COPERT 4
Background and future plans

JRC IES, Ispra, 2008-10-16
Contents

1. Background & History
2. Main sources of technical information
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4. Recent Updates
5. Process of COPERT update
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Background & History
Status of COPERT - Administrative Info

- The name stands for **CO**mputer **P**rogramme to calculate **E**missions from **R**oad **T**ransport

- Now in its COPERT 4 Version (fourth update of the original COPERT 85)

- It incorporates results of several research and policy assessment projects

- It is basically funded by the European Environment Agency through the ETC budget

- It is scientifically and technically supported by the Lab of Applied Thermodynamics

- It has recently attracted much attention from JRC who are willing to support its further development
Status of COPERT - Technical Info

- Calculates emissions of all (important) pollutants from road transport
- Covers all (important) vehicle classes
- Can be applied in all European countries and in several Asian ones (the ones using “Euro”-type of classification)
- Covers relevant technologies to perform total emission estimates from 1970 to 2020 (up to 2030 in TREMOVE)
- Provides a user-friendly (MS-Office like) GUI to introduce and view data
History - Early Generations


COPERT85
DGXI
CORINAIR Group

COPERT90
EEA Task Force
CORINAIR Group

COPERTII
EEA
MEET Group

COPERTIII
EEA
MEET

COST319 Report
National
COST319 participants

MEET Deliverables
DGVII
MEET Partners

ForeMove 1.0
DGXI
LAT/EnviCon

ForeMove 2.0
DGXI/Concawe
Auto Oil I

ForeMove Upgr.
ACEA
Auto Oil II

CASPER
DGXI
IFARE/LAT/EnviCon

Legend:
Product/Tool
Funding
Working Group

TRENDS
Eurostat/DGVII
LAT/DTU/INFRAS/Kalivoda

Legend:
Product/Tool
Funding
Working Group
History - COPERT II and III

- **COPERT II** was the first one with a GUI, built on MS Access 2 (1996). It provided emission factors up to Euro 1

- **COPERT III** was based on menus, similar to MS Office (2000) and it was built on VBA for MS Access 97. Compared to version II:
  - New hot emission factors for Euro 1 passenger cars
  - New reduction factors over Euro 1 according to AutoOil
  - Impact on emissions from 2000, 2005 fuel qualities
  - Cold-start methodology for post Euro 1 PCs
  - Emission degradation due to mileage
  - Effect of leaded fuel ban in Europe
  - Alternative evaporation methodology
  - Detailed NMVOC speciation (PAHs, POPs, Dioxins and Furans)
  - Updated hot emission factors for non regulated pollutants
COPERT 4 is the ‘official’ version since Nov. 2006. Main differences with Copert III include:

- **Software-wise**
  - Possibility for time-series in one file
  - Possibility of more than one scenarios in one file
  - Enhanced import/export capabilities (mainly Excel)
  - Configuration of fleet (local/regional vehicle technologies)
  - Data can be changed at methodological level (emission functions)

- **Methodology-wise**
  - Hot EFs for PCs and PTWs at post Euro 1 level
  - Hybrid vehicle fuel consumption and emission factors
  - N2O/NH3 Emission Factors for PCs and LDVs
  - Particulate Matter and airborne particle emission factors
  - Non-exhaust PM
  - New evaporation methodology
  - New corrections for emission degradation due to mileage
  - HDV methodology (emission factors, load factors, road-gradient)
Main Sources of Technical Information
Main sources of Technical Information - Hot Emissions

- Passenger Cars
  - Pre-Euro 1 based on COST, MEET, CORINAIR working group
  - Euro 1 to Euro 3 and Euro 4 gasoline based on Artemis (average speed approach)
  - Euro 4 diesel, Artemis and post Artemis data (TUG, LAT)
- Light-duty vehicles
  - MEET with improvements based on Artemis data, passenger car emission factors and reductions of emission standards
- Heavy-duty emission factors
  - ARTEMIS
- Power two-wheelers
  - TNO/LAT Work on emission standards development
  - JRC WMTC correlation exercise
Main sources of Technical Information - Cold-start Emissions

