub>2</sub> in acute winter conditions and on O<sub>3</sub> in acute summer conditions.

### 4.2.3 Interpretation and relevance

We may interpret these results not simply as a validation of the HEAVEN DSS, but also an evaluation of possible traffic management measures for reducing pollution.

The results are more than a validation since the underlying models (Pollux in particular) have been used previously and their validity is known. Also, the results of the HEAVEN sensitivity tests reproduce tendencies obtained in previous studies.

However, when interpreting the results as an evaluation of possible traffic management measures, we have to be prudent. The scenarios "no heavy duty vehicles", "no two-wheelers", "no traffic" are far too drastic to be realistic. The scenario "speed reduction" is formulated by a speed reduction that does not affect the traffic flow in terms of number of vehicles. In reality, a speed reduction would affect the flow. The scenario "Euro IV" seems the most practical one, but only in long term. The standard will enter into force in 2005, and the complete renewal of the fleet will take about 15 years.

With these precautions in mind, we may say that the HEAVEN sensitivity tests confirm that incisive measures, leading to a very strong reduction of NO<sub>x</sub> emissions, are required if the NO<sub>2</sub> quality objectives are to be obtained.

With respect to Ozone, the same statement is valid. None of the scenarios brings the concentrations in acute summer conditions below the information alert level (180 µg/m<sup>3</sup>). A further improvement of the Euro IV scenario could however be expected if a uniform application of the standard throughout Europe is supposed. In that case, the level of imported ozone would decrease also.

## 5 THE HEAVEN DSS DURING THE DEMONSTRATION PHASE

### 5.1 Summary of air pollution situation in Paris

The Ile-de-France region benefits from a mild climate that is favourable to the dispersion of pollutants with the relatively flat topography making the climatic conditions over the entire Ile-de-France Region quite homogeneous. Nevertheless, sunny periods with anticyclones and low wind speed combined with important thermal inversion conditions limit the dispersion process and lead to pollution episodes (around 20 days per year in average).

Over the last 10 years in Ile-de-France region, levels for SO<sub>2</sub>, lead and black smoke have declined to levels that are consistent with European guidelines. The same cannot be said for ozone and for the ozone precursors like NO<sub>x</sub> and Benzene whose levels have not decreased significantly and remain the subject of particularly intense monitoring. In the past years, NO<sub>2</sub> has been the pollutant which has provoked the entry of temporary emission reduction measures. Besides the concentration maximum, the annual average concentrations of NO<sub>2</sub> is superior to the legal quality objective in some parts of the agglomeration.

The ozone concentrations have repeatedly exceeded their threshold in the past years. The highest ozone peaks are recorded in the rural zones of the region. Besides the peaks, the average ozone concentrations are relatively high.

Two further points of concern are the benzene concentration, which are more than twice as high as the legal quality objective, and the particles. The legal limits relying on black-smoke measures are respected, but high concentrations of fine particles (PM<sub>10</sub> and PM<sub>2.5</sub>) are observed in the vicinity of road traffic.

Traffic is the main responsible for non-attainment of legal quality objectives.

The emissions are mainly concentrated in the dense urban area of the Ile-de-France region.

## 5.2 Paris' objectives of the demonstration phase

European and National legislation on air quality demands enhanced activities from the cities in terms of environmental monitoring, information provision to the public and setting up of action plans in order to reduce pollution, so that the limit values will be met.

In HEAVEN Paris has developed its capacity to know the impact of traffic management measures on air pollution. The goals of the demonstration phase have been to :

- **operate** the new modelling chain during a significant period of time,
- to **spread the results** to a general and professional public by means of the local HEAVEN web site,
- to apply the HEAVEN DSS to the case of **new bus lanes** on major axes within the city of Paris,
- and to perform the **evaluation** activities of HEAVEN.

The results of the demonstration phase are presented in the 3 following sections, with the exception Evaluation which is the object of WP3.

## 5.3 System operation

Regular operation of the HEAVEN system started in April 2002 when the modelling chain was integrated. Its components had been verified separately before. The correct functioning of the chain (interfaces for acquisition of dynamic data, traffic modelling, emission modelling, dispersion, modelling, operator interface for scenario modelling) has been verified in April 2002.

Since this date the hourly update of information takes place. No substantial problems have been encountered. During May and June 2002 acquisition of traffic data from SIER was incomplete due to problems located upstreams (outside of HEAVEN system). Since summer 2002 data acquisition is stable.

In September and October 2002, the local Heaven web site was upgraded and went on-line. The system was completed in November when the module for street level dispersion modelling was added.

The system was used in November for a case study on the impact of the reserved bus lanes in the City of Paris (see section 5.5). It has been applied for evaluating the impact of the Car-free day of 22<sup>nd</sup> of September 2002.

In November the system was presented at an public exhibition in Paris. In December it was presented at the HEAVEN conference in Prague.

The sensitivity tests (see section 4.2) have been performed in January 2003.

## 5.4 Information platform

The information platform is accessible at [www.airparif.asso.fr](http://www.airparif.asso.fr) following the link *En direct de la rue* ("Live broadcast from the street").



For accessing Paris' HEAVEN information platform, follow this link on the Airparif homepage ([www.airparif.asso.fr](http://www.airparif.asso.fr)).

The presentation of information is two-fold : compact in the *bulletin*, and detailed in the sections Context, System presentation, Traffic data, Emissions data, Street level concentrations, Background concentrations, Scenarios.

### 5.4.1 Bulletin

The aim of the bulletin is to give quick information.

- **Meteorology** : The picture shows the "backplume" representative of the provenance of the air.
- **Traffic** : Traffic volume is shown in relative terms of cumulative distance, on four linear scales corresponding to total Ile-de-France, City of Paris, inner ring of suburbs, outer ring of suburbs.
- **Emissions** : The bulletin shows the cumulative traffic emissions on 24 h, in relative terms.
- **Street level concentrations** : At present time (prior to full validation of HEAVEN's street level concentration modelling module), the bulletin shows measured values for NO<sub>2</sub>, CO, PM10, and Benzene.
- **Background concentrations** : The maps show maximal Ozone and NO<sub>2</sub> concentrations, accompanied by a comment specifying the percentage of area where a exceedance of the hourly threshold for information has been recorded.



