044671

VECTOR

Visualisation of the Exposure of Cyclists to Traffic on Roads

Specific Support Action
Science & Society

Publishable Final Activity Report

Starting date: January 1, 2007
Duration: 30 months

Prepared in August, 2009

Coordinator:
IVAM UvA BV
Jeroen Terwoert

044671
VECTOR

Visualisation of the Exposure of Cyclists to Traffic on Roads

Specific Support Action
Science & Society

Publishable Final Activity Report

Starting date: January 1, 2007
Duration: 30 months

Prepared in August, 2009

ISO-doc. 0930
Contact:
IVAM UvA BV
Jeroen Terwoert
P.O. Box 18180
NL-1001 ZB Amsterdam
Tel. 00 31 20 525 5080
Fax 00 31 20 525 5850
E.: jterwoert@ivam.uva.nl
www.ivam.uva.nl; www.vectorproject.eu

Contents

1. Project execution and results

1.1 Introduction and project objectives

The continued increase of traffic intensity in many EU member states has caused growing concerns about urban air quality. At the moment, about 8 out of every 10 kilometers travelled by passengers in the EU takes place in cars (Eurostat). The growing number of cars in cities gives rise to increased emissions of traffic exhaust. Motor vehicle emissions – and diesel engine exhaust in particular – are harmful, as they contain very small particles. These so-called 'ultrafine particles', i.e. particles smaller than 0,1 µm (0,0001 millimeter), are easily inhaled, and may penetrate into the lungs. In the lungs and higher airways, ultrafine particles contribute to the development of airway disease such as asthma and bronchitis. In patients having asthma or bronchitis, and also in patients having cardiovascular disease, ultrafine particles may worsen the complaints. In fact, fine and ultrafine particles cause over 300,000 of premature deaths in the EU each year (European Commission, CAFE). In addition, the particles that are generated by diesel engines are capable of causing lung cancer.
Several member states have introduced measures to cut fine particle emissions, such as financially stimulating particle filters in diesel cars, introducing tighter speed limits in densely populated areas, and 'environmental zones' in cities in which only relatively 'clean' vehicles may enter. Nevertheless, the limit values for particles in ambient air that have been set in the European Air Quality Directive are still exceeded at many locations in the member states. It has been demonstrated that this causes health impact, in particular among vulnerable citizens such persons suffering from asthma or cardiovascular disease (fig. 1).

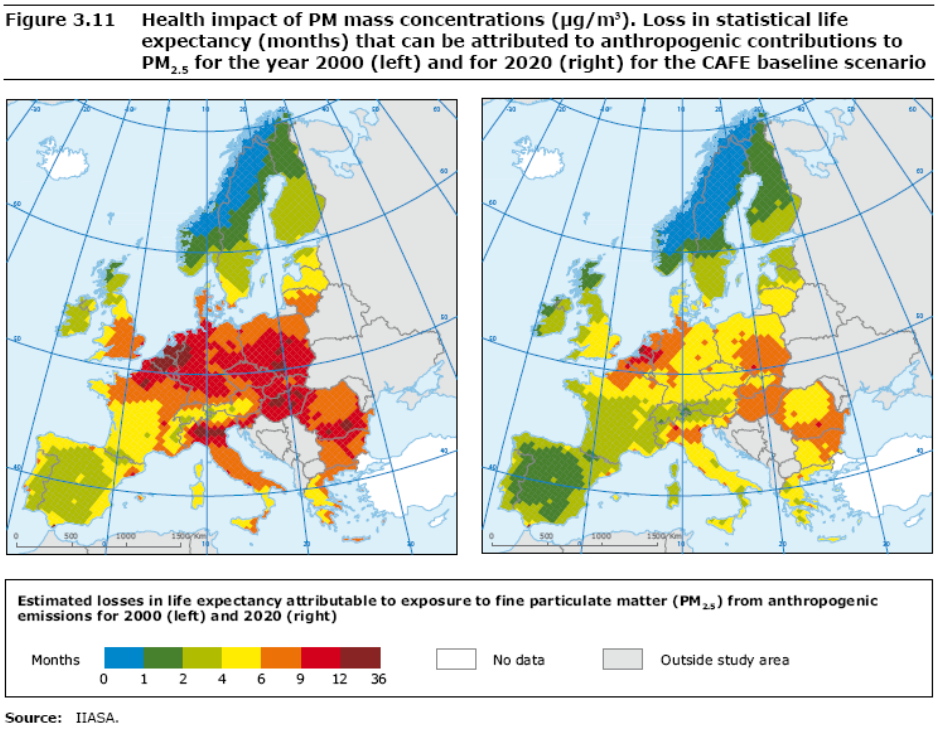


Fig. 1 – Health impact of fine particles (PM 2,5) in the EU (IIASA).

In order to reduce traffic-related air pollution in cities, it seems to be logic to stimulate bicycle use. Bicycles do not contribute to air pollution, they may be relatively fast - in busy city centres even faster than cars - and they are relatively cheap. Moreover, bicycling is a healthy exercise, which is considered a great benefit in Western countries in which the issue of relative physical inactivity, obesity and related health problems is getting more and more attention. However, certain health and safety risks are connected to bicycling as well. Cyclists are relatively vulnerable in busy traffic situations, and may more easily get hurt in

accidents. Unfortunately, cyclists also inhale traffic exhaust, and may even inhale relatively many particles as a result of the increased ventilation rate caused by the physical exercise.

To date however, actual 'personal' exposure levels of cyclists have hardly been explicitly documented. Measurements in the member states have focused on daily or annual average air-concentrations at fixed locations. In addition, the measurements have focussed on PM10, and more recently PM2,5, thus aiming at showing compliance with the EU-limit values for these fine an very fine particles. Information on *ultrafine* particles is even less available, while a large part of so-called primary emissions from vehicles belong to this ultrafine fraction. For all these reasons, most of the measured concentrations that are available cannot be related to *specific traffic circumstances* in cities.

Moreover, communication about the hazards involved has been limited, partly because of lacking data and partly because the communication tools at hand are not sufficient. Consequently, cyclist interest groups have had difficulties convincing (local) policy makers to take measures to reduce the exposure. At the same time however, evidence in literature of existing health effects among citizens due to traffic exhaust grows, in particular when related to fine and ultrafine particles.

VECTOR aimed at improving this situation by assessing - and particularly, *demonstrating* - the actual exposure of cyclists to traffic-related fine particles in cities, using a novel tool in environmental monitoring, which combines real-time measurements and video-recording (RTV). The '*real-time visualisations*' obtained in this manner clearly demonstrate cyclists' exposure in various traffic situations. These results have been and will be disseminated throughout Europe, in order to support decision-making.

The main objectives of the VECTOR project were:

Main goals:

1. to determine the actual exposure of cyclists to fine particles from traffic in a select set of different traffic-conditions in a number of European cities.
2. to inform cyclist interest groups, (local) authorities and the general public about the exposure risks of cyclists to fine particles from exhaust fumes.
3. to provide tools to improve the communication potential of scientific data.

Subsidiary goals:

1. to have cyclist interest groups, the general public and other important stakeholders better understand the risks of exposure to traffic related particles, with which they can better inform their members and convince (local) authorities to take exhaust-reducing measures if needed.
2. to provide tools to (local) authorities to decide on effective measures to reduce exposure of cyclists.
3. to stimulate the concept of Science Shops within Universities and promote the importance of problems raised by civil society.
4. to promote the use of real time visualisation for communicating scientific data to non-scientists.
5. to provide students with the opportunity to gain experience in collaborating at a European level on a multidisciplinary problem raised by the civil society.

