



Report on the MCMA-2003 Field Measurement Campaign

In the Spring of 2003 (April 1-May 5), a multinational team of experts led by Luisa Molina of MIT conducted an intensive, five-week field campaign in the Mexico City Metropolitan Area (MCMA). The overall goal of this effort is to contribute to the understanding of the air quality problem in megacities by conducting measurements and modeling studies of atmospheric pollutants in the MCMA. Such an understanding would help provide a scientific base for devising emissions control strategies to reduce exposure to harmful pollutants in the MCMA and also provide insights to air pollution problems in other megacities, including large urban centers in the US.

The MCMA-2003 field measurement campaign was designed to cover the height of the annual photochemical season just prior to the onset of the rainy season. Unlike the February 2002 exploratory field campaign (see Newsletter, Vol. 2, Fall 2002) that focused primarily on mobile laboratory measurements, the 2003 campaign also involved a highly instrumented "supersite" located at the National Center for Environmental Research and Training (*Centro Nacional de Investigación y Capacitación Ambiental* or CENICA), a component of the National Institute of Ecology (*Instituto Nacional de Ecología* or INE). The Aerodyne (ARI) Mobile Laboratory was deployed for measurements at various locations in Mexico City. In addition, extensive meteorological data and a wide range of fixed site chemical data were collected by our collaborating Mexican research groups.

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Sixth MCAQ Workshop: Implementing Change in Air Quality Management

Contributed by Jed Horne and Robert Slott

Hotel Royal Pedregal, Mexico City. It was just before dinner when the quake hit. At first it looked as if everyone in the room had decided en masse to drop what they were doing, possibly motivated by a sudden bout of hunger. After a long thirty seconds, it became clear what was going on: *Está temblando*, someone said. *It's shaking*.

Sexto Taller sobre Calidad del Aire en la Ciudad de México Programa Integral sobre Contaminación del Aire Urbana, Regional y Global Enero 2003



Panelists for the Metropolitan Coordination: Raúl Arriaga, Claudia Sheinbaum Pardo, Mario Molina, Adolfo Mejia Ponce de Leon, Luis Arturo Rivas, Alfonso Iracheta.

It was Tuesday night, the third evening of the Sixth Annual Workshop on Mexico City Air Quality organized by the Integrated Program on Urban, Regional, and Global Air Pollution at MIT and sponsored by the Comision Ambiental Metroplitana (CAM) and the North American Commission for Environmental Cooperation. This year's conference was held at the Hotel Royal Pedregal in Mexico City, an urban area known for its charm, sophistication, and, unfortunately, earthquakes.

But it wasn't seismology that had brought the scientists, engineers, and government officials together that evening, and seismology wouldn't keep them from the task at hand: tackling a solvable but no less scary threat to the region—the menace of air pollution, a challenge with implications far beyond the Valley of Mexico.

The *terremoto* was mild, the confusion momentary, and soon the conference-goers regained their composure and went back to work. The evening's activity was the much anticipated "negotiation game", the result of months of work by a team of MIT researchers led by Dong Young Kim and Professor Larry Continued on next page

Jed Horne is an undergraduate Research Assistant and Robert Slott is a Visiting Engineer with the Integrated Program on Urban, Regional, and Global Air Pollution.

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Susskind. The game assumes that eight representatives from federal, regional, and local government, business, and civil society have been invited to work together to negotiate an agreement regarding the best ways of combatting air pollution. Participants were assigned one of eight roles and charged with negotiating a set of air quality control measures in a fictitious metropolitan area in Latin America. Participants felt it was a huge success, and many learned negotiating valuable skills they would take back to their daily lives (see article by D.Y. Kim in this issue).

The group had come together two days ago, arriving at the Hotel Royal Pedregal in southern Mexico City from as far away as Boston, Massachusetts and Santiago, Chile. After registration and an elegant dinner, everyone rested up in preparation for the week-long conference.