- **Atmo index** : The map shows the air quality index used by Airparif since 1995 for public information.

### 5.4.2 Detailed information

The aim of the detailed information is that a visitor can understand and see the modelling steps which produce the HEAVEN information.

The **traffic** section gives detailed hourly maps of the modelled traffic situation of the current and preceding days on three spatial scales. For historic days, aggregated maps for 24 h and for the periods 6 - 10 h, 10 - 16 h and 16 - 20 h are available.

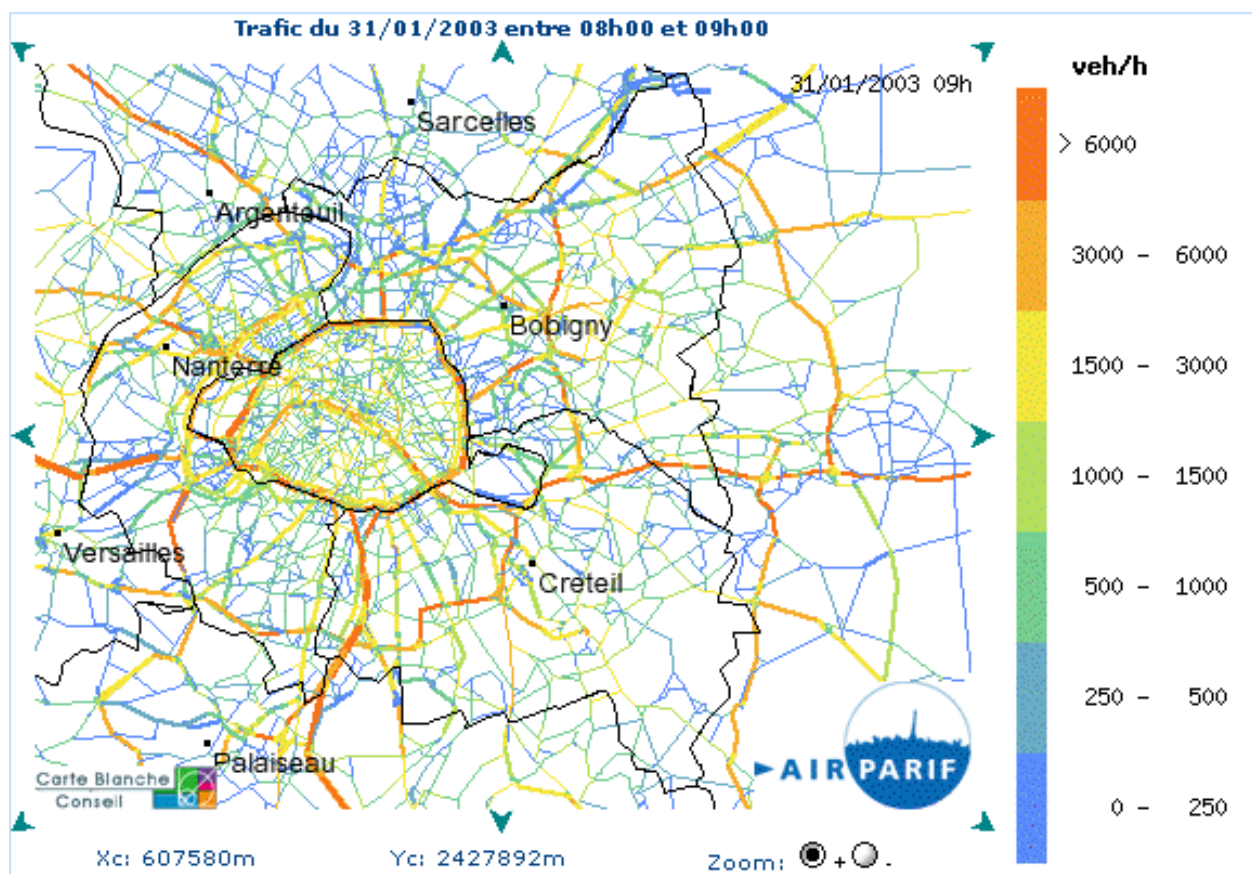
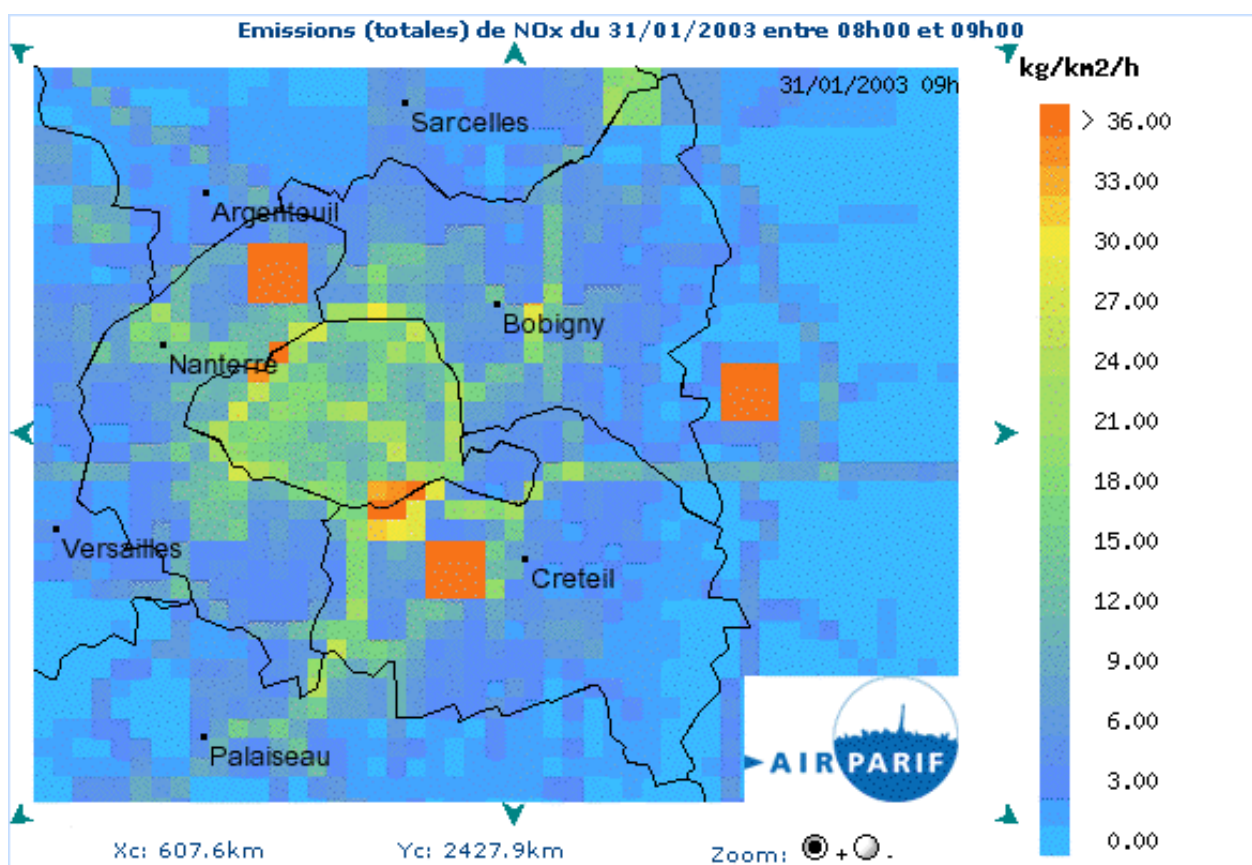