- Only covers passenger cars and light-duty vehicles
  - MEET results adapted to COPERT methodology

- Heavy-duty vehicles
  - Not considered important compared to hot emissions (long trips, diesel engines)

- Power two-wheelers
  - Cold-start assumed in the urban emission factor (urban emission factor obtained from cold-start WMTC part 1)
Main sources of Technical Information - Evaporation Emissions

- Joint JRC/CONCAWE/EUCAR Programme on Evaporative Emissions
  - 7 vehicles
  - 10 fuels (including ethanol blends)
  - Regulatory SHED test procedure

- LAT/CONCAWE/J RC work
  - 5 vehicles
  - 3 fuels (HC only)
  - Modified test protocol (improved vehicle preconditioning, more temperature profiles, consecutive diurnal tests, permeation tests)

- Literature data
  - Motorcycles (UBA-D work)
  - Carburetted and uncontrolled vehicles (older CONCAWE studies)
Other sources of technical information

- PM and particle properties: *Particulates* data
- \( \text{N}_2\text{O} \): TNO Reports, LAT Database of literature sources
- NH3: LAT Database of literature sources
- \( \text{NO}_2 \): AEAT, TNO Work
- Hybrids: LAT Experiments
- Biodiesel buses: Synthesis of literature data
- Mileage degradation: Artemis
- Fuel effects: EPEFE
- Tyre and break wear emissions: *Particulates*, ESPREME
- CH4: Artemis, TNO databases
Users and Applications
COPERT Application

- STEERS (CONCAWE)
- GAINS / RAINS / EC4MACS
- TERM
- TREMOVE
- COPERT
- FLEETS
- AEI G
- National Inventories
- Individual Use
## Field of applications - National level

<table>
<thead>
<tr>
<th>Country</th>
<th>Model</th>
<th>Contact Person</th>
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<tbody>
<tr>
<td><strong>EU27</strong></td>
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<tr>
<td>Austria</td>
<td>GLOBEMI</td>
<td>Barbara SCHOGL</td>
</tr>
<tr>
<td>Belgium</td>
<td>COPERT</td>
<td>Laurent BODARWE (Brussels)</td>
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<td>Pascal THATE (Wallon)</td>
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<td></td>
<td></td>
<td>Ina DE VLOEGER (Flanders)</td>
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<tr>
<td>Bulgaria</td>
<td>Tier 1</td>
<td>Tzvetina TZENOVA</td>
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<tr>
<td>Cyprus</td>
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<td>Chrysanthos SAVVIDES</td>
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<tr>
<td>Czech Republic</td>
<td>COPERT</td>
<td>Jiri DUFEK</td>
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<tr>
<td>Denmark</td>
<td>COPERT</td>
<td>Morten WINTHER</td>
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<tr>
<td>Estonia</td>
<td>COPERT</td>
<td>Helen HEINTALU</td>
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<tr>
<td>Finland</td>
<td>LiPASTO</td>
<td>Kristina SAARINEN</td>
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<td>France</td>
<td>COPERT</td>
<td>Jean Pierre CHANG</td>
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<tr>
<td>Germany</td>
<td>TREMOD</td>
<td>Gunnar GOHLISCH</td>
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<tr>
<td>Greece</td>
<td>COPERT</td>
<td>Dimitrios HADJIDAKIS</td>
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<td>Hungary</td>
<td>COPERT</td>
<td>Tamas MERETEI</td>
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<td>Ireland</td>
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<td>Eimer COTTER</td>
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<td>Italy</td>
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<td>Riccardo DE LAURETIS</td>
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<td>Latvia</td>
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<td>Intars CUKAR</td>
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<td>Aurelia CICENAITE</td>
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<td>Luxembourg</td>
<td>COPERT</td>
<td>Frank THEWES (to be replaced)</td>
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<tr>
<td>Malta</td>
<td>Tier 1</td>
<td>Christofer CAMILLERI</td>
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<tr>
<td>Netherlands</td>
<td>Agg. VERSIT+</td>
<td>Anco HOEN</td>
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<tr>
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<td>Janina FUDALA</td>
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<td>Pedro TORRES</td>
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<td>Slovakia</td>
<td>COPERT</td>
<td>Janka SZEMESOVA</td>
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<tr>
<td>Slovenia</td>
<td>COPERT</td>
<td>Martina LOGAR, Alenka FRITZEL</td>
</tr>
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<td>Spain</td>
<td>COPERT</td>
<td>Antonio FERREIRO</td>
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<tr>
<td>Sweden</td>
<td>EMV</td>
<td>Magnus LINDGREN</td>
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<tr>
<td><strong>UK</strong></td>
<td>National System</td>
<td>Justin GOODWIN</td>
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<tr>
<td><strong>Other Countries</strong></td>
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<tr>
<td>Belarus</td>
<td>COPERT</td>
<td>Hanna MALCHYKHINA</td>
</tr>
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<td>Bosnia Herzegovina</td>
<td>COPERT</td>
<td>Martin TAIS</td>
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<tr>
<td>Croatia</td>
<td>COPERT</td>
<td>Zeljko JURIC, Vjekko BOLANCA</td>
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<td>Moldova</td>
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<td>Alice GAUSTAD</td>
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<td>Switzerland</td>
<td>National System</td>
<td>Felix REUTIMANN</td>
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<tr>
<td>Turkey</td>
<td>Tier 1</td>
<td>Fatma Betül BAYGÜVEN</td>
</tr>
</tbody>
</table>
Evaluation of COPERT


