



Programme:	Information Society Programme
Key Action:	1
Action Line:	1-5-1
Project Number:	IST-1999-11244
Project Acronym:	HEAVEN

Deliverable Number:	D8.8
Deliverable Title:	Rotterdam Demonstration Report
Dissemination Level*:	LI
Nature**:	RE
Type***:	PD
Date of Preparation:	22 April 2003
Project's Internal Reference:	
Author(s):	Sef van den Elshout, Cleo Pouw, Johan Voerman, Leo Hermans, Leo de Leu

Project Co-ordinator:	Maurizio Tomassini Società Trasporti Automobilistici Via Ostiense 131/L 00154 Roma Italia
Phone:	++39-06-57118216
	Fax: ++39-06-57118547
	E-mail: m.tomassini@sta.roma.it

* PU-public usage, LI-limited to programme participants, RP-restricted to project participants

** PR-prototype/demonstrator, RE-report, SP-specification, TO-tool, OT-other

*** PD-project deliverable, X-submitted on request deliverable

Document Control Sheet

Project:	IST-1999-11244 HEAVEN
Document name:	Deliverable D8.8 – Rotterdam Demonstration Report
Document reference:	
Other internal reference:	
Prepared by (organisation):	DCMR, City of Rotterdam
Author(s):	Sef van den Elshout, Cleo Pouw, Johan Voerman, Leo Hermans, Leo de Leu
Editors:	Sef van den Elshout, Cleo Pouw, Leo Hermans, Leo de Leu
Reviewed by:	

Issue History

Issue	Description	Originator	Date of issue
Draft A	First Draft version – Issue for Comments	Leo de Leu	24 October 2002
Draft B	Second Draft version – Issue for Comments	Sef van den Elshout	1 November 2002
Draft C	Third Draft version	Sef van den Elshout / Cleo Pouw	7 March 2003
Issue 01	Final Rotterdam Demonstration Report	Sef van den Elshout / Cleo Pouw	22 April 2003

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. This document is a comprehensive guide for the demonstration performed in Rotterdam. It details how the objectives for WP8 are met and provides the evaluation results and the results of the Traffic Demand Management Strategies that are explored for the Rotterdam demonstration area. Furthermore the results of the implementation of a 80 km speed limit are presented.

The Rotterdam demonstration is centred around a public web site with real time concentration modelling. The DSS that was developed for Rotterdam combines real time information on traffic densities, meteorological conditions and background concentrations into a concentration calculation and a 24 hour concentration forecast. The presented information is updated on an hourly basis and kept on the web site for a year. The system currently covers the ring road and one busy inner city feeder road. Concentration modelling covers an area up to 500 m on each side of the road.

Selected key-users have a stand-alone version of the DSS that allows them to reanalyse the data logged by the main system or to design and analyse traffic situations. The interface for the DSS is built in a GIS environment and maps are mainly presented as maps.

In Rotterdam the Heaven project was used:

- to improve several existing air quality modelling tools.
- to tie together several existing subsystems into an information platform and DSS.
- to bring together all relevant local administrative parties involved in traffic, air quality and health.

The positive HEAVEN results supported the decision to continue the operation of the HEAVEN system after the project lifetime. A HEAVEN operator handbook has been prepared to support future maintenance and control of the HEAVEN system.

Table of contents

Executive Summary	3
1. Introduction	7
1.1 Guide to the reader	7
1.2 Objectives	7
1.2.1 <i>By project</i>	7
1.2.2 <i>By work package</i>	8
1.2.3 <i>By site</i>	8
1.3 Project structure	8
1.4 Summary of WP's	12
1.5 HEAVEN System Concept	14
2. Decision Support System in Rotterdam	18
2.1 General System Architecture	18
2.1.1 <i>HEAVEN architecture in Rotterdam</i>	18
2.1.2 <i>Hardware implementation</i>	19
2.1.3 <i>Operation and Function of the DSS</i>	20
2.1.4 <i>Data Exchange with external systems</i>	21
2.1.5 <i>Internal data exchange</i>	21
2.1.6 <i>Common repository</i>	22
2.1.7 <i>Traffic modelling</i>	22
2.1.8 <i>Air quality modelling</i>	22
2.1.9 <i>Decision Support System</i>	23
2.1.10 <i>Operator Interface</i>	24
2.2 Functionalities of the HEAVEN System	24
2.2.1 <i>Scenario Analysis</i>	24
2.2.2 <i>System Management</i>	25
2.2.3 <i>Information presentation</i>	25
2.2.4 <i>Health data</i>	28
2.3 General history of system development in Rotterdam	28
2.4 Future adaptations to DSS	29
3. Verification	30
3.1 Introduction	30
3.2 Main results from verification in Rotterdam	31
3.2.1 <i>Indicator 1: Accuracy of the DOAS compared to traditional equipment</i>	31
3.2.2 <i>Indicator 2: Accuracy of roadside description, air models</i>	31
3.2.3 <i>Indicator 3: Accuracy of roadside description, noise models</i>	31
3.2.4 <i>Indicator 4: Testing processes of DSS interfaces</i>	31
3.2.5 <i>Indicator 5: Testing DSS modelling and forecast processes</i>	32
3.2.6 <i>Indicator 6: Testing DSS operator interface and scenario processes</i>	32
3.2.7 <i>Indicator 7: The functioning of the system components and their interaction</i>	33
3.2.8 <i>Indicator 8: User acceptance by professional users</i>	33
3.2.9 <i>Indicator 9: User acceptance by the general public</i>	33
3.3 Summary	34
4. Evaluation in Rotterdam	35
4.1 Introduction	35
4.2 Validation of HEAVEN DSS Dispersion model in Rotterdam	36
4.2.1 <i>The TNO Dispersion model</i>	36
4.2.2 <i>The validation results</i>	36
4.2.3 <i>Benzene</i>	40
4.2.4 <i>Nitrogen dioxide</i>	41

4.2.5	<i>Particulate matter</i>	42
4.3	Calibration of HEAVEN DSS Dispersion model	43
4.3.1	<i>Model development for highway segments</i>	43
4.3.2	<i>Comparison between modelling and measurements</i>	45
4.4	Common TDM scenarios: sensitivity tests	46
4.4.1	<i>Emission reduction</i>	47
4.4.2	<i>Impact on concentrations</i>	50
4.5	HEAVEN Evaluation results	53
4.5.1	<i>HEAVEN Evaluation indicators</i>	53
4.5.2	<i>Rotterdam Evaluation conclusions</i>	55
4.5.3	<i>Conclusion</i>	57
5.	The HEAVEN Demonstration phase	59
5.1	Objectives of the demonstration phase in Rotterdam	59
5.2	Summary of the air pollution situation in the Rotterdam region	60
5.3	City Specific Scenarios	62
5.3.1	<i>Connection national highways A16-A13, extension A4</i>	62
5.4	Measured impact of the 80 km/h speed limit	66
6.	Conclusions	69
7.	References	70

APPENDICES

Fehler! Textmarke nicht definiert.

Appendices

Annex A: Validation of the HEAVEN DSS dispersion model

Annex B: Development of new atmospheric dispersion model

Annex C: HEAVEN project, the impact of a 80 Km speed limit

List of Figures

Figure 1: Management Structure of the HEAVEN Project	10
Figure 2: Interrelations between work packages and RTD and demonstration tasks	14
Figure 3: The dynamic Data Processing and Modelling Chain of the HEAVEN DSS	15
Figure 4: System Architecture development in HEAVEN Project	18
Figure 5: Overview of the Rotterdam DSS	19
Figure 6: Hardware components of the Rotterdam DSS	20
Figure 7: Presentation of user interface for scenario analysis by professional users	25
Figure 8: Example of the interface of the information platform for professional users	26
Figure 9: Impression of the public interface of the Rotterdam information platform	27
Figure 10: Emission reduction in scenario 1, 2 and 5 on the Pleinweg corridor	49
Figure 11: Emission reduction in scenario 1, 2 and 5 on the ring road	49
Figure 12: Modelled distribution of the emission by the different traffic participants	50

Figure 13: Concentration maps following scenario analysis	50
Figure 14: Daily course of NO _x contribution in several modelled scenarios	52
Figure 15: Evolution of pollutant concentrations in the Rotterdam area	60
Figure 16: Approximate routing of the A4 extension and the A13 - A16 branch	62
Figure 17: Existing situation 17-06-19.00 h. NO _x concentrations	64
Figure 18: Situation with extension A4 (= reduction of traffic by 40 %)	65
Figure 19: Situation with extension A4 + construction A13-A16 (= total reduction of 50 %)	65
Figure 20: The A13 highway leading into the city centre after introduction of the speed limit	66

List of Tables

Table 1: Responsibilities per Site	11
Table 2: Example of an export table (emissions) for selected road segments in 2 scenarios	24
Table 3: Measured and calculated concentrations at two distances from the centre of the highway	37
Table 4: Urban highway verification measurements (Data: TNO 2002)	37
Table 5: Some regression characteristics of the validation measurements	38
Table 6: Sensitivity tests to be modelled by all partner cities in the HEAVEN project.	46
Table 7: Modelled concentrations for the reference hour and changes (Δ) due to scenarios	52
Table 8: NO ₂ and PM ₁₀ concentrations in the urban area in 2001 and 2002	60
Table 9: Concentrations in 2 city specific scenarios compared to the general scenarios	63

1. Introduction

1.1 Guide to the reader

This document is a comprehensive guide to the demonstration plan for Rotterdam. It details how the objectives for WP8 will be met and the TDMS options that will be explored. Workpackage 8 is the demonstration phase of the HEAVEN project. The first chapter provides background information to the HEAVEN project and the context of work package 8. Chapter 2 and 3 describe the realisation and verification of a (near) real time environmental platform on air quality for:

- Professional users (DSS)
- General public (Public web site)

The performance of the dispersion model was first calibrated for 6 months, and afterwards validated. Results from both the validation and calibration are part of the Evaluation in chapter 4. Moreover a summary of the Rotterdam evaluation results is included, focussing on the indicators defined in WP3 (Evaluation).

Within the demonstration phase different Transport Demand Management Strategies to reduce pollution and avoid exceedances were developed, tested and evaluated in the Rotterdam demonstration area.

The results of the implemented Traffic Demand Management Strategies are described in chapter 5. Together with the HEAVEN online information system and the improved modelling capabilities, the HEAVEN system can be used as an important input for future traffic and environmental planning in Rotterdam.

1.2 Objectives

The project objectives can be considered on varying scales - on a HEAVEN basis, on a work package 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 work package

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

1.2.3 By site

Rotterdam wants to test new methodologies and systems for decision making to reduce transport related emissions to assist in achieving compliance with EU Directives on air quality

Key objectives of Rotterdam within this project are:

- to create a (near) real time Environmental information platform on air quality for:
 - Professional users (DSS)
 - General public / Road users/public (public web site)
- to assess TDMS measures and scenario's with regard to their impacts for reducing traffic derived pollution;
- to improve information dissemination with the public about traffic related air pollution;

The HEAVEN DSS combines real-time traffic flow information with vehicle emission and air pollution dispersion models to provide information on the contribution of mobile sources to air quality. The DSS can be used to provide on-line air quality analysis using real-time traffic density monitoring in combination with continuous environmental data (background concentrations, weather data). Alternatively, it can be used for scenario analysis by using general climatic and background data and projected traffic densities based on TDMS.

Due to the size and nature of the project it has been subdivided into several so-called work packages. This Deliverable package 8.8 deals with the demonstration of the results.

1.3 Project structure

The management structure of HEAVEN, as depicted in figure 1, includes the following roles:

- The Steering Group is formed by executive level representatives of the principal contractors and is responsible for providing strategic guidance and in charge of steering of the project.
- The Technical Management Committee is formed from all Local Site and Work package Managers and the Project Manager. The Committee meets regularly to review technical progress on overall and site level and identify needs for corrective actions; reports regularly to the Steering Committee via the Project Manager.

- The Project Manager (STA) is the single contact point for the European Commission Project Officer and has overall responsibility for the day-to-day management and all regular reporting according to the contract (e.g. tri-monthly progress reports, Annual reports, Annual Review Report), representing the Co-ordinating Contractor. The Project Manager has specific responsibility for administrative and financial management and quality control and assists the Steering Committee and prepares and follows up on its decisions. The project manager is in charge of the organisation of frequent partner meetings and discussion forums, as well as continual communication via email, fax and telephone conferences in order to ensure the necessary flow of information.
- The Technical Manager (Heich Consult) is responsible for the day-to-day management of the project, co-ordination of the various tasks and work between the sites and WP Leaders according to an overall project workplan, organisation of frequent technical meetings and information exchange between sites and partners via e-mail, fax, in order to ensure the necessary flow of information. The Technical Manager's responsibilities encompass work package supervision, interfacing with work package leaders, and overall co-ordination of deliverable production. Additionally, the Technical Manager is in charge of co-ordinating the participation in programme level clustering and ensuring a high level of evaluation.

The Work package Leaders have the key task to co-ordinate activities on site and at project level for the duration of a work package, assist the Technical Manager during the active period of their work package and co-ordinate production of the deliverables of the work package.

The Local Site Managers co-ordinate all contributions to the project from their respective local partners (especially during the demonstration and exploitation phase). They are the single contact point for their sites towards the project consortium.

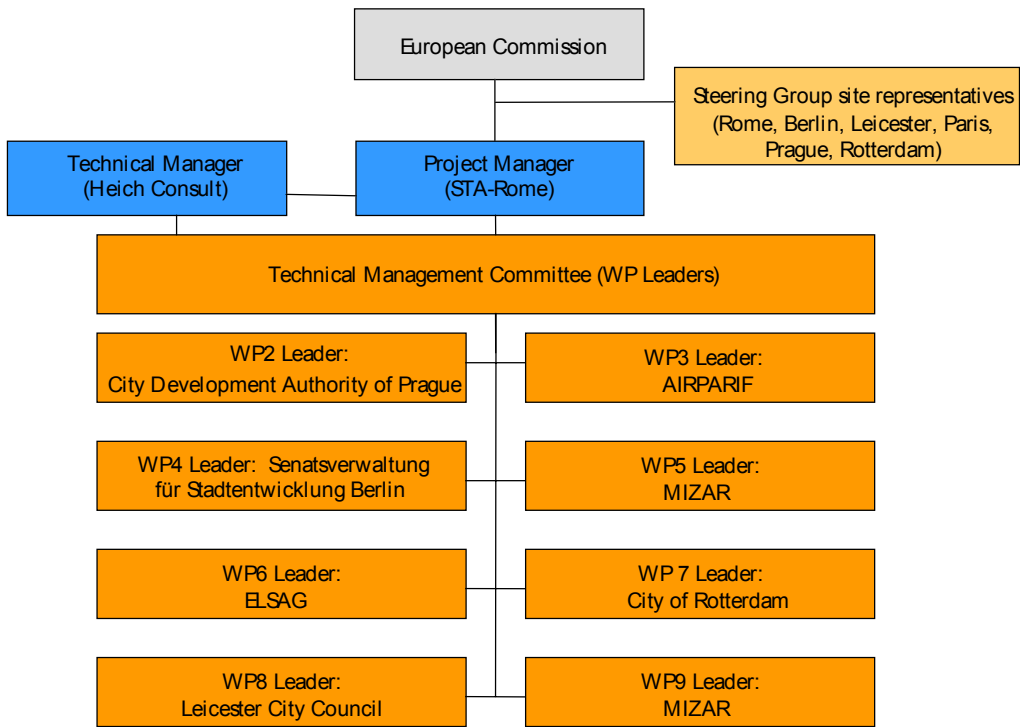


Figure 1: Management Structure of the HEAVEN Project

Table 1: Responsibilities per Site

	Rome	Berlin	Paris	Rotterdam	Leicester	Prague
Steering Committee Representative	Maurizio Tomassini, (STA)	Martin Lutz (SenStadt)	D.Gombert (Airparif)	Dr. Frank van Vliet	Nick Hodges	Maria Kazmukova
Local Project Manager	Fabio Nussio, (STA)	Rainer Voigt (IVU)	Fabrice Guilleux (Mercur)	Cleo Pouw	Nick Hodges	Maria Kazmukova
Local Evaluation Manager	Luca Persia, independent consultant	Harald Fietz (EA.UE)	Fabrice Guilleux (Mercur)	Peter van der Mede (GC)	Samantha Harris	Eliska Bradova
Local WP 2 Leader	Carlo Gentile, (STA)	Hanns-Uve Schwedler (EA.UE)	Bernard James (VdP)	Cleo Pouw	Nick Hodges	Petra Doleckova
Local WP 4 Leader	Claudio Baffioni, (STA)	Kai Tullius (IVU)	Gildas Baudez (CBC)	Cleo Pouw	Joanna Simpson	Martin Calek
Local WP 5 Leader	Carlo Di Taranto, (MIZAR)	Ingher Hoffmann (IVU)	Gildas Baudez (CBC)	Tjongcho Wang	Nick Hodges	Jiri Ctyroky
Local WP 6 Leader	Andrea Teschioni (ELSAG)	Lutz Trostoff (IVU)	V. Moutal (DREIF)	Peter van der Mede (GC)	Nick Hodges	Jiri Ctyroky
Local WP 7 Leader	Michela De Palo (STA)	Gabi Zink (B+SU)	V. Moutal (DREIF)	Cleo Pouw	Samantha Harris	Jan Macoun
Local WP 8 Leader	Fabio Nussio (STA)	Bernd Milde (SenStadt)	Peter Rapp (CBC)	Leo Hermans (DCMR)	Nick Hodges	Jiri Lavic
Local WP 9 Leader	Carlo Di Taranto, (MIZAR)	Tilman Bracher (IVU)	D. Gombert (Airparif)	Menno Keuken (TNO)	Helen Jenkins	Maria Kazmukova
Technical Support	Hermann Heich, (HC)	N/a	N/a	N/a	N/a	N/a

1.4 Summary of WP's

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 in Paris (December 2002) and a final conference in Prague (December 2002) 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 will also be made available through a project web site. In Rotterdam the address of the public web site is: www.luchtkwaliteit.rotterdam.nl.

