APAT

MEDITAIRANEO ROAD TRANSPORT

Guidelines relating to national and local emissions

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Centre Interprofessionnel Technique d'Etudes de la Pollution Atmosphérique

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Authors : *Jean-Pierre CHANG*
Guillaume GABORIT

Approval : *Jean-Pierre FONTELLE*

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SUMMARY

The road transport sector is one of the most important sources of air emissions regarding substances such as NOx, NMVOCs, CO and CO_2, for most European countries. This sector has multiple impacts on the environment on different spatial and temporal scales. This is why air emissions inventories for road transport are required on different spatial scales.
With regard to inventory applications on different spatial scales, the question of consistency between the local, regional and national inventories is raised. From a methodological point of view, this is equivalent to the question of consistency between bottom-up (micro scale) approaches and top-down (macro scale) approaches.

The purpose of this document is to provide some guidelines when preparing emission inventories for road transport at different spatial scales and both for bottom-up and top-down approaches.

In order to understand the possible problems of consistency and to seek ways of harmonising different approaches, general issues on top-down and bottom-up approaches are presented first. Then reasons of differences and discrepancies between both approaches are pointed out, and possible complementary issues.

After the presentation of the consistency problem between bottom-up and top-down approaches for the road transport sector, guidelines improving consistency of these approaches are provided both when working on local inventories, and when working on national inventory and spatial disaggregation. Especially, guidelines for implementing the top-down approach, developed in the frame of the MeditAiraneo project, are provided in a tiered approach.

Some uncertainty issues are then presented, both in the perspectives of bottom-up inventory approach and top-down approach.

INTRODUCTION

The road transport sector is one of the most important sources of air emissions regarding substances such as NOx, NMVOCs, CO and $CO_{2,}$ for most European countries. This sector has multiple impacts on the environment on different spatial and temporal scales. It is particularly an important contributor of greenhouse gas emissions at global spatial and temporal levels. It also contributes at regional level to long range transboundary air pollutions. At local level, road transport is responsible of the emissions of substances related to air quality issues such as NOx and NMVOCs that are also ozone precursors, CO, PM…
Because of these multiple impacts on different scales, air emissions inventories for road transport are required at different spatial levels from local applications (as urban inventories, air quality networks, local regulation plans, etc.) to regional applications (as atmospheric chemical / transport models) and national application for more global considerations, as for climate change issues.

The raised problem with regards to these different inventory applications is the question of the consistency between the local, regional and national inventories. From a methodological point of view, this is equivalent to the question of consistency between bottom-up (micro scale) approaches and top-down (macro scale) approaches.

Methodological analysis and developments, has been performed under the MeditAiraneo / road transport project supported by APAT, cf. "Road transport emission inventories, national versus local approaches – Methodological report" (Chang J.P. and Gaborit G., 2004) which constitutes the methodological basis for this guideline document.

1. TOP-DOWN AND BOTTOM-UP APPROACHES

Before providing guidelines for estimating national or local emissions for road transport, it is important to understand the discrepancies between inventories at different spatial scales. On the methodological point of view, this problem of consistency relates to discrepancies between top-down (macro) approach and bottom-up (micro) approach used for emission inventories. So, general issues are presented thereafter on these two methodological approaches.

1.1. TOP-DOWN APPROACHES

In the frame of large scale application, such as national or regional inventories, usually, top-down approaches are implemented when estimations at different spatial levels are expected.
A top-down approach consists of making an air emission inventory for a large area (the whole country or one given region) by the use of an emission model, and then estimating the emissions at a finer spatial resolution by using indicators for which the spatial distribution is available.

Thus, the standard top-down approach, within the EMEP/CORINAIR Atmospheric emission inventory guidebook (EMEP/CORINAIR, 2003), consists of using the COPERT emission model (Ntziachristos and Samaras, 2000) at the national level, and then using, surrogate data for the spatial allocation of emissions, which corresponds by default to a spatial disaggregation of activity data and the use of national emissions factors.

More specific top-down approaches had been experienced by some countries for the road transport sector. For instance, the Italian APAT agency (Italian Environmental Protection Agency) has used a "**cluster approach"** for the spatial disaggregation of the national road transport inventory. The principle of this approach is based on the identification of homogeneous areas ("clusters") with regards to transport activities. In a first step, the COPERT model is applied for the national level, and then the standard top-down approach is used to estimate emissions for the different provinces. In the other hand, the COPERT methodology is applied to the different clusters of provinces. From the comparison between cluster emissions issued from COPERT and the sum at cluster level of standard top-down provinces emissions, correction factors are deduced by cluster, type of vehicle and pollutant (De Lauretis R. and al., 2002).

Another example of specific top-down approaches relates to the top-down approach used within the French regional emissions inventories in the frame of the French Air Act on Air and Rational Use of Energy (30 December 1996). CITEPA was in charge of these Regional Air Quality Plans (RAQP) emissions inventories for the reference year 1994 and for all the French regions cf. RAQP reports (Fontelle J.P. and al., 1997), and APMS98 publication (Fontelle J.P., Chang J.P., 1998). The top-down approach developed for road transport, in this frame was based on three hierarchical spatial levels (national, regional and "local"/NUTS4 levels), and two complementary top-down processes.
One top-down process was applied from national to regional level with :

- the use of the COPERT model to estimate road transport emission at national level,
- a spatial assignation process for the input data (parameters) of COPERT at regional level, and regional COPERT runs,

- a normalisation of regional results on the basis of national emissions.
- Then a second top-down process was applied from the regional to the "local" level with :
- the introduction of linear sources for highways and main road sections,
- the use of specific local data (traffic counting) for the linear sources,
- a spatial distribution of traffic activities with relevant distribution key indicators,
- an estimation process for "local" emission factors on the basis of speed differentiation,
- an harmonisation between the "local" level and the regional level.

1.2. BOTTOM-UP APPROACHES

On the opposite of top-down approaches, bottom-up approaches are generally focussing on limited areas (urban inventories, local and regional inventories…) for which local data are available. These local data are used to determine emissions at the local level that can be then aggregated from bottom to top spatial level.
In case of local emission inventories, generally the bottom-up approach may concern both the spatial dimension and the temporal dimension.
The type of needed data for estimating local emissions varies according to the scope and the required accuracy. Different methodologies exist for estimating emissions at local level (NUTS 3, or finer level, small size cells as typically 1 km², etc.). Bottom-up approaches are generally more difficult to implement but enables better precision in terms of spatial and temporal resolution. Nevertheless, after bottom-up aggregation, this method is not necessary more reliable than top-down approach because of possible combination of a lot of uncertainties attached to local data or estimates.

Within the MeditAiraneo / road transport methodological report (Chang J.P. and Gaborit G., 2004), some bottom-up experiences are listed :

- ASPA / French air quality network of Alsace regional uses for road transport a bottom-up approach for the spatial and temporal dimensions.
- AIRPARIF / French air quality network of Ile de France region has implemented a "Real-time" bottom-up approach in time and space (Airparif, 2002) using the European HEAVEN system (HEAVEN, web site) for the traffic management.
- OFEFP / Swiss department for transport research (SET) of OFEFP has developed a particular methodology for Switzerland, i.e. a method using kinematics sequences. This bottom-up model is applied to the whole of the Switzerland (OFEFP, 1995, and 2000).
- VITO developed a bottom-up approach, in space and time, for the estimate of emissions from road traffic, i.e. MIMOSA (Lewyckyj, 2002) with TRIPS/32 traffic model.
- ESCOMPTE / French project with a local emission inventory for the Fos-Marseille area (Buffard, 2003).

In spite of various ways of applying bottom-up methods for road transport from various organisations or institutes in Europe, in most given examples, the calculation is obtained in two stages. First of all, traffic counting and/or modelling of traffic focus on the main roads. The resulting emissions relates to linear emissions. The smallest roads (in terms of vehicle flow) are dealt with separately and the related emissions are considered to be area source emissions.