This report presents an outline of the activities carried out in the VECTOR project and the results achieved. Section 1.2 describes the consortium and its aims to connect 'science' to 'society'. Section 1.3 presents a concise overview of the activities carried out, their goals and interrelationships. Section 1.4 presents and (shortly) discusses the results achieved and their expected impact. The actual use and dissemination of the results – a major goal of the project – has been described in a dedicated section: chapter 2.

The project partners are happy to direct interested readers to the project website at www.vectorproject.eu, at which all major project outputs can be viewed and downloaded.

1.2 The Consortium – making 'science' accessible to 'society'

In the VECTOR consortium, scientists and interest groups from society combined forces to jointly address the issue of urban air quality and its impact to citizen's health.
The research institutes involved represented The Netherlands and Germany:

- IVAM – Research and Consultancy on Sustainability; University of Amsterdam (coordinator)
- Kooperationsstelle Hamburg.

In addition, four national cyclists' associations were project partners:

- Fietsersbond - Netherlands
- Algemeiner Deutscher Fahrrad Club - Germany
- Hungarian Cyclists' Club (Kerékpárosklub) - Hungary
- Viesoji Istaiga 'Du Ratai' ('Two Wheels') - Lithuania.

The research institutes acted as science providers and coordinators. The cyclists' associations represented the interest groups aiming at the improvement of cycling policies and infrastructure in European cities, thus stimulating a healthy and non-polluting transportation mode. By combining with the research institutes in the VECTOR consortium, the interest groups obtained expertise as well as independent assessment of information that would not have been easy accessible without the EU-funding in the Science & Society programme.

The project team, taken at the start-up meeting in Amsterdam, January 2007

The VECTOR project partners aimed at increasing awareness among citizens (cyclists) as well as (local and national) policy-makers, mainly through the contacts of the cycling associations in the team. In addition, students of universities were involved in the project, in order to bridge the gap between science and society (figure 2). Both IVAM and Kooperationsstelle have been familiar with the involvement of students in their work, thus promoting a 'science shop' approach of universities making scientific expertise accessible for interest groups in society. Part of IVAM started its work as a science shop in the University of Amsterdam, while Kooperationsstelle has close connections to Hamburg universities as well as a legal role in bringing science to society. During the project, contact was sought and maintained with other science shops in the member states.

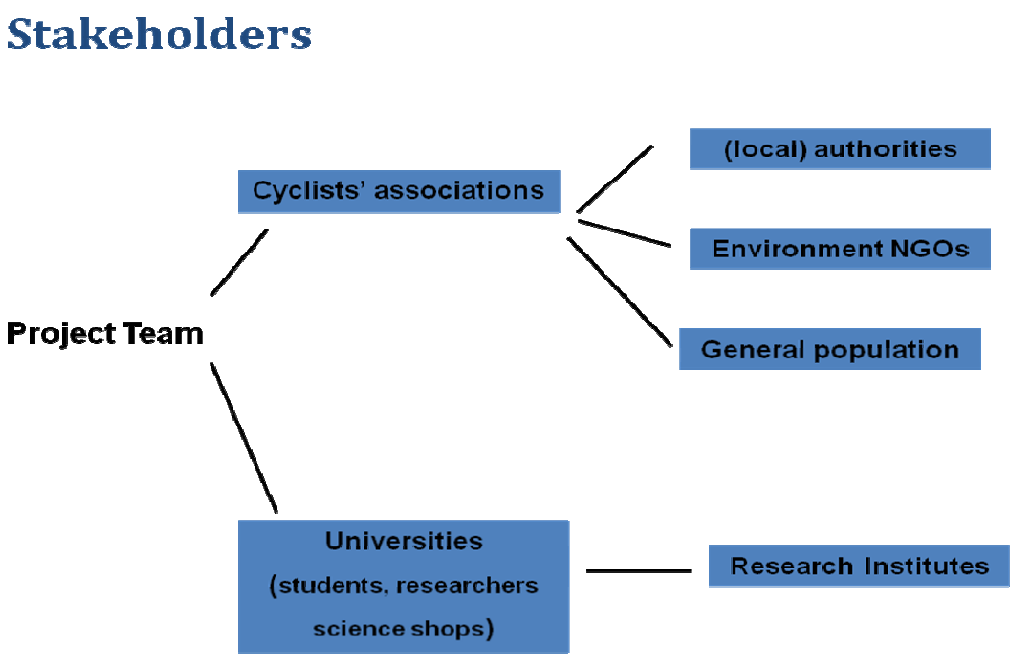


Figure 2 – Stakeholders in the VECTOR project

Part of the VECTOR team at the project meeting in Vilnius, April 2009

1.3 Overview and interrelation of activities carried out

In great lines, the major activities in the project aimed at:

- Measuring cyclists' exposure to ultrafine particles from traffic;
- Presenting the results in an innovative way: 'real-time visualisations' (exposure graphs combined with video recordings);
- Informing and 'activating' members of cyclists' associations, the general public and local authorities.

Concerning the latter point, the final aims were to:

- Demonstrate personal exposure of cyclists to (ultra-) fine particles.
- Demonstrate which traffic situations to avoid.
- Demonstrate 'favourable' situations.
- Advise cyclists and (local) policy-makers on how to reduce exposure.

Figure 3 below presents the interrelationships of the activities that were employed in order to achieve the project goals. A major 'general' activity was the involvement of universities and students in the project – creating a 'Virtual University'. Specific activities included desk research, the actual exposure measurement and visualisation, and finally the communication experiment. In the desk studies, the issue of (ultra)- fine particles, urban air quality and its impact on citizens' health was analysed, and existing policies on national and EU-scale were identified. Furthermore, the measurement technique was developed. Considerable parts of this work were performed in close cooperation between the project partners and students. During the actual exposure measurements the technique and measurement strategy was further optimised. Measurement results were analysed and documented in a student report and finally on the project-DVD. The impact of the exposure visualizations on the project-DVD was tested among target groups in a small-scale communication experiment. In turn, all the results were communicated and disseminated, an activity that will carry on after the end of the project.

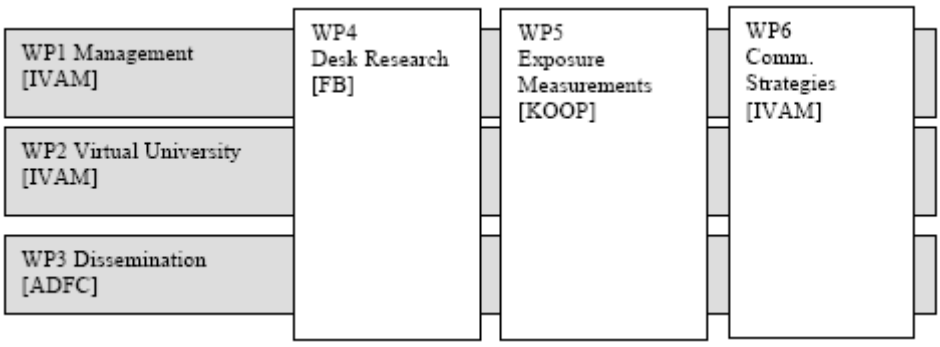


Fig. 3 – Activities in the VECTOR project

1.4 Results achieved

1.4.1 Overview – 'state-of-the-art'

Major steps have been taken to tackle the two main problems addressed by the project partners: the lack of data on cyclist's personal exposure, and the lack of convincing communication tools. The issue of fine particles was analysed in desk studies, and the measurement design (equipment, strategy) was developed. subsequently, the real-time measurements in the four cities Utrecht, Hamburg, Budapest and Vilnius have been carried out. Successful visualisations of exposure in various traffic situations in cities were achieved, as planned. A major activity was the production of a 'self-explaining' DVD-tool with all project results, of which 100 copies were produced.