Regional Coordination, Successes and Setbacks

Promptly at nine o'clock the next morning, the program kicked off with welcoming and opening remarks from Luisa and Mario Molina of MIT. The conference was organized finto four plenary sessions, each examining a different challenge to air quality management in the Valley of Mexico. The first plenary session, on implementing change in air quality management, consisted of three panel discussions. The first panel, Metropolitan Coordination, was moderated by Mario Molina and included the three officials for environment in the Federal Government, the government of the Federal District (DF) and the State of Mexico (EM). Raúl Arriaga of SEMARNAT, Claudia Sheinbaum (Secretaria de Medio Ambiente, DF) and Adolfo Mejia (Secretaria de Ecologia, EM) highlighted the successes and challenges of political reform, reaffirming a commitment to work with the new air quality management program (PROAIRE 2002-2010) and to expand on the efforts of the CAM to facilitate constructive political dialogue among the multiple stakeholders involved. The panelists agreed that Mexico is still maneuvering difficult political terrain with the end of its one-party political system; now federal, state, and municipal cooperation is the key to a renewed commitment to environmental planning. During the discussion, the three panelists were joined by two academics, Alfonso Iracheta (El Colegio Mexiquense) and Luis Arturo Rivas (Instituto Politecnico Nacional de Mexico). Rivas proposed revised the CAM so that it has an independent budget. Mejia added that a permanent technical secretary is needed along with reforms needed to improve its performance. Everyone agreed that change is needed, but the change should strengthen the

technical and scientific capability of CAM rather than being the result of a political compromise.

The second panel dealt with stakeholder involvement more explicitly. The panel, moderated by Lawrence Susskind, and including Alejandro Ramos (Reforma), Talli Nauman (Periodismo para elevar la Conciencia Ecologica), Guillermina Guillen (El Universal), Richard Cockett (The Economist), and Angelica Enciso (La Jornada), tackled difficult questions of journalistic responsibility, including what it means to be "evenhanded," where the responsibility to educate the public ends and where personal responsibility begins, and when journalism crosses the line from legitimate concern to sensationalism.

The third panel was about stakeholder involvement in the regulatory process. Raul Benet (Greenpeace), Alejandro Sosa (Iniciativa GEMINGO), Carlos Sandoval (Consejo Nacional de Industriales Ecologistas), Raúl Tornel (CONCAMIN), Arnold Ricalde (Diputado, ALDF), and Manuel Castañeda Rodriguez (Diputado, Estado de Mexico) took part. The panelists commented that there was a lot of mistrust between industry and the government in the past, but now they are managing to overcome this, by organizing forums and involving academics, NGOs, private companies, etc., with the idea of reaching an agreement that will minimize losses for industry. representatives in the Legislature are committed to improving air quality; collaboration between the State of Mexico and the DF is very important, but the Federation has not allocated enough resources for the development of metropolitan coordination mechanisms. Representatives from the industry commented that although they were beginning to feel that their contributions to the policy process are being recognized and included, there is still room for improvement in relations with the government. While the process is becoming more transparent and more participants are getting involved, politics continues to complicate the application of science in policy.

From Politics to Science: Technical Questions Dominate

Taking a stab at these problems from a technical, rather than a political, viewpoint, Adrian Fernandez of SEMARNAT opened the next session by moving to the questions of sustainable energy, fuel standards, and vehicle technology. Jason Grumet of the National Commission on Energy Policy in the United States outlined historical patterns of energy consumption in the US and the difficulty of breaking free from the country's dependence on foreign oil. Looking more directly at the Mexican case, Fernando Tudela of ITAM discussed greenhouse gas emissions in Mexico and their relationship to economic and population

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Panelists for Stakeholder Involvement: Lawrence Susskind, Alejandro Ramos, Angélica Enciso, Richard Cockett, Talli Nauman, Guillermina Guillén.



Metropolitan Coordination: Raul Benet, Alejandro Sosa, Raúl Tornel, Arnold Ricalde, Carlos Sandoval, Manuel Castañeda Rodríguez.

