

TRANSPORTATION
RESEARCH

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CIRCULAR

Environmental Research Needs in Transportation

TRANSPORTATION RESEARCH BOARD / NATIONAL RESEARCH COUNCIL

Cost: \$175,000
Duration: 12 months

AIR QUALITY

Air Quality - 1

Title: Improved UTPS-Type Transportation Demand Models and Development of Modal Modeling Capabilities

Problem Statement: The most detailed vehicle activity data currently used in emission inventory and modeling work are outputs from Urban Transportation Planning System (UTPS) type models. However, UTPS is no longer supported by the USDOT and modelling support needs to be reestablished. The UTPS-type models use a standard four step process: estimating trip production and attraction between zones, assigning the generated trips from zone to zone, assigning zone-zone trips to specific travel modes, and assigning the vehicle trips to specific links on a network model. The UTPS-type models are useful for estimating future regional transportation demand and for developing pavement management practices. However, they are not detailed enough to provide accurate vehicle activity estimates for air quality planning. Many research efforts should be undertaken to expand UTPS-type modelling capabilities and to improve their accuracy if they are to be used for air quality purposes. Modal vehicle activities are now known to contribute significantly to vehicle emissions. Constant speed cruise, idling, acceleration, deceleration, engine starts (cold/hot start distribution), engine shut-downs (hot soak evaporation) all contribute to vehicle emissions. Measuring vehicle activities is difficult, expensive and time consuming. The USEPA and CARB are currently undertaking a five year program to develop modal emission rates. However, to be of any use, these modal emission rates must be linked with modal vehicle activity data. Hence, the improvement of UTPS type models to provide modal activity outputs is also critical.

Proposed Research: Some general UTPS-type model improvements are recommended: (1) revising UTPS type models trip assignment subroutines to retain trip purpose information or other stratifications through the network assignment. Parameters such as time of trip, parking availability, and fleet characteristics depend on trip purpose; (2) revising UTPS-type models such that trip assignment subroutines account for congestion by allowing peak spreading; (3) ensuring that adequate feedback loops can account for latent demand; (4) redefining trip purposes to be "needs-oriented" (e.g.,

home-grocery store); (5) modelling recreational travel; (6) investigating improved means of validating transportation models; (7) investigating the existence of a trip making threshold (i.e. replacement of multiple trips that are linked to the work-home trip with single home-based trips); (8) adding trip-chaining procedures to modeling methodologies; (9) investigating the application of static and kinetic friction factors to trip making and trip chaining; (10) developing, as an option for commercially available UTPS-type models, an output report that lists node-specific fractions of cold and hot-transient vehicles; (11) improving the micro-scale resolution of UTPS models; (12) interfacing geo-coding or CAD software with UTPS output data files to produce project-specific traffic information; (13) integrating corridor level modeling of ramp-metering, high-occupancy lanes and accident mitigation strategies; and (14) investigating the development of a representative Nielsen driving family (a representative cross-section of families for study) with computer equipped vehicles for model validation. Models would be modified to provide modal vehicle activity data (i.e. acceleration, deceleration, cruise and idle activity) to combine with the latest modal emission factor model. Thus, emissions can be estimated for various combinations of strategies. To accomplish modeling improvements, and to provide these models with the capability of estimating modal vehicle activities, advanced vehicle monitoring concepts should be explored. Systems can be implemented to monitor trip-making behavior, and results can be used to determine how and why typical travel patterns are undertaken. Collected data would be used to improve vehicle activity models. Potential data collection techniques include: automatic vehicle identification systems, weigh-in-motion systems, inductive loop technology, video imaging equipment, computerized automobile black boxes, etc. Survey and monitoring protocols would be developed for these advanced monitoring systems.

Cost: \$500,000

Duration: 36 months

Air Quality - 2

Title: Identification of Fine Particles of Air Pollution for Source Apportionment - Measurement and Source Apportionment of PM₁₀ Emissions

Problem Statement: High levels of repairable particles present a significant health problem in many urban areas but the relative importance and contribution of stationary, area, and transportation sources of fine particles is not clearly known. Further, the conditions that contribute to violations of the standard, emission rates for

various sources of PM_{10} is not well understood. From a transportation standpoint, the relative importance of diesel particulate, reentrained dust, secondary nitrogen compounds and associated emission rates is poorly defined. Potential control strategy effectiveness has not been evaluated or documented.