The potential effectiveness of the RTV-tool was evaluated first on 'pilot-scale' by a student, among local policy-makers in the Netherlands. after that, the effectiveness of the DVD-tool in changing peoples' knowledge and attitude towards the issue has been assessed in a small-scale experimental set-up in three countries, among citizens and policy-makers.

Dissemination of project results was a major focus of the project, by means of the VECTOR final conference, external conferences, E-newsletter, newspaper articles, television broadcasts etc.

Furthermore, 10 students have been directly employed in the project for desk study, the measurements and data analysis, and the communication experiment. Contacts have been made to Universities, Science Shops, policy-makers, cyclist interest groups and other NGO's as well as researchers – also involving additional students and PhD students. At the time of the final project meeting in Vilnius, the partners were ready to strengthen communication and campaigning among their members as well as policymakers, with the help of the VECTOR achievements.

1.4.2 Virtual University: Student involvement

Each partner has taken up its task to involve students in the project, in order to bring them into contact with society-oriented research. Major contact persons at Universities and schools were informed on the project, initially by mail and telephone. Project descriptions of possible projects for students under Vector have been provided, and the project has been presented at Universities. In addition, articles were published in the international Science Shop Newsletter (see below) and on relevant websites that students use to look for internships.

In addition, ADFC developed the Student's Forum ("Virtual University") at the Vector-project website.The activities resulted in students being employed during internships at IVAM (2), Fietsersbond (2), Kooperationsstelle (4) and HCC (2). The students were involved in the desk studies, in the development of the measurement technique, in the execution of the measurements and data analysis as well as in the pilot-scale communication experiment. Much larger numbers of students were reached at presentations, among which the VECTOR final conference. Further contacts have been made to universities, and an article in the Living Knowledge Newsletter of University Science Shops was published. Much larger numbers of students were reached at presentations.

Article on VECTOR in the international Science Shop network newsletter, July 2007

LIVING KNOWLEDGE
The International Science Shop Network

Newsletter July 2007

Airborne particles and cyclists
– measuring & communicating health risks

European project 'VECTOR'

'Ultrafine particles' in ambient air is a 'hot issue' currently in the newspapers. Ultrafine particles (UFP), for which traffic emissions (mainly diesel engines) are a major source, have a negative impact on public health. In the Netherlands, each year 18.000 people prematurely die as a result of exposure to UFP. The European standards for ultrafine particles are exceeded at many locations in the Netherlands. This has forced the government to stop construction projects at these locations.
One of the ways to reduce emissions of UFP, is to stimulate the use of the bicycle. Unfortunately, cyclists are exposed to UFP as well. However, infrastructural measures, such as separate cycling lanes, may reduce the exposure. In order to draw attention to both the 'problem' of airborne UFP and to promote cycling and improvements in the cycling infrastructure, the Dutch Cyclists' Association ('Fietsersbond') has started the project 'Fietsbalans' ('cycling balance'). In this project, the exposure of cyclists to UFP has been measured (more information: www.fietsersbond.nl & www.fietsbalans.nl).

As a follow-up to 'Fietsbalans', IVAM University of Amsterdam - the former Chemistry Science Shop - has taken the initiative to set-up a European project under the Science and Society programme: VECTOR - Visualisation of the Exposure of Cyclists to Traffic On Roads. In this project, IVAM cooprates with the cyclists' associations in the Netherlands, Germany, Hungary and Lithuania, as well as with the German consultant Kooperationsstelle Hamburg. In VECTOR, a new measurement technique will be used, in which measurements of UFP are combined with video images. By 'mixing' both data, one may produce instructive videos or DVD's, showing the cyclist in a traffic situation, and at the same time (in the images) a graphical representation of the actual exposure to UFP. This method is known as 'PIMEX': Picture Mix Exposure Measurement.
The VECTOR project started in January 2007, and will run for 2,5 years. During the project, the measurements at cyclists will be carried out. In addition, a lot of effort will be put in 'disseminating' the results, towards the general population, policy makers and students (by means of a "virtual university").

Sub-projects
One of the aims of the European VECTOR project is providing an opportunity for students to participate in an interdisciplanary, community-based project. Therefore, we explore all possible ways of exchanging with students and university groups., students can take part in several sub-projects. Besides, students may take part in international project team meetings, where possible. Possible sub-projects are:

a. Literature study on former exposure measurements UFP (1 stud.)
b. Literature study on the health effects of UFP [diesel/exhaust] (1 stud.)
c. Study on existing regulations on ultrafine particles in EU member states (1-2 stud.) in particular in eastern-Europe.
d. Inventory of measurement techniques for UFP/ taking part in measurements!(1-2 stud.)
e. Inventory of 'current practices' in risk-communication. (2 stud.)

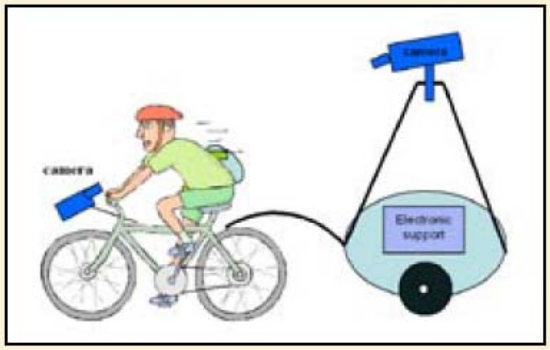


Figure: the measurement set-up. Two video-camera's are installed to record the traffic situation, on the body of the cyclist are the actual fine particle analysis devises. The electronic support needed for the camera's, the data analysis and their direct synchronisation are carried along in a small trailer.

Carrying out measurements in Budapest or Vilnius is an option. The measurements are planned between August 2007 and May 2008. Later in the project (early 2009) the communication-activities will be carried out.
The duration of the internship may vary from 6-8 weeks to 6 months. They offer work on various subjects, for students chemistry (analysis), environmental management, occupational hygiene, medicine/epidemiology, medical biology, physics, communication sciences/ sociology, politicology. In particular, students from Hungary or Lithuania are looked for. Generally, the location will be IVAM (Amsterdam); however, in certain cases the location might be the Dutch Fietsersbond in Utrecht, if desired.

You may find more information on the project at www.vectorproject.eu or mail to Fleur van Broekhuizen, fvbroekhuizen@ivam.uva.nl, or Jeroen Terwoert, jterwoert@ivam.uva.nl.

Most of the output in terms of student reports has been published on the VECTOR website, www.vectorproject.eu. The following reports have been placed on this website or can be ordered at the VECTOR partners:

Reports

Boogaard, H. & G. Hoek, 2008, Blootstelling aan ultrafijnstof tijdens fietsen en autorijden in Nederlandse steden [Exposure to UFP during cycling and car driving in Dutch cities], IRAS/ Science Shop Univ. Utrecht/ Fietsersbond – at: www.science.uu.nl/kennispunt

Jésus Rosales Carreon – "Risk communication and cycling. Potential of video to inform exposure to fine particles".

Philip Degenhard/ Joachim Tecklenburg, "Visualisation of the exposure of cyclists to traffic on roads; Zwischenbericht zum Studienprojekt" (on measurement design and results).

Dávid Rácz – "Human Health Effects of Ultrafine particles".

Dávid Rácz – "Smoking and UFP".

Dávid Rácz – "Is CMA the solution to get rid of UFP?".

Patricia Maas – "A literature (review)study on the health and environmental effects of Particulate Matter in the Netherlands" (also covering policies, incl. the EU-level).

Nkengfack, J., 2008, VECTOR, Bericht zum Studienprojekt, Sommersemester 2008, Hochschule für angewandte Wissenschaften Hamburg, (measurement technique, measurements, data analysis).