WP3: Validation co-ordination

Workpackage 3 assists both the verification and the demonstration stages of the project. Firstly, a draft validation plan was developed, in close co-operation with the local evaluation managers, who are responsible for performing the actual evaluation in workpackage 7 and workpackage 8. Secondly, the local evaluation work, both for the verification and the demonstration phase, will be guided through advice and direct assistance. Verification of systems was done in WP7, evaluation of the demonstration's impacts will be done in workpackage 8. Workpackage 3 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 workpackage focuses 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 were input to workpackage 5 for the design of the DSS and Information system and to workpackage 3 for the preparation of the Draft Validation Plan.

WP5: Functional specifications/system architecture

Workpackage 5 will develop the specifications for DSS and Information systems on the basis of the requirements captured by workpackage 4. The work was performed in each site according to local particularities and constraints, and following a common and structured approach, which helped to identify commonalities between sites. The underlying purpose of this work package was 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, workpackage 6 identified the set of components and actions to be undertaken in order to grant the implementation of the DSS and Information System. WP6 included 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 was assessed by focussing on indicators like the number of breakdowns, log-files and speed of the system. Secondly the acceptance by users interviewed in the context of workpackage 3. Users were 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 gave 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 occurred in workpackage 8. All the system component integration also occurred (traffic monitoring, environmental monitoring, emissions and dispersion models, etc.). The demonstration reflected 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 proceeded during the demonstration period, according to the milestone schedule. Once the system was in operation, the DSS was used to evaluate Traffic Demand Management Strategies (TDMS) 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

This work package is assessing 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 work package 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.

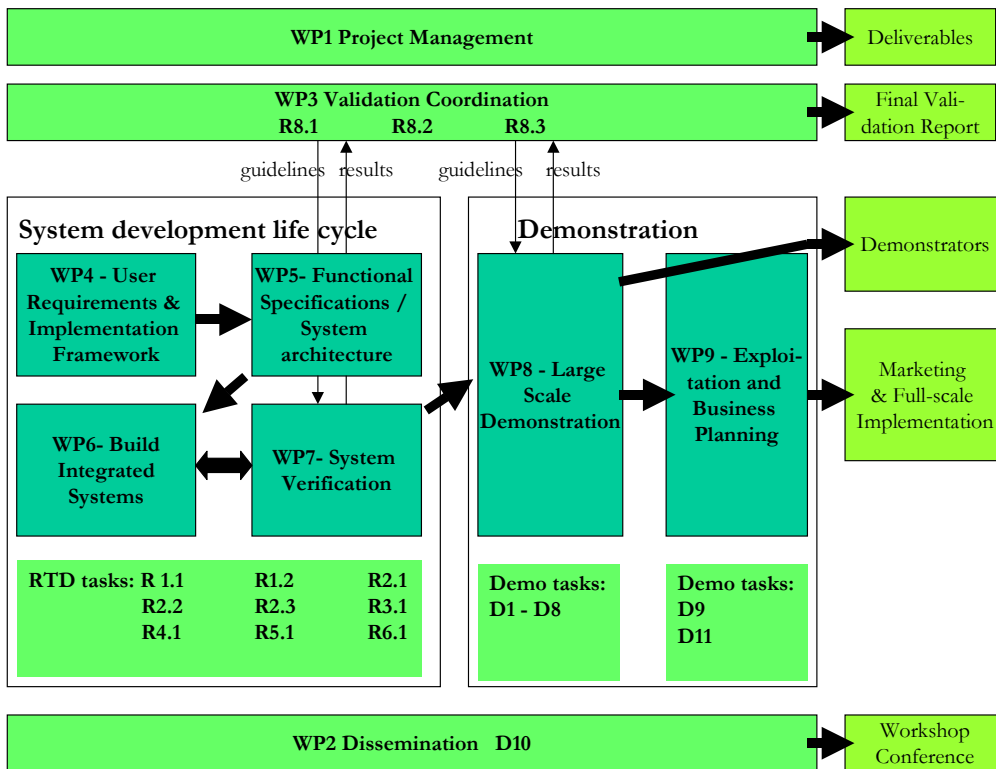


Figure 2: Interrelations between work packages and RTD and demonstration tasks

1.5 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 3 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.

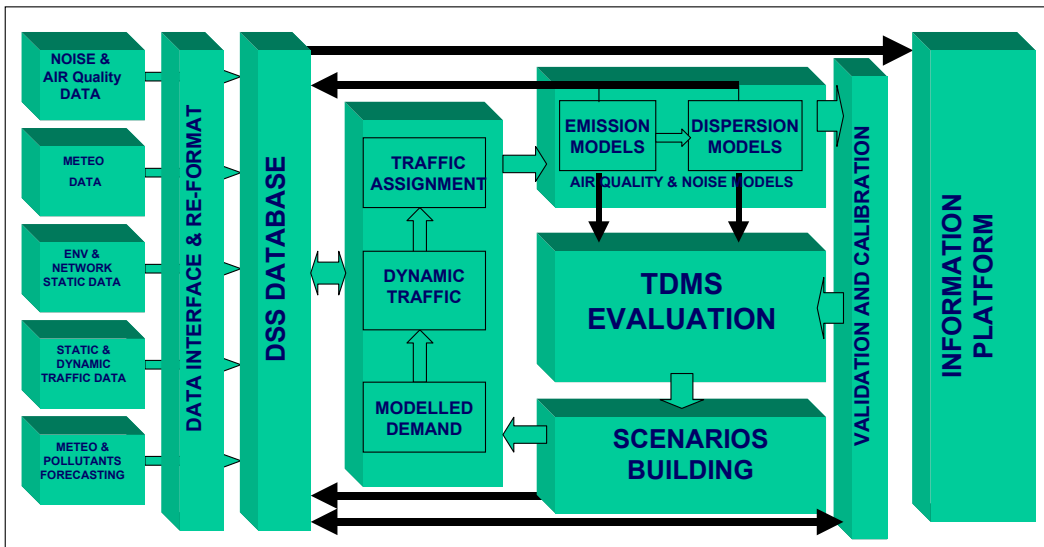


Figure 3: The dynamic Data Processing and Modelling Chain of the HEAVEN DSS

The main operational characteristics of the HEAVEN DSS emerge from the processes drawn in the diagram above. Noise is only applicable for Leicester and Berlin.

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 database 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 meteorological 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 undergoes 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 database. The information either as a whole or in part, 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 Rotterdam

The Rotterdam Decision Support System (DSS) was implemented according to the plans already outlined in deliverables D5.1, D5.2, D6.1 and D6.2. The system concept is summarised in this chapter.

2.1 General System Architecture

2.1.1 HEAVEN architecture in Rotterdam

Rotterdams' DSS has been developed according to the HEAVEN common structure taking into account specific features of Rotterdams' user needs and existing systems.

The scheme describes the steps performed to design the system architecture of both the HEAVEN DSS general concept and the local DSS demonstrators

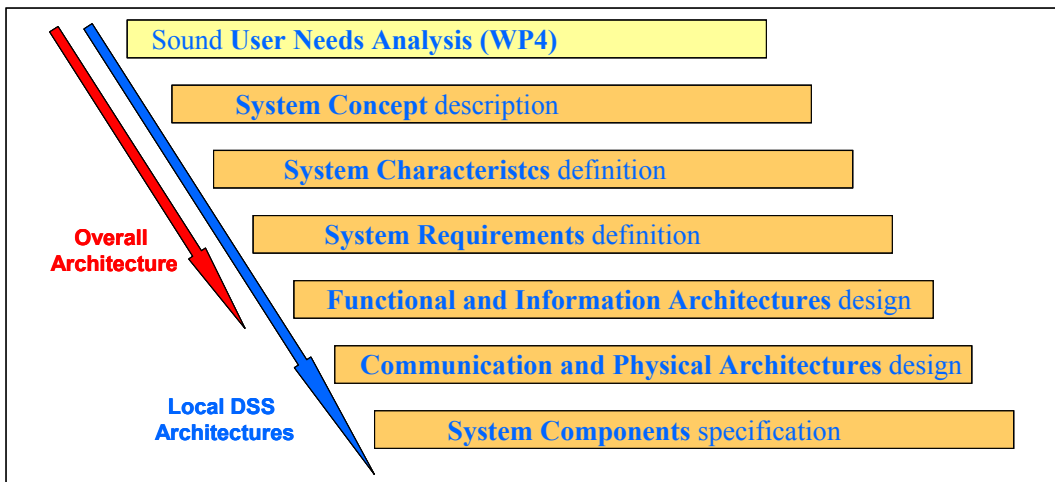


Figure 4: System Architecture development in HEAVEN Project

This approach has been developed according to the CONVERGE guidelines. The sound analysis of the user needs [3] performed by WP4 "User Requirements and Implementation Framework", covered the first step of the process and constituted the basis for the System Architectures design. The execution of the remaining steps have been assigned to the experts in both the traffic and environmental modelling involved in WP5 (System Architecture).

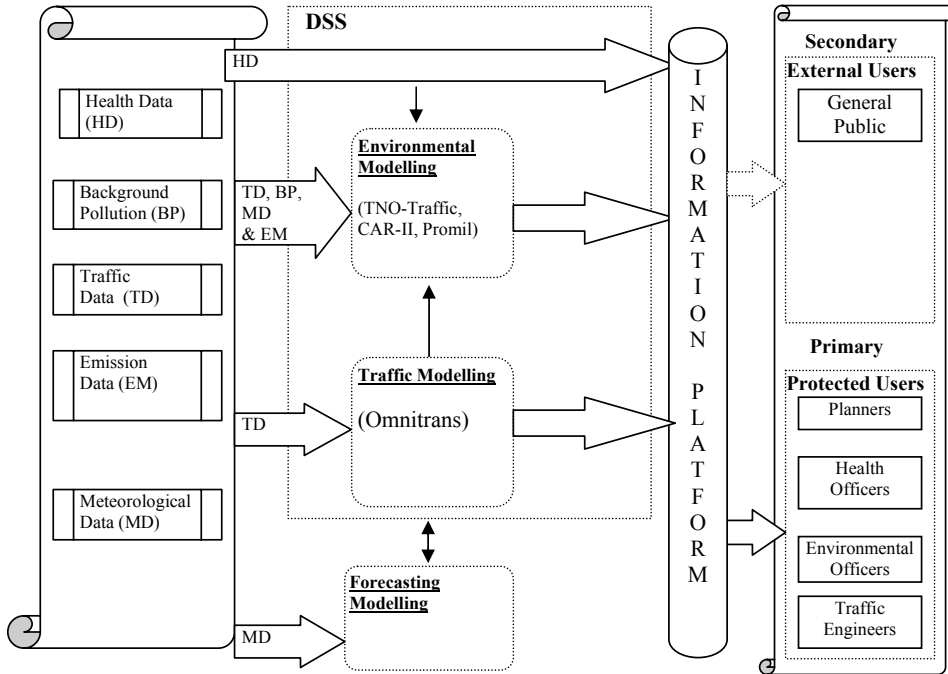
The design of the Functional and Information architectures conducted to the identification of the main modelling module - Air Quality Modelling in Rotterdam, and of other fundamental building blocks: the Operator Interface, the interface to the external systems and data sources, the Scenarios Management and the interface to the Common Information Platform.

The results of the Functional and Information Architectures design constituted the starting point of the detailed specification and implementation of the local DSS components in terms useful for the further activities developed in WP6 (Building the System):

- Elaboration processes that should be performed by the SW modules to implement the functions identified inside the functional architectures
- Characteristics and performance of the HW components
- Communication and Physical system architectures.

The DSS' physical architecture is presented below in the Overview of the Rotterdam DSS (Figure 5)

Figure 5: Overview of the Rotterdam DSS



The overall structure of the HEAVEN DSS consists of two main modules: the traffic and the air quality modules. The latter is subdivided in emission module and dispersion module. Both the primary data collected by the DSS from other sources and the calculated results are logged in a common location. The information is presented on a friendly and easy to use platform (website).

For key-users a scenario module, using a GIS interface, is available. They can access, analyse and manipulate the data for off-line analysis of the environmental impacts of specific TDMS defined by the primary user (representatives of city departments etc). The description of the Rotterdam DSS is reported in the following paragraphs.

2.1.2 Hardware implementation

The majority of functions are concentrated on one system (HEAVEN EIP -Environmental Information Platform-), The HEAVEN EIP system has its own console in order to allow direct maintenance. As the system is located at DCMR (Regional Environmental Protection Authority), it is connected to their local network. For other key-users, distribution is performed through an ftp server, but in general the functionality of the system is the same for all users.

The input of real-time traffic measurements and meteorological forecasts is completed through internet connections. The meteorological data from KNMI are the latest to be

available after completion of a hour: approximately 25 minutes. In the time between completion of an hour and those 25 minutes other sources can be approached and data downloaded. The Heaven database has been created. Data exchange by ftp from the DCMR network has been programmed and successfully tested. Transport of background concentrations from DCMR itself is also done by dialup connection as this is an easier solution for the existing system than transport through the internal network.

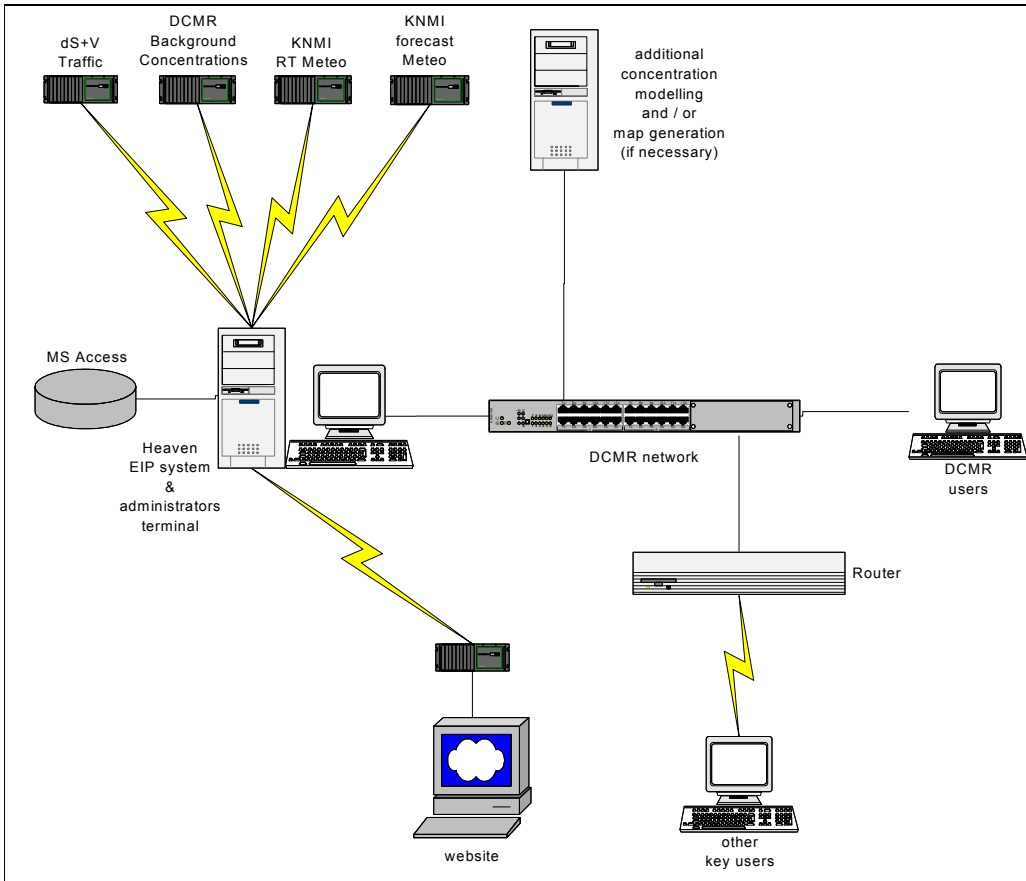


Figure 6: Hardware components of the Rotterdam DSS

The DCMR is running its own website. If was agreed that the HEAVEN website will be part of this pre-existing website, then updated information can be transported over the DCMR network. Otherwise an extra dial-up connection is required.

2.1.3 Operation and Function of the DSS

The operation and function of the Rotterdam DSS is dependent on real-time speed-volume data on urban motorways and an urban corridor (Pleinweg/Vaanweg). Furthermore it includes real-time meteorological data, background concentrations and air quality information (emission and dispersion) conform national and EU Daughter directives on NO₂, benzene

and PM₁₀. The HEAVEN system provides decision makers and the general public with information on air quality near all roads in the Rotterdam urban area and provides health related information. The information platform provides a medium for dissemination of the results from the Rotterdam decision system in various formats such as GIS, tables and graphs. On-line modelling of air quality every hour is achieved.

2.1.4 Data Exchange with external systems

Data exchange is made on-line for monitoring of meteorological conditions, background pollution, traffic and air quality. Manipulation, processing and reformatting of raw data are needed to facilitate the data exchange between monitoring systems and models.