Fabio Murena, Giuseppe Favale, Continuous monitoring of carbon monoxide in a deep street canyon, Atmospheric Environment, Volume 41, Issue 12, April 2007, Pages 2620-2629.


Field of Applications - Literature 2

Application

Leonidas Ntziachristos, Marina Kousoulidou, Giorgos Mellios, Zissis Samaras, Road-transport emission projections to 2020 in European urban environments, Atmospheric Environment, October 2008, accepted.


Jose M. Buron, Francisco Aparicio, Oscar Izquierdo, Alvaro Gomez, Ignacio Lopez, Estimation of the input data for the prediction of road transportation emissions in Spain from 2000 to 2010 considering several scenarios, Atmospheric Environment, Volume 39, Pages 5585-5596.


Roberto M. Corvalan, David Vargas, Experimental analysis of emission deterioration factors for light duty catalytic vehicles Case study: Santiago, Chile, Transportation Research Part D: Transport and Environment Volume 8, July 2003, Pages 315-322.

Salvatore Saija, Daniela Romano, A methodology for the estimation of road transport air emissions in urban areas of Italy, Atmospheric Environment Volume 36, Issue 34, November 2002, Pages 5377-5383.

Notes:
Information in this presentation collected from people that downloaded COPERT 4 in the period Jun 2006 – Nov 2007.
In total, 1131 individual downloads (without doubles) were registered.
The registration is only for people that have actually downloaded COPERT, not just visiting the site.

The following form needs to be filled by users every time COPERT 4 is downloaded (example with artificial data is given).

User's info:
Name: John Smith
Country: Italy
E-mail: John@Smith.edu
Organization: University of Emissions
Found out from: EEA
Usage: Calculate pollutants emissions

The following charts were produced by processing the information contained in these forms.
Continent Distribution

- Europe: 86.6%
- Asia: 0.5%
- Africa: 1.2%
- South America: 3.7%
- North America: 5.4%

- Oceania: 2.5%
Distribution of users from Europe
Distribution of users from Africa

- Algeria
- South Africa
- Egypt
- Morocco
- Ethiopia
- Mozambique
- Ghana
- Benin
- Tanzania
- Burkina Faso
- Saudi Arabia
- Sudan
- Cameroon
- South Africa
- Senegal
Distribution of users from Asia

