Preparation of Highway Vehicle Emission Inventories

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Passage of the Clean Air Act Amendments of 1990 has initiated a new round of state implementation plans, and their associated current- and future-year mobile source baseline emission inventories. Existing highway vehicle emission inventory practices are assessed in 15 urban areas throughout the country, and these existing capabilities are compared with recommended EPA guidance. Network-based travel demand model approaches are most frequently used and come closest to meeting urban area needs. However, existing approaches often are deficient in their estimation of highway vehicle speeds and also are inconsistent with methodological approaches used for national-level emissions inventories. A variety of institutional problems, though, may present more significant obstacles to the preparation of satisfactory mobile source inventories than any technical limitations. These problems include funding limitations, institutional fragmentation, lack of available technical expertise, and an unfortunately high level of staff turnover.

Passage of the Clean Air Act Amendments of 1990 has occasioned a significant resurgence of interest in the analytical methodologies required to support transportation-air quality related analyses. Issues associated with the preparation of base- and future-year mobile source emissions inventories are explored, particularly the estimation of highway vehicle miles of travel (VMT) and speed.

An important component of the Clean Air Act is the set of planning and analysis activities required by the states and designated nonattainment areas. State implementation plans (SIPs) are comprehensive documents that detail current emissions and air quality conditions, and demonstrate commitments to implement measures that are sufficient to achieve the national ambient air quality standards by a designated date.

As part of an SIP, emissions inventories are developed for all significant mobile, stationary, and area sources of pollutants. Such inventories are developed for both a base year and a projected future year and provide the baseline condition against which the effectiveness of alternative control policies can be measured. Mobile source inventories include all transportation sources of emissions: highway vehicles; off-highway vehicles, aircraft, railroads, and marine. The highway portion of a mobile source emissions inventory classifies vehicles by type (e.g., automobile, light truck, heavy truck, diesel) and estimates both VMT and speed by vehicle and roadway classification.

In addition to urban area and state emission inventories, EPA maintains a variety of national emission inventories covering each of the principal criteria pollutants. Separate trends inventories are maintained as well so as to be able to quickly determine year-to-year variations in emissions.

From a national perspective, it would be desirable if all emission inventories used consistent and identical methodologies, and produced consistent results. Currently, this is not the case and considerable effort is devoted to resolving inconsistencies.

At the state and urban area level, numerous practical problems can be encountered in preparing mobile source emission inventories. For example, it has been customary in past inventory analyses to assume that vehicle travel speeds are the same in future years as they are in the current or base analysis year. This generally has been justified on the basis that highway capacity will expand proportionally with the growth in vehicular travel. Realistically, it is often also based on the lack of information on which to base any other assumption.

Increasingly, however, the assumption of constant vehicular speed over time is being called into question. This change is resulting from an acknowledged cap on highway expenditures, a recognition that congestion is increasing in many urban areas, and results from urban transportation planning analyses. For example, the Southern California Association of Governments is projecting that the average daytime freeway speed in the Los Angeles area will decline from 35 to 20 mph over the next 20 years in the absence of full implementation of an ambitious transportation management and improvement program.

Analyses of the FHWA's Highway Performance Monitoring System (HPMS) traffic data base indicate similar findings. For urban areas, vehicle speeds generally are projected to decrease over time (Figure 1). Speeds decline the most for non-Interstate freeways and expressways, and next most severely for other principal arterials. As expected, the magnitude of the projected speed decrease becomes larger with lower levels of highway funding.

Accurate estimates of speed are particularly important given the nonlinearity with which emissions increase with decreasing vehicle speeds below 20 mph.