Real-time traffic data is provided by the traffic department, of the city of Rotterdam, dS+V. This department collects both data from the ring road and the internal corridor that is monitored in HEAVEN. The data from the ring road is collected from the Monica system that is operated by Rijkswaterstaat, the national highway authority. Rijkswaterstaat has labelled all segments of highways where traffic is measured with a unique number. Traffic data in Monica format is specified per detection point: intensity and average speed for three vehicle categories, on the measured period. The different vehicle types are:

- Personal cars and light (delivery) vans: length 0 - 5.10 m
- Light (single) trucks: length 5.10 - 12.5 m
- Heavy (articulated) trucks: length > 12.5 m

On a road segment with multiple lanes, every lane has its own detection point. For the Rotterdam ring road the HEAVEN system includes approximately 50 cross-sections, each containing at least 4 lanes.

For the city corridor Pleinweg/Vaanweg only traffic intensities are measured. As the traffic on this corridor is quite consistent the HEAVEN system will derive the speeds based on an algorithm.

The traffic data will be collected hourly from an ftp-site that is run by dS+V. The data is available within minutes after completion of a measured hour.

The dispersion model needs meteorological information about wind speed and wind direction. Every hour the meteorological data is provided from Rotterdam Airport by KNMI: the Royal Dutch Meteorological Institute.

The background concentrations are taken from the DCMR-network of stationary air quality samplers in the Rotterdam region that monitor specific pollutants. For the HEAVEN project, data from three stations are used.

2.1.5 Internal data exchange

Processing of model outputs into a format suitable for visual display is a key component of the HEAVEN system and an essential element of the dissemination process. Output from the air quality models update every hour is presented to users to aid decision-making and on the public website. Software has been developed which allow transfer of data.

2.1.6 Common repository

All monitored and modelled data is transferred and stored in the HEAVEN database, that serves as a common repository for professional users and decision makers.

The database will contain historical data, concerning traffic profiles in terms of traffic flow and speed, hourly emissions and concentration trends, concentration and meteorological data from the air quality monitoring network.

The common repository will be very useful for professional users and decision makers to evaluate the average traffic and air quality conditions over a long period. It can be useful to identify the most polluted areas such as hot spots where specific intervention on traffic is needed.

Key users can access recent data stored (up to one year) in the HEAVEN database using a dedicated FTP system. Older data are archived and are available on demand from DCMR.

2.1.7 Traffic modelling

The HEAVEN system in Rotterdam has no integrated traffic-modelling module. Calculations for the "real-time" situation are done only for road segments where traffic has been measured, and based on those measurements.

Calculations for future situations are done using static predictions for traffic for different types of days, using the transport model OMNITRANS.

OMNITRANS is a proprietary transportation planning software package. It is a new generation of software: open structure, designed for Windows GUI and advanced modelling techniques. But in general the application of it may be compared with software like Trips and Tranplan where traffic is assigned offline.

Static transportation models, designed for "type of day" will be generated and tuned with OMNITRANS. These static models will be used on behalf of forecasting: combined with forecasted meteorological conditions and forecasted background concentrations.

To allow this process to occur, the HEAVEN database has initially been loaded with several traffic scenarios. The addition of traffic scenarios is an operator task. For scenario investigations the user will be able to load traffic scenarios in to the HEAVEN database.

2.1.8 Air quality modelling

Short term urban highway model

The TNO-urban highway model computes the air quality impact of exhaust gas emissions from traffic on highways through and around cities on an hourly basis. The model is an enhancement of the TNO-traffic model, which is used to calculate the annual contribution to air quality around highways. TNO-urban highway model estimates the air quality for NO₂, PM₁₀ and benzene in urban areas, which are located in the direct vicinity of highways and inner-urban roads. The model requires hourly standard meteorological data. In Rotterdam, urban background air quality data is provided through the DCMR air quality monitoring network for different wind directions. Traffic data are generated by road loops that distinguish the type of vehicle (light, medium and heavy duty vehicles) and speed. Emission factors are derived from TNO-Automotive, which manages the national database on road traffic emissions. The model has been calibrated over 6 months for both the situation in the "open

field" (highway in open field) and the "build environment" (highway through the build environment of Overschie).

Street Canyon Model

For inner urban roads, the street canyon model CAR II has been recently modified by TNO in accordance to EU regulations. The model was tested over a year in the HEAVEN project in Rotterdam and the emission factors were validated by road tunnel measurements. CAR II is now widely applied by urban authorities in the Netherlands to meet regulatory demands under the EU directive. Contrary to the highway model, the street canyon model is usually applied to compute annual average concentrations based upon annual meteorological statistics, urban emission factors and annual traffic intensity data within the street canyon. The model has been calibrated for over 6 months as part of the HEAVEN project. The model is now adapted to be able to compute the air quality impact of exhaust gas emissions from traffic on the city corridor on an hourly basis.

Emission calculation Module

The emission calculation module in the HEAVEN system is an improved version of Versit, developed by TNO (the Netherlands Organisation for Applied Technological Research) - Automotive in the Netherlands.

This model calculates emissions based on traffic data per vehicle type: average speed, intensity and congestion class. The three vehicle types that are distinguished are: short, medium and long vehicles, the same classes as the real-time Traffic data from Monica. For each combination of pollutant + vehicle type + congestion class specific emission parameters must be provided.

Dispersion Calculation Module

For calculation of dispersion, TNO (the Netherlands Organisation for Applied Technological Research) – MEP (Energy, Environment and Process-innovation) is developing a new model: "Dutch (new) National Model" (DNM).

This model¹ was developed in 1998 and calculates the atmospheric dispersion of point and area sources on an hourly basis.

For the HEAVEN program is this model adjusted to make it suitable for highways (i.e. line sources). Both the Short-term urban highway model and the street canyon model are adapted from the New National Model.

2.1.9 Decision Support System

In the off-line mode, HEAVEN is used to assess the impact of Traffic Demand Management Strategies (TDMS) on air quality. An interface has been designed in order to allow the decision makers and professional users to easily handle all of the traffic and environmental parameters needed to define TDMS and analyse their impacts air quality. The DSS allows the analysis of mobility scenarios such as road closures, banning certain categories of traffic,

¹ New National Model, report of the research of the project group Revision National Model. 1998 TNO, KEMA, KNMI, VNONCW and RIVM. ISBN 90-76323-00-3.

speed reductions but can also be used to assess the impact of the renewal of the vehicle fleet.

2.1.10 Operator Interface

An user friendly interface has been realised in order to display real time traffic emission and dispersion data on the map of the demonstration area. Common tools such as zoom in zoom out, selected data in tabular form and a provision to look back are available. In addition links are provided to other sources of related information such as local and national air quality surveillance networks, public health information, meteorological forecasts, local traffic situation, etc.

2.2 Functionalities of the HEAVEN System

2.2.1 Scenario Analysis

Basically the key-user can import existing data (traffic density, speed and composition; meteorological data; background concentrations; traffic emission data) and modify one or more aspects. This can be done by hand, by across the board changes (for example: all density reduced by 30 %), or by combining for example the meteorological or background data with the traffic data from another hour in the database. This gives great flexibility and reasonable ease of use to analyse what the main contributing factors to pollution episode were or what would happen if traffic is routed in a different manner. All changes can be made to the complete network studied, or to separate road segments. The GIS offers the possibility for routine calculations (for example the area/number of people, which face a certain concentration) but for other purposes the attribute tables of the maps have to be exported to a spreadsheet. For example to be able to compare the concentrations across different scenarios attribute tables for each scenario are exported to a spreadsheet. Examples of the key-user interface are shown elsewhere in the document: section 2.2.3 describes and shows the interface and section 4.4 on the sensitivity test shows excerpts of output screens.

Table 2: Example of an export table (emissions) for selected road segments in 2 scenarios

Sc2:	no RI	LI	RV	LV	NAAM	RUW.	EM_CO	EM_CO2	EM_HC	EM_NOX	EM_PM10
trucks											
105	200.00	418.00	3.25	49.10	Vaanweg 1	0.50	0.20	26.27	0.04	0.08	0.01
57125	1222.00	635.00	89.21	97.76	A20 W3	0.50	0.99	86.09	0.07	0.34	0.04
57160	2506.00	2614.00	90.40	89.50	A20 NO2	0.50	1.61	207.10	0.20	0.69	0.04
57215	866.00	1297.00	90.53	88.89	A15 ZW3	0.50	0.62	87.69	0.08	0.29	0.02
57715	1517.00	2230.00	90.73	89.89	A16 O3	0.50	1.18	151.60	0.14	0.51	0.03
Sc5: Euro 5					Average ruit		1.098	133.120	0.122	0.455	0.035
105	328.00	497.00	3.25	49.10	Vaanweg 1	0.50	0.31	69.53	0.09	0.37	0.01
57125	1455.00	1423.00	89.21	97.76	A20 W3	0.50	0.86	217.90	0.11	0.84	0.03
57160	2759.00	2903.00	90.40	89.50	A20 NO2	0.50	0.95	243.10	0.07	0.49	0.03
57215	1386.00	1801.00	90.53	88.89	A15 ZW3	0.50	0.58	177.70	0.08	0.59	0.02
57715	1697.00	2551.00	90.73	89.89	A16 O3	0.50	0.72	189.70	0.06	0.42	0.02
					Average ruit		0.775	207.100	0.080	0.586	0.022

A key-user application is the analysis of the log files of the web site. In the course of time the web site will built a gigantic database with modelled concentrations which can be scanned or analysed in retrospect (for example the number of days with an average PM₁₀ concentration

> 50 $\mu\text{g}/\text{m}^3$) along a certain road. Currently the data are stored in a binary format for storage efficiency but an export facility to export selected data to a statistical database will be made available.

Figure 7: Presentation of user interface for scenario analysis by professional users

Gelöscht: <sp><sp>

2.2.2 System Management

The main system collecting the data and supplying the website is designed to work automatically and independently. The system keeps track of its well-functioning through elaborate log files. System management is mainly confined to periodically checking of the log files, storing old data and supplying logged data to relevant users who are not able to access the system through FTP.

As the system depends to a large extent on third party information for its operations, timely data communication is a critical issue. Scrutiny of the log files to check performance times and occasionally compressing the database is important.

Key-users operating their stand-alone off-line version are responsible for their own data management. Main functions are accessed using an Arcview interface. Data logged by the main system is added to a local database through FTP. Any other (imaginary) scenario can be constructed by manipulating imported data or storing new data to the system using either the Arcview interface or working directly on the Access database.

2.2.3 Information presentation

The Man-Machine Interface provides the users of the HEAVEN system with a friendly instrument for monitoring the near real time environmental situation along the demonstration area in Rotterdam.

The information platform has two appearances:

- GIS based interface for professional users.
- website for public users

At the centre of both presentations is a map of the Rotterdam city area showing the roads under study. Important users of the information platform are the so-called professional users (representatives of the Rotterdam HEAVEN partners) who can access stored data for further analysis and input into planning processes. The professional users have a different user interface and can perform more actions with the system.

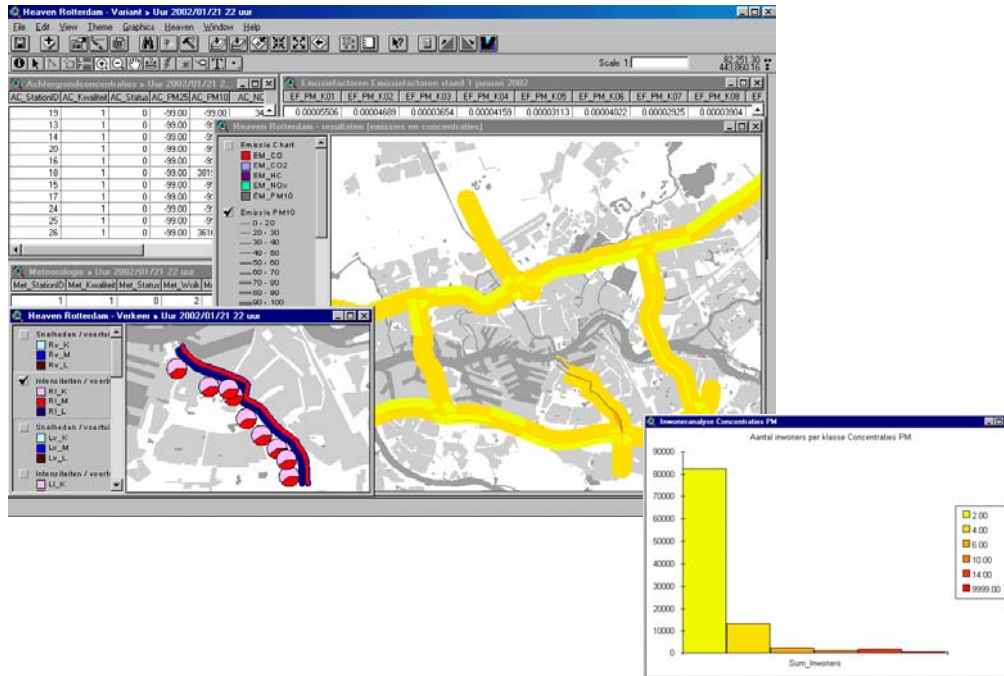
GIS-based interface for professional users

The professional user can open and review the measured values for recent and past situations by opening variants that contain all relevant data. The information will be presented in a standard GIS-interface (tables and maps) inside an especially for Heaven programmes variant-administration shell. There are lots of statistical evaluations possible, as peak-values or number of inhabitants per air-quality zone.

Furthermore, one can recombine different data and form scenarios, edit existing variants and create new scenario-data with special tools. For these variants the environmental model can

estimate impact-analyses of traffic-management, car-composition or extern factors such as weather and background concentration.

Figure 8: Example of the interface of the information platform for professional users



Website for public users

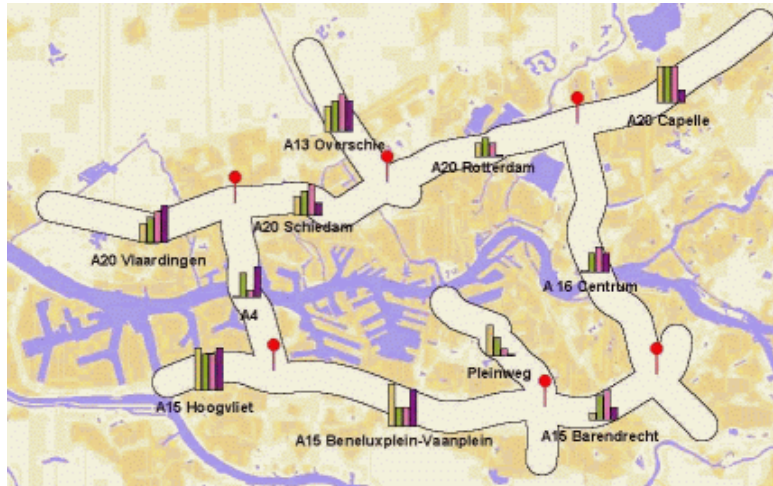
The web site (officially launched on 5 July 2002) provides the public with information on traffic related air-quality. The web site shows hourly NO₂ concentrations, and hourly updates of 24-hour moving averages for benzene, NO₂ and PM₁₀. It also provides a 24 hour forecast and information on air quality and health. Furthermore a "video" of the last 24-hours is added as extra feature. A separate information campaign to draw attention to the web site and promote its use was launched.

The website interface for the public presents the modelled concentrations for a band of 500 m on each side of the road, for benzene, NO₂ and PM₁₀. There are possibilities to look back at concentrations that were modelled in the past. Air quality interpretation is done by means of a colour coded legend. In addition the website provides background information on health and traffic issues, suggestions what people themselves can do, and frequently asked questions. In addition there are links to other sources of information such as the DCMR-EPA web site which provides real time measured concentrations in the wider Rotterdam area, and to the RIVM national air quality surveillance network which provides nation wide real time concentrations. An issue which is much in demand but currently lacking, is to integrate the DCMR and the HEAVEN information to be able to show which part of the modelled concentrations are traffic related and what is the general background (including industrial sources).

Below two impressions from the web site: firstly the general interface and the map with the modelled results for PM₁₀ (24 hour average concentration). Secondly the interface to the historic data: by clicking the graph for a particular road segment a screen opens, showing a graph and a table for the previous week (or year) for each of the three pollutants.

Figure 9: Impression of the public interface of the Rotterdam information platform





2.2.4 Health data

The Rotterdam Public Health Service (GGD) is one of the so-called key users of the system and can closely monitor exposure rates in two of the worst areas in the city. Exchange of information with Leicester and Rome has taken place on the status of the health conceptual framework.

Status of health conceptual framework Rotterdam

Every city which investigates air quality and its health impact is confronted with the issue of risk communication. Ideally health professionals would like to use local air quality data and local health impact data. Within the Rotterdam HEAVEN project, air quality data are generated either by measurement or by modelling. Relevant health impact data (daily hospital admissions, respiratory illness, medicine use) are not routinely collected. Rotterdam is investigating the feasibility of a panel study in which local asthmatic subjects report medicine use. The data would then be used to investigate if there are significant links between air pollution and the use of respiratory drugs. Rotterdam considers a monthly public report about on-going data collection. The intention is to raise public awareness concerning health effects of air pollution and to facilitate funding. We aim at a co-operation between the Institute of Risk Assessment Studies (IRAS) in Utrecht, the Environmental Protection Authority DCMR and the Environmental Health Department of the Municipal Health Service Rotterdam. This intended panel study is not a part of the Rotterdam HEAVEN project.