The bar chart shows the distribution of users from various countries in Asia. The countries are ranked from the highest to the lowest number of users. The countries included are China, India, Indonesia, Israel, Taiwan, Vietnam, South Korea, Bangladesh, Malaysia, North Korea, Bhutan, Thailand, Japan, Iran, Pakistan, and the Philippines.
Distribution of users from America
Monthly Distribution of Downloads
Daily Distribution of Downloads
- **Private sector** includes consultants, construction companies, emission and transport research, etc.
- **International organizations** include fuel, insurance and transport companies and authorities
- **Local authorities** mainly include regional environmental offices
Applications

- **Academic use** is for lectures, courses, theses.
- **Evaluation / research**: General application not specified in more detail by the users.
- **Emissions / emission factors**: Application on particular studies necessitating total estimates or just derivation of emission factors.

![Pie chart showing various applications]
There is a great interest for national inventories
- Requires simplicity in interface and limited input from the user
- There is a great interest for GHGs emissions
- They require a link to higher-level software (i.e. CRF, CollectER, etc.)

Several new MSs and NIS countries still consider that input data are difficult to collect
- How to allocate technology classes
- How to estimate mileage and road shares
- Sometimes use “rule of thumb” methods of questionable quality
Several “advanced” countries hesitate using a common methodology

- Have developed own tools and are familiar with
- Trust own methods provide more accurate results than a generic model
- Politics and priorities may also play a role

As a result:

- Countries’ absolute contribution may be misjudged
- Time-series reporting is less uncertain
- Introduction of a new model will require re-estimation in time series

Such a model is a very elegant tool for centralised emission estimates
Number of specialised uses is rather infinite

- In South Africa, it has been applied to a road 550 km between Durban and East London. Problem was level of maintenance.
- In Chile and Mexico, it is used for urban inventories in high altitude.
- Eurocontrol considers its use for estimating road transport contribution to local air quality in airport areas.
- Particular cases (Greek taxis, small vehicle categories in Italy < 800 cc, technology classes in Eastern Europe, etc.)
Recent Updates

COPERT 4 VX.Y

X… Methodology update
Y… Software update
Consistent with the following EMEP/CORINAIR Guidebook chapters:
- B710: Road Transport (Activities 070100 – 070500) Ver. 6.0
- B760: Fuel Evaporation (Activity 070600) Ver 2.1

Methodology issues added/updated in this version:
- Emissions from CNG Buses
- Emissions with use of Biodiesel
- Distinction of primary NOx emissions to NO2 and NO
- Emission factors of Euro 4 Diesel Passenger Cars
- Reductions for future emission standards Euro 5, Euro 6 and Euro V, Euro VI
- Revised CO2 calculation equations (biofuels and alternative fuels)
- Revised CH4 emission factors
- Corrected N2O and NH3 emission factors
- Revised calculation algorithm for CH4, N2O and NH3 hot/cold emissions
Consistent with the following EMEP/CORINAIR Guidebook chapters:

- B710: Road Transport (Activities 070100 – 070500) Ver. 6.0 with modified N2O emission factors for HDV
- B760: Fuel Evaporation (Activity 070600) Ver 3.0
- B770: Road vehicle tyre and break wear (Activity 070700) Ver 1.0

Methodology issues added/updated in this version:

- Determination of the fraction of Elemental and Organic Carbon in exhaust PM
- New methodology to calculate evaporation emissions
- Inclusion of non-exhaust (tyre & break wear) PM
- Updated N2O emission factors for HDV
Mainly a software update (bug corrections and additions)

- Mileage used for N2O and NH3 emission degradation changed (was annual – > became cumulative)
- Different RVP and Temperature values per year can be imported from Excel
- Corrected mileage import from Excel
- Warning message on evaporation emissions removed
- Evaporation method now works also for negative temperature values
Process for COPERT update
Normal process of COPERT Updating - 1(2)