Figure 13 : Map of modelled traffic situation.

Modelled **emission** results are given in forms of maps and numbers. Maps are available for the same periods as for traffic. They are available for traffic emissions only, and for total emissions after superposition of traffic and fixed source emissions on a grid.

Numbers are available for traffic emissions, for each pollutant and for individual road axes. They are given in relative terms.

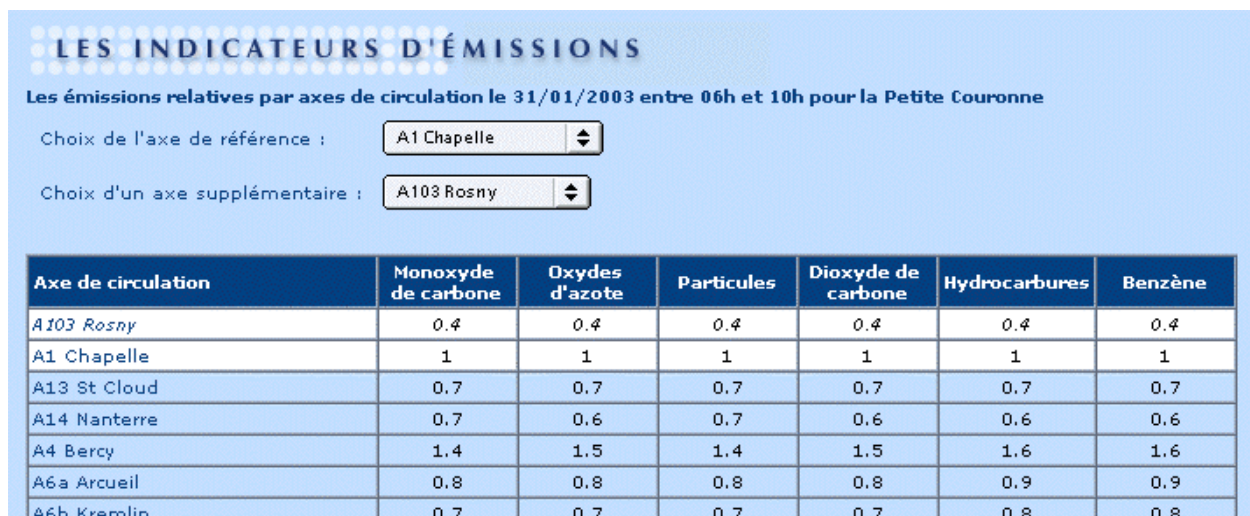


**Figure 14 : Map of total emissions resulting from the superposition of traffic emissions and fixed source emissions on a grid with cell size 1 km<sup>2</sup>.**

At present time (prior to full validation of the HEAVEN hourly street level concentration model), the section on **street level concentrations** gives the modelled annual mean estimates for CO, NO<sub>2</sub>, particles and benzene obtained with the Street model v4.

**Background concentration** maps are available for NO<sub>2</sub> and Ozone. There are hourly maps for the days D and D - 1. There are forecast maps of maximal concentrations for the days D, D + 1 and D + 2. For historic days, the maps of maximal concentrations are available.

The **scenario** section offers reports on case studies for download.



**Figure 15 : Table of traffic emissions. For a selection of road axes, the relative level of emissions is given for CO, NO<sub>x</sub>, particles, CO<sub>2</sub>, hydrocarbons and benzene.**

### 5.4.3 Public operation

The Heaven web site is public since November 2002. During the first month, 40 visitors per day have been counted on average. User feedback and evaluation results are presented in WP3.

## 5.5 Modelling of TDMS scenarios

### 5.5.1 New bus lanes

Airparif has used the HEAVEN DSS for evaluating the impact of new bus lanes in Paris.



**Figure 16 : Bus lane on Rue de Rivoli. Its width is 4.5 m. It is physically separated from the other lanes by a curbstone.**

The City of Paris has implemented the bus lanes in their present form during summer 2001. Their width is 4.5 m, and they are separated from the other lanes by a curb stone.

The new bus lane replace the previous ones, which were less wide, and not physically separated.

The use of the bus lane is restricted to public transport buses, taxis, cyclists, police and emergency vehicles, and cash transport. Delivery of goods takes place on other dedicated spaces, and is strictly regulated.