Proposed Research: Review available monitored violations and assess transportation contribution to the violations with special emphasis on transportation related diesel particulate, reentrained dust, and nitrogen compounds contributions during the episodes. Based on the findings, conduct monitoring studies near various roadway types for a variety of speeds and traffic volumes for identifying relationships between travel, roadway dust and diesel emissions. Samples for all of the particulate species will be collected at several downwind distances. Winds and atmospheric stability conditions will be measured. Background concentrations of particles, measured upwind of the road, will be subtracted from the downwind particle samples. Data will permit development of control strategies. Finally, evaluate the effectiveness of control strategies to eliminate the potential for standard violations.

Cost: \$300,000

Duration: 36 months

Air Quality - 3

Title: Air Quality as a function of Land-Use, Urban Form, and Trip-Making Behavior

Problem Statement: Traditional policies directing growth patterns and development in American cities result in sprawled low density development. Especially in areas where peripheral land use is unconstrained, government efforts to mitigate transportation impacts through impact fees or offset requirements have driven development outside the central city areas. This development trend results in greater transportation infrastructure requirements and costs, degraded air quality, lengthened trips, and limited access to alternate modes for the majority of the population. Recent trends to decentralize government services are also contributing to this problem. Local control over land use development is intensely guarded. However, as traffic-related emission impacts of land use become better understood, development of emission-related land use/land development performance standards (to include indirect source control programs) at the local level is likely. Mixed use development has been advocated by many for its vehicle-trip reducing opportunity. By providing a mix of uses at a particular site, residents or employees can make many of their trips on foot, by bicycle or on mass transit. A

better understanding of the balance of jobs and housing is necessary to determine their influence on commuter mode choices and patterns. Furthermore, a better understanding of other influential factors such as the role of service providers (e.g., energy utilities) is necessary to determine their effect on the generation of mixed use, high density patterns.

Proposed Research: (1) Investigate the impact of density and development patterns (to include jobs/housing balance) on personal transportation decisions, and the resulting air quality impacts. (2) Identify the various land use strategies that reduce vehicle activity by facilitating higher density and mixed use development served by mass transit. Also determine the characteristics that are necessary to support increased frequency of pedestrian and bicycle trips. (3) Investigate the role public utility commissions and regulated utilities can play in determining energy delivery systems and technology (e.g., district heating) to newly developing areas. Such demand side management strategies can result in higher densities, trip reduction, use of mass transit and other alternatives to the single occupant vehicle. (4) Identify indirect source mitigation strategies by land use type.

Cost: \$500,000

Duration: 24 months

Air Quality - 4

Title: Modal Emission Factor Development

Problem Statement: Research indicates "off-cycle" driving patterns (patterns not currently used in laboratory analysis of emission rates) may be responsible for significant amounts of uncertainty in current emission factor models. This creates problems in policy analysis for specific transportation activities. For example, drive-up window and truck idling restrictions cannot be evaluated to determine their potential air quality impact because current emission rates are not accurate enough to determine the emission tradeoff between a warm engine start and time at idle. Emission rates for specific vehicle activities, such as constant-speed cruise, idling, and specific acceleration rates (e.g., to represent on-ramp acceleration or stop-and-go traffic conditions) are needed. In addition, on-street operation of vehicles is likely to differ significantly from operating vehicles under standardized test cycles in the laboratory. For example, speed and acceleration rates vary widely from driver to driver, corridor to corridor, pavement to pavement, and situation to situation, resulting in potentially higher or lower emissions than might be noted in the laboratory under a transient test cycle.

Proposed Research: Analyze available modal emissions data to determine the extent to which high speeds and acceleration rates may affect current emission factors. Design and establish emission testing methods to quantify emissions at idle and very low speed operation as well as high speed and high acceleration rates. Develop modal emission factors for acceleration, deceleration, cruise, and idle modes of vehicle operation. When sufficient modal emission rate data are available, investigate means to further desegregate vehicle emission rates and activity estimates by mode. To facilitate the development of modal emission models, instrument test vehicles such that real-time emissions can be monitored from the vehicles as they operate in traffic. Compare chassis dynamometer results to street results (as affected by friction, grade, load, wind, etc.). Compare in-use emission factors to modeled (speed adjusted) factors, and develop potential corrections for inherent differences between dynamometer and field testing.

Cost: \$350,000

Duration: 30 months

Air Quality - 5

Title: Modifications to HPMS for Air Quality Analysis

Problem Statement: A variety of air quality control measures will automatically be invoked whenever a region's VMT exceeds the SIP projected value by 3% or more. The initial draft EPA rule-making requires that the highway performance monitoring system (HPMS) be used to make the VMT determination. Since HPMS was developed for other purposes, and because the accuracy of HPMS estimates is suspect, alternative means of collecting vehicle activity data are needed.