1.3. TOP-DOWN VERSUS BOTTOM-UP APPROACH

For a given spatial scale, the top-down and bottom-up approaches will give different emission results. Many reasons may explain the differences on results between both approaches. The different reasons can be presented in term of external and intrinsic reasons.

External reasons of discrepancies

The external reasons can be defined as causes on which it is possible to act externally to the different calculations and processes. There may be these following reasons :

- The bottom-up and top-down estimations are done by different teams which do not know in enough detail the estimation processes and assumptions used by the other team.
- Possible use of different emission models, or different versions of the same model (if the works are not done at the same period).
- Possible assumptions not compatible within both approaches.
- Input data or sources of information not consistent between both approaches.
- Differences in inventory specifications (different coverage of emission sources, not exactly the same reference years, etc.).
- Uncertainties in input data within both approaches.
- Validation processes not consistent between both approaches, or not existing for one or both approaches (e.g. energy balance when applicable).

In practice, it is difficult to meet really comparable exercises of top-down and bottom-up approaches because of the different causes of external discrepancies.

Intrinsic reasons of discrepancies

Intrinsic causes can be defined as causes that are internal to the emission models or more generally to the implemented methodologies. It is more difficult to act on this type of cause, because such actions may require to change some elements of methodologies or emission models themselves. Possible intrinsic causes are presented thereafter.

- Non linearity of the emission model :
  In case of non linear model, the consistency of input data, as regards to the different spatial levels, does not imply the consistency of the results of the model. In the event, the COPERT emission model is not a linear model, especially concerning the speed parameter.
- Distribution of parameter values in case of bottom-up approaches versus global average value of parameter within top-down approach :
  This issue is coupled with the previous one. This difference of principle (distribution of parameter values versus global average value) is especially a key cause of discrepancies in case of sensitive parameter (due to non linear relations). It is particularly the case for the speed parameter within the COPERT emission model.
- Respective uncertainties attached to the methodologies of both approaches :
  Supplementary to uncertainties attached to input data (external uncertainties), internal uncertainties (i.e. internal to the emission model / methodology of the chosen approach) are also causes of discrepancies between the top-down and bottom-up approaches (cf. also section "2.4. Uncertainty issues").

Because of these intrinsic causes of discrepancies between both approaches, even if all possible external causes of discrepancies are solved (consistent input data and assumptions, same emission model, etc.), the results of both approaches on a common spatial scale will be different, cf. for instance, sensitivity evaluation of speed distribution within COPERT model, French ADEME/SCM study (SCM, 2002).

2. GUIDELINES FOR NATIONAL AND LOCAL EMISSIONS

The aim of the following guidelines is to help improving emission inventories for road transport at different spatial scales, especially as regards to the issue of consistency between national and regional/local inventories, i.e. between top-down and bottom-up approaches.

2.1. COMPLEMENTARY ASPECTS OF TOP-DOWN AND BOTTOM-UP APPROACHES

In spite of discrepancies between top-down and bottom-up approaches, as presented in previous section, these two approaches can be regarded as complementary.

In practice, both estimation approaches, top-down and bottom-up, are generally not in competition. They are generally applied in different contexts :

- Spatial domain and resolution : generally, large domain and low resolution for top-down approach, versus limited domain and high resolution for bottom-up approach.
- Frequency : possibly annual for top-down approach, versus larger frequency for bottom-up approach.

So both approaches should be rather considered as complementary approaches. Especially, if large spatial domain (e.g. the whole country), high resolution and frequency are expected, then both approaches could be used and combined. Indeed, for a large country, a full bottom-up approach, every year, with a high resolution and covering the whole country, would be generally too much resources demanding (data, computer and manpower). A **complementary use of both approaches** can be considered within the concept of **multi-scale constraints**.

2.2. GUIDELINES FOR LOCAL EMISSIONS ESTIMATIONS

The multi-scale constraint concept, within a bottom-up strategy, will consist to use complementary top-down works or data with the aim of macro scale validation processes. Such macro scale validation requires having overlapped spatial areas between bottom-up and top-down approaches.

For instance, the sum of local emissions for a given region can be compared to the regional estimated emissions from a simpler top-down approach to verify the consistency and order of magnitudes of both approaches.

Fuel consumptions from the bottom-up approach can also be compared to regional (or sufficiently large area) fuel sales (gasoline and diesel oil separately). Generally, at a sufficiently large spatial scale, the fuel sales are relatively good indicators of the fuel consumption, so that energy balance validation is possible. Even within a large spatial scale, one exception occurs in case of a region/area with a foreign frontier. In such a case, a consistency check may be conducted, consisting to verify whether the bottom-up calculated fuel consumption is higher than the fuel sales in case of lower price of fuel in the neighbour country (fuel importation dominating) or the opposite in the other alternate case.

More exhaustively, the guidelines concerning the bottom-up approach for local/regional inventories may be the following :

- Use of GIS (geographical information system) to manage local spatial entities (linear sources for highways and main roads, area sources for small roads).
- Use of specific local data / traffic conditions for the main emitting sources (e.g. traffic counting, speed data for highways and main roads).
- Possible use of traffic model to estimate local/urban traffic.
- Used traffic model should be cross-checked/calibrated with available traffic counting data.
- Possible use of more simple estimation process for small emission sources (less available data, lower contribution…).
- As far as possible and relevant, use of regional/local vehicle fleet structures.
- Use of the regional/local information to get more relevant specific emission factors.
- Being aware of possible limits of emission model (e.g. at too small spatial scales).
- As far as possible, the uncertainties related to the emission estimations should be estimated (cf. section 2.4).
- Validation processes should be operated, e.g. with multi-scale constraint checking at higher spatial levels (as mentioned above).
- Etc.

2.3. GUIDELINES FOR NATIONAL EMISSIONS AND TOP-DOWN DISTRIBUTION

Within the objective of improving spatial disaggregation of road transport emission inventories, and increasing consistency between national and regional/local inventories, the key concept of multi-scale constraints is also followed within a top-down strategy.
When, in bottom-up strategy, multi-scale constraints relate to macro upper level constraints, in the present case of top-down strategy, the multi-scale constraints will cover two kinds of issues :

- Macro top level constraints assuming that the top level emissions (e.g. national emissions) are absolute references of emissions.
- Micro, local level, constraints, with possible available data from bottom-up approach to be used as external and independent reference data for calibration / consolidation of the spatial disaggregation estimation process.

2.3.1. Basis of MEDITRoad top-down approach

Within the MeditAiraneo / road transport project (supported by APAT), an improved general top-down methodological approach, so called MEDITRoad has been developed, cf. chapter 2 of the related methodological report (Chang J.P. and Gaborit G., 2004). It is proposed to follow this **general top-down approach** which is **flexible** enough to be implemented in **simple or sophisticated way**. An overview diagram of the top-down approach is presented in the next 2.3.2 section.

Top-down techniques on different spatial scales

The top-down approach from national to local level, concerning the emission inventories of the road transport, is based on two complementary top-down techniques to be applied on two different spatial scales and using the principle of multi-scale constraints :

- A meso scale top-down process, from national level to an intermediate meso scale, using the principle of the spatial assignation of COPERT parameters, followed by the COPERT model application on meso scale level, and a normalisation process with the national level.
- A "local" scale top-down process, based on the principle of spatial allocation of COPERT output data (COPERT aggregated results on activity and emission factors) from the meso scale level to the finest expected level, ensuring harmonised emissions between both different scales.

The meso scale identification

Starting from a COPERT (Ntziachristos and Samaras, 2000) application at national level (NUTS 0), the meso scale represents the spatial scale of transition between the two top-down presented techniques (cf. the overview diagram). As principle, the identification of the meso scale will be a free choice, according to the user preferences, national specificities, available data, available resources, the specifications and the objectives of the emission inventory.