Airparif studied 3 concerned streets : Rue de Rivoli (a section of 2.25 km), Boulevard de Sébastopol (1.28 km), and Boulevard de Strasbourg (0.63 km). The study compared data from 3 periods : October 2000 (before the implementation), October 2001 (just after implementation), October 2002 (one year after implementation). Each period was represented by data profiles for an average working day, the average day being extracted from the raw data of the first 3 weeks of the respective month.

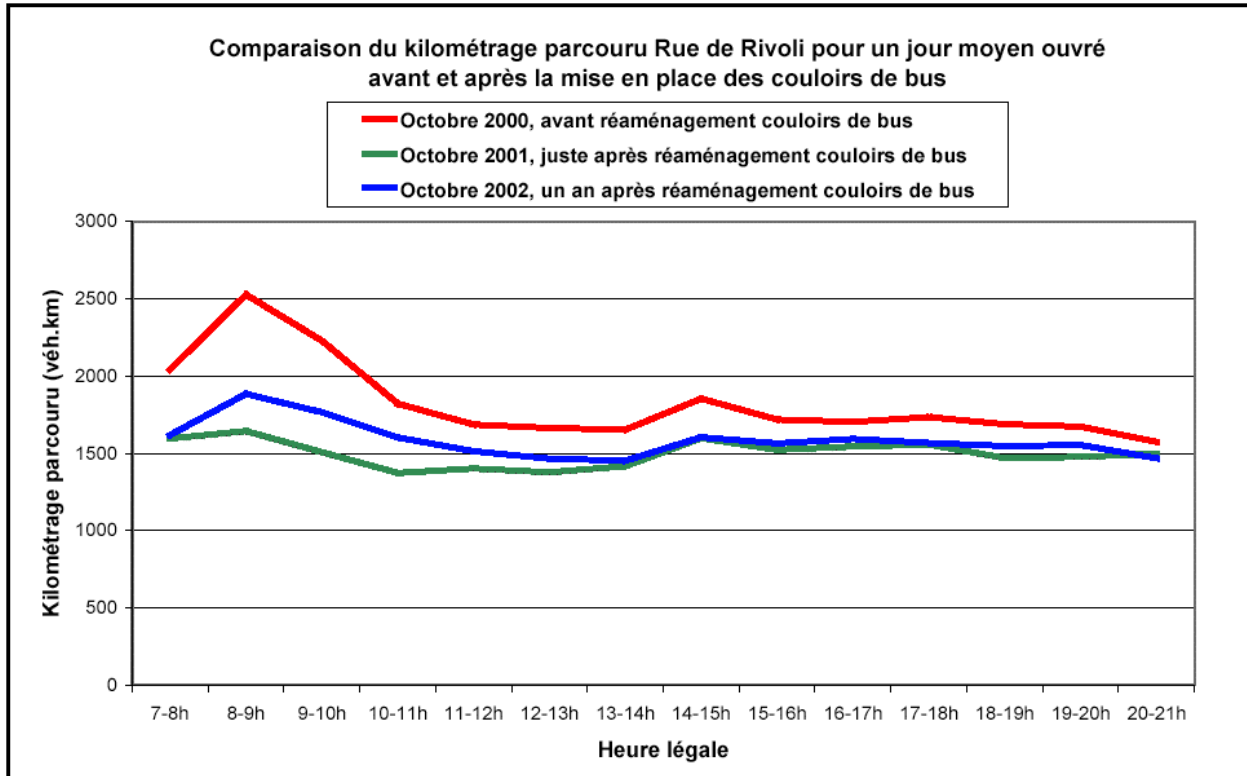
### **5.5.2 Impact on traffic**

The impact of the new bus lanes on traffic flow are known through automatic and manual traffic counts. Automatic counts by inductive loops give data on cumulative distance (=number of vehicles \* distance performed by each vehicle) and traffic speed. Manual counts, made during two 3-day periods in November 2000 and November 2001 respectively, give data on the composition of the traffic flow. All data refer to the time interval between 7:00 and 21:00.

On Rue de Rivoli, the cumulative distance has strongly decreased (-18 %) immediately after the implementation, and was 13 % below the initial level one year after the implementation. The decrease is strongest during the morning peak hour. Speed has decreased by 10 % immediately after the implementation, but has then re-augmented and is slightly above the initial level one year after the implementation.

On Boulevard de Sébastopol, the cumulative distance has decreased by 15 % immediately after the implementation, and was 11 % below the initial level one year later. Speed has not re-augmented one year after the implementation : it was at -11 %

immediately after, and at -14 % one year later. Traffic is congested during during most of the day and during evening peak hours (speed below 10 km/h).



**Figure 17 : Cumulative distance measured on Rue de Rivoli during the 3 periods of the analysis. For each of the three 3-week periods, the average profile for a working day was extracted. On Rue de Rivoli, the cumulative distance decreased by 18 % immediately after the implementation of the new bus lanes, and re-increased to -13 % of the initial value one year later.**

On Boulevard de Strasbourg, cumulative distance has decreased twice (-8 % immediately after the implementation and -11 % one year later). Speed has decreased twice also (-16 % immediately after, -18 % one year later).

Considerable modifications have happened in traffic composition also. On Boulevard de Sébastopol, the share of taxis (from 9.8 to 14.5 %), of Light Duty Vehicles (from 14.0 to 16.8 %) and of bicycles (from 1.6 to 2.6 %) has increased. The share of private passenger cars (from 57.4 to 50.1 %) and two-wheelers (from 12.3 to 11.2 %) has diminished. On Rue de Rivoli, the variations are comparable. The shares of private passenger cars and of two-wheelers have decreased by 3.2 and 3.5 % respectively.