Proposed Research: For urban areas of varying size, evaluate the current accuracy of HPMS by comparing estimates to actual ground counts and examining the sampling network for potential bias. Based on this work, determine the overall uncertainty of HPMS-derived regional pollutant emissions estimates. Make recommendations on how to supplement or modify HPMS to achieve the desired accuracy.

Cost: \$200,000

Duration: 24 months

Air Quality - 6

Title: Effectiveness and Acceptability of Transportation Control Measures

Problem Statement: We must evaluate the air quality benefits and public acceptability of transportation control measures, especially of those TCMs that have proven to be technically feasible and effective at decreasing mobile

source activity. For example, California has identified seven "reasonably available" TCMs: (1) employer based trip reduction rules, (2) trip reduction rules for other sources that attract vehicle trips, (3) management of parking supply and pricing, (4) high occupancy vehicle system plans and implementation programs, (5) comprehensive transit improvement programs for bus and rail, (6) development policies for motor vehicle trip reduction, and (7) development policies to strengthen on-site transit access for new and existing land developments. The effectiveness of these and other TCMs is usually evaluated based on changes in VMT and emissions, but has not been correlated with air pollutant concentrations. To complete the picture, estimates of reductions in criteria pollutant concentrations achievable by specific TCMs or combinations of TCMs are needed. These pollutant concentration reductions will not be directly proportional to reductions in emissions. Furthermore, multiple TCM strategies may result in synergism. Few studies have been conducted to determine how, when, and where TCMs augment or interfere with one another. Finally, transportation control measures face numerous barriers to acceptance. Different concerns are raised by different groups within the public. Public acceptance is essential for effective TCMs.

Proposed Research: Research into the emission-reducing effects and cost-effectiveness of reasonably available transportation control measures is needed. This research should be based on case studies and would involve monitoring and modeling. Existing ambient air quality data from areas where TCMs have been implemented would be analyzed over time to determine if an effect on air quality levels could be discerned. Locations would be chosen where TCMs will be implemented for "before and after" monitoring. For region-wide pollutants, such as ozone, modeled results would be used to quantify the effects of region-wide TCM implementation. The research would examine synergistic effects of transportation control measures. The project would also attempt to evaluate how groups are affected by TCMs, and identify strategies to overcome barriers to acceptability for each group. Acceptability should be determined through public meetings, focus groups or surveys of affected groups. Several sub-projects should be conducted, including the following: (1) Economic Incentives to Reduce Vehicle Pollution. Conduct surveys in several representative metropolitan areas to gauge traveler response to economic incentives or disincentives for modifying travel decisions (e.g., congestion pricing, parking management, etc.). Develop traveler behavior algorithms consistent with the findings of this research

and compatible with existing travel forecasting models. Define the net costs to local and regional economies (as well as internal economic transfers) of the various economic incentive strategies. In addition, evaluate distribution of social costs and benefits as well as internal transfers (i.e. who benefits, and who bears the costs). (2) **Parking Management.** Identify available parking management strategies. Identify the most effective strategies to manage available parking such that alternative mode travel is encouraged and should be identified. Compare identified parking demand management strategies to other transportation demand strategies such as car pools, in relation to their effectiveness in improving air quality. (3) **High-Occupancy Vehicle (HOV) and Ride-Sharing.** Evaluate the air quality consequences of strategies for increasing vehicle occupancy, including HOV lanes and ride-sharing. (4) **Telecommuting.** Identify current trends and emerging markets for telecommuting. Develop modified travel demand curves based on the projections of reduced trips due to telecommuting. Identify employer-based incentives to encourage employee trip reduction through telecommuting.

Cost: \$500,000.

Duration: 48 months

Air Quality - 7

Title: Latent Demand and Later Area Source Growth

Problem Statement: Many of the TCMs designed to improve traffic flow may also result in effective capacity increases. Driver trip-making response to new capacity is unclear. Some analysts have argued that individuals operate with a travel time budget, and that increasing capacity and flow may not appreciably change the number of hours spent behind the wheel of a vehicle. As people make more trips and drive greater distances, according to their travel time budget, demand may again exceed capacity. Thus, increases in infrastructure capacity may yield only temporary flow improvements. Most transportation models account for changes in route choice based upon travel time in the iterative network assignment process, but do not account for changes in trip generation as a function of congestion. Furthermore, temporary flow improvements can serve as an incentive for new development (growth) and changes in land use at the local level. Hence, emissions from new area and indirect sources may also be facilitated by roadway capacity increases.

Proposed Research: Expand the capabilities of UTPS-type models so they can address more of the latent demand phenomena. For example, trip generation,

distribution, and mode choice subroutines should be linked to congestion effects through feedback processes. Continue research into travel time budgets and their effect on transportation demand and congested flow. Incorporate GIS-type information systems. The relationship between the growth of area and indirect source emissions along new or improved transit corridors would also be investigated as a function of capacity increase. Study historical trends and develop methods to mitigate induced growth.