The meso scale identification may be based on homogeneous clusters of territorial units with regards to traffic condition characteristics. It may be also identified as a given NUTS level (cf. annex). The advantage of homogeneous clusters is to have fewer discrepancies of emission factors inside clusters. The advantage of the choice of a NUTS level as meso scale is that generally more data and statistics are available on the basis of administrative territorial units.

For example, the NUTS region level may be chosen as intermediate meso scale, and so the region level will be the spatial scale of transition between the two top-down techniques.
More generally, the meso scale may be chosen in principle as any of the different spatial scales : NUTS 0, 1, 2, 3, 4, 5 or finer spatial resolution in principle. Nevertheless, it is to be noted that for the meso scale, the finer the spatial resolution, the more resource demanding (as far as complete COPERT model application is implemented on the meso scale). The two extreme limit cases are the following ones (cf. as illustration, the general diagram of the top-down approach in the next 2.3.2 section) :

- Case where the meso scale is fixed as identical to the NUTS 0 level : this situation will relate to the case where the first top-down technique will not be applied, but only the second one. The COPERT application at national level is directly followed by a spatial allocation of the national results down to finest spatial resolution.
- Case where the meso scale is fixed as identical to the finest spatial resolution : this situation will relate to the case where the second top-down technique will not be applied, but only the first one. The COPERT application at national level is followed by the spatial assignation of COPERT parameters at the finest spatial resolution. Then, COPERT model is applied at the finest spatial resolution. Finally a normalisation process will harmonise the emissions on the finest scale, on the basis of the national emissions.

General principle

The two top-down methods (from NUTS 0 to the meso scale, and from the meso scale to the finest considered resolution) are based on a common general principle which is a kind of combination and use of the two general "top-down" and "bottom-up" approaches in a multi-scale constraint perspective :

– A "top-down" approach considering absolute values (considering especially that national absolute values of emissions represent references).

– A "bottom-up" type approach considering relative spatial contributions (with COPERT applications at meso scale level, and use of available local/regional data for calibration or consolidation of top-down processes).

That means that regional and local specificities are used to estimate the regional and local emissions. But these emissions are, at the end, normalised i.e. corrected as absolute values on the basis of the reference national emissions, ensuring harmonised emissions on the different spatial scales.

One may note that considering national emissions as references is a choice of principle, as far as the sum of detailed and local calculations is not necessarily more reliable than a global macro estimation. Especially, in the present case of road transport, the energy balance validation process within COPERT on macro scale and particularly at national level, may justify to consider the national estimations as reference emissions.

Top-down principles from national level to the meso scale

In view of increasing the reliability of emissions at intermediate meso scale, the following principle is applied. It is proposed to proceed to a spatial allocation of the input parameters of the emission model from NUTS 0 to meso scale, instead of the more classical spatial allocation of the outputs of the emission model. That enables to refine estimations using spatial distributions of traffic characteristics, or directly known traffic parameters on meso scale when available to apply then the emission model to meso scale.

The general principle of harmonisation with the national level is declined here by using the results of the COPERT model at national level (activity data and emissions) as absolute value references, and the results of COPERT model on meso scale as relative terms (which have to be corrected by normalisation factors so that sums of final meso scale results relate to the national data).

Top-down principles from the meso scale to the finest spatial level ("local" scale)

At the finest considered spatial resolution (so called also "local" level), two kinds of emission sources may be taken into account : linear sources (e.g. sections of highways and main roads), and the area sources (e.g. NUTS 5 territorial units) excluding the linear sources (to avoid double counting).

Because of a large number of spatial units (linear or area units) in principle at the finest considered spatial resolution, it would be too much time consuming to try to apply the same type of top-down technique than from the national level to the meso scale (i.e. estimating COPERT input parameters, applying the COPERT model to each of the finest spatial units, and processing to final normalisations). This is why another type of top-down technique is applied.

In order to increase reliability of emission estimations, the proposed top-down method from the meso scale to the finest resolution, adopts the following principles :

- Use, as far as possible, of data from traffic counting when available.
- A top-down approach in terms of absolute value on the basis of meso scale results (activity and emissions) assumed to be mesoreference data, and ensuring harmonised emissions on all spatial scales as far as the meso scale emissions are harmonised with the national emissions.
- A standard top-down allocation with surrogate data for the activity data from the meso scale to the finest spatial resolution, but with extended refinement by using more or less complex indicator combinations including degrees of freedom and calibration process.

- An extended top-down approach for the spatial differentiation of emission factors from the meso scale to the finest spatial resolution, on the basis of aggregated emission factor profiles depending on the speed and/or temperature, and taking into account the constraint of normalisation of emissions with the meso scale.

Principles of spatial allocations

In case of standard spatial allocation, the allocation calculation is quite simple and based on a linear relation approximation between the spatial data to estimate and an indicator known at the different spatial units. Furthermore, within the standard spatial allocation, data to be allocated are generally additive (especially the national value is equal to the sum of the values for the different units).

For the purpose of the spatial top-down assignation of COPERT parameters, further spatial allocation processes are required. Particularly, the following specific cases are used, cf. annex 1 from MeditAiraneo methodological report (Chang J.P. and Gaborit G., 2004) for detailed developments :

- Standard spatial allocation of additive data.
- Spatial assignation of sectoral percentages (e.g. spatial assignation of the traffic share as % between the three modes : highway, rural and urban).
- Spatial allocation of a non-additive data with a linear relation of type y= a.x (e.g. spatial assignation of the annual mileage per vehicle on the basis of the fuel consumption indicator per vehicle).
- Spatial allocation of a non-additive data with a linear relation of type y= a.x + b (e.g. spatial assignation of the average speed on the basis of traffic density indicators).
- Spatial allocation of a non-additive data based on a profile (e.g. spatial assignation of emission factors on the basis of emission factor's profiles according to speed and/or temperature).

2.3.2. Tier method implementation

According to available data, available resources, specifications and objectives of the emission inventory, different choices of implementation of the top-down approach are possible, from simple to detailed, more or less complex, implementations.