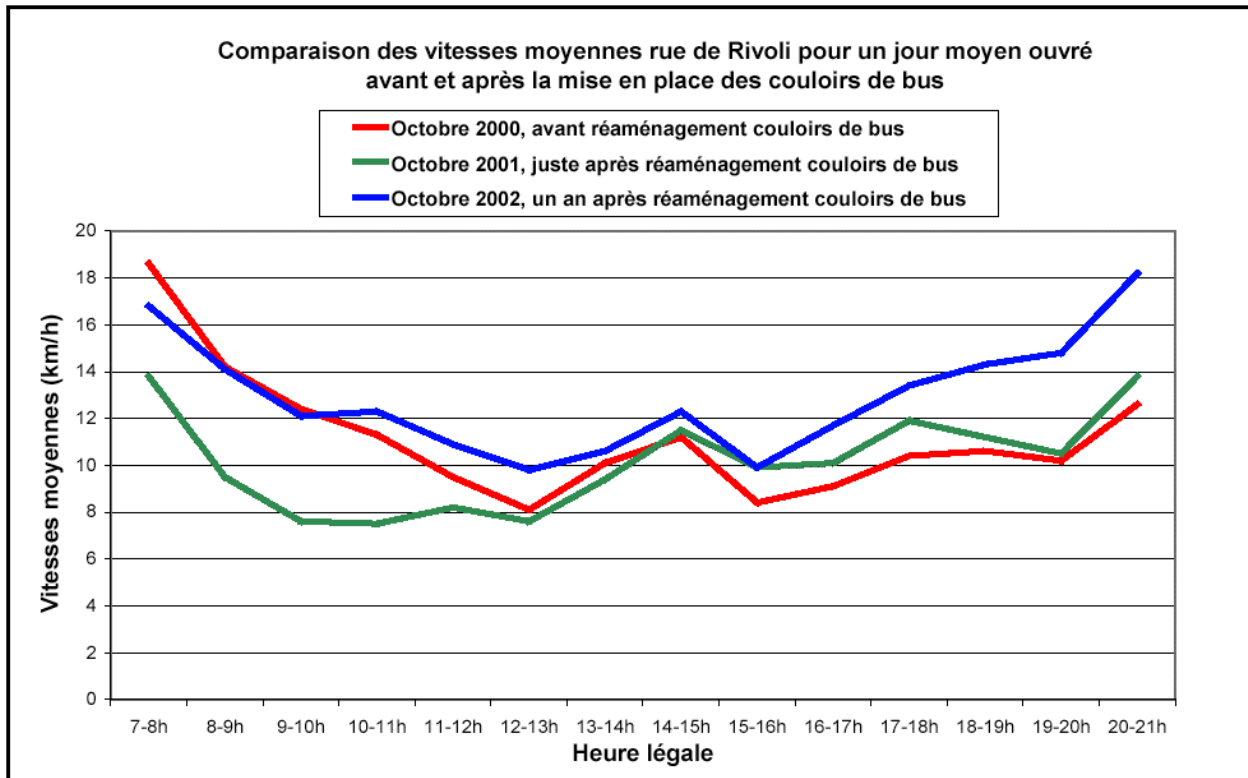


Figure 18 : Average speed profiles for the 3 periods of analysis on Rue de Rivoli. Speed decreased by 10 % immediately after implementation, but increased to a slightly higher value than the initial level one year later.

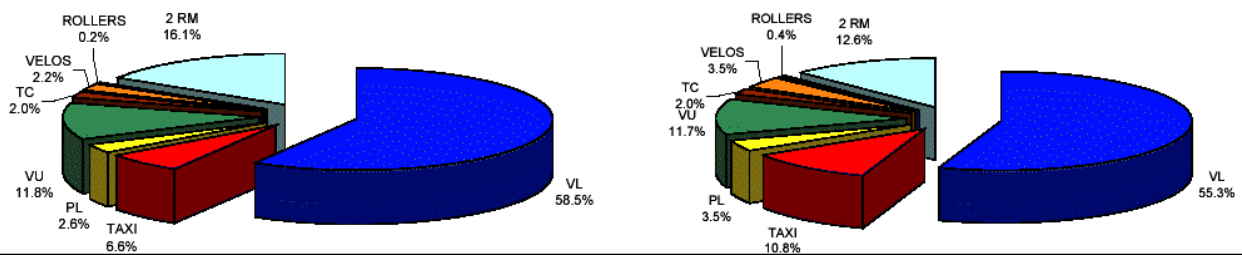


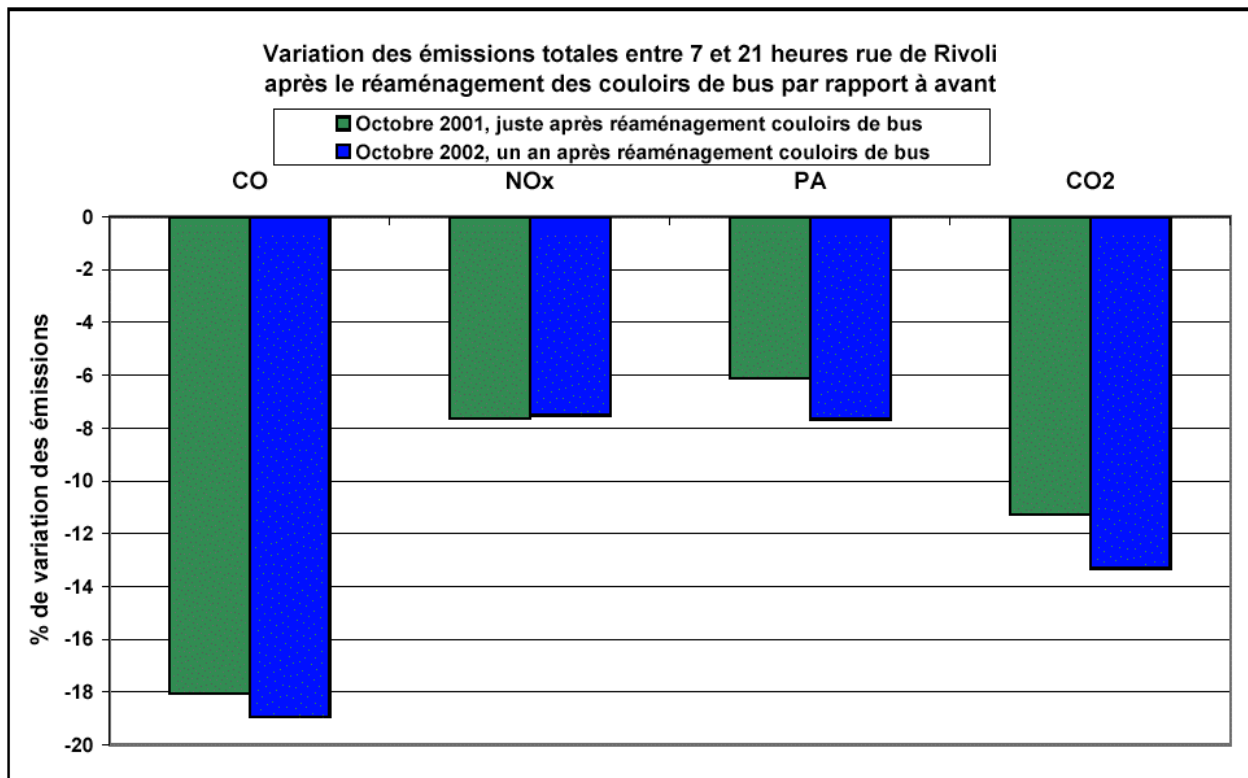
Figure 19 : Composition of the traffic flow on Rue de Rivoli in November 2001 (left) and November 2002 (right). The shares of taxis (red) and bicycles (orange) increased, while the share of private passenger cars (blue) and two-wheelers (light blue) decreased.