Mexico City and Santiago, Chile: Collaboration on Mobility and Air Quality

Contributed by Alvaro Covarrubias and Ralph Gakenheimer

At the Sixth Workshop on Mexico City Air Quality of the Integrated Program on Urban, Regional and Global Air Pollution, held in Mexico City in January 2003, there were two presentations by Chilean professionals Henry Malbrán and Pablo Trivelli.

Malbrán, now Director of SECTRA, the government agency in charge of transportation planning in Chile, presented the current situation and the perspectives for the transportation system in Santiago. He presented the new urban transportation plan for Santiago, which is scheduled for implementation by 2005. The new plan aims at curbing the reduction of modal share of transit, by making it an attractive option, even for car-owners. The plan anticipates exclusive corridors for transit, the creation of Bus Rapid Transit (BRT) lines, a fare integration of all bus lines and the metro system, an aggressive expansion of the metro network, the construction of two light rail lines and bicycle lanes. Planners intend to invoke some mechanism to charge vehicles to use the roads according to the level of congestion in them. At the same time, the plan tries to reduce car congestion by establishing reversible corridors, the construction of a new urban highway and the improvement of an existing highway. Finally, Malbrán described the transportation and land use simulation models used in Santiago, which were used to evaluate this new plan and other projects.

Trivelli is a professor at the University of Chile, and a consultant to the Ministry of Housing and Urbanism. In his presentation, he described the impacts that Santiago has suffered in the last decades. One of these changes was a rapid increase in land values, as a result of the economic growth of the nineties. This growth of land values has driven low-income people to the periphery. This process, along with the sub-urbanization of high-income people, has produced an extension of the metropolitan area, increasing the stress on the transportation system through the massive increase of radial commuting and school trips. The city has faced the formation of sub-centers, which have emerged around shopping malls. The relative importance of the central core has been reduced as a consequence of this process. The Chilean government has tried to reverse this trend by establishing a subsidy for the construction of apartment buildings in some old sections of the city, and by redeveloping the Cerrillos airport, which is close to the center of the city and is being used only by general aviation.

In the Transportation and Urban Planning breakout session on , the participants agreed that the problems of Mexico City and Santiago's transportation system and land-uses are very similar. Some of these similarities are the fast growth of the motorization rates as a consequence of economic growth; the reduction in the modal share of the public transportation systems; the lack of an effective integration between different transit modes; the relative loss of population in the central part of the cities;



Henry Malbrán (left) and Pablo Trivelli (right) with Mario Molina at the Sixth Workshop.

and the lack of effective coordination between land-use and transportation planning.

The problems of the transportation system and the land-use planning have been a matter of concern in Mexico City and Santiago for decades. Both cities have tried many different policies to cope with these problems, with different results. They have also developed tools and information systems to support their transportation and land-use planning. Unfortunately, there have not been many opportunities to share these experiences with each other or among other cities in the developing world that suffer similar problems. There has been instead a tendency to adapt solutions from the developed countries, which may not be the most appropriate for the reality of developing countries' megacities.

Participants in the breakout session agreed enthusiastically to pursue a collaboration program between institutions and professionals in both cities. The objectives would be to share experiences in the areas of transportation and land-use planning to reduce air pollution, to increase mobility, to enhance the professional capabilities in these areas, and to build databases and modeling tools to support the decision-making. In the future the program could include other megacities in Latin America or the developing world.

The enthusiasm of the first meeting led to convening a second. In April 2003, there was a meeting in Mexico City with twenty faculty, officials and professionals from Boston, Mexico City and Santiago. In this meeting we discussed specific tasks for a collaboration program, the most convenient way to manage it, and how to fund it.

Based on our plan for sharing experience and research, we expect to have a series of seminars in Santiago and Mexico City, where we will explore the different policies that have been applied in both cities, their qualified successes, means for their improvement, and how can some of them be adapted in other cities. Researchers in Santiago, Mexico, and Boston will assess the experiences in air quality and mobility, and propose future studies.