In the Environmental Information Platform the GGD has compared quality data with health guidelines. Health impact is now described in general terms on the public web site. If requested we will use non-local dose-response relations to translate exposure in effects. Currently the GGD is not using AirQ, but this could be an option when they will be asked to routinely assess health impact on the local population. The GGD is interested in any HEAVEN health spin-off projects.

2.3 General history of system development in Rotterdam

The HEAVEN system in Rotterdam system developed along several parallel lines.

- On the one hand the latest available knowledge on vehicle emission modelling and dispersion was integrated and test sites were installed where model predictions could be compared to actual measurements. This model improvement and fine-tuning period led to some interesting results indicating (amongst others) that the vehicle fleet active in the Rijnmond area during weekdays is slightly more modern than the national average, hence having lower emission factors. During weekend, when professional travel is substantially less, the regional vehicle fleet was comparable to national average. Model fine-tuning was completed by the end of 2001.
- The existing models were stand alone versions, to be started manually or in a batch process, using existing data input sets. For the DSS the models were integrated in an automated environment capable of running without constant user interaction. At the same time data acquisition systems had to be developed to get real time input (meteorological data, background concentrations, traffic intensities and velocities). Several problems occurred along the line, but early 2002 a system was up and running using historic traffic data. Resolution of the traffic data acquisition system took until June 2002 due to technical but mainly administrative problems.
- A GIS based presentation of the results was built and integrated into a public web site. The web site was officially opened in June 2002. Options for feed-back were provided and (minor) improvements as a result of public and professional response were implemented.
- Scenario analysis capability was developed alongside the interface for the public web site. From August 2002 until October 2002 key-users have been able to test the interface and perform the scenario analysis (see section 4.4. and 5.3) bringing traffic analysis capabilities to relative novices. Previously this capability was limited to those knowing how to handle the stand alone models. As a result of the first scenario calculations, some changes were made to improve the flexibility of the input and the output of this part of the DSS.
- Finally results of the DSS dispersion model in its fully automatic mode were compared against measured concentrations. (See section 4.2) As a result of this validation the way the system handles the background concentration was improved in November 2002.

2.4 Future adaptations to DSS

- Additional information in charts for selected hotspots with trends of last week and last year for specific hotspots will be included on the website.
- Integrated approach of environmental problems like air pollution, noise and safety.
- Rotterdam is highly affected by industrial air pollution. Through that background concentrations range a lot. The background concentration is crucial as model input. There can be a possibility to improve the input by better knowledge of the varying background concentrations.
- Extend the web site with a wider range of inner city corridors.
- Research into the effects of plants and trees along roads on the dispersion of air pollution and noise.
- Introduction of measures in periods with high concentrations. The public and the authorities are constantly aware now of the occurring and predicted concentrations.

3. Verification

3.1 Introduction

This chapter serves as a summary, and where necessary as an update, of the verification results previously reported in Deliverable 7.1.

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. The 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 took account of the main processes, data flows and data stores. The indicators have been grouped into the three main themes of verification a) Testing physical functioning of the system, b) Preliminary user acceptance and c) 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 was also in operation as part of the verification process. All other indicators in the verification stage were 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.

3.2 Main results from verification in Rotterdam

3.2.1 Indicator 1: Accuracy of the DOAS compared to traditional equipment

The Rotterdam experience was reported in Deliverable D8.2, section 5.2.1 (the Rotterdam Demonstration Plan).

3.2.2 Indicator 2: Accuracy of roadside description, air models

Detailed results were reported in D7.1.

In D8.8 additional results will be presented on roadside analysis in Chapter 4 (Evaluation)

3.2.3 Indicator 3: Accuracy of roadside description, noise models

This indicator is not applicable for Rotterdam.

3.2.4 Indicator 4: Testing processes of DSS interfaces

The system in Rotterdam was newly developed, and therefore a number of minor technical problems were experienced during the verification phase, which delayed the verification process. Finally all elements have been fully tested and the appreciation of some of the indicators were postponed to this document. The remaining indicators are treated in the next sections, completing the testing of the DSS.

The DSS was built and tested by Goudappel Coffeng. The version of the DSS, which acts as a HTML-server for the HEAVEN-Rotterdam website was officially opened on the 5th of July 2002. Individual copies of the DSS designed for scenario analysis were provided to key-users among the Rotterdam participants (municipality of Rotterdam, traffic department and environmental policy department; the regional public health service; the regional office of the ministry of traffic and public works; the province of Zuid Holland; the DCMR-EPA). The DSS was installed and after brief instructions key-users can operate the system independently. Experiences used to complete the remaining indicators in this document are generally based on key-user experiences.

Indicator 4a: Test interface to Traffic Monitoring process

The real-time traffic information works well for the corridor in Rotterdam. Real-time traffic information for the ring road became available in June. The system was fully operational, (stable connection, timely data transmission, etc.) on the 21st of June 2002. Since then the system has had two short breakdowns, which could be remedied by a reset. The system has been modified to provide automatic error messages to the operators in case of data-acquisition problems and automatically switches to using historic data (same day, same hour of the previous year) to supply the web site. Conclusion: the data-acquisition system for real-time traffic data is operational.

Indicator 4b: Test interface to Meteorological monitoring process

The data-acquisition for real-time meteorological information (process P4) is operational, barring third party problems. Typical data availability since July exceeds 97 %.

Indicator 4c: Test interface to Environmental Monitoring network

The real-time background concentrations (Process 5) from DCMR, did not reach the required operational time during the verification period. In this period operational time was 90 % (excluding one event, which caused the overall performance to drop to 77 %). Some modifications were made and the system improved. Since June 2002 the availability approaches 96 %. The way the system handles the imported background concentrations has been modified as a result of DSS verification analysis (see section 4.2 and annex A)

Indicator 4d: Test interface to static & infrequently updated information process

The import of static and infrequently updated data (Process P1) ran as planned during the testing period in December 2001 and January 2002. A further improved version was distributed to the key-users to automate the import of traffic emission factors. The data import now covers all user changeable aspects and operates correctly.

Indicator 4e: Test interface to information flow process

The system works up to expectations. Speed is sufficient to assure hourly updates of concentration predictions. The ring road is subdivided in 42 sections for which an emission calculation is made. Concentration calculations are made for some 785 receptor points. The main classes (good, moderate, bad, very bad) are easily distinguishable with contrasting colours. The class 'good' remains subdivided with different shades of yellow, to provide an additional impression of the quality at different distances from the road even if the overall quality is good.

3.2.5 Indicator 5: Testing DSS modelling and forecast processes

The indicators 5a (vehicle emission model), 5b (concentration model) and 5e (result collection) achieved an operational time of 100%. The speed of the tested processes (P111, P120b and P121a and c) was sufficiently high to collect the data and complete the necessary emission and concentration calculations on an hourly basis.

Indicator 5c (test noise modelling process)

Not applicable for Rotterdam.

3.2.6 Indicator 6: Testing DSS operator interface and scenario processes

Scenario calculations were done by a selection of the key-users. The system is sufficiently easy to operate, though prior knowledge of GIS is an asset. Results of the calculations are reported in section 4.4 and 5.3.

To do a scenario analysis for an existing hour a key-user will have to download the relevant data from the central system serving the web site. This option is implemented using FTP. However, most of the key-users are connected to their own organisations internal network and the network managers have generally prohibited FTP-activities. Currently the Public Health Service and DCMR-EPA (where the system is hosted) can access the data logs. Incidental data requests can be met by the DCMR-EPA but frequent users will have to arrange their own FTP access.

Indicator 7: The functioning of the system components and their interaction

The main system was operational in the verification phase but at that time some of the subsystems were not yet complete. Since June 2002 the system is complete and supplies the public web site with information. Problems in subsystems have not caused the main process to halt. The system is designed to make a fresh start in each hour. A malfunctioning subsystem will cause an hour to be skipped but will not cause the main system to 'hang'. The overall performance of the concentration modelling process (including down time due to the background concentrations, traffic data and meteorological data) met the evaluation criteria (95 % in three weeks) in June. This was verified by an automatic search of the log files. The quality of the dispersion calculations (the modelling as performed by the DSS) is up to standard (see section 4.2 and annex A).

3.2.8 Indicator 8: User acceptance by professional users

Key-users have been able to work with the system in the second half of 2003 and further. Some minor bugs and inconveniences in the interface were discovered and remedied and/or improved. The system currently works up to expectations and is reasonably fast. Scenario calculations take 10-20 minutes depending on the scenario and the hardware. The interface is built on the Arcview platform and prior knowledge of the GIS is an asset. For most of the key-user an FTP facility still has to be created by the participating organisation.

Key-users are enthusiastic and expressed the wish to include more roads. The historic database is likely to become an important source of information for urban planning. A provision to search and analyse yearly data sets will be welcome. A provision for extracting this kind of data will be available early 2003. A summary of the data resulting from the interviews is presented in section 4.5; detailed information is provided in the evaluation document (WP3).

3.2.9 Indicator 9: User acceptance by the general public

The web site presentation was shown to a group of concerned citizens prior to the formal opening. Some small changes were implemented. Since July 2002 the website is public and an on-line questionnaire was provided for reactions. Detailed results of the analysis of the questionnaire are reported elsewhere (WP3) but a summary of the results is available in section 4.5.

The general reaction is one of appreciation of the information. As the DSS focuses on the zone immediately adjacent (500 m on each side) to the major roads a lot of questions arise concerning the air quality outside the shown areas. This is a point that needs further attention in the future. Some information is provided by a link to the DCMR-EPA web site, which shows real-time concentrations of the regional air-quality network. Further information is provided by a link to the RIVM national real-time network.

A second point of attention is the wish to look back. This was implemented in a limited way: the public can cycle back through the last 24 hours and can search for the worst situation (since the last reset). The link to DCMR-EPA provides a 30-year history of year average concentrations. A website version with the possibility to look back to results in the past week and past year (tables and graphs) for selected road segments will be operational early 2003. Analysing the first batch of questionnaires has given an impression of the most frequently asked questions. A FAQ-pages has been added to the web site early November 2002. Other

minor improvements (improving the background map, etc.), that do not require substantial or specialist attention are implemented on a continuous basis as a result of the public remarks.

Finally it is good to note that the publicity surrounding the web site, in combination with the municipal air quality reports (recently published as a consequence of the implementation of the daughter directive on air quality in the Dutch law), has led to tremendous attention amongst the public and the local politicians, for the HEAVEN effort and the test with the 80 km speed limit.

3.3 Summary

- The most important action following the verification period was to achieve an operational time of 100% for the DSS. Solutions have been implemented to ensure the stability of the system. The system is now fully operational.
- The meetings with the public users concerning the web site have shown that there is certainly a need for easy access to information on traffic related air quality.
- In order to create a better living environment, the maximum speed on the A13 highway going through the Overschie district has been reduced from 100 to 80 km/h in May 2002.
- In conclusion, all users were very happy with the HEAVEN initiative!

4. Evaluation in Rotterdam

4.1 Introduction

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 define 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.

In this evaluation chapter of the demonstration report we concentrate on the validation and calibration of the dispersion model used in Rotterdam. Furthermore we will present a short summary of the results of the Rotterdam evaluation, based on the indicators defined in WP3 (Evaluation).

The emission-dispersion and street canyon models that were adapted and improved under the Heaven project underwent fine-tuning against specifically designed air quality

measurements during a calibration and verification period. After the calibration period the finished emission-dispersion model was further compared against measured values at two sites to create an independent validation period. One of the air quality monitoring sites used during validation will continue as a permanent monitoring station and can be used for future checks on the model. The other validation measurement site was a temporary site for the purpose of this project.

4.2 Validation of HEAVEN DSS Dispersion model in Rotterdam

The information presented in this section is part of the evaluation procedures of the HEAVEN project. It deals with the validation of the dispersion model in the HEAVEN Decision Support System (DSS) in Rotterdam. The predicted ambient air concentrations are compared to real-time measured concentrations and tested against predefined criteria. The TNO dispersion model was validated by DCMR (the regional environmental agency).

The DSS features a public website where modelled concentrations are shown in the form of a map. The concentrations are stored in a log file. The logged concentrations calculated at receptor points at 38 and 250 m from the centre of the road were compared with the measured values at similar distances for benzene, NO₂ and PM₁₀.

The complete report of the validation of the Rotterdam Heaven DSS Dispersion model is given in annex A.

4.2.1 The TNO Dispersion model

The dispersion model used in the HEAVEN DSS in Rotterdam was the TNO-urban highway model. This dispersion model computes the air quality impact of exhaust gas emissions from traffic on highways through and around cities on an hourly basis. The model is an enhancement of the TNO-traffic model, which is used to calculate the annual contribution to air quality around highways. TNO-urban highway model estimates the air quality for NO₂, PM₁₀ and benzene in urban areas, which are located in the direct vicinity of highways and inner-urban roads. The model requires hourly standard meteorological data. In Rotterdam, urban background air quality data is provided through the DCMR air quality monitoring network for different wind directions. Traffic data are generated by road loops that distinguish the type of vehicle (light, medium and heavy duty vehicles) and speed. Emission factors are derived from TNO-Automotive, which manages the national database on road traffic emissions. The model has been calibrated over 6 months for both the situation in the "open field" (highway in open field) and the "build environment" (highway through the build environment of Overschie).

4.2.2 The validation results

The results of the comparison between the log file of the dispersion model and the measured values in the first three weeks of July 2002 are shown in table 3. No selection for wind speed and direction was made. The case where the indicator does not meet the evaluation criteria is marked grey. Two indicators have been proposed (see annex A). ΔC allows positive and negative errors to cancel each other out. This might be an admissible indicator to judge the quality of a medium to long-term average concentration but it leads to overly optimistic results if the performance of the model on an hour to hour basis is judged. ΔC_a reflects the absolute value of the errors so over- and underestimates don't cancel out and this seems a more appropriate measure for the performance of the hourly values calculated by the DSS.

Two monitoring sites were used for the model validation. Monitoring site E1 is located at some 40 m east of the axis of the A13 highway. Site E2 is located at 210 m east of the A13. The model performs calculations for a series of so-called 'receptor points'. For the purpose of comparison an exact distance match between E1 and a receptor point exist. For E2 a receptor point at 250 m distance was used. The comparison applies to the overall performance of the model in the DSS and was not limited to selected directions of the wind and using a regional background concentration. Under these circumstances the model performs up to expectations (see table 3) If the evaluation had been narrowed down to specific wind sectors and the use of the corresponding background concentrations, as was done during the model development and verification period) the performance is likely to be even higher. This is confirmed by table 4, which summarises several months of verification measurements.

Table 3: Measured and calculated concentrations at two distances from the centre of the highway

Site	Number hourly observations	of Pollutant	Concentration ($\mu\text{g}/\text{m}^3$)		ΔC	ΔC_a	Criteria ΔC
			Measured	Calculated			
E1	368	NO ₂	36.5	41.2	0.07	0.30	0.6
E2	368	NO ₂	33.4	27.9	0.23	0.37	0.6
E1	376	PM ₁₀	42.6	39.3	0.12	0.20	0.5
E2	376	PM ₁₀	39.2	36.2	0.12	0.21	0.5
E1	344	Benzene	1.13	1.05	0.31	0.53	0.5
E2	374	Benzene	0.90	0.90	0.24	0.46	0.5

Table 4: Urban highway verification measurements (Data: TNO 2002)

Site	Pollutant	ΔC	ΔC_a	Criteria ΔC
E1	NO ₂	0.04	0.28	0.6
E2	NO ₂	0.28	0.33	0.6
E1	PM ₁₀	0.06	0.15	0.5
E2	PM ₁₀	0.05	0.15	0.5
E1	Benzene	0.23	0.38	0.5
E2	Benzene	0.64	0.72	0.5

July – August 2001, wind sector 210-340.

The shaded cells do not meet the evaluation criteria.

The DSS uses the measurements of one of the permanent monitoring sites as a background concentration depending on the direction of the wind. These monitoring stations are not truly background stations as they are designed to pick up the impact of the industrial activities in residential areas as well. Therefore heightened industrial activity or incidents might influence the station that was used as DSS background. The Rotterdam ring road (Ruit) which is subject to the DSS modelling passes nearby industrial areas so for some parts of the Ruit the

background concentration transmitted to the system is indeed the true background. However, the DSS monitoring sites are located further away from the main petrochemical areas. This occasionally leads to background concentrations that are too high and hence to calculated concentrations that are too high. This effect occurs more frequently in the case of benzene as traffic emissions are relatively small.

Though the DSS operated up to standard the observed problem with the use of measured background concentrations has led to a modification (early November) to further improve the system. Instead of using a single background station depending on the direction of the wind, the background will be calculated as the average of all regional stations operational in the said hour (currently 3) except the station with the highest concentration. This should provide a more representative background concentration and weed out freak values due to an incident near one of the monitoring sites.

A background model could have prevented this problem but at the time of building the Rotterdam DSS no real time background model to start from was available. Currently only long-term average background data are available for the calculation of year average concentrations. Developing a real time background model was not considered as real time data was readily available from air quality monitoring stations from the local EPA (DCMR).

A major advantage of a background model instead of an average background concentration based on measurements is the spatial differentiation over the area. It is envisaged that at some point in the future (2004) the traffic related air quality information (as shown on the web site linked to the DSS) is integrated with information available from the web sites of the local EPA and of the national air quality monitoring network. At that point a real time contour map for the whole Rijnmond area will have to be generated and the use of some kind of background model will be necessary.