### 5.5.3 Impact on emissions

Starting from the average hourly profile of traffic flow, traffic speed, fleet composition, and temperature, Airparif has modelled the emissions of CO, NO<sub>x</sub>, PM10 and CO<sub>2</sub> using the emission module of the HEAVEN DSS. The fleet composition in terms of emission

factors has been held constant for the 3 years, with values representative for 2002. The percentage of cold vehicles has been held constant at 13 %.

The results for Rue de Rivoli show that the emissions have diminished by amounts between 6 % and 19 %. Depending on the pollutant and on the period, the emissions thus amplify or attenuate the variation observed in traffic volume.



**Figure 20 : Emissions on Rue de Rivoli immediately after implementation (green) and one year later (blue). The decrease is strongest for CO, where the diminution of traffic volume adds to the decreased share of two-wheelers. The two effects compensate partly for NOx and particles, leading to a limited decrease of emission for these two pollutants. The decrease of CO2 emissions follows closely the decrease in traffic volume.**

The diminution is strongest for CO (-18 %), where the decrease of traffic volume adds to the decreasing share of two-wheelers, which are strong emitters of CO. The two trends compensate each other partly, in the case of NOx and particles. The resulting decrease in emission is limited (-8 %). CO2 depending much less on the fleet composition, the resulting decrease follows the decrease of traffic volume (-11 to -13 %).

On Boulevard de Sébastopol, the emissions have decreased by 12 to 14 % immediately after the implementation, but have re-increased one later to -6 to -10 % of the initial levels. The re-increase of emissions, and the fact that the total decrease of emissions is weaker than the decrease of traffic volume, are due to the continuous degradation of traffic flow and the increase of congestion. The fuel consumption by vehicle increases with the increase of congestion.

On Boulevard de Strasbourg, the emissions of NO<sub>x</sub>, particles and CO<sub>2</sub> have slightly increased (+0.5 %) immediately after the implementation, and are 3 % below the initial level one year later. CO has decreased by 3 % immediately after, and by 5 % one year later. This contrasted evolution is related also to the significant degradation of traffic fluidity and increased congestion.

#### **5.5.4 Impact on street-level concentrations**

Airparif has modelled the street-level concentrations of CO, NO<sub>x</sub> and PM<sub>10</sub> using the Street v.4 model. This model is validated for estimating average concentrations on long periods (From 1 year down to 15 days). Airparif has used this model previously to HEAVEN. It has been integrated to the HEAVEN DSS as backup solution for the hourly street level concentration module of the HEAVEN DSS, which is still under calibration.

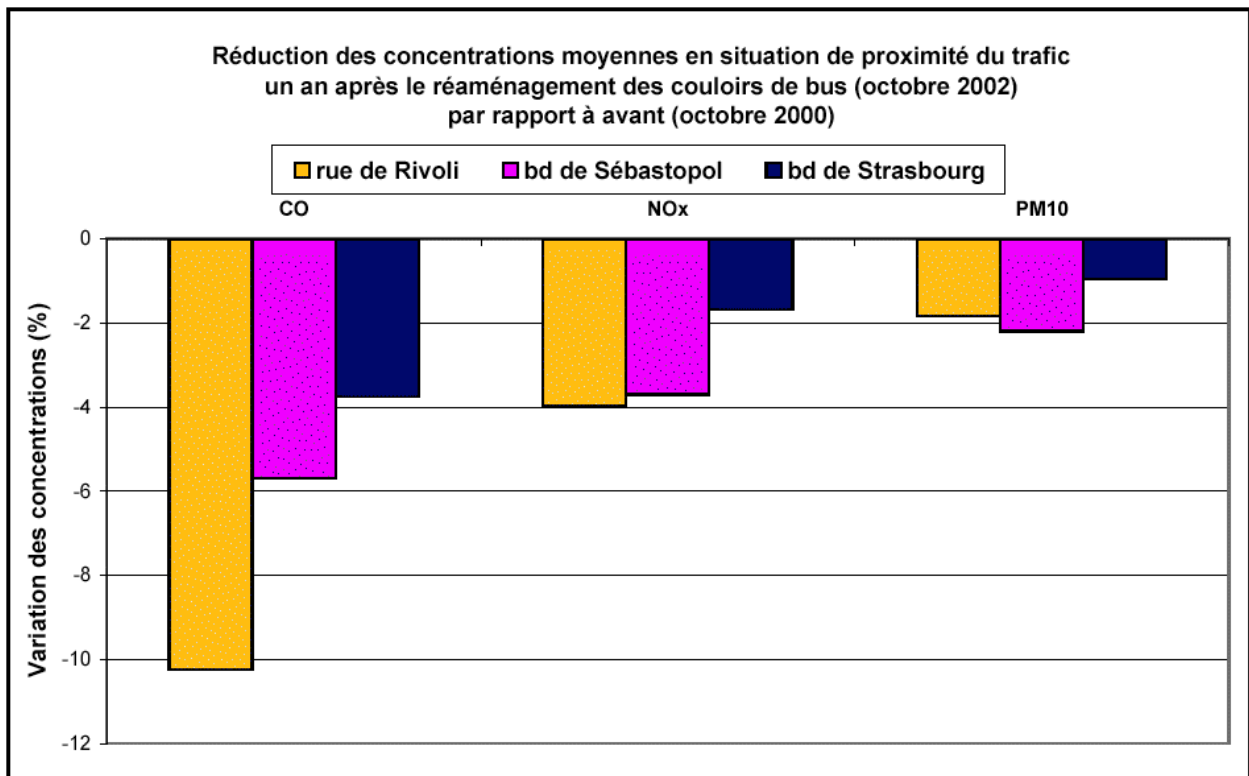
Additional input data are the average wind direction, the building characteristics of the streets, and the background concentration levels.