RESEARCH AND OBJECTIVES

EPA (*1*) prepared a revised guidance document for the preparation of mobile source emission inventories. This document covers all transportation modes: off-highway vehicles, highway vehicles, aircraft, railroads, and marine vessels. For highways, it provides a comprehensive discussion of factors affecting highway emissions; the use of MOBILE4, vehicle

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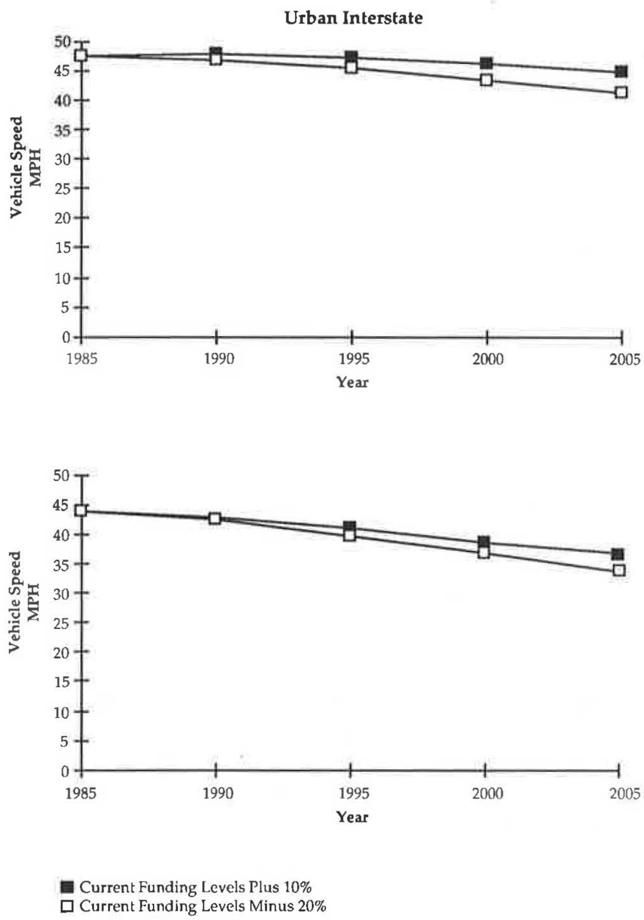

FIGURE 1 Projected changes in automobile operating speeds over time (*3*).

inspection, maintenance, and antitampering programs; and the urban transportation planning process and associated computerized modeling systems. Particular questions that remained after preparation of this guidance document included the following:

- What is the ability of the states to comply with EPA's emission inventory guidance with respect to the use of urban transportation planning data and model systems?
- How can the interface between transportation models and mobile source emission models be improved?

To gain an improved understanding of specific urban area issues, representatives from environmental and transportation agencies involved in the preparation of mobile source emissions inventories were interviewed to determine the problems being encountered in preparing the traffic-related portion of a mobile source emission inventory. These contacts represent the following urban areas: Detroit, Phoenix, San Francisco, Los Angeles, Atlanta, Tampa, Houston, Pittsburgh, Portland (Oregon), Boston, Denver, Chicago, Nashville, Fresno, and Hartford.

On the basis of the list of nonattainment areas for ozone and carbon monoxide, these cities represent different sizes, levels of sophistication, and technical capability. The objective was to sample the problems and solutions from different tiers of urban areas that could be encountered in preparing mobile source inventories, with the overall goal of providing a reasonably quick assessment of the range of methodologies currently being used, the problems being encountered, and the opportunities available for improvement. The approach centered on open-ended telephone conversations with representatives of urban area agencies involved in preparing the mobile source inventory for their nonattainment area.

AVAILABLE VMT AND SPEED METHODOLOGIES

A diverse range of methodologies is being used to estimate VMT and vehicle speeds, as presented in Table 1 (*2*). These methodologies can result in a wide range of accuracy. The following is an overview of the VMT and speed methodologies that are being used by the interviewed urban areas. In general, the techniques that have the ability to analyze and document disaggregate components offer better precision. Urban areas that rely on more coarse methodologies are less precise.

VMT Estimation Methodologies

Network

Network-based VMT methodologies rely on volumes generated as output from an urban area transportation network model. Those models generally are either FHWA's Urban Transportation Planning System (UTPS) or a variation of UTPS operating on a microcomputer. Volumes are calculated internally by the network modeling process used by many Metropolitan Planning Organizations (MPOs). VMT is calculated by multiplying the volumes by link distances. Depending on the specific urban area, links coded into a network model generally correspond to the following facility types: freeway, expressway, major arterial, minor arterial, and major collector. The amount of links coded into a network and the facility classification depend on the sophistication of the model. VMT can be calculated only for the facility types (links) that are coded.