2.3.2.1. Detailed methodology implementation (tier 3 implementation)

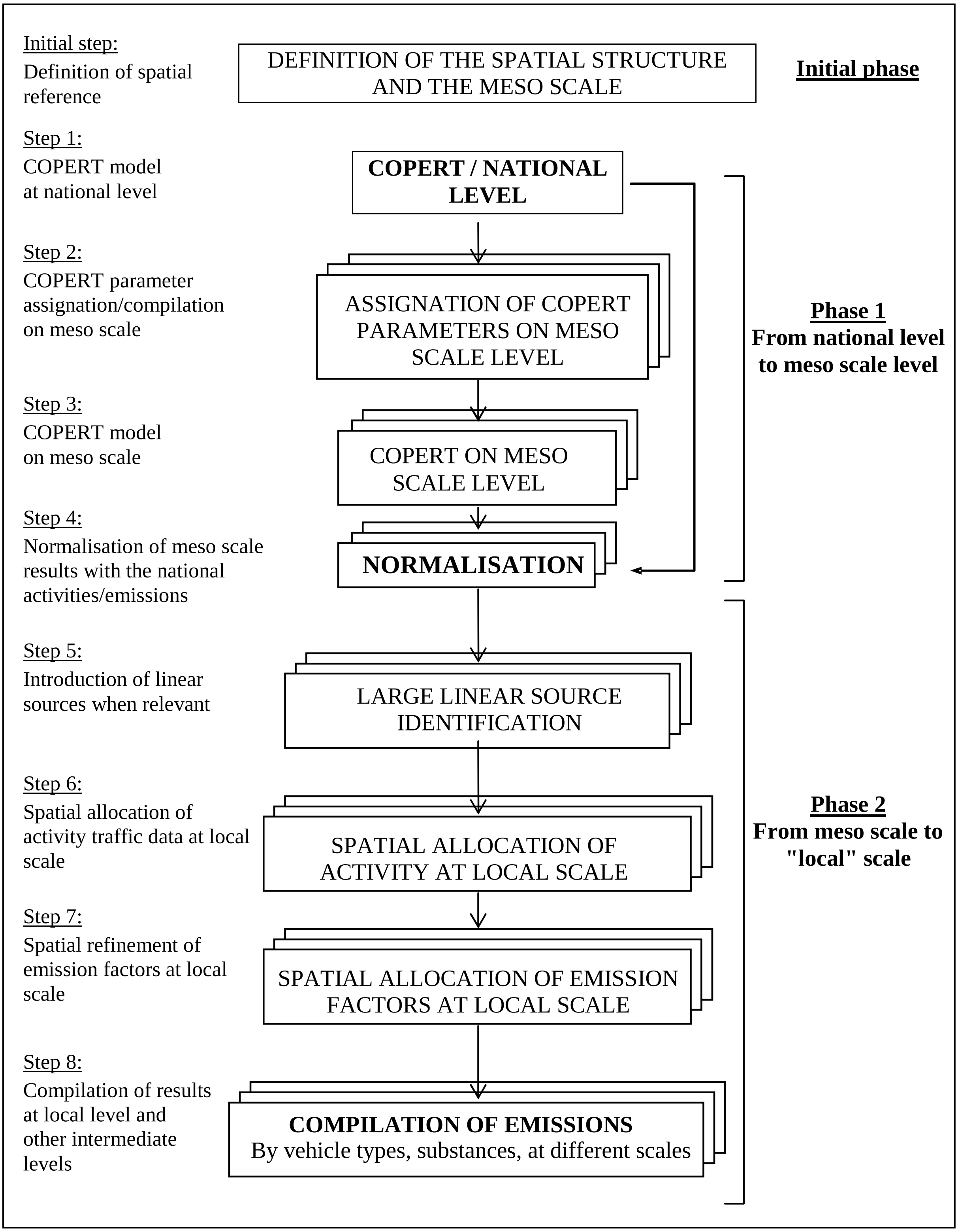
The detailed methodology implementation relates to the exhaust application of the general top-down approach for all different steps as presented in the following diagram.
Such a detailed top-down implementation is quite resources and time demanding. Thus, this tier 3 implementation could be used for specific studies or for periodical spatial inventories of which the period is relatively large.

Initial step

Before starting the top-down process for the emissions of road transport, it is necessary to clearly define the structure of the spatial dimension (coverage and resolution) of the emission inventory and especially the choice of the meso scale relating to the spatial scale transition in the top-down method. Especially, at the finest spatial scale ("local" level), it will be necessary to decide to introduce linear sources or not.
The choice of meso scale identification will actually depend on user preferences (e.g. use of cluster or NUTS units), national specificities, available data, available resources,

specifications and objectives of the emission inventory, remembering that the finer the spatial resolution will be for the meso scale, the more resource-demanding the process will be. Typically, in the present tier 3 implementation, the meso scale could be chosen as an actual intermediate spatial scale (e.g. the region level for a national spatial inventory).

OVERVIEW DIAGRAM OF THE TOP-DOWN PROCESS



Phase 1 : from national level to meso scale level

This phase 1 consists on applying the first top-down technique from the national level to the meso scale, using the principle of the spatial assignation of COPERT input data (COPERT parameters), COPERT application on meso scale level, followed by a normalisation of the results with the national level.

Phase 1 - step 1 : COPERT emission model application at national level

The COPERT emissions model is used as usually at national level as reference emissions, and starting point of the top-down process.

Phase 1 - step 2 : determination of COPERT parameters on meso scale level

Applying the principle of spatial assignation of COPERT input data (instead of COPERT output data) on meso scale, consists on setting a process using the COPERT parameters at national level and key indicators to estimate the COPERT parameters on meso scale level, as input data for the emission model on the meso scale level. Nevertheless, some parameters may be assumed to be the same as for the national level (e.g. fuel specifications, average length trip, etc.), and others may be direct input as far as they may relate to available meso scale data (e.g. fuel consumptions, temperatures at meso scale…).

Thus, the determination of the COPERT parameters on the meso scale will require indicators or basic data as following :

- total, urban and rural inhabitants,
- total, urban surface,
- numbers of passenger cars, light duty vehicles, heavy duty vehicles, motorcycles,
- lengths of highways, roads, …
- fuel consumptions,
- average monthly temperatures,

<u>Spatial assignation of the vehicle fleet</u>

In case the vehicle fleet by type and by age (or European Directive) is not available on mesospatial scale, the COPERT vehicle fleet on meso scale may be estimated on the basis of the national detailed fleet structure and meso indicators as meso aggregated fleet estimations or statistics of meso sold vehicles by type of vehicles. The related spatial assignation corresponds to the standard spatial allocation of an additive data.

<u>Annual mileages per vehicle on meso scale</u>

Different situations may be examined.

1) Fuel consumption are available on meso scale and energy balances are expected to be reached at the different territorial units of the meso scale. In this case, the annual mileages per vehicle can be at the starting point, the same as the national level annual mileages. Then for the different meso territorial units, the energy balance may be reached by fitting the annual meso mileages.
2) Energy balances are not expected to be reached, but a relevant indicator is identified for a spatial assignation of the annual mileages on meso scale. The spatial assignation relates here to a spatial allocation of a non-additive data, so requiring a non-additive indicator (e.g. " annual fuel consumption per vehicle").
3) Energy balances are not expected to be reached, and no specific discrepancies are expected between the different meso territorial units. In this case, the annual mileages at meso scale are the same as at national level.

Traffic mode share on meso scale level

It is proposed to apply a spatial assignation to this COPERT parameter, traffic share between the three modes, urban, rural and highway. In this case, three correlated parameters have to be dealt with simultaneously, the urban, rural and highway traffic share percentages whose sum is 100%. The related mathematical development of this spatial allocation is described in the annex 1 from MeditAiraneo methodological report (Chang J.P. and Gaborit G., 2004).

For this traffic share parameter, it is necessary to identify three traffic indicators respectively for the urban, rural and highway traffic. The expression of the resulting traffic share on meso scale is given by the following formula :

- U, R, A, the traffic percentages respectively for urban, rural and highway modes,
- i : the reference to a given territorial unit of the meso scale,
- o : the reference to the national level,
- Fu, Fr, and Fa : the traffic indicators respectively for the urban, rural and highway traffic.

$$U_i = \frac{100.\alpha_i.U_0}{(\alpha_i.U_0 + \beta_i.R_0 + \gamma_i.A_0)} \qquad \alpha_i = \frac{Fu_i}{Fu_0}$$

$$R_i = \frac{100.\beta_i.R_0}{(\alpha_i.U_0 + \beta_i.R_0 + \gamma_i.A_0)} \qquad \beta_i = \frac{Fr_i}{Fr_0}$$

$$A_i = \frac{100.\gamma_i.A_0}{(\alpha_i.U_0 + \beta_i.R_0 + \gamma_i.A_0)} \qquad \gamma_i = \frac{Fa_i}{Fa_0}$$

The three traffic indicators should be the traffic counting on the different modes when available. When not available, the three traffic indicators may be built as possible combinations of the following indicators :

- capacity indicators : surface of urban area for the urban mode, length of roads for rural mode, length of highways for highway mode, etc.,
- frequency indicators : urban population, rural population, total population.

Then, when no specific frequency indicator as traffic counting is available, the following generic type of combination for traffic indicators is proposed concerning the traffic mode share **:**

Indicator = C1 * Capa + C2 * (Pop U)^q * (Capa)^p + C3 * (Pop R)^q *(Capa)^p
(capacity term) (urban frequency term) (rural frequency term)

With :

- Capa : indicator of capacity (as surface of urban area for the urban mode, length of roads for rural mode, length of highways for highway mode).
- Pop U : urban population within the urban frequency term.
- Pop R : rural population within the rural frequency term.
- C1, C2, C3 : set of coefficients to be fitted, respectively for the three traffic modes.
- p : exponent of the capacity indicator within the frequency terms.
- q : exponent of the population indicator within the frequency terms.