Rue de Rivoli is a canyon street, the ratio between street width and building height being close to 1. Boulevards de Sébastopol and Strasbourg are less canyon-like and have a ratio close to 2.

On the three sites, the results show a decrease in the pollutant concentration levels. The decrease is between 4 and 10 % for CO, between 2 and 4 % for NO<sub>x</sub>, and between

1 and 2 % for PM10. The decrease is weaker than for emissions, since the background levels are added.

The strongest decrease results for Rue de Rivoli. On Boulevards de Sébastopol and Strasbourg, the decrease of pollutant concentration is limited due to the degradation of traffic fluidity.



**Figure 21 : Decrease of street level pollutant concentrations one year after implementation of the new bus lanes. The decrease is weaker for Boulevards de Sébastopol and Strasbourg than for Rue de Rivoli, since on these sites the degradation of traffic fluidity increases the fuel consumption per vehicle.**

In absolute numbers, the modelled street level concentrations for CO and NOx of Rue de Rivoli and Boulevard de Sébastopol fall 10 to 20 % below the measured values of the street level stations Avenue des Champs-Élysées and Rue Bonaparte (1400 µg/m<sup>3</sup> of CO, 250 µg/m<sup>3</sup> of NOx). The resulting concentrations for Boulevard de Strasbourg are higher and come close to the measurement values of the street level station at Quai des Célestins.

### 5.5.5 Press response

Airparif and the City of Paris have presented the results of this evaluation at a press conference on 2<sup>nd</sup> December 2002. The newspapers *Figaro*, *Metro*, *20-minutes*, *le Parisien*, have published articles on the subject.



Figure 22 : Article published by "20-minutes" on 3/12/2002, following the press conference by Airparif and City of Paris on the results of the Bus lane impact evaluation performed with the HEAVEN DSS.

Airparif's full report (in French) is available for download in the "scenario" section of the HEAVEN information platform.

### 5.5.6 Car-free day 22<sup>nd</sup> of September 2002

Airparif has used the HEAVEN DSS for evaluating the impact of the car-free day "En ville sans ma voiture" of Sunday 22<sup>nd</sup> of September 2002. On this day, access to six designated areas has been restricted to public transport vehicles, taxis, bicycles, low-pollution vehicles (GPL, electrical), vehicles on duty, vehicles for handicapped persons, and residents. Speed has been restricted to 30 km/h in these areas. The restriction lasted from 9 a.m. to 7 p.m.

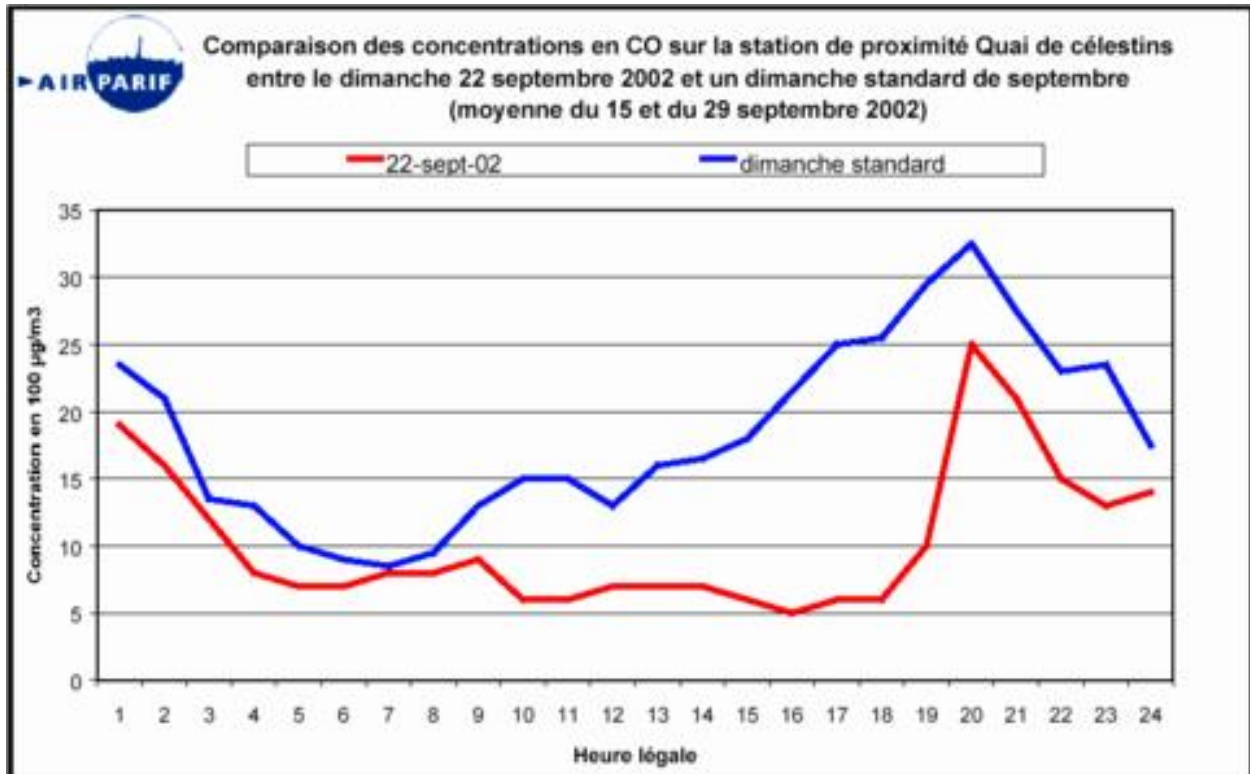
The impact on traffic is characterized, with respect to a normal Sunday, by a diminution of 6 % of traffic within the City of Paris, and a diminution of 63 % in the restricted areas. Speed has increased by 6 % within the restricted areas. The most significant shift in traffic composition is given by a share of 4,6 % of buses in the restricted areas with respect to 0,9 % on a normal Sunday.