The overall conclusion is that the urban highway model performs consistently up to expectation under a wide range of conditions. Details per component (Benzene, Nitrogen dioxide and Particulate matter) are presented below:

First we present a summary table of the regression results presented in the next sections:

Table 5: Some regression characteristics of the validation measurements

	Raw regression data				Regression after correction for outliers			
	site E1		site E2		site E1		site E2	
	coefficient	R ²	coefficient	R ²	coefficient	R ²	coefficient	R ²
NO ₂	1.17	0.64	0.79	0.60	1.08	0.76	0.85	0.74
PM ₁₀	0.90	0.53	0.90	0.46	0.93	0.72	0.93	0.69
Benzene	0.87	0.16	0.96	0.24	0.85	0.47	0.91	0.51

NB:

- all regressions are forced through the origin;
- the regression coefficient corresponds to the measured value (as in the graphs in the following sections);
- R²-values are based on hourly values.

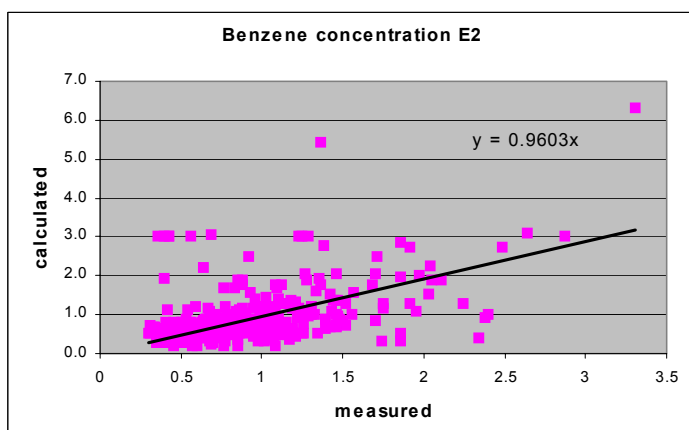
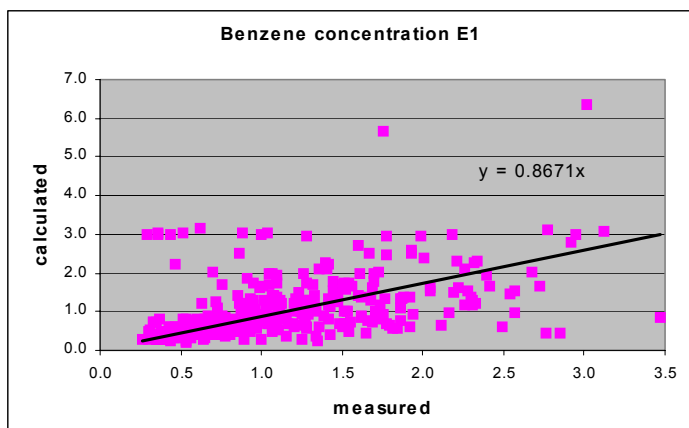
The graphs presented in the next section are the raw regression data and reflect the performance of the DSS under normal operation conditions in the validation period. The worst problems with background concentrations have been solved in the mean time but, as

discussed above, especially benzene remains sensitive to the used background concentration. This can be seen from the broad scatter in the diagrams and the poor R^2 -values. To get an impression of the quality of the DSS¹ as it currently operates one could look at the regression results after correction for outliers. This leads to considerable improvements in the R^2 -values. A more thorough assessment of the performance of the DSS will be made after a full-years operation when seasonal influences (especially on PM_{10}) can be accounted for.

¹ To assess the quality of the individual dispersion model one would have to analyse the data using selected wind directions and dedicated background concentrations. This was done during the calibration period and reported previously by TNO. Those results were summarised in table 4.

4.2.3 Benzene

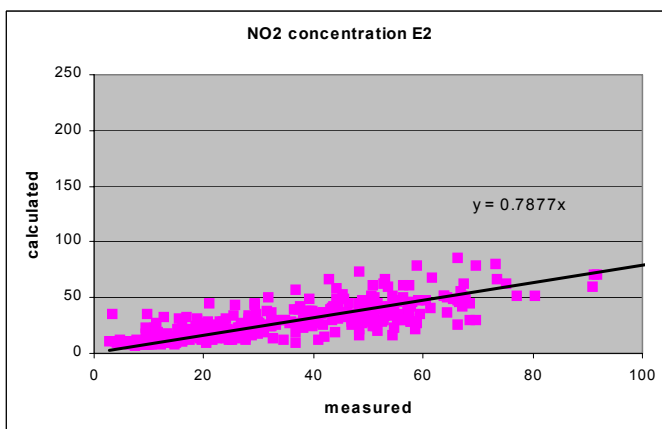
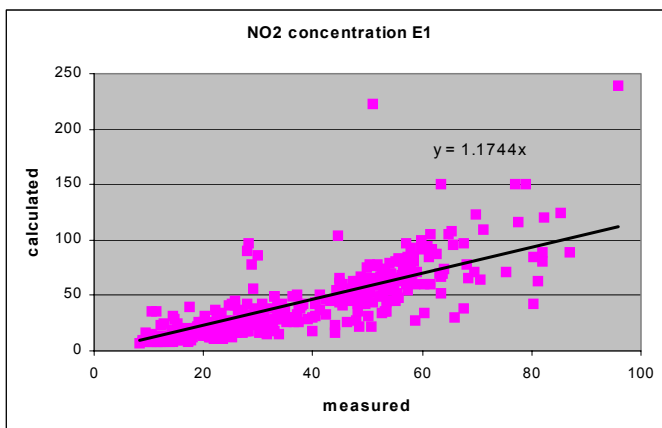
For benzene two cases with calculated concentrations above 20 $\mu\text{g}/\text{m}^3$ have been discarded but the scatter plots show that there are still a number of suspect cases in the data set. For example the series of points with a calculated concentration around 3 $\mu\text{g}/\text{m}^3$ irrespective of the measured concentration are likely due to erroneous background concentrations. The values above 5 probably have the same problem as these concentrations are not affected by the distance from the road.



Note that the regression line was forced through the origin.

4.2.4 Nitrogen dioxide

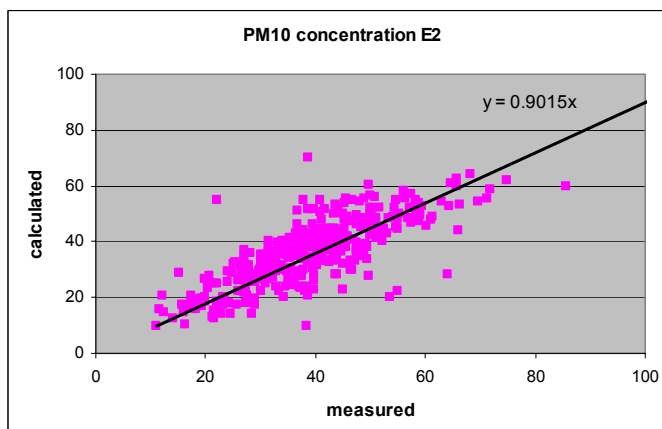
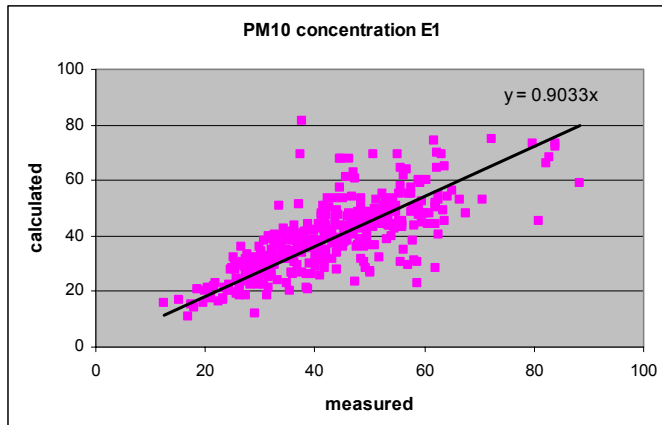
The same applies to NO₂ but to a lesser extent: the traffic related NO₂ concentration is substantial compared to the background concentration so undue background variation has a smaller impact than in the case of benzene. The graph at E1 probably suffers from two outliers. At E2 the model predictions seem low but this can be attributed (at least partly) to the fact that E2 is closer to the road than the point of calculation.



Note that the regression line was forced through the origin.

4.2.5 Particulate matter

The PM₁₀-concentrations correspond very well. The PM₁₀ background is rather stable and substantial so the impact of the vehicle emissions on the concentrations is less than for example in the case of NO₂. The calculated concentrations are smaller than the measured concentrations at both distances. This is probably due the correction factor, which was applied to the measured concentrations. This factor tends to be higher in the winter than in the summer. Applying the year average correction factor to the July measurements will overestimate the measured concentrations.



Note that the regression line was forced through the origin.

4.3 Calibration of HEAVEN DSS Dispersion model in Rotterdam

This section describes the development and calibration by TNO for their ambient air modelling module within the HEAVEN project in Rotterdam.

The TNO report R 2002/377 (HEAVEN project, report on the TNO measuring and modelling results in 2000 and 2001 for use of the development of a new atmospheric dispersion model) presents all detailed results of the model calibration performed by TNO.

In annex B a selection of the TNO model calibration report is presented, describing the development of the new atmospheric dispersion model.

The development of the modelling has taken place in two stages. In the first stage the model development was based on dispersion modelling for an "open field" situation. It was reasoned that in this first stage the model to be developed should be able to calculate ambient air concentrations from traffic emissions with a relative high degree of confidence in an "open field" situation without any obstacles such as noise barriers, buildings, and so on. For the tuning and validation of the model measurements of among others NO/NO₂, PM₁₀ and traffic intensity have taken place in an open rural area close to Rotterdam.

In the second stage the modelling has taken place for an urban area (the Overschie district) in Rotterdam. The highway A13 runs through Overschie and has noise barriers at both sides of the highway. The previous measurement stations were transferred to Overschie and measurements of the mentioned components were continued to improve and tune the model for the urban situation (now including urban obstacles such as noise barriers and buildings).

Furthermore a measuring station was located at an inner-urban road segment (street canyon) for the development of a hourly model for inner-urban roads.

After tuning of the model a validation period of several months has taken place in which modelling results and measurements were compared. From these validations performance characteristics of the model have been determined.

4.3.1 Model development for highway segments

The model used is a bi-gaussian dispersion model which is derived from the (new) Dutch National Model (developed in 1998). As the Dutch National Model is used for the calculation of the atmospheric dispersion of point and area sources on a hourly basis, this model has been adjusted to make it suitable for highways (i.e. line sources) to make it suitable for the HEAVEN project.

Adjustment for highways

The highway being studied is partitioned into a number of road segments. For every calculated hour these segments are projected onto the governing wind direction. In this way a box is constructed, perpendicular to the wind, in which homogenous mixing of the traffic emissions is assumed. The side of the box then acts as an area source. The dispersion from this area source is then calculated in a standard way using an analytic expression for the contribution of every road segment to every receptor. Care is taken to partition the road into an appropriate number of segments in order to avoid numerical problems at small angles. Later optimizations of the model could focus, among others, on the best partitioning algorithm to minimize computing time. The height of the box is essentially a measure of the turbulence over the road. A comparison with literature and the existing TNO traffic model indicates that a appropriate box height is 2.5 - 5.0 meters. This is one of the parameters

which have been tuned to fit the measuring results for the open field situation as well as the urban situation.

Calculation of dispersion parameters

For the calculation of the concentration at a certain receptor point the dispersion coefficients for the Gaussian plume model are needed. The necessary dispersion coefficients are calculated from meteorological data on an hourly basis using a meteorological preprocessor. for each hour in which meteorological data is available.

Calculation of the traffic emissions

The traffic emissions are calculated on basis of actual traffic intensity data obtained from the Dutch Highway Authority and emission factors. The emissions factors were obtained by the TNO-Automotive institute. Through a conversion module the traffic intensity data were converted to a distribution of certain vehicle types (HDV, LDV and cars) with the associated emissions to a total traffic emission value for each hour.

Background concentrations

In general the model calculates only the contribution of a source (in this case the line source of traffic emissions) to the background concentration. The true or total concentration can be obtained by adding this calculated contribution by the traffic to the background concentration. The background concentrations were obtained from background stations.

Tuning of the model

Measurements from the "open-field" situation were used to tune and validate the model under relative simple dispersion conditions (no obstacles as in urban areas such as noise barriers, buildings and so on). In the second stage measuring data were used from the urban measurements to tune the model to in more complex dispersion conditions in urban areas. The tuning of the model were focussed on the earlier mentioned box height, roughness and other dispersion determining parameters (such as wind profiles in urban areas).

Model development for inner-urban roads

The air quality for inner-urban roads in Rotterdam is modelled using the TNO "traffic" model, which has developed and based on extensive wind tunnel studies in the past. Using the orientation of the street, the type of buildings, the local meteorological conditions (on an hourly basis) and traffic intensities the model predicts the air quality at any point in the street.

The traffic is modelled as a set of line sources. Using dispersion relations the concentration of the pollutant(s) can be determined at any location. The influence of traffic induced turbulence is compensated for by increasing the initial dispersion of the pollutant plumes. Building influence is treated by using empirical relations derived from extensive wind tunnel studies in the past.

[1] Traffic intensities at the Pleinweg (station E4) are not (yet) available on an hourly basis, however use have been made of available visual countings of a representative daily traffic intensity cycle as well as daily total traffic intensities. The model results are compared to the actual hourly measured ambient air quality levels at the Pleinweg on an hourly basis.

Measurement set-up

Open field measurements

As described earlier measurements haven taken place at an "open field"location for a five month period at the A13 highway. This highway runs roughly in northerly direction from

Rotterdam to the city of Delft. As the prevailing winds in the Netherlands are mainly southwesterly, three measuring stations were projected in such a way that one station (A3) was used as a background station west of the A13 and the two other stations (A1 and A2) as influenced stations east of the A13. The background station (A3) was located about 1 km in a rural area with no influence of nearby roads. The first station (A1) under influence of the A13 traffic emissions was located about 50 m east of the A13 and the second station (A2) under influence at about 200 m east of the A13.

The measuring stations were equipped with continuous NO_x analysers, BTEX-analysers, PM₁₀ (TEOM) monitors, CO analysers (except A2) and O₃ analysers (except A1). Furthermore at each station meteorological data (such as wind direction and wind speed, global radiation and temperature) was monitored. The ambient air concentration were measured as hourly averages.

One of the inputs of the model is the traffic intensity. The hourly traffic intensity was obtained from the highway department of the Federal Agency for Roads and Waterways (Rijkswaterstaat), through electronic traffic counting systems in the road pavement.

Urban measurements

The urban measurements were performed during a period of about 6-8 months at three measuring stations in the urban area in the district Overschie in Rotterdam and one measuring stations at an inner-urban road in the southern part of Rotterdam. To this the previous described measuring stations were moved from the open field location to Overschie. The stations were located at a city background location (E3) with the prevailing westerly winds, at a location directly influenced by the highway A13 (station E1, about 10 m from the highway behind a noise barrier) and at a location (station E2) about 200 m east from the highway in the urban area. The location (station E4) in the southern part of Rotterdam at the inner-urban road was located at a four lane road with two adjacent parallel roads which give access for parking in front of the house blocks. The total width of the street canyon was 50 m. And the height of the house blocks is four apartment levels.

The following components were measured :NO_x , BTEX, PM₁₀ (TEOM), CO and O₃ . The ambient air concentration were measured as hourly averages.

The measuring stations were equipped with continuous NO_x analysers, BTEX-analysers, PM₁₀ (TEOM) monitors, CO analysers (except E2) and O₃ analysers (except E1 and E4). Furthermore at each station meteorological data (such as wind direction and wind speed, global radiation and temperature) was monitored. The ambient air concentration were measured as hourly averages.

4.3.2 Comparison between modelling and measurements

In the TNO report R 2002/377 (HEAVEN project, report on the TNO measuring and modelling results in 2000 and 2001 for use of the development of a new atmospheric dispersion model) presents all detailed results of the model calibration performed by TNO. In annex B the TNO calibration report is presented (describing the development of the new atmospheric dispersion model). In this section we present a short summary from the TNO calibration results.

The comparison between modelling and measurements and thus performance of the models show the following results:

- At each location it showed that in all - except but one – situations the (monthly) average deviation was below the prescribed 60% for NO₂ and below the prescribed 50% for PM₁₀ and benzene.
- For the *open field location* it showed that in 50% of the cases the average difference was even below 10%. Furthermore the *hourly* deviation between modelling and measurements was around 20% in 50% of the cases.
- For the *urban location* it showed that in 50% of the cases the average difference was below 12%. The *hourly* deviation was around 30% in 50% of the cases.
- For the *street canyon* It showed that in 50% of the cases the average difference was below 10%. The *hourly* deviation was around 30% in 50% of the cases.

From the comparison between modelling and measurements it shows that the agreement is reasonable, encouraging and is within the demands laid down in the HEAVEN-project. Nevertheless there is still room for further refinement. More detailed analysis of the modelling results will be presented in a separate report.

The vast amount of data presented here will serve as a basis for further analysis of traffic related air pollution studies in urban areas and specific in the City of Rotterdam.

4.4 Common TDM scenarios: sensitivity tests

Within the HEAVEN project, two sets of scenarios have been implemented. The first set is common to all the cities and is termed the five sensitivity tests. These are listed in table 7. The calculation of the scenarios is done for an hour with an average pollution episode, representative for high summer concentrations. The second set comprises the city specific scenarios (see 5.3) for the same hour.

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.

Table 6: Sensitivity tests to be modelled by all partner cities in the HEAVEN project.