Notes :

- "rural frequency term" does not relate exclusively to rural traffic mode, but means a frequency term due to rural population. Similarly "urban frequency term" means a frequency term due to urban population that may occur not only for urban mode but also for rural and highway modes. Generally, urban, rural or highway traffics are due to both urban and rural populations, but with possible different contributions according to the different modes.

- The population represent by default the number of inhabitant, but it could be considered as a more generic indicator of population (e.g. population equipped with car, number of employees, etc.)

The generic combination of indicators has to be specified for the three different modes urban, rural and highway, with different values of the set of coefficients C1, C2, C3, and specific capacity indicator for each mode. Nevertheless, the exponents p and q may be the same for the three modes.

Thus, for the urban traffic mode, the capacity indicator could be the urban surface, and the main component of the combination should be the urban frequency term. Note : in case of French RAQP 1994 inventory (Fontelle J.P. and al., 1997), C1 and C3 were fixed as zero, and the urban traffic indicator was : $(\text{urban population})^q$ x $(\text{urban surface})^p$.

For the rural traffic mode, the capacity indicator could be the road lengths, and the main components of the combination should be the rural frequency term, $(\text{rural population})^q$ x $(\text{road lengths})^p$. Note : in case of French RAQP 1994 inventory, C2 was fixed as zero and C1 was relatively small compared to C3.

For the highway traffic mode, the capacity indicator could be the highway lengths, and the three components of the combination should be considered. Note : in case of French RAQP 1994 inventory, the default surrogate indicator was not used, as far as the traffic counting was available on the highways.

The free parameters, as the exponents p and q, and the coefficients of the indicator combination for the different modes, need to be fitted with a "calibration" process, on the basis of references from territorial unit for which the traffic share are known from specific estimations. For instance, in case of French RAQP 1994 inventory, the "calibration" process was based on external data on traffic shares from three reference regions.

The factor $(\text{Capa})^p$, within the frequency term, is needed to get in principle a null traffic in case of null capacity. So the p exponent should be a small number (lower than 1), to avoid to have too much impact in the frequency term (e.g. in case of French RAQP 1994 inventory, the exponent p was chosen as 0.1).

The exponent q for the population, within the frequency term, is used to get indicators, $(\text{PopU})^q$ and $(\text{PopR})^q$, whose correlations with the traffic frequencies are better (e.g. in case of French RAQP 1994 inventory, the exponent q was chosen as 0.55).

Note : for a given traffic mode, the same traffic indicator may be used for the different vehicle type. But for possible refinement especially for heavy duty vehicles, it could be more relevant to use more specific default frequency indicators : for instance the population as inhabitant could be replaced by the population of employees from transport companies as one possible refinement.

<u>Assignation of average speed on meso scale level</u>

At the local level of road or highway section, there is a strong correlation between the flow speed and the density of vehicle (decrease of speed when the density is increasing down to the saturation condition).

Except in case the average speeds on meso scale for the three traffic modes are available from traffic counting, it is proposed to estimate them with a spatial assignation process. For that purpose, it is assumed a linear correlation between the average speed and the density indicator as following type : speed = a*density + b. This kind of correlation requires the availability of the average speeds for two territorial units of reference, the national one, plus another one on meso scale for which the average speed and the density indicator are known.

In principle the density indicators should be traffic density indicators as "numbers of vehicles per length of road/highway". When such specific indicators are not available, for each traffic mode, the density indicators D could be defined as following :

$$D = D_1*(\text{total Pop.})^q / \text{total surface} + (D_2*(\text{Urban Pop.})^q + D_3*(\text{Rural Pop.})^q) / \text{capacity indicator}$$

With :

- D1, D2, D3 : set of coefficients to be fitted, respectively for the three traffic modes.
- Capa : an indicator of capacity (as surface of urban area for the urban mode, length of roads for rural mode, length of highways for highway mode).
- total Pop. : the total population
- Urban Pop. : the urban population
- Rural Pop. : the rural population
- q : exponent of the population indicator within the frequency terms
- capacity indicator : the capacity indicator which can be respectively for the different traffic modes :
    - the surface of the urban area for the urban mode indicator,
    - the length of roads for the rural mode indicator,
    - the length of highways for the highway mode indicator.

The q exponent could be in principle the same as for the traffic mode share indicators (cf. previous item).
The coefficients D_1, D_2 and D_3, need to be fitted for each traffic mode with a "calibration" process, on the basis of known average speeds for some reference regions. In practice, the ratio between the coefficients D_2 and D_3 (from urban and rural contributions) could be the same than the ratio between the coefficients C_2 and C_3 from the traffic mode share indicator (see previous item).

Furthermore, some simplification for the different traffic mode could be applied : for instance in case of French RAQP 1994 inventory, for the urban indicator, D_3 was assumed be null, and for the rural indicator, D_2 was assumed to be null.

Note :

- The first term of the combination formula is a background common term which enables to avoid too much large discrepancies of resulting average speeds on meso scale. Especially it may avoid to get resulting average speeds outside of relevant domains.
- For a given traffic mode (urban, rural or highway), the same average speed indicator can be used for the different vehicle types.

Phase 1 - step 3 : COPERT application on meso scale

After all COPERT parameters on the meso scale are determined, they can be used as input data to the COPERT emission model. Then the COPERT model can be applied to the different territorial units of the meso scale. Because of a non-linear emission model, the sum of COPERT emissions on meso scale will be different from the reference COPERT national emissions.

Phase 1 - step 4 : normalisation of meso scale results with the national level

In the principle of a top-down approach, the national emissions are considered as the reference emissions. This is why, the COPERT emissions on meso scale (by pollutant, vehicle type and traffic mode) are corrected by a normalisation coefficient corresponding to the COPERT national emissions divided by the sum of COPERT meso scale emissions (for a given pollutant, vehicle type and traffic mode). The same normalisation process can be applied to the activity data (vehicle*km), so that aggregate meso scale emission factors (e.g. according to SNAP nomenclature) can be deduced.

Phase 2 : from meso scale level to the finest scale

After the determination of the meso scale normalised emissions, this phase 2 consists on applying the second top-down technique from the meso scale to the local scale. For that purpose, on this spatial scales, more classical principle of spatial allocations are used for activity data plus emission factors local refinement.

Phase 2 - step 5 : possible introduction of linear sources

At the local scale level, according to the emission inventory specification and the available data, large linear sources (as main road / highway sections) may be requested to be identified and treated separately. Particularly, for that purpose, it is expected to have available traffic counting for the linear sections and geographical information system (GIS) for the identification and reporting issues.

When introducing linear sources, therefore, it is necessary, avoiding double counting, to consider the local territorial units as area sources excluding the defined linear sources.
Furthermore, to be able to know the emissions by local territorial units including the linear sources, it is necessary to be able with the GIS to split the linear section according the borders of the local territorial units. That should be done at the beginning within the definition process of the linear sources.

Phase 2 - step 6 : determination of traffic activities at local level

At this spatial level, the used top-down technique to allocate the meso scale traffic activities down to the local level (for area and linear sources) is the standard spatial allocation of an additive data.
Especially, when linear sources (highways / main road sections) are defined and related traffic counting is available, the traffic counting can be used as spatial top-down allocation key. Indeed, generally the traffic counting is not as detailed as the activity nomenclature (e.g. the traffic counting does not differentiate gasoline and diesel cars).
For the area sources (territorial units) at the local level, when exhaustive estimations of traffic counting are available (e.g. from traffic models), they can be used as spatial top-down allocation key. Generally, the traffic counting for the area sources is not available. So, more general indicators have to be used. Thus, **a same generic indicator** than for the traffic share on meso scale can be used **at this translated scale**, **but with different coefficients and combined basic indicators**.