- Autumn Year x
  - UNECE Task Force of Emission Inventories and Projections meeting takes place
  - The Transport Expert panel operates within TFEIP and discusses priorities for improvements of the AEIG. The panel is open to anyone - mainly consists of inventory experts in each country.
  - The priorities list is presented to the plenary and it is modified or approved
  - LAT evaluates which of the priorities can be addressed through the European Topic Centre Air and Climate Change budget (30-50 kEuro per year) and includes them in the annual plan for year x+1
  - Priorities which cannot be addressed (mainly due to financial issues) are either postponed or alternative funding / collaborations / sources are sought =>Role of JRC
Normal process of COPERT Updating - 2

- **Spring Year x+1**
  - LAT / partners work on the update of the AEIG
  - Ad-hoc meetings take place on priorities/ discussions which are used as input to the Transport Panel (e.g. JRC and EEA workshops)

- **June Year x+1**
  - LAT submits the draft revised chapter to TFEIP for review

- **July/August Year x+1**
  - LAT/partners revise the chapter and send it to TFEIP for approval by the EMEP Steering Committee (Sept Year x+1)

- **September/October Year x+1**
  - LAT introduces the revised chapter into COPERT and makes software improvements
Next Steps
### Wish List/ Users’ Perspective
(Example from EEA COPERT Workshop – June 2008)

<table>
<thead>
<tr>
<th>User</th>
<th>Request</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferreiro Antonio</td>
<td>IPCC Uncertainty Calculations</td>
</tr>
<tr>
<td>Ricardo de Lauretis</td>
<td>Mopeds – further improve emission factors in the light of huge influence to Italian inventory</td>
</tr>
<tr>
<td>Martin Adams</td>
<td>Corrections for CO2 (based on weight classes or more detailed capacity classes)</td>
</tr>
<tr>
<td>Antonella Bernetii</td>
<td>Include slope correction as a geographical parameter and not a vehicle specific parameter</td>
</tr>
<tr>
<td>Helen Heintalu</td>
<td>Send information on updates / new versions to national experts</td>
</tr>
<tr>
<td>Antonella Bernetti</td>
<td>Make possible importing different fuel specifications per year from the Excel spreadsheets</td>
</tr>
<tr>
<td>Andrei Pilipchuk</td>
<td>Include the effect of idling (in particular cold idling) on road transport emissions</td>
</tr>
<tr>
<td>Martin Adams</td>
<td>Provide export files to communicate to new CollectER and XML formats</td>
</tr>
</tbody>
</table>

In addition, 3-4 emails per day with requests (including clarifications)
# Wish List / Experts’ Perspective

*(JRC Transport Inventories Workshop - Nov 2007)*

<table>
<thead>
<tr>
<th>Class.</th>
<th>Theme</th>
<th>Particular Issues</th>
<th>Priority</th>
<th>Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Uncertainty characterization and sensitivity analysis</td>
<td>Perform Monte-Carlo or similar type of statistical treatment to models to identify most important variables, give guidance on the detail required for activity data, uncertainty range of final calculation</td>
<td>12</td>
<td>48</td>
</tr>
<tr>
<td>2</td>
<td>Cold-start emissions</td>
<td>Better detail cold-start emissions, perform new measurements on new vehicle technologies, use PEMS to record cold over emissions, revise the methodology</td>
<td>11</td>
<td>48</td>
</tr>
<tr>
<td>3</td>
<td>New technologies including hybrids</td>
<td>Develop emission factors, emission methodologies for new emission control technologies, such as strong hybrids, mild hybrids, SCR, GDI, Flexifuel</td>
<td>10</td>
<td>47</td>
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<tr>
<td>4</td>
<td>Biofuels and alternative fuels</td>
<td>Characterize links of vehicle technology / fuel use / blend, for example E85 effect on Euro 3 passenger cars, second generation biofuels, CNG, LPG, Biogas, Non-regulated pollutants</td>
<td>11</td>
<td>46</td>
</tr>
<tr>
<td>5</td>
<td>CO2 / fuel consumption characterization</td>
<td>Develop more classes for CO2 emissions (e.g. diesel &lt;1.6 l, SUV, gasoline &lt;1.0 l, etc.), develop correction factors based on average weight / capacity, CO2 from urea consumption</td>
<td>10</td>
<td>44</td>
</tr>
<tr>
<td>6</td>
<td>Characterization of the emission factors quality/variability</td>
<td>Assign a quality index on each emission factor (e.g. A, B, C) or a coefficient of variation value to express uncertainty, explain/discuss uncertainty, provide guidance for uncertainty of different approaches</td>
<td>9</td>
<td>43</td>
</tr>
</tbody>
</table>
## Wish List / Experts’ Perspective
### (JRC Transport Inventories Workshop - Nov 2007)