No.	Scenario Description
1	20% flat reduction of vehicle speed
2	100% - 0% reduction of Heavy Goods Vehicles (over 3.5 tonnes) without compensation
3	100% - 0% reduction of two-wheelers (not applicable for Rotterdam)*
4	100% - 0% reduction of traffic*
5	100% of vehicles fulfil Euro5 emission standards

*Motorised two-wheelers make up a negligible quantity in the Rotterdam fleet. The traffic monitoring systems do not include two-wheelers as a separate category, therefore scenario 3 will not (can not) be analysed in Rotterdam.

4.4.1 Emission reduction

The graphs (figure 10 and 11) show the results of three emission scenarios. The reference hour was 17-06-2002 at 19.00h. The hour is an example of a typical summer situation with fairly high concentrations and a substantial difference between roadside and background concentrations. Modelled concentrations for the reference hour are set at 100 % and the results are expressed as a percentage relative to the stated hour.

Graph (figure 12) shows the distribution of the emission by the different traffic participants as predicted by the DSS model.

The results show that the standard emission model as it is implemented in the DSS is insensitive to a 20 % speed reduction in the range of 80 to 100 km/h. At the Pleinweg no changes are expected (average speed changes from 50 to 40 km/h). A dedicated version of the emission model was used to analyse the impact of a change in maximum speed in the Overschie area (see section 5.4). This version of the model predicted a 20 % decrease in NO_x emissions. The need for a special version of the model becomes apparent by taking a closer look at the emission model. See box.

BOX: The TNO traffic emission model

The vehicle emission model is based on research by TNO Automotive¹. After a review of available data and field research it was decided that idealised driving cycles (for example as in Eurotest) do not fully reflect actual vehicle emissions under real world conditions. After a series of driving tests a set of classes were identified that could be used to categorise highway congestion situations. Class borders were based on criteria such as: real traffic conditions as imposed by the existing speed limits, traffic congestion and traffic density. This led to nine classes, which were convenient and reasonably homogeneous, both to typify vehicle emissions as well as to categorise congestion situations. For free flow highway traffic class borders occur at 75, 100 and 120 km/h. A further distinction is made between traffic densities above and below 1000 vehicles per lane/hour. It turned out that real world emissions in the speed range below 100 km/h were mainly determined by driving dynamics (accelerating/decelerating). At velocities above than 100 km/h, speed itself became a major influence on emissions, next to driving dynamics.

A situation with homogeneous moving high way traffic at a speed of 80 km/h (as imposed in the Overschie demonstration test) does not normally occur, and therefore was not included in the TNO research. Hence currently there is no emission category for that situation. In fact, high way traffic moving at 80 km/h is currently a sign of congestion!

As a consequence of these class borders, a 20 % reduction of the vehicle speed would have no impact if all vehicles were moving at 100 km/h. The reason why the DSS version of the model does show some effects is due to the fact that, despite the original speed limit, some vehicles were moving faster than 100 km/h. Nevertheless the average effect on the whole

¹ Emissions and Congestion - Estimation of emissions on road sections and the Dutch motorway network. Executive summary. Gense et al. 2001. TNO report 01.OR.VM.044.1/NG.

traffic stream is limited. A second interesting phenomenon is visible from the modelled data, if one looks at the VOC emissions. If an across the board reduction of the vehicle speed, at the said hour, of 20 % is implemented some of the heavy traffic ends-up at vehicle speeds below 75 km/h. In this class (40-75 km/hour) engine efficiency is less than in the 75 to 100 bracket, resulting in seriously higher emissions, especially for VOC. In fact, for the hour used in this test the 20 % speed reduction results in a 1 % increase of VOC emissions. So the test results show that the model in the DSS operates in a consistent way and in line with the research which led to the model. The model does not yet capture, the previously non-existent, combination of modest speeds without congestion.

The second issue is the apparent inconsistency between the two versions of the traffic emission model: one which is not very sensitive to a speed reduction of 20 % and another which predicts an impact of the reduction of the maximum speed from 100 to 80 km/hour. The reason for the different outcome is related to the way the information is fed into the model: if the maximum speed is reduced to 80 km per hour driving dynamics are virtually eliminated and **all** vehicles can drive at this speed. To model the effect all vehicle speeds were fixed at 80 km/h, **raising** the speed of some part of the traffic (notably trucks) to an environmentally more efficient speed of 80 km/h. In the scenario 1. exercise (for which the results are shown below) the vehicle speeds were simply lowered by 20 % without taking into account the traffic homogenising, resulting in minor positive (and negative, VOC) effects.

Figure 10: Emission reduction in scenario 1, 2 and 5 on the Pleinweg corridor

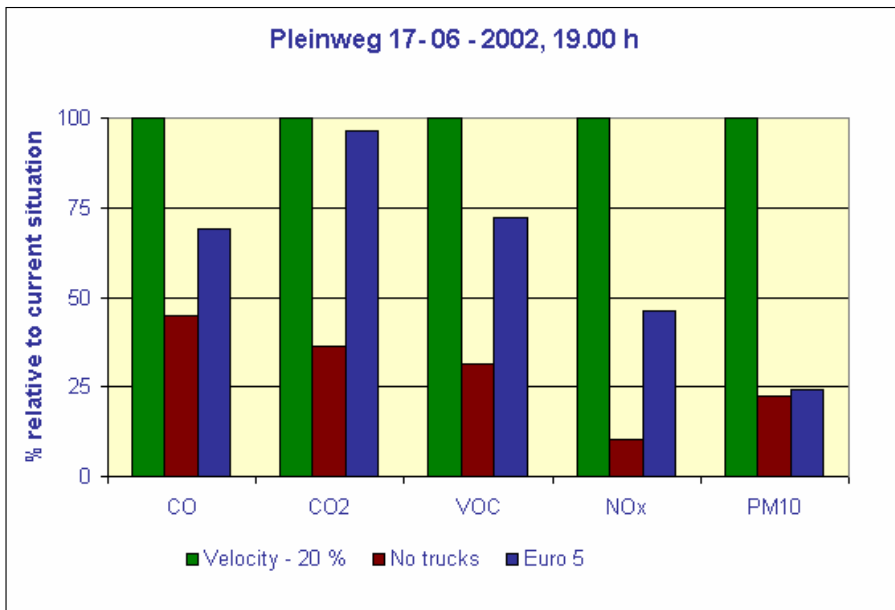


Figure 11: Emission reduction in scenario 1, 2 and 5 on the ring road

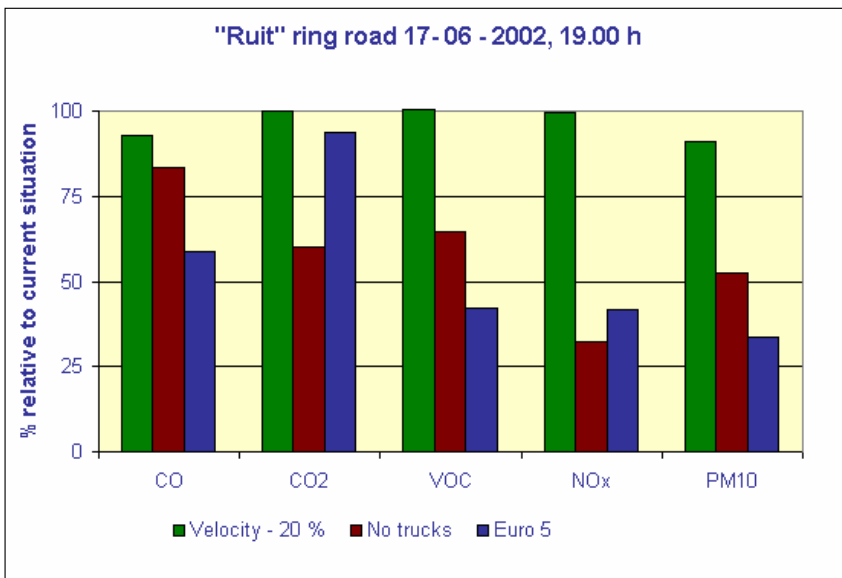
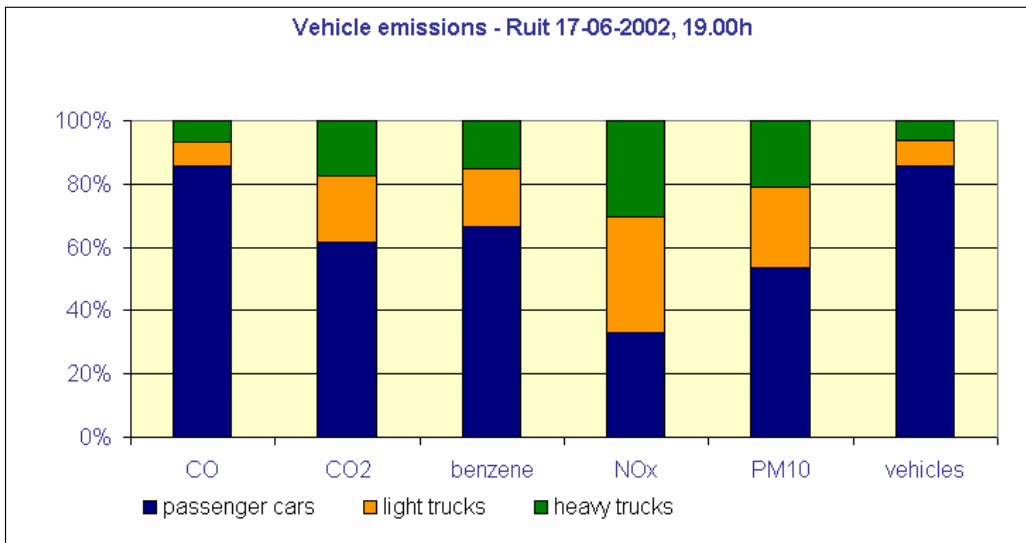


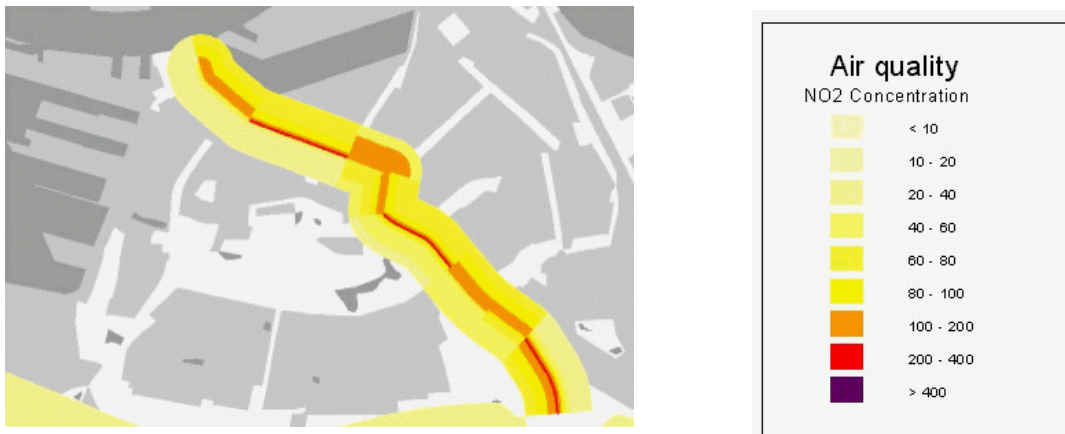
Figure 12: Modelled distribution of the emission by the different traffic participants



4.4.2 Impact on concentrations

Figures 13, a. to d. show the concentration maps from the web site. The air quality concentration maps present the case of the 1 hour average NO₂-concentration in the different scenarios. The example is from the Pleinweg corridor.

Figure 13: Concentration maps following scenario analysis



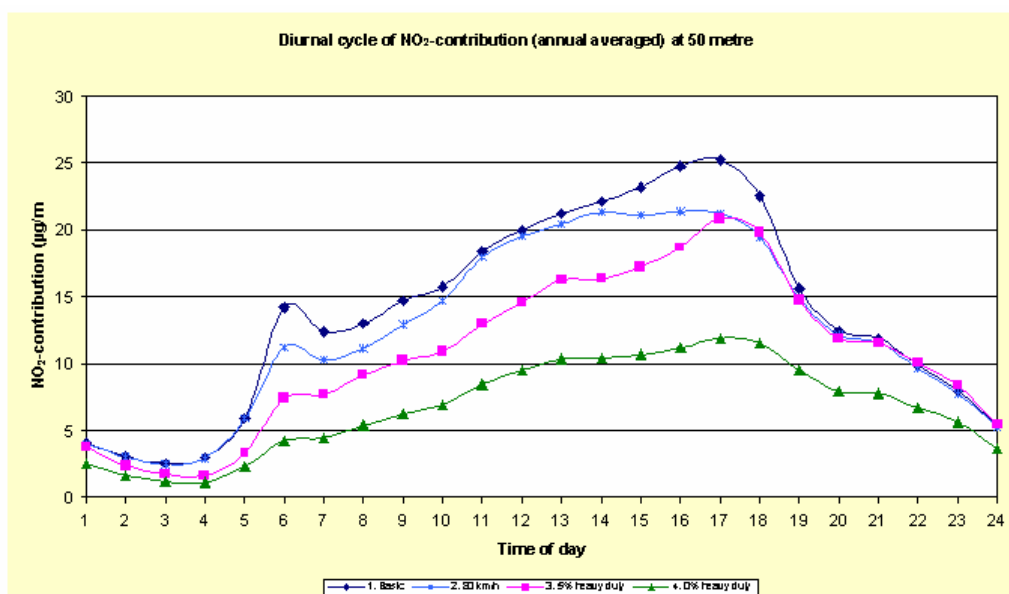
a.: The reference situation at the Pleinweg

Table 7: Modelled concentrations for the reference hour and changes (Δ) due to scenarios

Scenario	Benzene ($\mu\text{g}/\text{m}^3$)		NO ₂ ($\mu\text{g}/\text{m}^3$)		PM ₁₀ ($\mu\text{g}/\text{m}^3$)	
	Pleinweg	Ruit	Pleinweg	Ruit	Pleinweg	Ruit
Reference situation: 17 – 06 – 2002, 19.00 h	1.5	1.2	92.1	85.8	77.9	75.9
Scenario 1: Δ =	0.0	0.0	0.0	0.1	0.0	0.2
Scenario 2: Δ =	0.2	0.6	46.2	30.5	4.0	1.0
Scenario 4: Δ =	0.5	0.7	59.4	53.1	5.2	3.1
Scenario 5: Δ =	0.2	0.2	22.5	30.2	3.9	2.0

Reductions on the Ruit are smaller and average concentrations are slightly less as the zone for which the calculations are made is wider for the Ruit (500 m each side) than for the Pleinweg (300m). At 500 m distance from the road the concentrations approach background levels hence reducing average concentration and average effect.

Reductions for scenario 1 are 0 at the Pleinweg with a speed limit of 50 km/hour. At the Ruit some impact was expected but this hardly shows in the modelled concentrations.


 Figure 14: Daily course of NO_x contribution in several modelled scenarios¹

¹ Source: TNO/MEP: Spoelstra, H. en Wesseling, J.P. 2002. Luchtkwaliteitsmetingen Overschie. Fase 1: Nulmetingen. 2002. TNO-rapport R2002/340.

Summarising the results of the sensitivity tests one can conclude that in general the model is sensitive to the parameters studied. However, it was also shown that the model is sensitive to the way a speed reduction is implemented in the model. If this is done by simply reducing the speed, the impact is less than expected; if at the same time traffic dynamics are reduced by homogenising the vehicle speeds the results are in a credible range. The DSS can easily be modified to include an extra class designated for high way traffic at a modest speed without congestion. Whether this is necessary remains to be discussed by the key-users in collaboration with TNO-Automotive.

4.5 HEAVEN Evaluation results

The evaluation is part of WP3 (Evaluation) and will be extensively reported in the evaluation report. In this section we will provide a summary of the most important results.

4.5.1 HEAVEN Evaluation indicators

[1] The indicator list presented below is developed in HEAVEN workpackage 3 (Evaluation). This was taken as the basis for the Rotterdam Evaluation report.