There are some significant problems associated with network-based techniques. VMT generated by non-network-coded facilities, such as minor collectors or residential streets, are not accounted for in a typical transportation network model. Typically, 10 to 15 percent of low-speed VMT data are generated by these non-network-coded facilities. If the emission inventory area is larger than that covered by the transportation network, VMT generated outside the network also will not be accounted for.

Another important problem is the fact that VMT generated by a network model corresponds to a typical weekday, with no recognition of seasonal variation in volumes. Most urban network models have the capacity to simulate average daily, peak (congested), and off-peak volumes.

Presently, stand-alone urban area transportation network demand models are reasonably accurate at simulating regional transportation demand. However, network models under certain conditions may not accurately simulate the variations in link level traffic operations during peak conditions. An important advantage of the network model approach is the fact

TABLE 1 MATRIX OF SPEED-VMT METHODOLOGIES

SPEED:[1]	Network: V/C HCM	Distance Matrix	Capacity Restraint	Speed Runs	MOBILE4 Defaults
VMT:[1]					
Network	Phoenix Detroit Hartford		San Francisco Nashville Houston Los Angeles		
Network/Hybrid		Portland	Atlanta Denver		
HPMS				Boston	Fresno
Manual					Chicago
Fuel Apportionment			Tampa		

[1] The specific highway vehicle emissions inventory procedures utilized in the Pittsburgh urban area are still to be decided upon by the relevant transportation and environmental agencies

that urban area network models represent a repository of important link level data and information. With refinement, these data can be used to simulate link level traffic operations, an important requisite for an accurate emissions inventory.

Network Hybrid

The network hybrid approach generically identifies urban areas that are attempting to deal with problems of coordinating their inventory over many jurisdictions, or the lack of non-network-coded facility data inside or outside the urban network boundary.

For instance, Portland, Oregon, has a unique problem in which the inventory area encompasses nonmodeled rural areas and modeled urban areas of two states, with three agencies involved in traffic modeling. Because the models of these agencies are not coordinated and rely on different data bases and networks, facility types must be aggregated to reach some level of consistency. This process of aggregating to the metropolitan statistical area (MSA) level significantly complicates the process of a link-by-link network-based analysis VMT estimation method.

HPMS

Some urban areas that were contacted are coordinating their emission inventory with the data collected for the HPMS, a traffic data base developed and maintained by the FHWA (*3,4*). State transportation departments are responsible for collecting the sample roadway travel data for various facility types and reporting it to FHWA. FHWA compiles the information and expands it for analysis.

The problems with HPMS data are as follows: (a) HPMS data are representative at the national, state, and larger metropolitan areas only—samples may be too small to be representative for smaller rural and urban areas; (b) VMT is generated at a regional level; and (c) only higher classification roadways are included in samples (i.e., for highways, arterials, and collectors), and urban and rural local VMT data may be limited or nonexistent.

Manual

The manual method represents the most aggregate or coarse method of developing VMT input data for a mobile source emission inventory. Chicago is the only example of this method. VMT is provided by 11 facility types by county ranging from highway to local roads on the basis of the Illinois Department of Transportation's traffic counting program. No attempt was made to assign VMT to facilities within the county or account for the effect of congestion. Future estimates of VMT are extrapolated on the basis of past trends. This method represents the most consistent coverage from one single data source but lacks the ability to document link level operational characteristics.

Fuel Apportionment

This method uses fuel sales as a factor in determining VMT. Daily average fuel consumption multiplied by miles per gallon represents total VMT. Tampa, Florida, is using a variation of this method to determine VMT, where total VMT minus network-derived VMT equals nonnetwork VMT.

Speed Estimation Methodologies

An underlying premise in performing this work has been that estimates of link-level traffic volumes are regarded as being both reasonably reliable and more accurate than link-level speeds produced by urban transportation model systems such as UTPS or microcomputer-based systems. Speeds developed through the modeling process serve as a means of allocating trips to balance the network. As such, they really are more of an input rather than an output of the model. On the other hand, the vehicle speed data in *Highway Capacity Manual* (HCM) (*5*) are considered to be more reliable than estimates based on network models. In free flow (uncongested) conditions, network and HCM speed estimates appear to be similar. However, under congested conditions in which vehicle speeds may drop below 20 mph, these estimates begin to differ significantly. Estimating speeds under congested conditions is crucial in air quality analysis because large shares of VMT occur during peak conditions and because of the nonlinear relationship between speed and emissions below 20 mph.