Boogaard, H. & G. Hoek, 2008, Exposure to ultrafine particles during cycling and driving in 11 Dutch cities, IRAS/ Science Shop Univ. Utrecht/ Fietsersbond, November 2008; also at: www.science.uu.nl/kennispunt

Pauw, C. de, 2008, Beschrijving en risicocommunicatie van de blootstelling aan ultrafijnstof tijdens fietsen in Nederlandse steden [Description and risk communication of exposure to ultrafine particles during cycling in Dutch cities, in Dutch], IRAS Univ. Utrecht/ Fietsersbond.

Articles in peer reviewed journals

Boogaard, H., F. Borgman, J. Kamminga, G. Hoek (submitted), Exposure to ultrafine and fine particles and noise during cycling and driving in 11 Dutch cities, Atmospheric Environment [Fietsbalans & Vector].

Furthermore, students have held presentations at several meetings, within their own university as well as at external meetings. A survey of these has been presented separately, in the final plan for using and disseminating the knowledge.

1.4.3 Desk research and development of the measurement technique

An important activity during the preparations of the actual measurement campaigns was desk research, which has been organised by IVAM, Kooperationsstelle, HCC and Fietsersbond. Subjects studied include:

- sources, emissions and concentrations, of airborne particles;
- health effects of airborne particles;
- current policies on airborne particles in the EU and its member states;
- measurement technologies;
- measures to reduce particle emissions or concentrations.

In addition, one student studied the state-of-the-art in risk communication and evaluated the communicative impact of a preliminary version of a real-time visualisation of particle exposure of cyclists. The results of the desk research have been documented in various ways:

- Reports; published at the project website and by the Universities of the students involved;
- Power Point presentations – presented at project meetings and at meetings at Universities or partners' organisations, and partly published at the project website;
- Internal papers and memo's, used for e.g. the development of the measurement design.

The measurement technique and set-up has been developed by Kooperationsstelle, with the help of internship students, and with advice of Fietsersbond. A Condensation Particle Counter and a Dust Trak were used to perform the particle measurements (particle-counts and mass concentration, respectively). With respect to the particle-count measurements, only the particles smaller that 2,5 µm (PM2,5) were counted. In addition, a small 'finger

camera' and a GPS system were obtained. In cooperation with the supplier of the PIMEX-software, the integration of measurement data and video recordings was fine-tuned. Finally, a measurement-bike was set-up which contained all necessary equipment. The measurement set-up was tested in a number of test-runs in Hamburg. After the first measurement campaign in Utrecht, September 2007, the method was further fine-tuned. Figures 4 and 5 present the set-up of the measuring bicycle. In the Annex a more extensive description of the measuring techniques is presented.

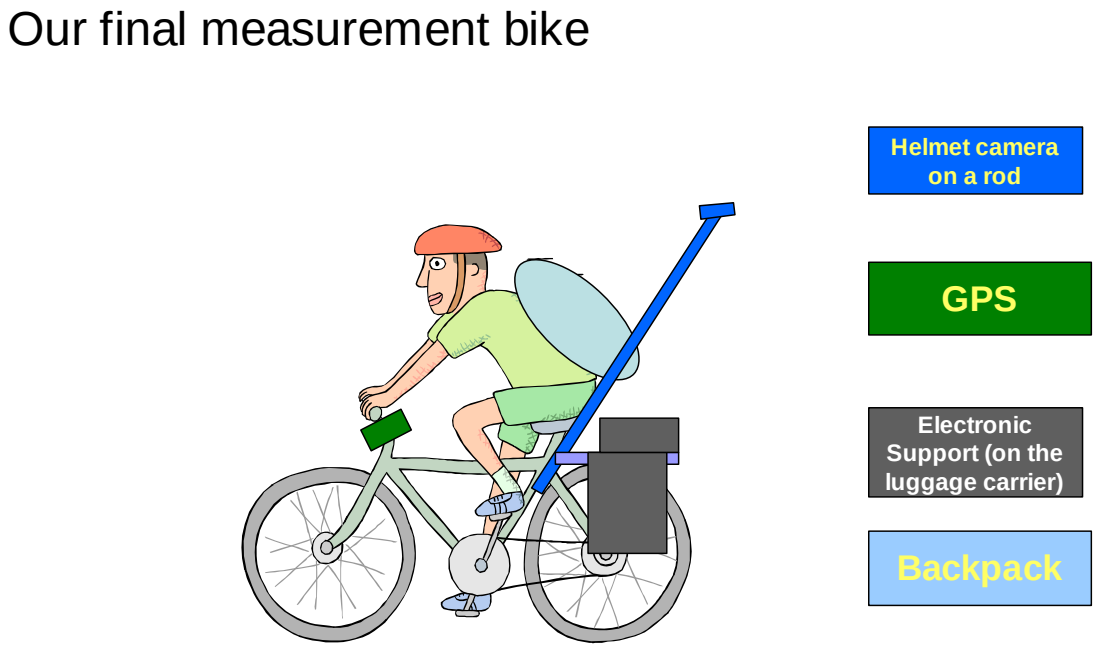


Fig. 4 - The final design of the measurement bike

Fig. 5 – The measurement bicycle 'in real life'

In order to view further results of the desk studies, the interested reader is directed to the VECTOR website at www.vectorproject.eu. Results of the desk studies can be viewed at the sections:

- Knowledge base (external reports, presentations, articles);
- About VECTOR – Our scientific output;
- News section: Newsletters, Measuring technique, presentations from the Final conference.

An overview article has been written as a 'proceedings' article in relation to the presentation of the VECTOR project at the Vélo-city 2009 conference in Brussels, on May 15, 2009 (see section 2 – Dissemination as well).

1.4.4 Measurement campaigns

The measurements in the first two cities - Utrecht and Hamburg - were carried out in September and October 2007, respectively. After adapting for some technical problems, a number of successful measurements were made in both cities. In both cities, frequently-used bicycle-routes were chosen, in which both busy and quiet parts of the city were passed. In addition to the measurements with the bicycle, a few measurements were made in a car, to serve as a reference

On the basis of the experiences in the first two cities, Utrecht and Hamburg, the measurements in Budapest and Vilnius were planned. Criteria for route selection originally included:
- the routes should be actually used frequently by cyclists, i.e. routes connecting living areas, shopping centres and working or school and university-areas;
- a variety of 'busy' and 'quiet' routes;
- a variety of traffic situations (e.g. with respect to the presence of traffic lights, roundabouts etc., both combined roads for cars and motor vehicles and free cycling paths etc.).

In the first two cities, the length of the routes varied from 10-20 minutes. However, as there is always a factor of 'chance' that influences the actual traffic situation (how many cars pass, how many heavy trucks, how many mopeds etc.), it was decided to be a little more 'selective' at the measurements in Budapest and Vilnius. Shorter measurements (between one and a few minutes) in characteristic situations have been carried out as well, and enhanced the capacity of the visualisations to demonstrate 'good and bad practice' in city design. The Hungarian project partner HCC proposed a wide variety of 22 measurement situations in Budapest, and for the measurements in Vilnius the project partner DuRatai selected the routes.

The measurements in the last two cities - Budapest and Vilnius - were carried out in April and May 2008, respectively. Kooperationsstelle was supported by two students as well as the local partners. In both cities, a large number of routes were measured. In Budapest, bad weather conditions (rain) disturbed part of the measuring campaign, but after all, the measuring team was able to finish all measuring routes as planned. Weather conditions were not all the time that favourable in Vilnius as well, and a few adaptations to the routes proposed were necessary. However, a sufficient amount of data was collected after all. In addition to the measurements with the bicycle, again a few measurements were made in a car, to serve as a reference. Successful visualisations of exposure in various traffic situations in cities were achieved, as planned.