Then, **the generic type of combination for traffic indicators** is expressed by :

$$\text{Indicator} = \underbrace{C1 * \text{Capa}}_{\text{(capacity term)}} + \underbrace{C2 * (\text{Pop U})^q * (\text{Capa})^p}_{\text{(urban frequency term)}} + \underbrace{C3 * (\text{Pop R})^q * (\text{Capa})^p}_{\text{(rural frequency term)}}$$

With :

- Capa : an indicator of capacity (as surface of urban area for the urban mode, length of roads for rural mode, length of highways for highway mode).
- Pop U : the urban population within the urban frequency term.
- Pop R : the rural population within the rural frequency term.
- C1, C2, C3 : set of coefficients to be fitted, respectively for the three traffic modes.
- p : exponent of the capacity indicator within the frequency terms.
- q : exponent of the population indicator within the frequency terms.

The same notes than on meso scale are relevant here too, i.e. :

- "Rural frequency term" does not relate exclusively to rural traffic mode, but means a frequency term related to rural population. Similarly "urban frequency term" means a frequency term related to urban population. Generally, urban, rural or highway traffics are due to both urban and rural populations, but with possible different contributions for the different modes.
- The population represent by default the number of inhabitant, but it could be considered as a more generic indicator of population (e.g. population equipped with car, number of employees, etc.)

Specific note : here, at the local scale, if partial traffic counting is available (e.g. limited to the main road sections), this more specific indicator could be used as first component replacing the "capacity" term.

The generic combination of indicators has to be specified for the three different modes, urban, rural and highway (except if the traffic counting is directly used as indicator for a given mode), with different values of the set of coefficients C1, C2, C3, and specific capacity indicator for each mode. Nevertheless, the exponents p and q may be the same for the three modes, and the same as for the meso scale application. But, the coefficients C1, C2, C3 are not necessary the same as on the meso scale application.

For the urban traffic mode, the capacity indicator could be the urban surface (or partial traffic counting if available), and the main component of the combination should be the urban frequency term (plus the partial traffic counting if available).

For the rural traffic mode, the capacity indicator could be the road lengths (or partial traffic counting if available), and the main components of the combination should be the rural frequency term (plus the partial traffic counting if available). Note : in case of French RAQP 1994 inventory, C2 was fixed as zero.

For the highway traffic mode, the capacity indicator could be the highway lengths (or partial traffic counting if available), and the three components of the combination should be considered. Note : in case of French RAQP 1994 inventory, the default surrogate indicator was not used, as far as the traffic counting was available on the highways.

As far as the exponents p and q are fixed as same as for the meso scale assignation process, the remain degrees of liberty for the coefficients C1, C2, C3, may be fixed possibly with a "calibration" process if some local extra data on traffic level are available, for instance from some local traffic model results or local traffic counting. Note : in case of French RAQP 1994 inventory, no calibration on local scale was performed, but partial traffic counting was used as main term completed by the population frequency terms urban and rural with related urban/rural weights similar to the meso scale application.

Phase 2 - step 7 : spatial refinement of emission factors

On this spatial scale, although the emission model is not applied, it is proposed in this step to refine the meso scale emission factors at the local level, for the area sources and linear sources.

For this purpose, the main sensitive parameter of the emission factors which is the average speed, is selected as the refinement parameter. Thus, profiles of aggregated emission factors need to be built as function of the average speed. Another possible emission refinement relates to temperature corrections which require another kind of aggregate emission factor profiles according to average temperature.

<u>Determination of profiles of aggregate emission factors according to speed</u>

If the SNAP activity nomenclature, combined with NAPFUE fuel nomenclature, is chosen as the inventory compilation reference, the point is to build profiles of aggregate emission

factors as function of the average speed, for the different vehicle types and traffic modes as defined with the SNAP/NAPFUE nomenclatures.
In principle, these emission factors profiles according to speed, should be set up for each meso scale territorial unit, as far as these aggregate profiles depend also on the vehicle fleet and climate condition (which may be different within the territorial units of the meso scale).
In practice, it could be possible to make the approximation of using aggregate emission factor profiles based only on the national condition. This approximation is reasonable because of the following issues :

- The climate conditions and the speed are independent parameters within the COPERT emission model.
- The age structure of the fleet will be generally the same between the national level and the meso scale level.
- The aggregate profiles are used to get relative differentiation of emission factors at local level, but not direct absolute values (because of final normalisation process).

Then, the aggregate emission factor profiles by vehicle types, traffic modes and pollutants, can be built by successive simulations of the COPERT emission model with successive close values of the speed.

Determination of profiles of aggregate emission factors according to average temperature

Similarly, it is proposed to use the approximation principle of separating the speed and temperature corrections, and to build the aggregate emission factors profiles according to temperature on the basis of the national conditions plus variations of the average temperature (e.g. successive COPERT national runs with increasing or decreasing temperatures).

Determination of average speeds at local level

To be able to refine emission factors on local scale, it is necessary to be able to estimate speed differentiation on local scale.
That speed differentiation on local scale may be based on different approaches :

- data from traffic counting,
- estimation based on partial traffic counting data,
- estimation from traffic models,
- simple estimations / assumptions (e.g. average speed for highways within urban area is 70 km/h, whereas it is 110 km/h for highways outside urban area),
- ***spatial assignation based on indicators***.

This last approach is proposed as default method when no specific data or estimations are available. The same process of spatial assignation of the speed parameter that was proposed from national level down to the meso scale, can be translated down to the local level, using by default the following generic density indicators D :

$$D = D_1 * (\text{total Pop.})^q / \text{total surface} + (D_2 * (\text{Urban Pop.})^q + D_3 * (\text{Rural Pop.})^q) / \text{capacity indicator}$$

Similarly to the top-down process from national level to meso scale, a calibration process can be performed down to local level, if some particular average speed data are available at local level.

Determination of emission factors at local level

In the general case where speed and temperature corrections are expected, it is possible to refine local emission factors when aggregate emission factors profiles (by speed and temperature) and average speeds are determined, and when temperatures are available at meso and local levels.

Formally, this process can be expressed as an allocation of a non additive data on the basis of a profile, with the following formula :

$$F_i = \left(\frac{A_0.F_0}{\sum_j a_j.f(V_j).g(T_j)} \right).f(V_i).g(T_i)$$

with :

- F_i : the aggregate emission factor for the local territorial unit (i),
- F_o : the aggregate emission factor for the meso scale related territorial unit,
- a_j : the traffic activity for a local territorial unit (j),
- A_o : the traffic activity for the meso scale related territorial unit,
- V_i : the average speed for the local territorial unit (i),
- $f(V_i)$: the emission factor profile as function of speed for the local territorial unit (i),
- $g(T_i)$: the temperature correction factor for the local territorial unit (i), i.e. the E.F. profile applied with the local temperature divided by the E.F. profile applied with the related meso temperature.
- Σ_j : sum within the meso scale related territorial unit.

Note :

- In case no speed correction is expected, $f(V_i)=1$.
- In case no temperature correction is expected, $g(T_i)=1$. That could be the case when it is considered that within each meso territorial unit, the average temperature does not change so much.

Phase 2 - step 8 : compilation of emissions at local level and other intermediate levels

At this final step, all traffic data and emissions factors by vehicle type and traffic mode are available at national level, meso scale level, and local level. Then it is possible to calculate and compile the emissions at all the different spatial levels including the other possible intermediate levels.

2.3.2.2. Intermediate methodology implementation (tier 2 implementation)

This intermediate methodology implementation relates to the case where the meso scale is chosen as identical to the NUTS0 national level. In this case only one top-down technique is applied i.e. the spatial allocation of COPERT result at national level directly down to finest spatial resolution.

This tier 2 implementation may be differentiated into two cases :

- A tier 2a implementation without linear sources consideration.
- A tier 2b implementation taking into account linear sources.

The usefulness of such tier 2 implementation is to have a more simple top-down method, to save time and resources. So that such tier 2 implementation could be used with a higher frequency : e.g. possibly every year for at least the tier 2a implementation (taking into account that the tier 2b with linear source feature should be more resources demanding).