Network: Volume to Capacity

This technique uses the link-level volume output from the transportation network model and establishes a volume-to-capacity (v/c) ratio for each link that is then used to estimate a speed value for that link. The primary advantages of this method are that the relationship between v/c and speed is based on data from actual operating conditions compiled from the HCM, and it closely simulates traffic operations at the link level.

This method appears to offer a higher level of precision because it documents the daily variations in travel speeds due to congestion which significantly influences the quantity of mobile emissions produced. The primary disadvantage to this method is the cost and coordination necessary to customize an existing network model to replicate link level operational characteristics.

Distance Matrix

Portland, Oregon, calculates speed on the basis of the time it takes for a vehicle to travel between the various zone centroids. Speeds from the traffic assignment process are not used. This method had been selected because of criticism of network-derived travel speeds.

A problem with this method is that speed data for urban and rural non-network-coded facilities are limited. For the Portland SIP, factors to disaggregate statewide local road VMT data were used to assign VMT on facilities not coded in the network. This method does not account for variations in link-level operational characteristics that may have an impact on emissions.

Capacity Restraint

The capacity restraint method is a type of traffic assignment algorithm that attempts to model congested speeds during peak conditions for all facility types. The capacity restraint methodology is used as a default formula in many urban areas' traffic assignment models. The capacity constraint function is based on the assumption that speed decreases as congestion increases.

However, the unique manner in which the capacity restraint function manipulates speed for a particular link does not necessarily represent an accurate estimate of speed for that link but rather a value that optimizes traffic assignment over the entire congested network.

The basic problem with the capacity restraint function is that it does not document well the variations in traffic operating conditions, especially on very congested links. It may be unreasonable to assume that a single formula is able to accurately estimate speed for facility types with very different operating characteristics. A more appropriate procedure includes the use of separate methods for estimating speed for each facility class for each condition, i.e., peak versus off-peak conditions. A primary advantage of the capacity restraint method is that it is institutionalized at many MPOs.

Speed Runs

Some urban areas, such as Boston, use manually collected speed runs for various facility types as input to the mobile source emission inventory. This method is based on samples of representative facility types. Speed runs, however, can be both costly and labor intensive. The samples need to be very large to account for daily variation in travel. If sample size is small, an average speed by facility class is used, which may neglect temporal variations in travel.

MOBILE4 Defaults

The Chicago component of the Illinois SIP is using the MOBILE4 internal default speed of 19.6 mph for all facility types, corresponding to the average speed of the Federal Test Procedure (FTP). Using 19.6 mph as a default value may overestimate vehicle speeds on congested freeway and arterial links that are characteristic of larger urban areas during peak-period operations. This, in turn, may underestimate the amount of mobile emissions generated.

SYNTHESIS OF KEY ISSUES

The following is a list of 12 key issues synthesized from the urban area interviews. In conducting these interviews, it was found that institutional arrangements (or lack of) may have more of an impact on the quality of the mobile source inventory than technical methodology. Therefore, the list includes problems of institutional and administrative arrangements as well as technical considerations.

Adequacy of Transportation Network Model for Air Quality Emissions Inventories

A transportation network model establishes the analytical basis for assessing future transportation needs and evaluating projects that will satisfy those needs. Emphasis generally is on planning for major corridor-level projects, and on projecting traffic volumes on major radial and circumferential roadways. Considerably less importance is given to travel speed and to minor or local streets. A stand-alone transportation network model normally needs customization to be an effective tool for the emission inventory process.

Phoenix, Detroit, and Los Angeles are three examples in which customized procedures have been developed to analyze variations in link-level VMT and travel speed, which are important requisites for an accurate inventory. In Phoenix, peak-period spreading of traffic volumes is explicitly considered. Forecast link volumes are then converted to *v/c* ratios for use in a special speed estimation procedure. The Los Angeles DTIM computer program calculates link-level emissions, accounting for VMT and speed on each link rather than aggregated by facility type. These modifications have proven to be both workable and valuable, and need to be undertaken by a larger number of urban areas.