Ind. Nr.	Indicator	Berlin	Leicester	Paris	Prague	Rome	Rotterdam
Impact 1: Enhanced Description of Current Environmental Situation							
1.1	Increased coverage of the traffic and roadside pollution network	⊗	✓	✓	✓	✓	✓
1.2	Increased grid resolution	⊗	⊗	✓	✓	✓	✓
1.3	Accuracy of roadside description	✓	✓	✓	✓	✓	✓
1.4	Increased frequency of update intervals regarding air quality	✓	⊗	✓	✓	✓	✓
1.5	Increased efficiency of air quality description	✓	✓	✓	✓	✓	✓
1.6	Increased frequency of update intervals regarding noise pollution	✓	✓		✓	✓	
1.7	Increased efficiency of noise pollution description	✓	✓		✓	✓	
1.8	Noise roadside emission : Length of network	⊗	✓		✓	✓	
Impact 2: Enhanced Environmental Scenario Analysis							
2.1	Increased coverage of the traffic and roadside pollution network	⊗	✓	✓	✓	✓	⊗
2.2	Increased grid resolution used in modelling	⊗	⊗	✓	✓	✓	✓
2.3	Reduced time to produce environmental descriptions regarding air quality based on scenario analysis	✓	⊗	✓	✓	✓	✓

Ind. Nr.	Indicator	Berlin	Leicester	Paris	Prague	Rome	Rotterdam
2.4	Reduced time to produce environmental descriptions regarding noise pollution based on scenario analysis	✓	✓		✓	✓	
Impact 3A: Improved Access and Quality of Environmental Information for Professional Users							
3A.1	Improved time resolution	✓	⊗	✓	✓	✓	✓
3A.2	Reduced delivery time	✓	⊗	✓	✓	✓	✓
3A.3	Increase in usefulness (interviews)	✓	✓	✓	✓	✓	✓
3A.4	Increased efficiency of daily/weekly bulletin	✓	✓	✓	✓	✓	✓
Impact 3B: Improved Access and Quality of Environmental Information for Public Users							
3B.1	Improved time resolution	✓	⊗	✓	✓	✓	✓
3B.2	Reduced delivery time	✓	⊗	✓	✓	✓	✓
3B.3	Increase in usefulness (questionnaires)	✓	✓	✓	✓	✓	✓
3B.4	Increased efficiency of daily/ weekly bulletin	✓	✓	✓	✓	✓	✓
Impact 4: Improved Institutional Co-operation							
4.1	Increased quality of co-operation (interviews)	✓	✓	✓	✓	✓	✓
4.2	Increase in time-efficiency of information exchange	✓	✓	✓	✓	✓	✓
Impact 5: Increased Support of Urban Planning on an Environmental Basis							
5.1	Amount of data entered in common repository including quality of data structure and storage	✓	✓	✓	✓	✓	✓
5.2	Increased usefulness for urban planning	✓	✓	✓	✓	✓	✓
Legend: ✓ Indicator will be applied. ⊗ No new development within the framework of HEAVEN, since impact has already been achieved in the past. Evaluation results from previous initiatives or projects will be reported in HEAVEN. Noise pollution is not a specific concern of the city within HEAVEN.							

Source: Frank Wefering et al., D3.1 Final Evaluation Plan, 17 May 2001

4.5.2 Rotterdam Evaluation conclusions

The local Evaluation report for Rotterdam was presented to all HEAVEN participants in February 2003. In this section we have summarised the most important conclusions for each impact. This summary was taken from the Rotterdam Evaluation report 'HEAVEN or Hell?' (RTD102/Bmm/1081) prepared by Goudappel Coffeng.

Where relevant, actions that have already been taken are discussed. In total five impacts have been defined. Impact 3 is divided into 3A for professional users and 3B for the general public. The following are discussed:

- impact 1: The improved depiction of the current environmental situation;
- impact 2: Improvements in environmental scenario analyses;
- impact 3A: Improved access to environmental information for professional users;
- impact 3B: Improved access to environmental information for the general public;
- impact 4: Improved co-operation between various government departments;
- impact 5: Increased support for environmentally friendly city planning policies.

Impact 1: The improved depiction of the current environmental situation

The HEAVEN-project has significantly improved the description and representation of the current environmental situation, as is shown by the following facts:

- for 75 road-kilometres in the Rotterdam region (Ring and Vaanweg - Pleinweg) hourly data is now available for the concentrations of NO₂, PM10 and benzene;
- the environment models provide sufficiently accurate data;
- new data is now available on an hourly basis for both the professional users and the general public;
- it is possible to generate a good picture of the current air quality without installing extra measuring stations.

Though the DSS operated up to standard the observed problem with the use of measured background concentrations has led to a modification (early November 2002) to further improve the system. Instead of using a single background station depending on the direction of the wind, the background will be calculated as the average of all regional stations operational in the said hour (currently 3) except the station with the highest concentration. This should provide a more representative background concentration and weed out freak values due to an incident near one of the monitoring sites.

Impact 2: Improvement in environmental scenario-analyses

Before the start of the HEAVEN-project, Rotterdam already had a good instrument for long-term scenario calculations, in the form of the RVMK (Rotterdam Traffic and Environmental Chart). An improvement that has since been implemented in this system is the ability to generate hourly scenarios. However, the HEAVEN system requires less time for the input and calculation of scenarios than the RVMK needs. In the section concerning impact 5 we discuss the experiences of the users with the scenario module.

When the evaluation took place there was no coupling yet between the RVMK and the HEAVEN system. In the mean time this direct coupling has become available. We expect that the users experience this as an additional improvement.

Impact 3A: Improved access to environmental information for professional users

HEAVEN has significantly improved the professional users' access to the environmental information. This conclusion is based on the following results of the evaluation:

- the smallest time unit for which data concerning the air quality along the roads are available for professional users has been reduced from one year to one hour for the pollutants NO₂, PM10 and benzene;
- a new current depiction (refresh) of the air quality along the roads is available after only 105 minutes, compared to the three months required by the RVMK;
- the professional users find the information comprehensible, easy to use, detailed and reliable;
- five out of the six professional users indicate that they would continue to make use of the up-to-date information in the future.

The most relevant points for improvement according to the professional users are:

- requirement for information at address level and expansion to more roads in the underlying road network;
- the relation between environmental and health information should be clearer;
- functionalities should be developed to tie in better with the governmental reporting obligations (number of times limits are exceeded, annual averages).

Early 2003 an option to request more easily data on a yearly basis will be installed (to facilitate the year reports)

Impact 3B: Improved access to environmental information for the general public

HEAVEN has significantly improved the general public's access to information about the air quality along the roads. This is shown by the following:

- the smallest time unit for which data about the air quality along the roads are available to the general public has been reduced from one year to one hour for NO₂, and to 24 hours for PM10 and benzene;
- a new current depiction (refresh) of the air quality along the roads is available after only 120 minutes compared to the three months required by the RVMK;
- a majority of the respondents considers the HEAVEN-website to be an important addition to the environmental information facilities (both quantity and quality);
- visitors to the website find the information comprehensible, practical and reliable;
- a majority of the respondents indicated that they would continue to visit the website.

The points for improvement most frequently mentioned by the respondents concern:

- more detailed information about air pollution at street level;
- expansion of HEAVEN with other types of environmental information, such as noise and soil pollution;
- more information about the contaminants and the consequences for health;
- more clarity over the meaning of the colours.

Since the start of the website in July 2003 there have been various alterations made to the site. The new feature 'most frequently asked questions' should provide answers for the most important uncertainties. In addition, work is being carried out on a description of the air quality in table form, whereby more distinction 'between the colours' is possible. These actions address the two last mentioned points for improvement. A description of the air quality at street level, and expansion with other types of environmental information, is not currently provided for in the HEAVEN project.

As was expected, the HEAVEN-website has not led to a behavioural change by the travellers in the region. The respondents echo that behavioural change is a slow process. They think that reports on radio, television and matrix signs, and articles in the newspapers could add to general awareness.

After a peak around the introduction of the site, the number of visitors seems to have stabilised at about 600 per month. The profile of the respondents indicates that these are mainly people who are professionally involved in care of the environment or information technology. The customers of HEAVEN would appear to be the early adopters. More publicity is required if a wider group of people is to be reached. Implementing the points for improvement mentioned by the respondents will also help increase the number of visitors.

Impact 4: Improved co-operation between the various civil service departments

The HEAVEN-project has had a positive effect on the co-operation between the government departments involved. The elements of this improved co-operation include:

- a significant gain in time in exchanging traffic and air quality data;
- the regular meetings of the HEAVEN-project team, lead to better mutual comprehension and contact;
- an increased understanding of each others requirements for data, and agreement about the use of data;
- a good starting position for the co-operation required for the Decree for Air Quality;
- new co-operations within existing and newly started projects.

Impact 5: Increased support for environmentally friendly city planning policies

HEAVEN contributes to the possibilities for environmentally friendly city planning policies, because:

- a large database is being built up in which hourly information about traffic, emissions, background concentrations, weather conditions and concentrations along the road is being stored;
- the professional users find the data in the historical database and the results of the scenario-analyses comprehensible and detailed;
- nearly all users of the HEAVEN-system find it useful for both long and medium term planning activities;
- five of the six organisations involved intend to use the database and scenario-analyses in the future;
- once data has been built up over a longer time, the dataset can be used to make environmental zone maps and for carrying out research into health.

The professional users mentioned the following points for improvement:

- expanding the system to more provincial roads;
- adding standard datasets to determine the effects of various policies;
- the data could be used to calculate annual averages, and to monitor the number of times per year that limits are exceeded.

4.5.3 Conclusion

For each of the impacts, we have drawn positive conclusions and can therefore ascertain that the HEAVEN-project is certainly not hell. The evaluation does however offer points for further improvements. Some of these signals have already been addressed.

In the before HEAVEN situation the public could receive information on air quality and noise only in the yearly reports by DCMR. Also the actual information from the air-quality monitoring network can be obtained from the DCMR web site. Additional information can be obtained from other occasional studies. Citizens can also directly contact DCMR or the health department for questions/complaints about pollution. The general public and the media will benefit from HEAVEN because of the availability of real time information on traffic related air pollution for a number of roads in the region.

The web site is the focal point of information to the public. The site not only contains information on air quality and related health effects but also suggestions about what an individual can do to reduce traffic related air pollution (alternative transport, driving habits, etc.). Apart from the reaction page attached to the web site a survey of the use and usefulness of the web site is conducted. A small panel of citizens was already involved in testing the draft version of the web site.

Furthermore a brochure was produced to raise awareness on the effects of mobility decisions and to promote the HEAVEN web site in Rotterdam. Multiple articles in national and local newspapers have been published.

Publicity related to the reporting obligations as a result of the EU daughter directive on air-quality ("besluit Luchtkwaliteit") have also raised awareness amongst the public and local politicians especially in hotspots. Especially in Overschie a citizen's platform "Healthy Overschie" was an active partner in the ongoing debates on the improvement of the local air quality.

Within the HEAVEN evaluation process the key-users and authorities were interviewed. The improved institutional co-operation and improvement of basic work arrangements as a consequence of the HEAVEN collaboration were much appreciated. Until the start of the HEAVEN project there was no organisational framework in which the different institutions with task on traffic related air pollution, were meeting on a regular basis.

The local structure of the HEAVEN project brought together all relevant organizations in the field of traffic related air quality in the Rotterdam region. This included four municipal departments (for health, traffic, environment, city development), the regional environmental authorities, the highway authorities and the province. Private partners were TNO for modeling and Goudappel Coffeng as system integrators. During the project lifetime contacts were also established with the ministry of traffic and transport and the ministry of environment.

The HEAVEN local steering committee has regular meetings (every 4 weeks). Communication and mutual understanding is judged to be improved considerably. The HEAVEN project facilitated the establishment of direct contact and direct information exchange between organizations.

At the moment there are no mechanisms that generate (short-term) traffic measures based on air quality measurements. Presently the so-called smog alarm only has consequences for industry in the region. Within the HEAVEN project, possible policy measures for traffic are being considered. The HEAVEN project will contribute to the discussion on what organisations will have to take up the responsibility for the respective measures.

5. The HEAVEN Demonstration phase

Objectives of the demonstration phase in Rotterdam

The new EU Directives on air quality demand enhanced activities from the cities in terms of environmental monitoring, information provision to the public and setting up action plans in order to reduce pollution, so that the new limit values will be met. Given the predominant share of the traffic emissions in the air pollution, the city measures to reduce air pollution will have to address especially the transport sector.

In Rotterdam there are three main objectives in the Heaven project:

- realisation of a (near) real time environmental platform on air quality for:
 - Professional users (DSS)
 - General public (Public web site)
- To assess Traffic Demand Management Strategies (TDMS) and scenarios with regards to their impacts for reducing traffic derived pollution
- To improve information dissemination to the public about traffic related air pollution

This chapter will start with a short description of the air pollution situation in the Rotterdam region (section 5.2).

Within the demonstration phase the project has developed an integrated system to assess the environmental effects of TDM strategies in urban areas. The topic of vehicle related environmental burden mitigation through TDM strategies is on the agenda of European cities since many years. The cities involved in the HEAVEN project are considering a wide variety of such measures and have already gained a lot of experience with the process of implementing such measures. It is not always easy to implement measures that have likely positive effects on the environment because of political, legal and financial constraints. By means of the HEAVEN system it is now possible to assess the environmental effects of TDM strategies on the basis of scenario calculations without having the TMD strategies actually implemented. The results of such scenario calculations will serve as a basis for decision making on city and regional level.

In the HEAVEN project in Rotterdam, different scenarios and measures were analysed and tested regarding their effectiveness to reduce pollution in the Rotterdam demonstration area.

These measure consist of:

- Common Traffic Demand Management Scenarios: Sensitivity tests to me modelled by all HEAVEN cities (section 4.4).
 1. 20% flat reduction of vehicle speed
 2. 100% - 0% reduction of heavy goods vehicles (over 3.5 tonnes) without compensation
 3. 100% - 0% reduction of traffic
 4. 100% of vehicles fulfil Euro V emission standards
- City Specific Scenarios: re-routing traffic by construction of bypass roads (section 5.3)
- Implementation of one of the TDM strategies: reduction of the maximum speed from 100 to 80 km per hour (section 5.4). Annex C gives the complete report of the impact of a 80 km/h speed limit.

5.2 Summary of the air pollution situation in the Rotterdam region¹

DCMR operates several air-quality monitoring sites in the larger Rotterdam area (Rijnmond). Traditionally they were located to the west of Rotterdam and SO₂ was the main concern. As the importance of industrial pollution has diminished the network has been adapted. RIVM also operates 2 sites in the area that are used for the national air-quality monitoring network. Despite major achievements in reducing industrial emissions the concentrations of pollutants, which have a strong traffic component (NO₂, PM₁₀) have hardly gone down. See table 8 for current concentrations.

Table 8: NO₂ and PM₁₀ concentrations in the urban area in 2001 and 2002

Monitoring site	Year average hourly NO ₂ concentration (µg/m ³)		Number of hours with a NO ₂ concentration >200 µg/m ³		Year average hourly PM ₁₀ concentration (µg/m ³)		Number of days with a daily average concentration > 50 µg/m ³	
	2001	2002	2001	2002	2001	2002	2001	2002
Schiedam	44	43	-	2	43	45	98	103
Hoogvliet	42	43	-	-	na	44*	na	99*
Maasluis***	34	35	-	-	na	40**	na	71**
Rotterdam Centre (RIVM)	43	38	-	-	37	39	49	74
Overschie 1	56*	49	-	-	46*	46	116*	115
Overschie 2	51**	45	-	-	40**	44	68**	88
Overschie 3	37**	38	-	-	38**	43	60**	90

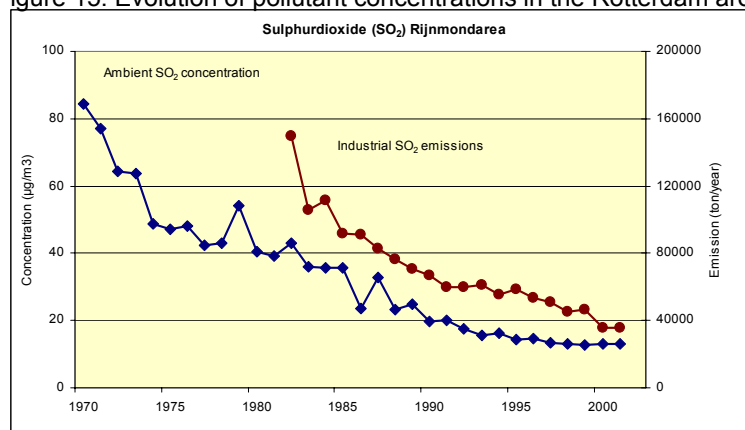
* Estimated after 6 and 9 (**) months of measurements; corrected for seasonal influences.

*** Monitoring site outside the main urban area.

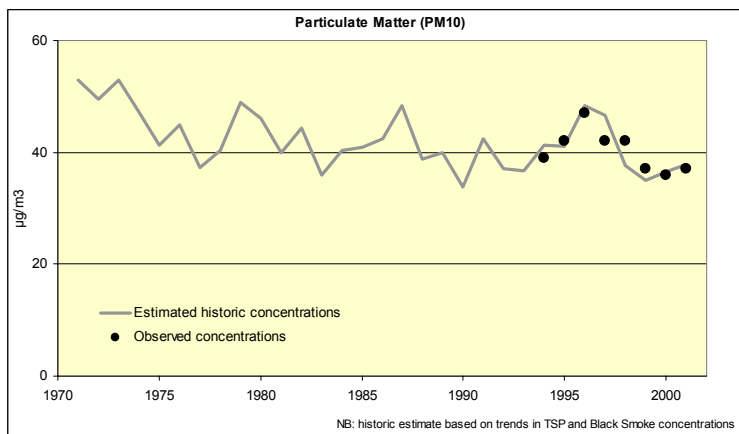
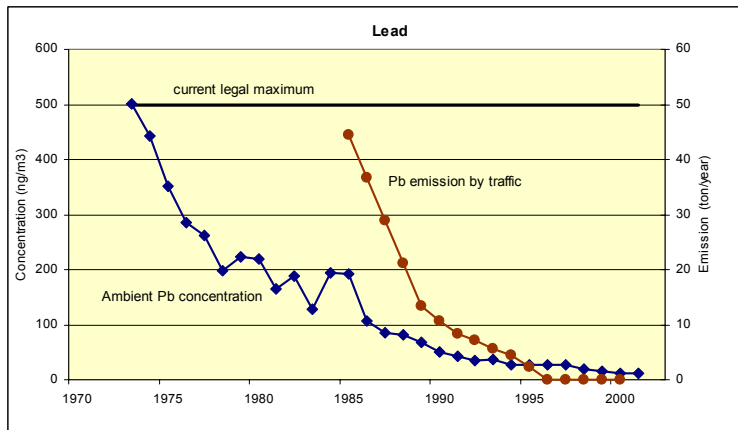
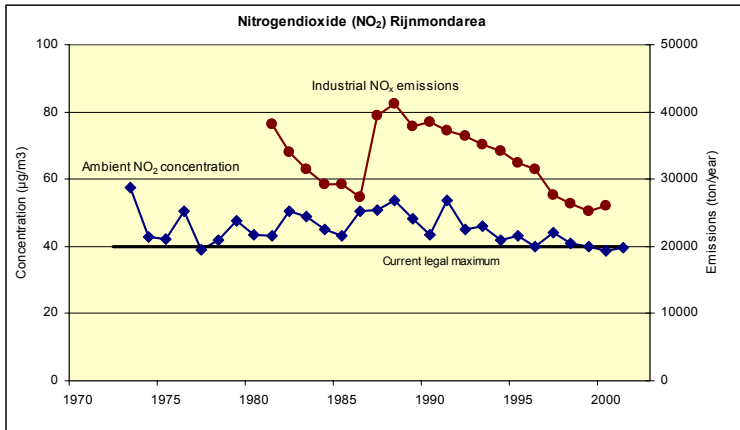
More detailed information is presented in Deliverable D8.2, the Rotterdam demonstration plan about:

- the description of the demonstration area, including maps (D8.2 Chapter 3.1).
- locations of the monitoring stations (D8.2, Chapter 3.2.1.1).
- modelling tools used (D8.2, Chapter 3.2.1.3)

Figure 15: Evolution of pollutant concentrations in the Rotterdam area



¹ This is a summary of Chapter 3 of Deliverable 8.2 to situate the reader.