More precisely, this intermediate implementation corresponds to the following situation referring to the general MeditRoad top-down process (cf. general top-down diagram) :

- Initial step (definition of spatial reference) : the meso scale is chosen as identical to the NUTS0 national level (for direct top-down process from national to the finest spatial level).
- Step 1 to 4 (i.e. phase 1 – from national to meso level) are skipped as far as the meso scale is equal to the national level, here.
- Step 5, linear source introduction, is skipped with tier 2a, remains with tier 2b.
- Step 6, spatial allocation of activity data, remains.
- Step 7, refinements of emission factors at "local" scale, remains.
- Step 8, compilation of emission results, remains.

The last steps of the phase 2 (from meso to local scale) remain the same as within the full top-down implementation, with the particular situation of only one territorial unit at meso scale (i.e. the national level).

In the present case of no actual intermediate meso territorial units, the temperature correction (as complementary to speed refinements) for local emission factors is quite useful to take into account the climate variation within emission factors. Indeed, in case of tier 3 implementation, this climate variation is already taken into account in principle at meso level when applying COPERT model to the meso territorial units, which is not the case here.

One benefice of the tier 3 full implementation compared to the tier 2 implementation could be seen in term of reliability as following : with the tier 3 implementation, intermediate scale constraints at the meso level (e.g. possible energy balance at meso level) may enable consolidation of the top-down process at an intermediate spatial scale.

2.3.2.3. Simple methodology implementation (tier 1 implementation)

This simple methodology implementation relates to the standard spatial allocation from national emissions to the finest spatial level using surrogate data and without emission factor refinement at the finest spatial level.

This implementation corresponds to the following situation referring to the general MeditRoad top-down process (cf. general top-down diagram) :

- Initial step (definition of spatial reference) : the meso scale is chosen as identical to the NUTS0 national level (for direct top-down process from national to the finest spatial level).
- Step 1 to 4 (i.e. phase 1 – from national to meso level) are skipped.
- Step 5, linear source introduction, is skipped.
- Step 6, spatial allocation of activity data, remains.
- Step 7, refinements of emission factors at "local" scale, is skipped.
- Step 8, compilation of emission results, remains.

This simple implementation may be differentiated into two cases :

- A tier 1a implementation with spatial allocation using simple indicators (surrogate data) i.e. without complex indicator to be calibrated on the basis of reference data at local level.
- A tier 1b implementation with spatial allocation using complex indicator to be calibrated on the basis of reference data at local level (cf. Phase 2 - step 6 : determination of traffic activities at local level).

The tier 1b implementation should be in principle more relevant than the tier 1a, as far as some local constraints are taken into account within the tier 1b implementation. It is generally true when using surrogate general indicators. In case of available actual specific indicators (e.g. traffic counting), tier 1a implementation with such specific indicators will be more relevant than tier 1b implementation with combination of general indicators even calibrated.

Limit of the simple implementation :

The main weakness of this simple implementation relates to the fact that the spatial variability of emission factors are not taken into account. Using the same emission factor at local level than the average ones from the national level, corresponds to assume that the same average traffic conditions (respectively for highway, rural and urban traffic) is applied to all local areas. Knowing the important influences of the traffic conditions (especially the speed) on emission levels, high uncertainties may be attached to local allocated emissions. Especially, average emission factors are quite different for highways within urban areas and highways within rural areas, because of average speed differences and more frequent traffic jams on urban highways.

2.4. Uncertainty issues

The question of the uncertainties of emission inventories is not a new question, but only recently systematic approaches for quantifying these uncertainties has been furthermore developed in the frame of emission inventories. It is especially the case with the works related to IPCC "Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories" (IPCC, 2000). In principle, this guidance and techniques for quantifying the uncertainties of national GHG emissions may be also applied or extended to other gases.

But, when considering uncertainties for spatial emission inventories, not so much works have been done, because of the difficulties of such uncertainty quantification and the data availability issue.

Uncertainty considerations within bottom-up approaches

The quantification of uncertainty within the IPCC tier 1 simple approach (cf. IPCC, 2000) deals with the uncertainty propagation when aggregating the sectoral emission contributions of the national inventory. In principle, this IPCC tier 1 approach may also be applied when aggregating spatial emission contributions (i.e. extension from a sectoral bottom-up application to a spatial bottom-up application). The condition of applying the tier 1 IPPC approach remains the same : no correlation and not too large combined uncertainties. In practice, even if this condition is not actually fulfilled, the tier 1 approach may provide a first order estimate of uncertainties.

If more resources and uncertainty data are available, the IPCC tier2 stochastic simulation approach (Monte Carlo) could be applied in principle to local emission calculation processes and their spatial aggregation. But implementing such uncertainty simulation approach to COPERT emission model on local scale and aggregated levels will certainly be very time consuming. The other significant problem would be to get enough basic uncertainty data (uncertainties on input local data i.e. local traffic conditions, issued from traffic counting or traffic models, related uncertainty distributions, uncertainties of emission factors of the emission model, etc.). The ADEME/SCM study (SCM, 2002), on COPERT methodology, uncertainty and sensitivity analysis, can illustrate such local uncertainty quantification in case studies of single road section application. Then, if such simulation calculations are expected to be implemented for hundreds or thousands of road sections, and their aggregations, it would require huge amount of time, computer and manpower resources. May be combined tier 2 and tier 1 IPCC approaches should be foreseen. Anyway, further specific works, developments, and feasibility studies would be necessary before such complete implementation within bottom-up approaches.

Uncertainty considerations within top-down inventories

IPCC tier 1, simple approach for combining uncertainties is not applicable to quantify top-down emission estimations for the two following reasons : uncertainties are generally quite large and correlations need to be taken into account (especially the spatial correlations and the allocation processes).. Furthermore, the IPCC tier 1 approach is designed for uncertainty propagation when aggregating emissions. In present case of top-down inventories, the objective would be rather to be able to describe uncertainty propagation when disaggregating emissions.

On the opposite, IPCC tier 2 simulation approach for combining uncertainties (Monte Carlo approach) is general enough to be applied as well for national inventories as for spatially disaggregated inventories. Indeed, the simulation approach is in principle applicable to all kind of calculations, processes and models.

So, in theory, the simulation approach is quite adapted to top-down emission inventory for road transport. Indeed, it enables to combine uncertainties on one hand within COPERT emission model itself, and in the other hand, through the top-down allocation processes. The main problem is that such uncertainty quantification works would require specific developments and important resources for implementation and application. The other significant issue is to get enough basic uncertainty inputs to implement relevant information (uncertainties on input data, correlation functions and attached uncertainty when choosing indicators for the spatial allocation processes, uncertainty distributions, etc.).

Top-down versus bottom-up approaches and uncertainty considerations

As mentioned in section "1.3. top-down versus bottom-up approaches", the uncertainties, external (relating to input data) and intrinsic (relating to the model / methodology) from both approaches, top-down and bottom-up, contribute to the discrepancies that may be met when both approaches are compared on a common spatial scale.

Especially, even if significant efforts are made on the consistency and the accuracy of input data for both approaches, the intrinsic uncertainties and the other intrinsic causes of discrepancies will remain.

So, by principle, it is not possible to have direct equivalent results from both approaches for a common spatial scale. Nevertheless, it is possible to know the nature of discrepancies, and to have an idea of their level.

External uncertainties (attached to input data) are generally more easily accessible than intrinsic uncertainties. Within the French ADEME/SCM study (SCM, 2002), both external and intrinsic uncertainties have been taken into account within Monte Carlo implementation of case studies.

Furthermore, concerning the uncertainties attached to top-down estimation processes with spatial allocations, it will be necessary to pay specific attention when implementing simulation method as Monte Carlo for uncertainty quantification. Indeed, the uncertainties related to estimations using spatial allocation processes will directly depend on the more or less relevant choice of surrogate indicators, i.e. the level of uncertainty attached to the correlation between indicators and data to be spatially disaggregated. Especially, this specific type of uncertainty will have to be introduced within the Monte Carlo simulation.