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Air Pollution Negotiation Game

Contributed by Dong Young Kim

On January 21, 2003, as part of the Sixth Mexico City Air Pollution Workshop at Hotel Royal Pedregal, Mexico City, we tried something new. In an effort to examine the probable sources of institutional resistance to the air quality management ideas likely to flow form an "integrated assessment" of the sort we are undetaking, we ran a multi-party negotiation simulation. The game, dubbed "The Air Pollution Crisis in Varara," asked participants to play a variety of roles in order to simulate the kinds of dialogue likely to emerge in response to the results of a hypothetical assessment of air quality management options.

Inspired by the success of the "negotiation and conflict resolution" class led by MIT Professor Lawrence Susskind at the Mid-Career workshop organized by the the Integrated Program for Urban, Regional, and Global Air Pollution in August 2002 (see Newsletter vol. 2, Fall 2002). Dong-Young Kim, with the aid of Javier Warman and Jed Horne, worked for six months to develop the game, which was then tested by the Mexico City scenario analysis team and other Mexican experts at MIT.

The game features a range of environmental difficulties caused by high levels of ground-level ozone (O₃) in an imaginary city and region called Varara and Sandoa. This is a country suffering from global economic drag. With Professor Susskind's help, the game was designed so that participants could acquire basic scientific knowledge about ground-level ozone, other party's concerns, negotiation skills, and facilitation skills. Most of all, the participants were given a chance to take in the whole picture of air quality management in a megalopolis and the prospects of using multi-stakeholder dialogue to work out political differences. Game participants were asked to discuss the following measures that might help to improve air quality: 1) Sulfur content of gasoline, which is a precondition for advanced vehicle emission control technology, 2) Vehicle Emission Standards, 3) Inspection and Maintenance program, 4) Public transportation, and 5) Implementation plans.

The situation in the Metropolitan Area of Varara and Sandoa represents well an institutional context in which many political, and economical interests collide while multi-tiered jurisdictions jockey for the political upper hand. Right into that situation, Integrated Assessment data such as the material produced as part of the current MIT scenario analysis is introduced to help the parties gauge their options and make individual and

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Workshop participants playing the negotiation game.

group decisions about them. Each of the stakeholders also had information which they did not share with the other parties or the facilitator. This information reflected the interests of the organizations that the negotiators were representing.

Among the participants, sixty-eight people from a wide range of governmental agencies, corporate entities, NGOs, and student organizations participated in the two-hour exercise. Eight selected facilitators were briefed about necessary facilitation skills one day before the negotiation exercise. There were five Spanish-speaking groups and three working in English. For the Spanish speakers, Professor Basilio Verduzco at the University of Guadalajara, Mexico, translated the game into Spanish.

Even though the exercise started after 5 PM after the long and intensive plenary sessions ended, participants in the game were very serious in their deliberations. Facilitators stood up to coordinate. At some tables, very serious, loud communication was observed. Even an earthquake of over 7 on the Richter Scale did not prevent them from hammering out agreements.

All eight negotiation groups reached near unanimous agreement on ground ozone regulation, although one party at some tables was excluded. With the assessment data provided, participants could calculate how much emission reduction they might achieve as well as how much money it would cost them to do so.

We learned important "truths" about the interaction of negotiations and the use of integrated assessment data. Decisionmakers and stakeholders in a metropolitan area can arrive at reasonable, effective, wise, agreements regarding air quality management policies if: (1) they have an opportunity to share an in-depth exchange of views in a well-designed multi-stakeholder dialogue; (2) they are provided with relevant technical information in a suitable format; and (3) formal integrated assessment is considered legitimate, useful, and credible by as many decision-makers and stakeholders as possible.

The following morning, the participants gathered to debrief with Professor Lawrence Susskind, and compare their results with other groups' performance. They discussed the importance of facilitators, as well as real Mexican context in terms of multiparty negotiation potential.

Many people requested simulation materials after the exercise. Luisa Molina, director of the Integrated Program for Urban, Regional, and Global Air Pollution, decided to post the negotiation simulation game online for use in classrooms or offices for those interested in negotiation and conflict resolution.