In both cities, press meetings were organised during the measuring campaign, at which the measurement equipment was present as well. This generated a lot of attention from press, scientists and policy-makers in the countries involved. Figures 6 and 7 present two situations in the measurement campaigns.

Fig. 6 – One of the measurements in Hamburg

Fig. 7 – One of the measurements in Utrecht

1.4.5 Analysis of the results

After finishing the measurement campaigns in all 4 cities, in total more than 400 km. of measuring routes had been cycled and more than 20 hours of video material was collected. Supported by two students, the data were analysed and conclusions were drawn in cooperation with all partners. Illustrative video and measuring material for the project DVD, the website and external presentations was selected. The analyses have resulted in a number of 'major conclusions', relating to exposure-modifying factors such as the impact of weather (wind, rain), the general design of a city, the car park (old vs. new cars), disturbing sources of particles (e.g. fires), the local cycling infrastructure (road design, cycle lanes, green strips) and the placing of the measurement equipment:

* With the measuring set-up used, it appeared to be very well possible to visualise the personal exposure of cyclists to ultrafine particles, in specific traffic situations;

* The exposure to particles is higher when the cyclists moves closer to the motorised traffic;

* Barriers between the road for motor vehicles and the cycle lane reduce the exposure;

* Separated cycling lanes at a certain distance from busy roads for motor vehicles reduce the exposure significantly;

* External sources of particles, such as house fires or construction sites, may disturb the measurements and increase the exposure significantly;

* Relatively old diesel vehicles or two-stroke engined vehicles (mopeds) increase the exposure significantly;

* Frequently, cyclists are exposed to relatively short, high peak concentrations of ultrafine particles, which drop to the background concentrations relatively fast;

* However, ultrafine particle concentrations in cars show longer lasting high values - caused by particles entering through the ventilation system - which drop only slowly;

* The weather circumstances (heavy rain, wind) play a decisive role;

* Highest exposures to ultrafine particles were measured in tunnels, street canyons (narrow streets with high building along) and underpasses.

* When the measuring equipment was placed on a low position - at children's height - higher exposures were measured.

Altogether, a *comparison* of the four cities in which measurements were carried out, was only possible on the basis of the *average background* concentrations: Utrecht ca. 8,000-10,000 particles/cm^3, Hamburg ca.10,000-20,000 particles/cm^3, Vilnius ca.15,000-30,000 particles/cm^3 and Budapest ca. 25,000-40,000 particles/cm^3. The differences seem to reflect partly city design (´open´ vs. ´narrow´), the average age of the car-fleet, the traffic intensity, and the cycling infrastructure (separated cycle lanes present or not).

Fig. 8 – One of the measurements in Budapest, with real-time visualisation of particle exposure

Fig. 9 – One of the measurements in a car, with real-time visualisation of particle exposure

1.4.6 Presentation of the results – development of a project-DVD

As soon as all measurements had been done, the results were documented in a student's report (Ngengfak, '08; see Scientific Output on the VECTOR website), in internal and external presentations, and on the VECTOR website. Major conclusions were shown at the Final conference of VECTOR on May 13, 2009 in Brussels and at the international Vélo-city conference 2009 (www.vectorproject.eu/127_1), and an article for the Proceedings of this conference was produced.

Another major activity was the production of an instructive, 'self-explaining' DVD-tool with all project results. At the 2nd project meeting in Utrecht, in September 2007, the contents of such a DVD had been extensively discussed – partly based on the advises that resulted from the pilot-study on the impact of real-time visualisations of exposure to the target group (Rosales Carreon, '07; see Scientific Output on the VECTOR website). One major conclusion was, that the DVD should be 'self-explaining'. This means, that it was necessary to use a voice-over and/or texts in the images.

A professional filmmaker was contracted, which carried out his work in close cooperation with ADFC and all other partners. Additional video shootings and interviews before camera were organised, and a "The making of" film was produced, which explains the aims, methods, outcome and recommendations resulting from the VECTOR activities. The project-DVD that has been produced contains:

- a 15-minute movie, presenting the issue of air quality in cities and cyclist's exposure, a short introduction of the equipment used and PIMEX (real-time visualisation), pictures of the cities involved and the routes measured, interviews with stakeholders, and statements explaining what local policy makers and individual cyclists may do.
- an explanatory real-time visualisation clip, explaining what the viewer can see;
- a set of 14 short real-time visualisations, clearly demonstrating the influence of various parameters on cyclist's exposure, and showing good and bad practice in city design (explained by texts);
- a slide-show, "the making of".

The movie is available with an English and German voice-over. Subtitles of the movie as well as the PIMEX-clips have been made in English, German, Dutch, Hungarian and Lithuanian.

All participants to the final conference of VECTOR on May 13, 2009 in Brussels (50) received a copy of the DVD. Furthermore, an additional 50 copies were available for interested stakeholders. these were distributed by the partners. The contents of the DVD

were placed on the VECTOR website as well, and the DVD may be ordered at this location (www.vectorproject.eu/29_1).

1.4.7 Communication experiment

The effectiveness of the DVD-tool in changing peoples' knowledge and attitude towards the issue of citizens' fine particle-exposure in cities has been assessed in a small-scale experimental set-up in three countries.

Within the framework of preparing his master thesis, a student of University Groningen carried out the preliminary preparation of the communication experiment. The student was directed to IVAM by the Science Shop Chemistry in Groningen. The report "Risk communication and cycling. Potential of video to inform exposure to fine particles" (J. Rosales Carreon, '07; published on the VECTOR website) contains the results of the study.

In the course of this study, 10 local civil servants working at the travel planning departments of 10 Dutch cities were interviewed. Questions were asked about their knowledge of airborne particles in cities, on their perception of that problem, on potential measures etc. Subsequently, a preliminary example of a real-time visualization of cyclist's exposure to particles was shown, after which a number of additional questions were posed. The study resulted in:

- a description of major theories on risk perception of the public;
- a description of the State of the art in environmental risk communication;
- a questionnaire and interview design to be used in the actual communication experiment;
- a number of recommendations on the preparation of a final DVD, containing the RTV's.

The latter recommendations have been discussed at the 2nd project meeting in Utrecht (Sept. '07), at which the student presented his work. The major issue was, to add more explanations to the RTV's.

The draft questionnaire that was developed was further elaborated by IVAM, and adapted. As a result of the delayed delivery of the final project DVD (which was the subject to be tested in the experiment), the planning of the communication experiment was adapted in such a way, as to allow both face-to-face interviews and questionnaires that were sent by E-mail. In addition, the face-to-face interviews were partly organized in groups instead of one-by-one. Both local policy-makers and members of cycling clubs were addressed. The method adopted included:

- Contact person fills out a 'pre-DVD' questionnaire (or interview held);
- Contact person watches the VECTOR project DVD;
- Contact person fills out 'after-DVD' questionnaire (or interview held), to measure the effect of the DVD on the person's attitude and knowledge.

In the report that describes the test (on the VECTOR website), the questionnaires used can be found.

The actual measurements took place after the final delivery of the project DVD, during May and June 2009. The questionnaires and interviews were used in The Netherlands (IVAM), Germany (ADFC) and Lithuania (Du Ratai). In The Netherlands, 3 local policy-makers in the region of Eindhoven were involved. In Germany and Lithuania, 9 and 10 local members of cycling clubs were involved, respectively. In total: 22 participants. Additional viewings were organised in Hungary, with members of the cycling club.