Cost: \$400,000

Duration: 18 months

Air Quality - 8

Title: Cost and Other Externalities Associated with Congestion

Problem Statement: The Clean Air Act of 1990 requires states and municipalities to plan for and implement programs to reduce congestion. To accomplish this, the public and its elected officials will need to know the true cost of congestion (other than air quality impacts) and the savings that will accrue from widespread, effective adoption of transportation control measures.

Proposed Research: Update and expand existing literature and models on cost allocation and transportation externalities (including FHWA's "Cost Allocation Study." Refine the cost estimates associated with different levels of congestion and estimate the cost savings attributable to implementation of specific transportation control measures. Baseline operating speeds from which congestion delay is determined and assumptions in traffic flow models for calculating congestion delay would be standardized. Standardize analytical methods, such as the defined economic values associated with passenger congestion and goods movement delays. Other externalities, such as fuel efficiency effects and petroleum dependency, would also be analyzed.

Cost: \$200,000

Duration: 18 months.

Air Quality - 9

Title: Contribution of Near-Field and Area-Wide Emissions to High Concentrations Near Intersections

Problem Statement: The highest CO concentrations are typically observed near high-volume, signalized intersections. Violation of ambient standards at these locations result from the combination of near-field and area-wide emissions. The relative contribution of these two problems is not well understood in many urban areas. Modeling these locations accurately is crucial to both region-wide and project-specific conformity determina-

tion. Current models are available to address these two problems independently, but data and some aspects of model formulations are deficient.

Proposed Research: Combined monitoring and modeling studies are needed that concurrently address both (1) vehicular activity and emissions, and (2) ambient concentrations and dispersion processes. For the vehicular activity/emissions component, a possible approach is to select and customize network and corridor traffic models to provide urban- and intersection-scale descriptions of vehicle activity. Results of this modeling should be compared to "floating car" surveys to verify the characterization of intersection activity parameters, such as acceleration rates and idle time. For the ambient concentration and dispersion component, these studies will require ambient CO and meteorology monitoring at numerous locations near the intersection, as well as at nearby neighborhood-scale locations. This monitoring should be conducted during periods of high concentration. Dispersion modeling should incorporate the latest modal emission factors into an appropriate line source or intersection dispersion model, and should include a detailed evaluation of model performance, exploring the conditions under which poor performance is observed. Alternatives to typical Gaussian dispersion treatment of near-field low wind dispersion processes in urban settings should be identified and evaluated as part of this assessment. These studies should be conducted in several cities, and at multiple locations within cities. Variability in neighborhood-scale "background" concentrations from day to day and location to location should be reviewed with micro-scale analyses to determine if project-level (e.g., conformity) analysis can legitimately be conducted independently of area-wide emissions and assessments, or if project impacts should routinely be evaluated within the context of area-wide planning. This project should provide practical guidance to transportation planners regarding the factors that determine the relative contribution of near-field and area-wide emissions to "hotspot" concentrations.

Cost: \$650,000

Duration: 36 months

Air Quality - 10

Title: Heavy Duty Vehicle Emissions and Activity Levels.

Problem Statement: None of the research projects focus specifically on the emission inventory for heavy duty vehicles. Research in the area focuses primarily on Light Duty Vehicles because they are the largest emission component of the mobile source problem. However,

Heavy Duty Vehicles (HDVs) are responsible for a large component of the NO_x, SO_x and PM₁₀ emissions. The emission rates for HDVs are far more uncertain than the ones for Light Duty Vehicles (LDGVs), even when they play a fundamental role in the movement of goods through the highway system.

Proposed Research: Undertake a research effort for HDVs that encompasses two main areas: (1) a good characterization of the emission components such as, acceleration, deceleration, idling and cruise emission rates; and (2) an evaluation based on area specific studies and on activity level components such as acceleration, deceleration and idling times for typical truck operations. In general, traffic forecasting using UTPS type models do not account for heavy duty trucks VMTs or speeds. Because the pollutant emissions and type of driving modes of these vehicles are different from the passenger car, this type of data would allow the analysis of the emissions of heavy trucks as a separate component in future traffic prediction models. To avoid the installation of new facilities, the first aspect of this work, could be conceived as a coordinated task taking advantage of the facilities and work being done by CARB and/or EPA for LDGVs. The knowledge in this area could be used as a framework to determine the specific scope of this type of project.

Cost: \$500,000

Duration: 3 to 4 years