Metropolitan Planning as a Requisite for a Better Future for the MCMA

Contributed by Alfonso Iracheta

The new socio-spatial conditions of metropolitan regions derive from global changes and demand new ideas for their government and administration. We need stable formulas of political and administrative organization beyond mere coordination of the parts of the metropolis. Such formulas must be permanent in order to overcome centralism; it is becoming more obvious that associations composed of local units (municipalities, departments, cantons, etc) to handle common problems is possible and constructive, provided the national and state powers recognize that appropriate redistribution of public expenditure is crucial for each local unit to act according to the demands of the area.

Metropolitan coordination cannot be imposed, but is stimulated by strategic planning, and by rewarding regional organizations instead of interfering and attempting to control them. Coordination, not only among federal entities but also municipalities, is what allows new paths to develop for solving the problems of conurbation. General agreements on the character and direction of metropolitan projects are the basis in order to coordinate and guide the efforts of the parties involved.. Besides this orientation, it is necessary to offer incentives to resolve problems that exceed one particular municipality.

It is the state's role to correct market deviations and not to follow it; this means new forms of analysis on the development of large cities and the ways to coordinate and correct the action of different social agents that transfer the city on a daily basis.

Environmental sustainability demands a metropolitan vision, since problems and phenomena related to management of natural and environmental resources are not constrained to politico-administrative territories

Metropolitan planning in the Valley of Mexico

Conurbation in the Valley of Mexico is the only one in the country that requires the concurrence of multiple authorities to legislate its structure and functioning as well as implement its plans and programs. The federal government, the governments of the Federal District and the State of Mexico, the municipal governments of the latter as well as the national and local legislative bodies have presence and authority here. In this metropolis the lack of a metropolitan formula exists, to such an extent that it seems that the federal government—and the governments of the Federal District and the State of Mexico—have not operated as if they realized the existence of this large conurbation.

The institutional relationships between the Federal District and the State of Mexico during the last three decades have been characterized by centralism and state sovereignty, disagreement, lack of political will to cooperate and isolation of centralized resolutions, institutional planning and personal decision. The problems of each entity have become more acute and complex as a result of conurbation. From the government's point of view, the metropolis is made up of two or, even, a multitude of cities. For both the Federal District and the State of Mexico, each city

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ends when it reaches its corresponding limits, and both consider that the other entity is, in fact, 'other' in almost every sense. This attitude has already started to emerge even within these two organizations, in the delegations of the Federal District and in the municipalities of the conurbation belonging to the State of Mexico.

The issues that require metropolitan coordination and agreement are diverse and complex. Little or no progress has been achieved on many of these issues, making life more difficult for the almost 19 million of inhabitants of the MCMA.

Water has been included in the public agenda for decades. Apart from increasing its supply, there is no metropolitan hydraulic project taking advantage of technological opportunities which would reduce risks of supply outages and infrastructure deterioration. Although the Federal District is not growing anymore, population and physical expansion are central matters, since metropolitan municipalities are growing at rates over 2% per year. This shows nearly all demographic increase and urban sprawl will be in the municipalities of the State of Mexico. The distribution of public resources is also an issue that has hindered the two governments from cooperating, since historically the Federal District has been favored with federal investments and educational subsidies that the State of Mexico has not received. Transport and air pollution are issues with higher possibilities of reaching metropolitan agreements, as proved by programs such as Monitoreo Atmosférico, Hoy no Circula, Placa Metropolitana and Proaire. Still, there is a lack of political will to face the problem of air pollution and, above all, to develop a metropolitan policy of traffic and transport linked to policies of general metropolitan development.

The above-mentioned differences between the two entities that share the MCMA have resulted in more, higher-quality infrastructure and equipment for the Federal District. Yet, it is also true that this entity has had more suitable revenue policies and greater government administrative capacity to face the problems of the metropolis, which results in better possibilities to plan and develop projects in different areas . As a consequence, the Federal District has tended to be more influential in the management of metropolitan matters.