When the results of the questionnaires and interviews were analysed it appeared that not all respondents had filled-out the questionnaires to a sufficient extent. Nevertheless, first indications of the DVD's impact could be obtained. Based on the answers before and after viewing the DVD by the German respondents, it seems that the general concern regarding

UFP increases by approximately 15 per cent after viewing the DVD. The public (cyclists) in general are aware of possible health effects of Ultra Fine Particles and seem in majority worried about these health effects. They see however possibilities in how they as cyclists can avoid exposure to UFP and they seem willing to make use of these possibilities (figure 10). But they would not be eager to switch to another mode of transport, instead of their bicycle. The policymakers seem willing to adjust their policies because of health effects and cyclists' safety. Further research on the impact would be an interesting follow-up. In fact, all cyclist association members of the VECTOR consortium have organised additional 'viewings' of the DVD, combined with discussions on the results and the viewers' response to it, and will carry on to do so.

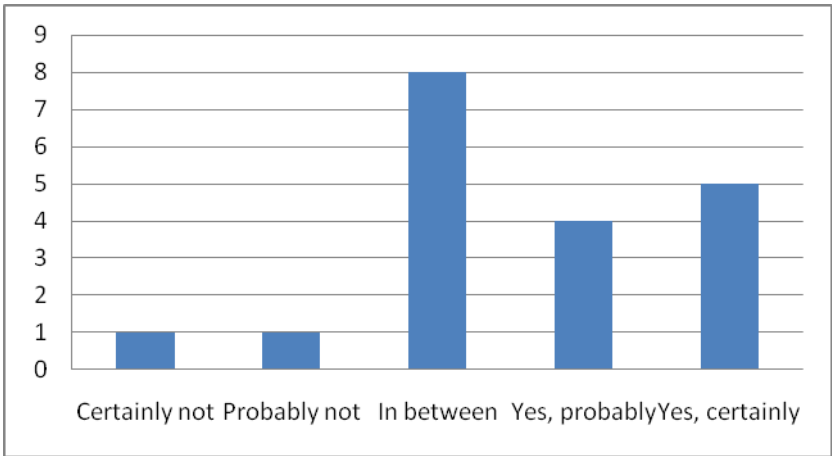


Figure 10 - Intention to adjust cycling behaviour in the future to reduce exposure to UFP.

2. Using and disseminating the knowledge

2.1 In summary

The Vector project in fact has 'dissemination of knowledge' as its central aim. Thus, much effort has been put in the dissemination of the project set-up and results, and in generating publicity. The project website has been established by ADFC, at www.vectorproject.eu. Regular updates were placed on the VECTOR website. Relevant stakeholder organisations have been contacted, including environmental NGOs, local authorities and universities. An E-Newsletter was developed, and sent twice to the (by the end) 106 subscribers The project has been presented at international symposia as well as at a range of national workshops. Besides, articles have been published in the partners' own magazines and newsletters and in the international Science Shop newsletter "Living Knowledge" (twice). Finally, press conferences were held in connection to the measurement campaigns and project team meetings. These generated a lot of publicity in newspapers, on the radio and on television. On May 13, 2009, the VECTOR Final conference "Making fine particles visible – for healthier cycling in cities" was organised, along the Vélo-city 2009 conference in Brussels. About 50 participants were present, ranging from lobbyists, scientists and policy-makers. The proceedings are available through the VECTOR website.

All partners have made plans for further dissemination and exploitation of results, including further measurements, impact study and campaigning. One major occasion for dissemination will be an item on VECTOR in the German television programme "W wie wissen" on the nationwide station ARD, on August 2, 2009.

2.2 Exploitable knowledge and its use

Exploitable knowledge from the Vector project constitutes the final report and the 'self-explanatory DVD' that contains the real-time visualisations of cyclists' exposure to traffic-related ultrafine particles as well as a 'movie' on the issue. In addition, a project **website** has been developed, as well as three e-newsletters.

The **final report** contains a description of VECTOR, and in a concise form the main findings from the desk research, outcomes from the cyclist exposure measurements and real time visualisations (RTV), and the results from the validation of the awareness raising potential of the RTV ('communication experiment'). The report has been tuned to the interests of the cyclist interest groups, but will be of interest to researchers active in the area of air pollution or traffic planning, as well as for local, national and EU-level policy-makers in these areas.

The **DVD** contains a selection of 14 illustrative real-time visualisations of cyclists' exposure to traffic-related ultrafine particles in European cities, as well as an explanatory video that puts the RTV's into perspective. Besides, it contains a 'movie', presenting the issue of air quality in cities and cyclist's exposure, a short introduction of the equipment used and PIMEX (real-time visualisation), pictures of the cities involved and the routes measured, interviews with stakeholders, and statements explaining what local policy makers and individual cyclists may do. Thus, the DVD is 'self-explaining', meaning that target groups (cyclist interest groups, policy makers) will be able to understand the content without further accompanying explanations.

Use of the final report and DVD

It is expected that the final report (plus DVD) may give cyclist interest groups the tools required to present (local) policy makers a realistic, though qualitative view on the exposure of cyclists to particles in various realistic traffic situations in urban regions over Europe. In addition, it is expected that cyclist interest groups may demonstrate 'better practices' in cycling infrastructure to local policy makers, with the help of the final DVD. In fact, all VECTOR partners that are cyclist interest groups have carried out activities like this already.

Both the final report and the visualisations have been put on the Vector project website, to start with. However, a more active dissemination has started as well through articles in public newspapers and magazines, in cyclist interest group magazines and in (semi-) scientific magazines, and through presentations at symposia. In addition, the cyclist interest groups in the consortium will continue to directly approach local policy makers through their networks after finalising the VECTOR project, in order to stimulate and help them in *formulating policies* that may improve local cycling infrastructures.

The VECTOR **project website** is www.vectorproject.eu. contains an introduction to the project and its aims, the project partners, a news section, a knowledge base, the 'virtual university' (student's forum), project outcomes (e.g. student reports), the possibility to subscribe to an E-mail newsletter and the complete contents of the VECTOR project-DVD: measurement clips (real-time visualizations), an explanatory clip, a 15-minute movie explaining the aim, methods, results and follow-up, and a photo-show.

Sections like the "Knowledge Base" – a collection of assorted documents, studies and presentations on the topic – have grown continuously since the start. Registered users have access to more than 35 dedicated papers, several video-files and a number of press articles about the VECTOR project.

The website is ranked first by Google Search, referring to the keywords "Particulate Matter" and "VECTOR". It has been agreed that the VECTOR website will be maintained during 6 months after finishing the project and that after that 6-months period, the contents will remain accessible, though without updates being made. The homepage will then contain a message stating that the results of the Vector project can be found, but that no further updates will be made.

Fig. 11 - Presentation and discussion of the VECTOR results at the Lithuanian Ministry of Environment, Vilnius, April 2, 2009

VECTOR e-Newsletter

In total 3 issues of the Newsletter were produced and sent:

- November 2008: An introductory newsletter, sent to over 1000 stakeholders of all partners:
    - Short introduction to the project and to the website
    - Reference to the opportunity to subscribe for the e-newsletter.
- February 2009: A newsletter sent to the – by then – 99 active subscribers:
    - Description and explanation of the measuring devices and measuring bicycle used in VECTOR
    - Announcement of the final conference of VECTOR on May 13, 2009 in Brussels.
- June 2009: A final newsletter sent to the **106** active subscribers:
    - Announcement of the release of the project-DVD with all results
    - Announcement of the DVD-contents being placed on the VECTOR website
    - Short report of the discussion on the VECTOR Final Conference, with references to the Power Point presentations at the VECTOR website.

The Newsletters are still available on the VECTOR website.