Considering the uncertainty issue in both top-down and bottom-up approaches, in principle, it could be reasonable to consider that both approaches may be considered as consistent if input data in both approaches are consistent and if results of both approaches are covered within a common uncertainty range. If it is not the case with consistent input data, that could mean that uncertainty estimations are maybe too optimistic (within one or both approaches) or that both approaches are intrinsically inconsistent.

Particularly, such a case of inconsistency could happen when the emission model is used at the limits of application of the model. That could be the case especially when COPERT model is applied on too small local scale. Indeed, COPERT model is rather designed for applications whose spatial resolution must not be below a certain threshold. Particularly, the emission factors are based on driving cycles assumed to be representative of mean figures from the set of kinematic sequences established for an average driver during a journey of 10 to 20 minutes, respectively for the different driving modes (rural ,urban, highway). Then, the use of COPERT model at too small sections where full driving cycles do not occur, will introduce supplementary uncertainties. This issue of emission model limits on too small local scale, points out that a bottom-up approach from local scale, although more precise at local scale, is not necessary more reliable than macro approaches at intermediate spatial scale. Particularly, the use of speed distributions on local scale may significantly provide different emission results compared to the approach using a single average speed as for macro scale approach (cf. SCM, 2002).

As summary, **both estimation approaches** for road transport emissions, top-down and bottom-up, **have important attached uncertainties (external and intrinsic)**, and it is difficult to say in general **which one is more reliable and less uncertain** when comparing them at a common spatial scale.

CONCLUSION

In spite of intrinsic reasons of discrepancies between macro top-down emission inventories and micro bottom-up emission inventories for road transport, it is possible to improve the consistency of both types of emission inventories and by the way the quality of both types of inventories. In the perspective of such better consistency, the proposed guidelines are based on the principle of **complementary use of both approaches** (top-down and bottom-up) and the principle of **multi-scale constraints**.

Especially, within a **bottom-up strategy**, starting from local emission estimations, the **multi-scale constraint** principle consists to use **complementary top-down works or data** in the objective of **macro upper scale validation processes**.

Within a **top-down strategy**, starting from macro emission estimations (especially national emissions), the **multi-scale constraint** principle consists of a top level constraint (e.g. national emissions as absolute references) and of a micro, local level, constraints, with possible available local data to be used as reference for calibration / consolidation of the spatial disaggregation process.

This top-down strategy has been furthermore developed within the MeditAiraneo / road transport project, supported by APAT, and is proposed as guidelines for top-down estimation process. The interests of the proposed top-down approach are the following ones :

- It is a **general top-down methodological approach** applicable to any situation.
- It integrates the **multi-scale constraint** principle, improving the possible quality and consistency of estimates at the different spatial scales.
- It is **flexible** enough to be **implemented in tiered approaches** from a very simple way to quite sophisticated ways according to available data, resources, time, inventory specifications and objectives, national specificities, user preferences…

Uncertainty issues are also considered within these guidelines, as far as it is a key issue concerning the questions of quality and consistency of both inventory approaches (top-down and bottom-up). Especially, when relevant, **IPCC uncertainty quantification** approaches (IPCC, 2000) are proposed to be extended in principle to the **spatial propagation** issues. Nevertheless, in practice, such a quantification of uncertainties within spatial emission inventories (with top-down or bottom-up approaches) should require a lot of further works and developments.

ACRONYMS AND ABBREVIATIONS

ADEME	Agence de l'Environnement et de la Maitrise de l'Energie (Agency for the Environment and Energy Resources) (France)
APAT	Agenzia per la Protezione dell'Ambiente e per i servizi Tecnici (Italy) (Agency for Environmental Protection and Technical Services)
ASPA	Association pour la Surveillance et l'Etude de la Pollution Atmosphérique en Alsace (France) (Alsace Association for Atmospheric Pollution Monitoring and study)
CITEPA	Centre Interprofessionnel Technique d'Etudes de la Pollution Atmosphérique (France) (Interprofessional Technical Centre for Studies on Atmospheric Pollution)
COPERT	Computer Programme to calculate Emissions from Road Traffic (European programme)
CORINAIR	CORe INventory of AIR emissions (European project)
EMEP	European Monitoring and Evaluation Programmme (European)
ESCOMPTE	Expérience sur Site pour COntraindre les Modèles de Pollution atmosphérique et de Transport d'Emission (Field experiments to constrain models of atmospheric pollution and transport of emissions) (France)
GHG	GreenHouse Gas
GIS	Geographical Information System
HEAVEN	Healthier Environment through the Abatement of Vehicles Emissions and Noise (European project)
IPCC	Intergovernemental Panel on Climate Change
NAPFUE	Nomenclature for Air Pollution of FUEls
NUTS	Nomenclature of Territorial Units for Statistics
OFEFP	Office Fédéral de l'Environnement, des Forêts et du Paysage (Federal Office of the Environment, of the Forests and the Landscape) (Switzerland)
RAQP	Regional Air Quality Plan
SCM	Société de Calculs Mathématiques (France) (Company of Mathematical Calculations)
SET	Service d'Etude des Transports de l'OFEFP (Departement for Transport Research of the OFEFP) (Switzerland)
SNAP	Selected Nomenclature for Air Pollution
TRIPS	TRansport Improvement Planning System
UNECE	United Nations Economic Commission for Europe

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Annex - Correspondence between NUTS levels and national administrative units for European countries

Correspondence between NUTS levels and national administrative units

	NUTS1		NUTS2		NUTS3		NUTS4		NUTS5	
BE	Régions	3	Provinces	11	Arrondissements	43	-		Communes	589
DK	-	1	-	1	Amter	15	-		Kommuner	276
DE	Länder	16	Regierungsbezirke	40	Kreise	441	-		Gemeinden	16 176
GR	Groups of development regions	4	Development regions	13	Nomoi	51	Eparchies	150	Demoi/Koinotites	5 921
ES	Agrupación de comunidades autónomas	7	Comunidades autónomas + Ceuta y Melilla	17 1	Provincias + Ceuta y Melilla	50 2	-		Municipios	8 077
FR	Z.E.A.T + DOM	8 1	Régions + DOM	22 4	Départements + DOM	96 4	-		Communes	36 664
IE	-	1	Regions	2	Regional Authority Regions	8	Counties/County Boroughs	34	DEDs/Wards	3 445
IT	Gruppi di regioni	11	Regioni	20	Provincie	103	-		Comuni	8 100
LU	-	1	-	1	-	1	Cantons	12	Communes	118
NL	Landsdelen	4	Provincies	12	COROP regio's	40	-		Gemeenten	672
AT	Gruppen von Bundesländern	3	Bundesländer	9	Gruppen von Politischen Bezirken	35	-		Gemeinden	2 351
PT	Continente	1	Comissões de coordenação regional + Regiões autónomas	5 2	Grupos de Concelhos	30	Concelhos - Municípios	305	Freguesias	4 208
FI	Manner-Suomi/Åland	2	Suuralueet	6	Maakunnat	20	Seutukunnat	85	Kunnat	455
SE	-	1	Riksområden	8	Län	21	-		Kommuner	286
UK:		12		37		133		443		11 095
England	Government Office Regions	9	Counties (some grouped); Inner and Outer London	30	Upper tier authorities or groups of lower tier authorities (unitary authorities or districts)	93	Lower tier authori--ties (districts) or individual unitary authorities	354	Wards	8 619
Wales	Country	1	Groups of unitary authorities	2	Groups of unitary authorities	12	Individual unitary authorities	22	Wards	908
Scotland	Country	1	Groups of unitary authorities or LECs	4	Groups of unitary authorities or LECs (or parts thereof)	23	Individual unitary authorities or LECs (or parts thereof)	41	Wards (or parts thereof)	1 002
N.Ireland	Country	1	Country	1	Groups of districts	5	Districts	26	Wards	566
EU-15		78		211		1093				98 433

http://europa.eu.int/comm/eurostat/ramon/nuts/introannex_regions_en.html