Although during the past these differences could be regarded as normal, today they do not meet the needs of a metropolis that is more populated in the metropolitan municipalities than in the Federal District. For that reason, the state and federal government should consider the whole region when making decisions about public resources for the metropolis.

The political distance between the governments of the Federal District and the State of Mexico, which has affected so much the development and management of the MCMA, probably has among its roots the historical difference and inequity in distribution of federal public resources for the big city, rather than other relevant aspects such as the political differences between their governments or between the parties that have ruled these entities of the federation. The Treasury and Public Credit Department and, in general, the federal government have practically disregarded this matter, raising greater problems between the federal entities.

The governments of both the Federal District and the State of Mexico have made statements, in general poorly informed on

both sides, concerning the costs incurred by each entity as a result of meeting the needs of the population from the other part of the metropolis. The government of the Federal District has declared that a significant burden upon its economy stems from the 'use and consumption' of the City of Mexico by a floating population that mainly comes from the State of Mexico without receiving any compensation for it. Since the 80s, and especially since the end of the 90s, the government of the State of Mexico, in turn, has forcefully demanded from the Federal District to make up for the water that the former exports to the Federal District (although some part goes to the conurbated municipalities), with a greater effort in meeting educational expenses and adjusting the imbalance in the distribution of shares that the federal government gives to the federal entities every year, which come from the state tax collection and represent the greatest part of Mexican states' budget.

Finally, what is clear for practically every national government should be also clear for the government of Mexico. The financial resources that the national capital requires, especially when in comparison with the rest of the urban system of the country, must also come from the federal government. Until now those resources have been preferentially channeled to the Federal District, neglecting the metropolis as a whole.

The metropolitan problem of the Valley of Mexico is not a local matter anymore since the critical situation faced by its urban development and environment has surfaced in the national policies and social structures. It is crucial to understand this metropolitan issue as a basic condition to reorganize and develop the MCMA. And in so doing, the responsibility for a balanced distribution of national resources to face the needs for infrastructure and equipment falls on the Mexican government.

The two state governments must become more mature in their relationship and in their conception of the large urbanized area of the Valley of Mexico as a metropolis, rather than as two isolated parts in which individual and separate policies are designed without agreement and applied separately without coordination.

The evolution of the metropolitan phenomenon and its spillover towards the central region of the country, building up a megalopolis whose size and complexity causes the need for institutional ways of cooperation, agreement and management of policies and joint projects among the spheres of government responsible for its administration and development.

There are fundamental limitations that prevent policies and actions from reaching a metropolitan level of performance. Such limitations derive from the heterogeneity of legislation and regulations between both entities and the lack of harmonization of diverse policies and norms, which has provoked the disorganization of infrastructures and services that should be, in principle, common.

The design, management, approval and implementation of new ways of metropolitan coordination, which take into account political plurality and joint management by various social groups, is a necessity that has long surpassed the politico-administrative sphere between the governments of the two entities, to become a strategic part of the economic and social development of the great conurbation and the Mexican nation.

Evaluation of Toxicity Induced by PM₁₀, and PM_{2.5} from Three Different Zones of México City in Relation with Their Composition

Contributed by Universidad Nacional Autónoma de Mexico, Universidad Autónoma Metropolitana, Instituto Nacional de Cancerología Multidisciplinary Group

Health effects related to air pollution exposures have been reported to be very similar in cities around the world. Ambient concentrations of criteria pollutants (e.g., ozone, particulate matter (PM), SO_2 , NOx) correlate with increases in mortality, emergency room visits, asthma attacks, school absenteeism or impaired pulmonary function. Although these effects are probably the result of exposures to a mixture of contaminants, epidemiology has shown that PM has the strongest effect.

