Minutes of the 3rd TPT working group meeting

Zürich, Sunday October 1st 2000

AGENDA:

14.00-14.20: **Petra Kastner-Klein:**

Opening of the meeting and short summary of the TPT-WG activities/achievements **(1)**

Presentation of a theoretical framework for the parameterisation of traffic produced turbulence **(2)**

14.20-14.35: **Silvia Trini Castelli:**

The parameterisation of the traffic produced turbulence: Review of some methodologies and application to highways **(3)**

14.35-14.45: **Gerhard Jirka:**

TPT work planned for a young researcher to stay in Karlsruhe during the final stage of TRAPOS **(4)**

14.45-17.00: **Discussion and formulation of the answers to the 3 following questions (5):**

I) Formulation of the importance of the subject for street level pollution

II) Presentation of the TRAPOS contribution to the advancement of the subject

III) Transformation of the results into recommendations for practical model

The discussion was continued on Monday, 2nd October from 9.30-10.30.

AD 1: STATE OF THE ART OF TPT ACTIVITIES:

Since the TPT working group meeting in February in Cambridge a active collaboration between the teams at CERC, NERI, ETHZ and U.Karlsruhe developed. The different methodologies of the teams in parameterisation of traffic produced turbulence were analysed and discussed. A framework to link the different approaches and to attribute them to different flow regimes depending on the traffic density was presented by Silvana and Rex at the second working group meeting in May in Nantes. This work stimulated a vivid interchange of ideas on the basic approach to, and the scaling concepts for different regimes of traffic produced turbulence. A consensus on a consistent approach for all regimes and the significance of length scales and averaging volumes was finally obtained (see ad 2).

The analysis of the full-scale turbulence and concentration data of the Nantes´99 experiment is continued at ECN. The data set is considered to be a unique data source for testing of TPT parameterisations. It is planned to verify the TPT parameterisation integrated in CHENSI against the data.

At NERI the Nantes´99 data were applied for intercomparison studies of calculated (with OSPM and MISKAM) and measured concentrations. The results again pointed out the importance of TPT parameterisations in dispersion models. In model calculations disregarding TPT effects, the average concentration at the sampling point location in Rue de Strasbourg, Nantes were overestimated by a factor of 4-5.

At TNO Silvia initiated numerical experiments with TASK-flow to study dispersion near highways. The influence of vehicle motions were taken into account by a movement of the traffic lanes and fixed obstacles. The results will be further analysed and a comparison with other data is planned. Furthermore the usefulness of wake theory for an incorporation of TPT effects in CFD models was analysed by Silvia (see ad 3)

AD 2: THEORETICAL FRAMEWORK FOR THE PARAMETERISATION OF TRAFFIC PRODUCED TURBULENCE

Between the teams at NERI (Ruwim and Matthias), CERC (Rex and Silvana), ETHZ and U. Karlsruhe (Petra and Evgeni) an agreement on a theoretical framework for the parameterisation of traffic produced turbulence was reached. This framework was shortly presented by Petra. It can be summarised in the following way:

- it is possible to differentiate between three different flow regimes depending on the traffic density
  (1) sparse-traffic: associated with large spacing between vehicles and independent vehicle wakes
  (2) medium vehicle spacing leading to interaction between the vehicle wakes
  (3) dense traffic with low vehicle spacing confining the wakes
- the turbulence production-dissipation balance is a suitable approach for all three flow regimes
- for the first two flow regimes a geometrical scale h of the vehicles is the proper choice for the dissipation length scale, since the boundary conditions of the vehicle-wake flow are related to h. For the third regime the dissipation length scale is defined by the distance between the vehicles.
- the proposed approach leaves some freedom in the definition of an averaging area S_c. The proper choice of S_c is depending on the particular problem under consideration. If one is e.g. interested in average near ground concentrations the choice of the "traffic layer" $S_c=h \bullet W$ is recommended, whereas choice of the canyon cross-section $S_c=H \bullet W$ is appropriate if one considers average concentration levels inside the canyon.