'Final Workshop'

On May, 13, 2009, the planned final workshop, actually called 'final conference' of the VECTOR project was held in Brussels. The conference was held along the large international 'cycling promotion conference' Vélo-city 2009, in the same venue, Tour & Taxis. At the conference, presentations were held by external experts as well as VECTOR partners, presenting sand discussing the results of the project. The audience contributed to a very lively discussion. All participants received the Vector DVD afterwards.

A report on the conference has been placed on the VECTOR website. The report includes the presentations held by the speakers, as well as a short report on the discussion on the conference.

Fig 12 - Press meeting – explanation of the measuring equipment, Budapest, April 17, 2008

2.3 Planned follow-up activities

After the end of the project, direct contacts between cyclist interest groups and major stakeholders (i.e. their members as well as local and national policy makers) will be continued and strengthened because the DVD with the real-time visualisations as the major project outcomes is now available. The partners will continue to try and connect to existing

local environmental campaigns, such as 'Earth day week' and "Critical Mass" which is held each year in many cities. In addition, the issue will be raised on each occasion that in local or national policy-making discussions on air quality and health are held.

Any opportunity to publish articles in newsletters, magazines or newspapers will be taken. This will also include articles in the own partners' newsletters.

Presentations at external conferences will be continued as well. A few presentations and submissions have been planned or carried out already.

The VECTOR website will be maintained during 6 months after finishing the project and that after that 6-months period, the contents will remain accessible, though without updates being made. The homepage will then contain a message stating that the results of the Vector project can be found, but that no further updates will be made. The items that will remain accessible include an introduction to the project and its aims, the project partners, a knowledge base, project outcomes (e.g. student reports), the E-mail newsletters published during the project and the complete contents of the VECTOR project-DVD: measurement clips (real-time visualizations), an explanatory clip, a 15-minute movie explaining the aim, methods, results and follow-up, and a photo-show.

Kooperationsstelle will continue to use the VECTOR exposure-visualisation method. IVAM is considering opportunities to continue as well.

The method of measuring personal exposure to particulate matter in mobile subjects optimally stood the test in this project. Kooperationsstelle We intends to initialize further projects. The measuring system shall be advanced and adjusted to the state-of-the-art regarding measuring. Initial discussions with the university Düsseldorf, Professor Weber and University Osnabrück, professor Derhake have been promising. Furthermore the measuring system will be integrated in project offers regarding environmental protection and occupational health and safety, if possible and reasonable. Ideas are:

- exposure of ultra fine particles of bike couriers
- exposure of ultra fine particles of traffic policemen
- exposure of children (buggies, pushchairs, bike trailers)
- exposure of cycling postmen
- exposure of other road users

Because of the lectures within the VECTOR-project the Kooperationsstelle Hamburg got requests from various communities and cities to support them at town planning (e.g. Berlin, Frankfurt).

At IVAM, initial talks have been held with an occupational health service, suppliers of nanoparticle measuring devises (Philips Aerasense). A few ideas being explored are, exposure-visualisation of (ultra-) fine particles in offices, in road construction and on highways in general. Additionally, projects aiming at developing improved filtration devices for ultrafine particles in trucks will be explored – based on the VECTOR measuring results.

ADFC in Germany has succeeded in getting the interest of the German nationwide television station ARD. On August 2, 2009, an item on Vector has been broadcasted, in the programme "W wie wissen". An introductory article has been placed on the website of ARD, which could be read by the time of writing this report (see annex 2). Direct contacts with policy-makers and stakeholders will be continued, using the project-DVD.

HCC has submitted the VECTOR DVD for a presentation at the Budapest Bicycle Festival 2009 (http://www.fest21.com/en/blog/bubi/budapest_bicycle_festival_free_entry) and organises many additional viewings and meetings with local HCC groups as well as policy-makers.

Specific follow-up activities in a 'low awareness region' – the case Lithuania

As result of the VECTOR project the local NGO activists in Lithuania were able to create a communication basis among “official” experts, mainly working in municipal and national organisations. There is no national NGO working intensively on the issue of air pollution, more dominant issues are waste management, healthy life style and partly renewable energy sources. Questions in the specialised discussion pages (like via http://ekoblogas.wordpress.com/) appear rarely and on very special issues.
At the end of the project (in 2009) there was a raising interest on the different Health institutions (Public Health Centre). Thus, the public interest is still low, press articles on VECTOR appeared “only” in special publications – ecological orientated newspapers, web pages or special eco-pages of bigger newspapers, for the wider mass media the subject still seems to be to complex.

The production of the VECTOR-DVD lead to its planned presentation for some public events: The national environmentalists' days (organised by the Ministry of Environment), the European Youth Week “Velomanija Vilnius”. Furthermore, shortly after the end of the project (29-7-´09) a public viewing of the DVD was organised during the Youth Week "Velomanija Vilnius 2009".

There are only very few experts working on air pollution issues in Lithuania and on Particle matters in particular. It is likely that they will use the knowledge received by VECTOR in future as well as visit the VECTOR web page. Air pollution by itself seems to be “god given”, mostly invisible and nothing to do about it. There is low conscience on air pollution as Lithuania supports its green image as a low industrialised, agricultural country. That the real situation in the cities is something different is not much to be heard by now. To this end it is more likely that the requests from outside, by name: EU regulations and requirements, will force a better situation. During the Vilnius VECTOR meeting the discussion in the Ministry of Environment did show that officials are expecting more direct instructions than general research results.

For the Lithuanian local NGO activists the VECTOR results serve as arguments for better bicycle route planning and the limitation of motorised traffic in the city centre (as it is now planned for Vilnius city in 2010).

Lithuanian Cyclists' Community/ Du Ratai is trying to influence the guidelines for bicycle infrastructure planning in Vilnius city and on the national level and the VECTOR project results will certainly influence this process. In the future it is very likely to have an even stronger discussion on health issues in Lithuania, in connection with a support of cycling and stronger measures on the regulation or banning of motorised traffic. Hopefully the VECTOR team experts will be able to pass the project experience to a network of regularly updates in the field of PM research, as the results of the ongoing research only bit by bit is creating a whole picture. As a small country the Lithuanian partner will carry on working creating the connection between the questions appearing in the country and the big experience created internationally. The task will stay to reply direct demands and to started online discussions for the Lithuanian language community.

Specific follow-up by Fietsersbond in the Netherlands

Fietsersbond has approached 48 policy-makers and civil servants of municipalities already, to discuss the issue of cyclists’exposure to ultrafine particles already, and will continue.
One of the follow-up activities is a project called “Fietsen voor schone lucht” (Cycling for clean air): a manifestation together with the Astmafonds (asthma fund) and ANBO (an elderly organisation). It aims at showing people how to contribute to cleaner air, by e.g. cycling instead of using cars. The VECTOR DVD was presented at a meeting that was organised within the framework of this project, shortly after the end of the Vector project.

In addition, in 2008 Fietsersbond participated in a program of CROW, named SOLVE: a project about air quality and transport. The bike is included as a solution in a large database with measures for improving the air quality. The recommendations of SOLVE are in line with the recommendations of VECTOR. Winter 2009 a toolbox will be available for Dutch cities. More information can be found at www.crow.nl/luchtkwaliteit/_t61_p0_m7_i6452.htm.

2.4. Summary of publishable results

Publishable results involve - apart from this report - student reports and the project-DVD.