<table>
<thead>
<tr>
<th>Class.</th>
<th>Theme</th>
<th>Particular Issues</th>
<th>Priority</th>
<th>Total Score</th>
</tr>
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<tbody>
<tr>
<td>7</td>
<td>Refine activity data</td>
<td>Conduct probe surveys on vehicle utilization, better describe vehicle classification (new, second-hand, deregistered, mopeds), collect and refine already available information from transportation statistics</td>
<td>9 7 2</td>
<td>43</td>
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<tr>
<td>8</td>
<td>Validate existing emission factors</td>
<td>Validate existing emission factors (mostly based on dynamometer studies) by means of tunnel or roadside concentration measurements or Portable Emission Measurement Systems (PEMS), air-quality measurements</td>
<td>9 6 2</td>
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<tr>
<td>9</td>
<td>Provide methods for spatial / temporal resolution</td>
<td>Develop good-practice guidance with regard to top-down and bottom-up approaches of road transport emission inventories, develop models to support such approach, streamline average-speed and traffic situation models</td>
<td>7 8 3</td>
<td>40</td>
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<tr>
<td>10</td>
<td>Idling emissions</td>
<td>Provide idling emission factors (g/h) which may be significant for parking lots, for school busses, etc.</td>
<td>6 9 4</td>
<td>40</td>
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<tr>
<td>11</td>
<td>Provide rules/values for projections</td>
<td>Develop detailed good-practice guidance for road transport projections, produce assessments of emission factors for emerging technologies, refine methodologies for stock replacement</td>
<td>8 5 5</td>
<td>39</td>
</tr>
<tr>
<td>12</td>
<td>Emission corrections</td>
<td>Corrections for ambient temperature, altitude, use of auxiliaries (air-con), vehicle age</td>
<td>6 9 3</td>
<td>39</td>
</tr>
<tr>
<td>13</td>
<td>Non regulated pollutants</td>
<td>Conduct studies to measure NH$_3$, NO$_2$/NO, NMVOC speciation, PM speciation, metals from fuel consumption, metals from lubricant, metals from attrition, ion emissions (sulfate nitrate ammonium), PAHs and POPs</td>
<td>4 12 1</td>
<td>37</td>
</tr>
<tr>
<td>14</td>
<td>Non-CO2 GHGs</td>
<td>Perform new measurements to characterize N$_2$O, CH$_4$ based on vehicle technology, operation conditions, fuel use</td>
<td>3 12 2</td>
<td>35</td>
</tr>
<tr>
<td>15</td>
<td>Ultra-emitters</td>
<td>Estimate share of ultra-emitters by remote-sensing, provide emission factors for ultra-emitters, estimate the effect of OBD</td>
<td>4 10 3</td>
<td>35</td>
</tr>
</tbody>
</table>
Scheduled (funded) work

- Year 2008 – Copert 4 V6.0
  - Updated hybrid cars emission factors
  - Updated metal profile from tyre/brake wear
  - Corrections of software bugs

- Year 2009 – Copert 4 V7.0
  - Update of the Euro 3 motorcycle emission factors
  - Prepare homogenized activity dataset for all EU countries (EC4MACS, TREMOVE) on the basis of Fleets
  - Update LDV emission factors on the basis of JRC post-processing of Artemis data

LAT
Longer-term outlook

- Continue and improve support to member states in preparing national official submissions
- Fulfill national obligations in reporting
- Introduce as much available scientific / experimental information as possible
- Develop methodology in line with the availability in activity data
- Promote its use abroad (outside of Europe)