Over the past 30 years there have been major improvements in the air quality situation, notably with the industrial SO₂ emissions and with the traffic related lead emissions. Progress on the traffic related NO₂ and PM₁₀ concentrations has been modest. Benzene (not shown here) is being monitored since 1991 and has never been a problem (ambient concentrations < 4 µg/m³).

5.3 City Specific Scenarios

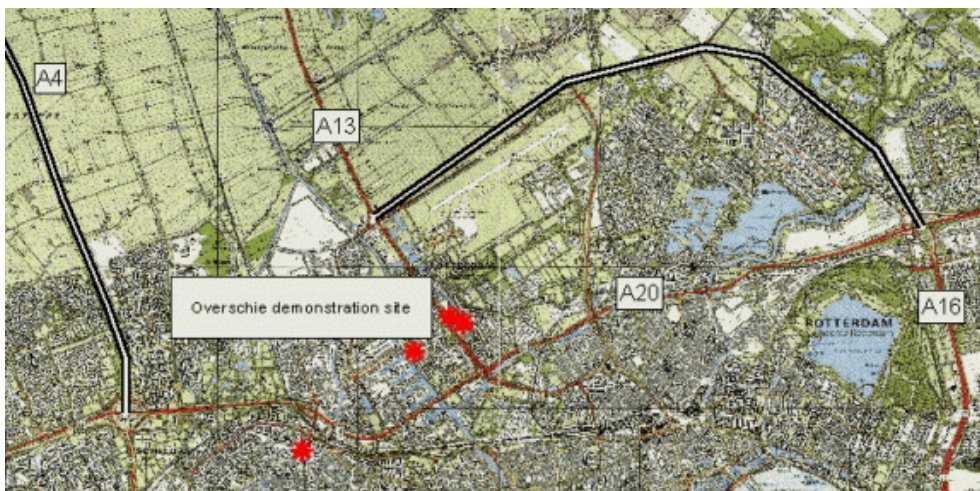
A selection of short- and medium-term options to reduce traffic related air pollution has been identified in Deliverable 8.2. Two scenarios (re-routing traffic by the construction of bypass roads) were evaluated using the DSS and are presented in this section.

5.3.1 Connection national highways A16-A13, extension A4

Long term measure to solve air quality problems in Overschie could be the construction of additional roads (connection A16-A13, extension A4).

Plans exist (in fact major preparatory work has been done) to extend the highway A4 to Schiedam. This would provide a second link between the ring road around Rotterdam (the Ruit) and The Hague. It was estimated that this would reduce the traffic on the A13 from roughly 150000 vehicles/day to 90000 vehicles/day. A second plan, which has been considered, is the construction of a branch of the ring road further to the north of the residential areas in Rotterdam. This branch would link the A16 to the A13 north of the main residential areas and north of Rotterdam Airport. This branch will reduce traffic on the inner-city parts of the A20 and A13. Both planned road segments are shown in figure 16.

Figure 16: Approximate routing of the A4 extension and the A13 - A16 branch



An environmental impact assessment¹ of the construction of a northern extension of the ring road estimated that the traffic density in Overschie would be reduced to 73000 vehicles/day assuming that the extension of the A4 was already in place. Compared to the existing traffic at the A13 this is roughly half of the current traffic density. The construction of the A4 extension and of the A13 - A16 branch do not have an impact on the Pleinweg.

Construction of both roads (shown in black and white in figure 16) will largely eliminate heavy-duty traffic on the A13 where it passes the Overschie area. For the scenarios as they are presented here a simple approach is used with a stepwise reduction of traffic densities

¹ J den Boeft en M. van Loon, 31 maart 1999. Luchtkwaliteit MER-Studie RW 16/13 - alternatieven en varianten (2010).TNO-MEP rapport R99/123.

from 150 to 90 and to 75 thousand vehicles. The impact of these scenarios is than compared to the HEAVEN scenarios 'No trucks' and 'Euro 5 emission standards'. Results are shown in the table below. DSS export images are shown in the figures 17, 18, 19.

Table 9: Concentrations in 2 city specific scenarios compared to the general scenarios

Scenario	Benzene ($\mu\text{g}/\text{m}^3$)	NO ₂ ($\mu\text{g}/\text{m}^3$)	PM ₁₀ ($\mu\text{g}/\text{m}^3$)
17 - 06 - 2002 19.00 h	1.2	85.8	75.9
No trucks : ΔConcentration =	0.6	30.5	1.0
No traffic ΔConcentration =	0.7	53.1	3.1
Euro 5 emission standards ΔConcentration =	0.2	30.2	2.0
Extension A4 (40 % traffic reduction) ΔConcentration =	0.6	20.4	1.3
Additional construction of A13 - A16 (50 % total reduction) ΔConcentration =	0.6	25.6	1.6

The differences between the two extra scenarios are minor. For benzene there is no additional improvement but for NO₂ and PM₁₀ the 10 % additional reduction of traffic leads to additional reductions in ambient concentrations.

The impact of the extension/construction scenarios are approximately half of the 'No traffic' scenario. This is expected, as this is what actually happens.

The 'No trucks' and the 'Euro 5' scenarios have a slightly higher impact. It is assumed that by 2010 the average vehicle emissions in the Netherlands correspond to Euro 5 levels. So ambient concentrations are likely to drop, even without road construction, unless there are dramatic increases in traffic density.

The 'No trucks' scenario is highly theoretical at this moment, as no alternative routes are available. However, if the A4 and/or the A13 - A16 branches are constructed heavy vehicles can be barred (partially or completely) from the stretch of A13 that passes through Overschie. If this is implemented the likely effects of the A4 and A13 - A16 scenario's will (obviously) outdo the 'No trucks' scenario. Full implementation of both the A4 and the A13 - A16 could reduce the A13 in Overschie from a 7 lane highway to a 2 lane feeder road for the city centre.

Please note that the studied hour was one with relatively high summer concentrations. The average impact is likely to be smaller. On the other hand it should be noted that construction of these alternative routes will make it feasible to virtually eliminate heavy-duty traffic from the Overschie Area. This will further improve the impact of the scenarios.

Figure 17: Existing situation 17-06-19.00 h. NOx concentrations

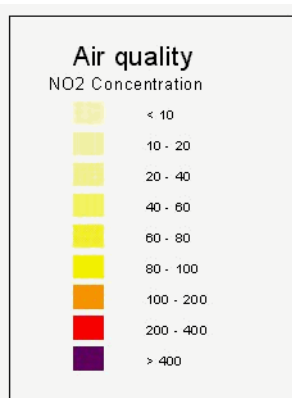


Figure 18: Situation with extension A4 (= reduction of traffic by 40 %)



Figure 19: Situation with extension A4 + construction A13-A16 (= total reduction of 50 %)



5.4 Measured impact of the 80 km/h speed limit

Overschie is a hotspot in the Rotterdam region for traffic related air pollution. The traffic volumes on the national highway A13 that crosses the district are among the highest in the region and the first line of residential flats and houses are at less than 30 metres from the road. The NO₂ concentration in Overschie exceeds the limit set in the EU directives on air quality. Local, regional and national policy makers were looking for possible measures to reduce the number of people that are affected by traffic related air pollution in this area. The HEAVEN DSS has been a useful tool in this process. By means of the TDMS the impact on the NO₂ concentration of the 80-km/h speed limit in Overschie became visible for the main actors.

Figure 20: The A13 highway leading into the city centre after introduction of the speed limit



Analysis of the Overschie situation has led to a number of options to improve local air-quality. A short-term option was the reduction of the maximum speed from 100 km/h to 80 km/h on a stretch of 2.5 km with the aim to reduce the **dynamics** of the traffic passing at Overschie (see also 5.3.1: TNO traffic emission model). This is effective as of 11 May 2002. The police enforces the speed limit with a new automatic camera system resulting in a close to 100 % detection rate of speeding drivers with additional monitoring (and extra measures) for repeating offenders. Reduction of the maximum speed in this particular case has two impacts on the emissions:

- A small reduction due to a reduction in driving speed. This mainly applies to vehicles, which did not obey the previous speed limit of 100 km/h as the emission reduction from a change from 100 to 80 km/h appears small.
- A substantial reduction due to a more homogeneous traffic flow as everybody (trucks and passenger cars) now travel at the same speed. As the area is a major junction, lane changes (an important source of driving dynamics and hence emissions) can not be avoided. However, the speed limit, combined with the rigorous enforcement reduces lane changes to the bare minimum.

Based on provisional model simulations by TNO¹ the year average NO_x emissions are expected to be 20 % lower and ambient NO_x concentrations are expected to drop by 7 %.

The question to be answered is: does the reduction of traffic dynamics induced by the speed limit have an impact that can be measured? It is very difficult to answer this question and several methodological issues are discussed in annex A. A short-term comparison has been made: the period 1/4/2002 -10/5/2002 has been compared to the period 12/5/2002 - 30/6/2002. The long term, final, comparison will be made by TNO in the course of 2003. The results of the short-term comparison presented here and in annex A are therefore provisional.

There are three project monitoring sites in the area (see maps in annex A):

- E1 is immediately next to the highway A13. The dispersion models predict an effect at this point.
- E2 is at some 210 m from the A13. In case of wind from the south E2 is likely to be influenced by the A20 as well. An effect from the speed limit on the concentrations at E2 is not expected.
- E3 served as a dedicated background station during model development, especially in the case of wind from the west.

Apart from these three project sites DCMR has three regular monitoring stations in the wider Rotterdam area. These stations are used as regional background.

As the change from winter to summer coincides with the evaluation period, a correction of the data for seasonal influences seems unavoidable. The necessity of this correction and the way it is done will be discussed.

An analysis of the uncorrected data showed that (a) the speed limit had an impact, and (b) there was a seasonal change in the concentrations that needed correction. The impact on NO_x was significant. The impacts on PM₁₀ and benzene were not significant. This does not mean that the speed limit does not affect PM₁₀ and benzene but that the effect was too small to be established undisputedly in this analysis.

After a weak correction of the data the concentrations before and after the introduction of the speed limit were compared. This analysis showed that there is a significant difference in the NO_x concentrations before and after the introduction of the speed limit at monitoring site E1. The differences occur at the hours when traffic densities are high. This is according to expectation and it is also a clear sign that the observed effect is traffic related. Furthermore: the observed effect does not occur at E2 and E3. Again this is expected and it indicates that the correction has been effective to eliminate seasonal influences and, at the same time, not a source of bias in itself.

The average effect of the speed limit on the NO_x concentration in the study period is estimated at 14 %. The range is estimated at 5 to 16 %. The results correspond well to the modelled predictions.

The results are provisional and a full evaluation over the period of a whole year will lead to more definite conclusions. If the observation period is longer the need for correction is less. This implies that evaluation can be done by 'true' measurements.

Annex C gives the complete report of the impact of a 80 km/h speed limit.

¹ The model calculations led to slightly different results than those from the 20 % reduction of scenario 1. See the discussion on model peculiarities in section 4.4.1.

A long term measure to solve air quality problems in Overschie could be the construction of additional roads (connection A16-A13, extension A4). This scenario has been analysed using the DSS software and the results are shown in section 5.3. Concerning the public transport, a new subway branch parallel to the western side of the "ruit" (ring-road rectangle) connecting the two sides of the river has opened in November 2002 potentially reducing pressure on the western branch of the ring-road.

6. Conclusions

The objectives of introducing the HEAVEN system in Rotterdam were threefold:

- realisation of a (near) real time environmental platform on air quality for:
 - Professional users (DSS)
 - General public (Public web site)
- To assess Traffic Demand Management Strategies (TDMS) and scenarios with regards to their impacts for reducing traffic derived pollution
- To improve information dissemination to the public about traffic related air pollution

Though the DSS operated up to standard the observed problem with the use of measured background concentrations has led to a modification (early November 2002) to further improve the system. Instead of using a single background station depending on the direction of the wind, the background will be calculated as the average of all regional stations operational in the said hour (currently 3) except the station with the highest concentration. This should provide a more representative background concentration and weed out freak values due to an incident near one of the monitoring sites.

The overall conclusion is that the urban highway model performs consistently up to expectation under a wide range of conditions. Details per component (Benzene, Nitrogen dioxide and Particulate matter) are presented in section 4.2.

The DSS system serving the public web site currently achieves the 95 % operating standard, and if there are breakdowns operators are automatically informed. Generally a reset is sufficient to get the system up and running. Likewise the key-users can operate the standalone version of their local DSS for scenario analysis without expert support.

The public and decision makers have access to near real time (a one hour delay) modelled air quality information related to the main traffic arteries in the area by means of a web site automatically providing hourly updates.

We would like to stress that the HEAVEN system will stay in operation after the project lifetime. A HEAVEN operator handbook has been prepared to support future maintenance and control of the HEAVEN system.

Within the demonstration phase different Transport Demand Management Strategies to reduce pollution and avoid exceedances were developed, tested and evaluated in the Rotterdam demonstration area. A long term measure to solve air quality problems in Overschie could be the construction of additional roads (connection A16-A13, extension A4). This scenario has been analysed using the DSS software and the results are shown in section 5.3. Concerning the public transport, a new subway branch parallel to the western side of the "ruit" (ring-road rectangle) connecting the two sides of the river has opened in November 2002 potentially reducing pressure on the western branch of the ring-road.

The web site draws considerable attention (1000 unique hits per month) in the first months after opening and the public welcomes the kind of information provided.

The whole HEAVEN process generates interest from political decision makers and urban planners as a source of information for potential solutions for traffic related air pollution.

Preliminary results of a test with an environmentally induced speed limit in one of the demonstration areas (Overschie) show a significant impact. During weekdays it is estimated that the NO_x concentration in the study period is decrease by 14 %. The results correspond well to the modelled predictions.

Communication and mutual understanding is judged to be improved considerably by the key-users and authorities. The HEAVEN project facilitated the establishment of direct contact and direct information exchange between organizations.

Finally it is good to note that the publicity surrounding the website, in combination with the municipal air quality reports (recently published as a consequence of the implementation of the daughter directive on air quality in the Dutch law), has led to tremendous attention amongst the public and local and national politicians. Recently the vice-minister for the environment announced that, pending the final evaluation of the Overschie test, the measure might be extended to other sensitive areas as well.

7. References

IST Programme

Annex 1 - Description of Work

HEAVEN IST-1999-11244 22nd October 1999

Bell, M., Chen, H., Ctyroky, J., Di Taranto, C., Heich, H., Hoffmann, I., Mietlicki, F., Nussio, F., Wang, T.

D5.1 Environment Monitoring and DSS Architecture

HEAVEN IST-1999-11244 11th January 2001

Cera, E., Chen, H., Ctyroky, J., Di Taranto, C., Hoffmann, I., Mietlicki, F., Teschioni, A., Wang, T.

D5.2 Overall System Architecture and Implementation Action Plan

HEAVEN IST-1999-11244 31st January 2001

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 10th July 2001

D6.2 Analysis of actual implementation from the sites

HEAVEN IST-1999-11244

DePalo, M., Harris, S., Heich, H., Jenkins, H., Kazmukova, M., Macoun, J., Pouw, C., Rapp, P., Tullius, K., Weiland, P., Zink, G.

D7.1 Final verification Plan

HEAVEN IST-1999-11244 17th June 2002

Elshout, S van den., Pouw C., Voerman J., Hermans L. Th M.

D8.2 Rotterdam Demonstration Plan

HEAVEN IST-1999-11244 31 July 2002

Spoelstra, S., Hollander J.T.C., Verhagen H.L.M., Wesseling, J.P., Teeuwisse, S.D.

HEAVEN project, report on the TNO measuring and modelling results in 2000 and 2001 for use of the development of a new atmospheric dispersion model.

TNO report R 2002/377 –July 2002

Bemmelen, M.J., Dijk, B.P. van

Hemel of Hel? Evaluatie van het HEAVEN-project (evaluation of the Rotterdam part

Goudappel Coffeng, RTD102/Bmm/1081, 17 January 2003