Validity of Network Based Speed Estimates

Significant concern was expressed in a number of urban areas with respect to the validity of the speed estimates produced by network-based traffic assignment procedures. In response, a number of urban areas have developed special speed estimation routines which calculate *v/c* ratios, and then use either HCM or locally derived relationships to convert *v/c* into speed estimates. A direct network-derived speed estimate may overestimate link speeds because the capacity restraint algorithm used is based on the equilibrium adjustment necessary to obtain a reasonable region-wide trip allocation rather than on observed speeds of the roadway link.

San Francisco, Nashville, Atlanta, and Denver are urban areas identified as using network-based speed estimates. The problem is especially crucial during congested conditions. Network-based methodologies are fairly reasonable at simulating freeflow or uncongested conditions. During congested periods, however, speeds associated with links with heavy volumes may be overestimated. In terms of the emission inventory, this condition would underestimate emissions produced by that link.

Coverage of Local Roads

Transportation network models typically do not include minor and local roads, yet an emissions inventory requires that all travel be covered. Available data on nonnetwork modeled local road characteristics may be nonexistent or limited. Procedures used to estimate local road VMT data may be based on judgment and be of questionable accuracy.

To replicate local street travel, a variety of techniques currently are being used. For example, the Hartford inventory assumes the distance of all traffic generated by centroid connectors, a point where all traffic is loaded on the network, to be 0.96 mi long and operating at uncongested level of service C for peak and off-peak conditions. Denver doubles its network-covered local road VMT data to approximate total local road conditions. A consistent and accurate procedure needs to be developed because lower-classification roadways, especially in urban areas, generally operate at low speeds and may be susceptible in certain conditions to congestion during peak periods.

Inconsistency in Accounting for Peak and Off-Peak Travel

There is a lack of a consistent methodology being used to disaggregate VMT and speed data by time of day. The failure to reasonably account for congested (high-volume, low-speed) conditions may underestimate emissions. Using default speeds may not be appropriate considering that most urban area speeds are lowest on facilities that have the highest volume of traffic.

At the lower end of the precision spectrum in terms of accounting for the variation in peak and off-peak travel are urban areas such as Boston, Fresno, and Chicago that use HPMS or aggregate manual methods for estimating VMT and speed. Their use of facility-type VMT data by county and the use of an average daily speed value for that class of facility does not adequately take into account peak-period congestion.

The methods developed by urban areas using a transportation network based technique, such as San Francisco, are able to disaggregate volumes and speeds by a.m.-p.m. peak periods and for daily conditions. This method falls within the middle of the precision spectrum because the methodology to estimate volumes appears to be more reliable than the methodology to estimate speeds.

Of the urban areas interviewed, the Phoenix and Detroit methods represent the highest level of precision. Their methodologies relate speed to volumes on a link-by-link basis, closely simulating real traffic operating conditions for peak as well as off-peak periods.

Lack of Current Transportation Data

The validity of a transportation network model is directly related to how frequently travel behavior data are collected and integrated into the modeling process. Most larger MPOs conducted large-scale household travel surveys in the 1960s and 1970s. Because these efforts require extensive resources, most urban areas cannot replicate these early survey efforts given the current lack of funding. In order to make up for this deficiency, network models increasingly are being validated incrementally with the use of census data and smaller-scale surveys.

The Los Angeles area is a typical example in which their current model was developed using surveys and roadside interviews in 1967, and which subsequently has been updated using information from a 1976 survey and the 1980 census. Representative and up-to-date travel surveys are a critical component of a regional emissions inventory because they provide the base line travel assumptions against which an areawide transportation model can be calibrated.

Problems of County-Wide Reporting

For areas that are not using network model traffic outputs or areas in which the air quality planning area is larger than the transportation network, traffic volume data may be limited. Facility classifications may be inconsistent with the network model. Care must be taken in mixing empirical data with model results. The cost of obtaining detailed information from nonmodeled areas, however, may not be worth the expense because of the small fraction of total emissions these areas produce.