The existence of all three regimes seems realistic. The effective vehicle wake length can be estimated as 10-20 h which corresponds to approximately 20 m. It follows that for a spacing of approximately 25 m the transformation from regime (1) to (2) is realistic and a good estimate for the transformation from regime (2) to (3) is a spacing of approximately 15 m. For a average vehicle velocity of 30km/h these values correspond to traffic flow rates of 1200 veh/h and 2000 veh/h, which are quite typical for European urban streets.

AD 3: THE PARAMETERISATION OF THE TRAFFIC PRODUCED TURBULENCE: REVIEW OF SOME METHODOLOGIES AND APPLICATION TO HIGHWAYS

Silvia presented a review on the wake theory of Eskridge and Hunt and discussed the implementation in CFD modelling. She proposed a combination of wake theory with similarity theory for the atmospheric boundary layer. The modification of conservation equations for mean flow and turbulence quantities in the case of E-ε and Reynolds stress closures was outlined. The problem of additional empirical constants was analysed. A test of the presented approach is depending on a CFD code which allows the proposed implementations. So far such code is not available for Silvia.

The group generally agreed that Silvia´s proposal describes a promising approach, but Rex annotated that the wake theory of Eskridge and Hunt is valid only for velocity-deficit wakes, whereas vehicle wakes are vorticity wakes.

AD 4: TPT WORK PLANNED FOR A YOUNG RESEARCHER TO STAY IN KARLSRUHE DURING THE FINAL STAGE OF TRAPOS

Beginning of November an Italian student from Roma starts at U.Karlsruhe a TRAPOS contract for 6 months. He will perform an experimental study in the wind tunnel, investigating the influence of different realistic vehicle shapes (cars, trucks) and the analogy to simplified geometries. Furthermore the influence of vehicle spacing on wake characteristics will be studied.

AD 5: DISCUSSION AND FORMULATION OF THE ANSWERS TO THE 3 FOLLOWING QUESTIONS (5):

The members of the TPT working group agreed on the following statements. They are applicable for a typical European urban street canyon configuration, which is characterised by closely packed buildings on both sides of the street, values for the aspect ratio, i.e. the ratio of street width to building height, near one, and relatively high traffic flow rates.

I) Formulation of the importance of the subject for street level pollution

- ⇒ The analysis of laboratory (wind tunnel study at U.Karlsruhe) and field data (Göttingerstr., Schildhornstr, Jagtvej, Rue de Strasbourg) has shown that TPT is an important aspect for dispersion of traffic emissions.
- ⇒ Neglecting TPT parameterisations in dispersion models causes significant concentration **overpredictions up to a factor of 4-5**.
- ⇒ The existing empirical formulations, like e.g. the VDI-method, lead to improvements, but operationally significant differences still occur for **roof level wind speeds** $\leq 4-5$ **m/s.**
- ⇒ One TRAPOS team disagrees.

II) Presentation of the TRAPOS contribution to the advancement of the subject

- ⇒ The confusion in methodology between the different teams was removed.
- ⇒ A consistent application of TPT modelling was promoted.
- ⇒ A coherent parameterisation for TPT was developed for operational models.
- ⇒ For CFD models a parameterisation was developed by one group and tested against field and laboratory data.
- ⇒ A technique to combine turbulent quantities related to wind and traffic was developed.
- ⇒ A database, which allows verification of future parameterisations was generated.

III) Transformation of the results into recommendations for practical model

- ⇒ Practical models need some kind of TPT parameterisation. For further specification we distinguish between 3 type of models:
- ⇒ **OPSM-type models:**
  The approach presently used in OSPM is ok.
  Models of that type should include the OPSM approach.
- ⇒ **VDI method ⇔ velocity scaling of concentration:**
  The VDI method has deficiencies.
  OSPM- type of concentration scaling is an improvement.
  We would recommend the OPSM scaling method with more verification.

⇒ **CFD models:**

TPT parameterisations must be implemented.

For a k-ε model TPT parameterisations have been developed.

They are an improvement compared to CFD without TPT parameterisations.

More verification, which possibly will not be finished during TRAPOS, is necessary.

LIST OF PARTICIPANTS:

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additional participants on Sunday:

Allesandro Dorio, TNO
Antonio J. Gamez, IBAL
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