Students reports have been published on the website of the Vector project (at "About Vector", then "Our Scientific Output"):

- Jésus Rosales Carreon – "Risk communication and cycling. Potential of video to inform exposure to fine particles".
- Dávid Rácz– "Human Health Effects of Ultrafine particles".
- Patricia Maas – "A literature (review)study on the health and environmental effects of Particulate Matter in the Netherlands" (also covering policies, incl. the EU-level).
- Nkengfack, J., 2008, VECTOR, Bericht zum Studienprojekt, Sommersemester 2008, Hochschule für angewandte Wissenschaften Hamburg, (measurement technique, measurements, data analysis).
- Boogaard, H. & G. Hoek, 2008, Exposure to ultrafine particles during cycling and driving in 11 Dutch cities, IRAS/ Science Shop Univ. Utrecht/ Fietsersbond, November 2008; also at: www.science.uu.nl/kennispunt

The major publishable result however is the DVD with all measurement outcomes and additional information. This will be used after the project as well for major activities of the cyclist organizations involved in the project, such as approaching policy-makers, cyclist members and other stakeholders.

The DVD contains:

- a 15-minute movie, presenting the issue of air quality in cities and cyclist's exposure, a short introduction of the equipment used and PIMEX (real-time visualisation), pictures of the cities involved and the routes measured, interviews with stakeholders, and statements explaining what local policy makers and individual cyclists may do.
- an explanatory real-time visualisation clip, explaining what the viewer can see;
- a set of 14 short real-time visualisations, clearly demonstrating the influence of various parameters on cyclist's exposure, and showing good and bad practice in city design (explained by texts);
- a slide-show, "the making of".

The movie is available with an English and German voice-over. Subtitles of the movie as well as the PIMEX-clips have been made in English, German, Dutch, Hungarian and Lithuanian.

All participants to the final conference of VECTOR on May 13, 2009 in Brussels (50) received a copy of the DVD. Furthermore, an additional 50 copies were available for interested stakeholders. these were distributed by the partners.

The contents of the DVD were placed on the VECTOR website as well, and the DVD may be order at this location (www.vectorproject.eu/29_1).

3. Conclusions

After finalising the very interesting VECTOR project, a few general conclusions can be drawn upon its set-up and impact. Detailed conclusions on the specialised issues themselves that were dealt with in the project have been drawn elsewhere in the report, as well as in Annex 4.

- The project set-up involving both science providers and interest groups from society proved very fruitful. The interest groups obtained expertise as well as independent assessment of information that would not have been easy accessible without the EU-funding in the Science & Society programme.

- The opportunity to contribute to solving problems that are relevant to society, in an international setting, attracted motivated students that had valuable inputs to the project.

- The VECTOR project has drawn the attention of the international Science Shop community as well as other University and research institute representatives, with which the VECTOR partners have collaborated.

- The technique of real-time visualisation of the exposure to (in this case) fine particles proved to be successful in an environmental setting as well, after its implementation in occupational health settings since the early 1990's.

- At national and international meetings, in direct contacts with stakeholders, in press meetings and finally in the communication experiment, the real-time visualisations that were developed appeared to be very appealing, and instrumental in raising awareness on the issue – among various target groups such as 'normal' citizens, active cyclists, scientists, policy-makers and interest groups.

- With the real-time visualisations of the exposure of cyclists to fine particles it has been possible to demonstrate 'good and bad practice' related to e.g. the choice of cycling routes and city design, which is regarded very useful in future talks and campaigns by the cyclist associations involved.

Annex 1 – Description of VECTOR measuring set-up

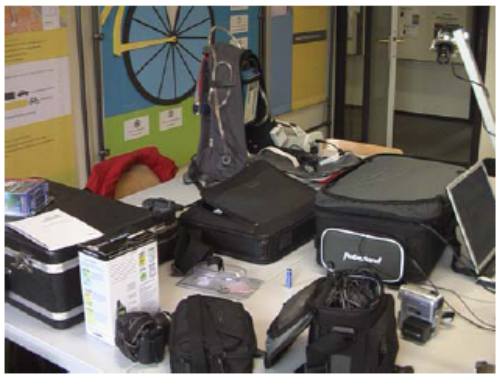
The mobile real-time analysis/video recording system of the European project VECTOR.

1st Requirements
The task of the VECTOR project was to measure and visualize the UFP-load of cyclists, e.g. PM 2.5 and smaller. For this purpose it was necessary to develop a new measuring system. On the one hand, this system should show the situation of the cyclist on the road and on the other hand the fine dust particles loads should be measured and synchronously recorded with the traffic situation. For this task measuring systems being able to measure in real time were required. A further precondition was that these systems are battery-operated so that they could be used on a bicycle.

For the video record an as small as possible digital video system was required which could easily be connected to a notebook.

As the measurement of data and the video recordings have to be effected synchronously, a special software was required.

2nd Realization
Important preparatory work for the development of such a system were performed by Dutch Fietsersbond. In the frame of the project '*Fietsbalans*' two measuring systems of the company TSI were used. These measuring systems met the requirements in an ideal way. Moreover, they had already been tested in many operations before. The Dutchman had shown that an application on a bicycle is possible. However, a backpack with special brackets was needed.



The video system, however, proved to be somewhat difficult. A video camera being small and light enough to be fixed on a bike was not available. On occasion of a project meeting with the participating organizations from Hungary, Lithuania, the Netherlands and Germany, the idea was developed to use a helmet camera. This helmet camera could simply be fixed to a thin and lightweight aluminum rod. It showed the same road section which also could be seen by the cyclist. The cyclist himself was in the picture, too. This is important; hence the actions of the cyclist on the road could be visualized.

An adequate software being able to process the video data with the measured data in real time was also found very soon. This is the PIMEX system which has successfully been used

for years within the field of Occupational Safety and Health. The Austrian manufacturers, the company KOHS, has realized the adaptation to the measuring systems TSI CPC 3007-2 and DUSTTRAK aerosol monitor.

TSI CPC 3007-2

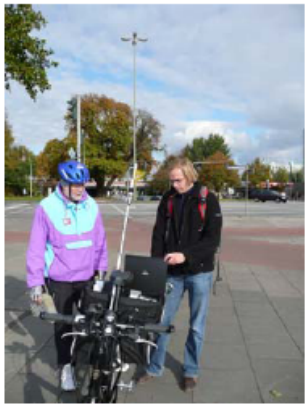
DUSTTRAK Aerosol Monitor

A bicycle bag was purchased in order to store the PIMEX notebooks with the software, the digital video camera, an audio amplifier and the necessary batteries.

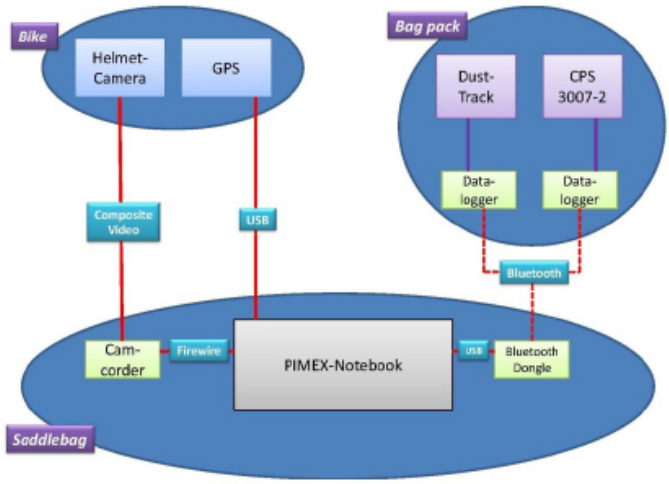
For orientation of the cyclist a GPS of the company Garmin was used. The recorded routes served also partly for documentation.

The entire test set has been arranged so that it could be fixed to any standard bicycle.

For the test runs realized within the project, a bicycle named VECTOR was provided by the company Koga-Myata.



1. Schematic measuring setup



2. Setup of a condensations particle counter CPC 3007-2 (Handbook TSI)