If consistent methodologies are desired, there may be a tendency to aggregate and report VMT and speed data to the least common denominator. HPMS statistics may be used, and inventory results may be reported only at the county level. This approximation will not document the nuances of different urbanized and rural area traffic behavior for a specific facility type.

In the cases of Illinois and Massachusetts, for example, VMT data are inventoried at the county or regional level by facility type with an areawide average travel speed assigned to that class of facility.

Lack of Alternative Approaches

With appropriate adjustment and postprocessing, transportation network demand models may be the best available tool for predicting traffic inputs to the mobile emission inventory process. However, for areas without traffic demand models, alternative acceptable approaches need to be agreed on to assess VMT and speeds. Alternative methodologies can be defined that are consistent with the magnitude of the problem. If congestion is a major component of the transportation system, a detailed link assessment could be required. In areas having relatively little travel, simpler methodologies could be used.

Portland, Oregon, is an example of an inventory area in which both alternative and a mixture of approaches are necessary. Their inventory area encompasses both nonmodeled rural areas and modeled urban areas of two states. Three separate agencies are involved with network modeling, but with none of the models being consistent and in a transferable format for a regional link-level emissions inventory.

Requirements of a Mobile Source Inventory are not Consistent with the Metropolitan Area Transportation Planning Process

The urban transportation planning process, and its associated set of computerized (UTPS) travel demand models, was not explicitly designed to develop mobile source emissions inventories. This inconsistency of objectives has a number of manifestations. The typical day in terms of average traffic used for transportation planning purposes will not correspond to the same time period that should be used for either a CO or VOC emissions inventory.

The urban transportation planning process used by larger MPOs typically results in a regional transportation plan with a single 25-year planning horizon. In contrast, the forecast emission inventory for an SIP is required at 5-year increments. There is no easy mechanism to accurately interpolate transportation data every 5 years. Accurate 5-year forecasts require a separately coded transportation alternative, something that normally is not done.

A related issue is what transportation alternative to use as the basis for the future-year base emissions condition. The preferred alternative may satisfy demand, but is it realistic considering funding restraints? The preferred alternative may also overestimate VMT. The no-build alternative may likewise underestimate VMT.

The base year for transportation planning purposes usually will not be the same as the air quality base year desired by EPA. This means that VMT and other travel projections cannot be directly translated into EPA terms. Ideally, an entirely new set of transportation analyses should be produced, but this is a time-consuming and expensive task. Thus, transportation and emission inventory analyses are frequently out of synchronization in terms of their base and horizon analysis years.

The Tampa inventory process is currently confronted with this issue of what network model to use. The choice is an out-of-date model that would probably underestimate VMT or wait for a calibrated model. The transportation planning and the mobile source emission inventory processes ideally should be developed in tandem with each other.

Available Expertise

Full-scale transportation network modeling requires greater sophistication and capability than is available in many areas. The urban transportation planning process requires extensive expertise in computer programming and operations research. Typically, only the large urban areas have these resources. The computer interface between urban network models and MOBILE4 may require customization that is beyond the resources of smaller MPOs.

Many smaller urban areas are just trying to financially cope with the mechanics of the routine transportation modeling process, i.e., data collection, network coding, calibration, etc., and do not have resources to customize their transportation model for air quality purposes. Tampa is an example of an urban area that is attempting to provide a new model to meet EPA criteria. It is estimated, however, that it will take at least 18 months for this work to be completed.

Staff Turnover

Lower-level staff are usually responsible for running MOBILE4, and may have only a limited understanding of transportation data and complex urban area travel forecasting models. Typically, once they have been trained and experienced, they move on to higher positions. Internal expertise is not institutionalized over the long term.

Problems of staff turnover and inexperience were identified in both the Detroit and Boston interviews. It is assumed that most urban areas are confronted with these issues because of the large amount of time since the last emissions inventory. A related issue is the fact that air quality planning staff may not be trained to appreciate that temporal variations in VMT and speed inputs in the MOBILE4 model can have significant influence on the amount of emissions that are produced.

Funding Limitations

State and local agencies are being asked to assume more responsibility in completing a more detailed mobile source inventory for a larger geographic area, and to do this for less money.