The following table shows the variations in emissions. For all pollutants, the decrease in emissions is smaller than the decrease in traffic volume, due to partial compensation by higher speed and by a higher share of buses.

	Total city area		Restricted area	
	0 - 24 h	9 - 19 h	0 - 24 h	9 - 19 h
NOx	-6,5 %	-10 %	-19 %	-30 %
CO	-9 %	-16 %	-27 %	-47 %
Particles	-7 %	-11 %	-26 %	-43 %
CO2	-8 %	-13 %	-28 %	-47 %
VOC	-9 %	-15 %	-24 %	-39 %

**Table 2 : Variation of pollutant emissions during the car-free day of 22<sup>nd</sup> September 2002. For all pollutants, the decrease in emissions is smaller than the decrease in traffic volume, due to partial compensation by higher speed and by a higher share of buses.**

The impact on street level concentrations has been determined by hourly measurements on two sites. They show a decrease by up to 60 % during the restriction interval (see figure 23).



**Figure 23 : Comparison of measured street level CO concentration values on a site within the restricted area. Car-free day (red) vs. Average of preceding and subsequent Sundays (blue). The concentration decreases by up to 60 % during the restriction interval (9 a.m. to 7 p.m.).**

The meteorological conditions were windy and favorable for dispersion of pollutants. Due to this, no significant impact on background concentrations could be shown.

Airparif's full report (in French) is available for download in the "scenario" section of the HEAVEN information platform.

## **5.6 Future adaptations of DSS and reasons why**

The calibration of the street level pollution model SIRANE has revealed that the fleet description must be refined. This concerns in particular the VOC emissions, which seem to be overestimated at present time. Refinement of the fleet decomposition is a task that is usually hindered by the fact data sources are scarce and incomplete.

The traffic modelling approach chosen in HEAVEN gives priority to a correct restitution of traffic flow, sometimes at detriment of correct restitution of speed. Since both parameters are important for correct modelling of emissions, the Paris partners will consider the possibility of overwriting modelled speed values by measured values where available (prioritarily on motorways), at detriment of a coherent overall traffic assignment.

The regional background dispersion model Pollux will be upgraded to a new version within the next 12 months. The new version will take into account more detailed meteorological data.

The inventory of fix emission sources is currently updated to the situation of year 2000. As soon as it is available, the new inventory will be integrated to the HEAVEN DSS.

The calibration and testing of the street level pollution model SIRANE will continue.

## 6 CONCLUSIONS

HEAVEN is a success for all French partners. The project has achieved its technical objectives, and it has brought forward the institutional co-operation.

The technical achievements of HEAVEN enhance the modelled air quality information in the Ile-de-France region. Firstly, by introducing measured real-time traffic data as a direct data source to air quality modelling. Second, by refining the traffic description for air quality modelling through a refined traffic module, and through engaging interchange of expert knowledge between traffic and air quality specialists. Besides, the refined traffic module and its reference traffic assignment database constitute a exploitable result for DREIF. Third, HEAVEN has integrated an automatic *quasi* real-time modelling chain going from traffic to pollutant concentrations. The chain operates on-line without raising problems. Used off-line, the integration significantly increases Airparif's productivity in studying scenarios. Fourth, HEAVEN has progressed in street-level pollution modelling. The technical difficulties encountered in this field, normal in research & development, do not lower the merits of the project in any way.

The HEAVEN system has proved its benefit for the City of Paris in the case study on new bus lanes. It allows the assessment of strategic traffic management measures. In the case of bus lanes, its results support the City's policy.

The partners intend to pursue common prospective scenario studies. They will address the expected impacts on air quality of the current regional transport master plan (PDU), and the required reduction of motorised traffic for achieving the objectives of the regional air quality protection plan (PPA). Earlier prospective studies of Airparif have shown that a reduction of emissions by 50 to 80 % would be necessary for achieving the air quality objectives defined by the European directives. Traffic being the principal emitter of pollutants in the Ile-de-France region, the evaluation of the air quality impacts of traffic management measurement will remain a central issue in forthcoming years.

All partners wish now to increase the audience of the HEAVEN web site. The web site is an optimal tool to ensure transparency on how public policies affect air quality.

## 7 REFERENCES

Bell, M., Ctyroky, J., DePalo, M., DePisi, P., Moutal, V., Rapp, P., Teschioni, A., Tullius, K., Wang, T.

D6.1 Definition of System Components and Analysis of Commonalties

HEAVEN IST-1999-11244 10<sup>th</sup> July 2001

Tullius K., Rapp P., Mietlicki F., Bell M., Ctyroky J., Wang T., De Palo M., De Pisi P., Biora F., Teschioni A.

D6.2 Analysis of actual implementation from the sites

HEAVEN IST-1999-11244 18<sup>th</sup> December 2001

Wefering F. et al.

D3.2 Evaluation Report

HEAVEN IST-1999-11244 To be published.