Atlanta and Houston are examples of urban areas that are confronted with the situation of producing a more detailed emissions inventory for a larger geographic area without the benefit of EPA Section 175 funding. During the early 1980s, the Atlanta area produced an emissions inventory for seven counties, which approximated the area covered by the local MPO transportation network model. The current emissions inventory covers a total of 12 counties, in which 8 are included and 4 are not included in the network model.

Institutional Fragmentation

Because there no longer is a formal funding mechanism in place to coordinate transportation and air quality planning, relationships between air quality agencies and the designated transportation MPOs are now largely restricted to informal contact. Development of a mobile source inventory requires a large number of agencies in either a direct or review role. Input from other agencies is frequently accepted on faith, with little understanding of how it was developed and only minimal concern with the consistency or accuracy of underlying assumptions. In some cases, transportation agencies that were responsible for running the emissions model in the 1970s and early 1980s are currently not involved.

According to representatives from the Chicago Area Transportation Study (CATS), the formal institutional relationship that existed in the 1970s and early 1980s between the environmental agency responsible for running the emission models and CATS has ended. Currently, only informal and infrequent data exchange occurs. Consequently, the current Illinois SIP will have only limited urban area expertise to complete their inventory. Reliance instead is being placed on state level data developed by the Illinois Department of Transportation.

RECOMMENDATIONS

These observations imply the following recommendations with respect to the preparation of mobile source emission inventories:

1. The traditional four-stage, urban transportation planning, travel demand model systems are the best available current methodology for urban area level inventories, but generally are not totally satisfactory in their current form for air quality purposes. Refinements and a postprocessor vehicle speed estimation capability need to be added. In addition, improved vehicle fleet information will be required as more emphasis is placed on the production of clean alternative fuels and low-emission vehicles.
2. Emission inventory procedures should not be oriented to urban and rural conditions, but to the categories of nonattainment severity as defined by the new Clean Air Act. Different methodological approaches will be appropriate for different urban areas, and possibly even within an area. In some situations, a hybrid of procedures will be appropriate; for example, in a situation in which the nonattainment area is significantly larger in size than the geographic area covered by the computer-coded transportation network. Standardization is an admirable, but probably neither an obtainable nor even a necessary objective.
3. Mobile source inventory methodologies should support future as well as current-year baseline projections. In addition, whenever possible, the same quantitative methodology as is used for preparation of the inventory also should be used for forecasting the effectiveness of alternative transportation control strategies. Although this is normally routine in transportation analyses, it is not always the standard procedure in stationary and area source analyses.
4. Monitoring or tracking of emission trends will become increasingly important at the urban area level with the new Clean Air Act. This monitoring will have to relate to the overall emissions inventory, but be able to be efficiently performed on an annual basis. Even more important, though, annual monitoring will have to be conducted so as to be able to determine the effectiveness of individual measures relative to a base case condition.
5. The desired level of inventory accuracy and disaggregation should dictate the choice of inventory methodology. If grid-based urban area dispersion modeling is going to be done, then mobile source emission inventory methodologies that are accurate at a zonal level of disaggregation will be necessary. This almost always will imply use of a UTPS-style approach. However, air shed modeling is exceedingly expensive and time consuming, and may not always be needed for analysis purposes. In these cases, non-UTPS approaches may be sufficient.
6. Mobile source inventory procedures that are appropriate at the national level will not be satisfactory at the urban area level. Different methodologies should continue to be used for national than for urban area inventories, with the inevitable but understandable inconsistencies in their results.
7. Institutional and resource considerations are potentially more significant barriers to achieving satisfactory emissions inventories than are any technical problems. Priority, care, and sensitivity need to be devoted to establishing a long-term cooperative working relationship of shared responsibilities between transportation and air quality agencies at the state and local levels of government.

In responding to the Clean Air Act Amendments of 1990, care must be taken not to let the mobile source portion of an SIP become a resource-intensive modeling exercise that loses sight of policy considerations and implementation objectives. The ultimate objective of the SIP analytical process is not a plan or an elegant analytical exercise. It is the implementation of action programs that will contribute to attainment of the National Ambient Air Quality Standards. This implementation-oriented objective must be kept in mind as states and urban areas undertake the development of a new cycle of mobile source emission inventories.

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