Most of those epidemiologic studies relied on PM monitoring that only evaluate concentration $(\mu g/m^3)$ and size as defined by the aerodynamic diameter. They established correlations in which smaller particles have stronger effects, indicating deeper PM penetration into the respiratory system. However, there are other variables besides PM size and concentration that could be considered if we were looking at different health outputs. For example, little is known about the participation of PM in chronic diseases such as cancer or atherosclerosis or in the impairment of the immune system that could result in an increase of infectious diseases. Adverse health effects could be related to particle composition. We do not know if PM emitted from different sources (industry, motor vehicles, natural) would represent the same risk, due to differences in size and composition. Preliminary experimental studies from our group indicated that there are differences in the effects induced in cells exposed to PM from the north, center and south of Mexico City, suggesting that such differences could be related to particle composition besides particle size, since the PM sources differ by location. The lack of direct evidence on particle composition and particle size distribution on the PM₁₀ used in that study, motivated the present one which has the aim of collecting large amounts of PM_{10} and $PM_{2.5}$ in three zones of Mexico City. The selected zones have differences in the predominant PM sources: North (industry) at FES Iztacala; Center (traffic) at La Merced and South (traffic and vegetation) at CCA, UNAM. PM samples will allow for: morphological analysis and analysis for elements, organic compounds, black carbon, and microorganisms and some of their products. Parallel experimentation will asses the impact of PM samples on cells: the induction of death, secretion of pro-inflammatory cytokines and DNA damage.

Preliminary results indicate that $PM_{2.5}$ levels between January and July of 2002 vary both by region and time of the year (Figure 1). Levels were higher in the North. Levels diminished in all zones at the beginning of the rainy season. Due to technical problems with the monitors, we could not sample simultaneously in all three zones during the whole period.

Morphologic analysis of the PM samples indicate the presence of soil particles in the three zones and elemental analysis

This work is supported by the Integrated Program on Urban, Regional and Global Air Pollution with funds from Comisión Ambiental Metropolitana.





indicates a higher metal content in the particles from the North and the Center than in the South (Figure 2). These differences are more important in the coarse fraction than in the fine one. Total carbon is \sim 50% in the samples from the three zones and elemental carbon is higher in the fine fraction to about the same degree in all regions. Detailed analysis of organic compounds content is underway. The analysis for biologic components in the PM indicates the presence of endotoxin. PM₁₀ had the higher endotoxin content than $PM_{2.5}$. The highest concentration was found on PM_{10} from the South (406 EU/mg). Endotoxin content partially correlated with the activation of serum complement (serum complement is a potent defense mechanism strongly activated by endotoxin), suggesting that other components capable of activating serum complement may be present in the PM. Additionally, toxicological evaluation indicates that PM. were able to produce OH radicals and cell death (Figure 3) and this activity is related to the metal content in the PM_{10} .

At the present time we can conclude that there are differences in the levels and composition of PM obtained from three different zones in Mexico City. These differences account for differences in cellular responses induced by in vitro exposure to the PM. We have accomplished approximately 70% of our goals and new results will allow for further correlations.



Figure 2. Mean elemental concentration (ng/m³) in the coarse fraction sampled in three different zones of Mexico City.



cells. This is only observed in proliferating cells. Particles from the Center are the most potent



Congratulations

Celebration party hosted by the Integrated Program on Urban, Regional and Global Air Pollution for the June-2003 graduates: Kellyn Roth, Lisa Grogan, Ali Mostashari, Karen Thundiyil, Alejandro Bracamontes, Araceli Vargas, and Armando Yanez.





Taxis and Pollution in Mexico City

Contributed by Bernardo Navarro Benítez

Taxis and the City

Within the public transportation in the Federal District (DF), taxis have the largest fleet, adding between 103,000 to 106,000 formally registered units, besides the unregistered ones, popularly known as "pirates." Hence, the taxi fleet is three times higher to that of 'colectivos' (minibuses) -see Table 1- although colectivos make 58% of the total trips in the city and taxis only 4.4% of them. The number of registered taxis per habitant is larger than that of cities like Madrid, Paris and even Sao Paulo and New York City. In order to add up the total number of taxis in the city, we must add 6,109 units of the neighboring municipalities of the State of Mexico, besides the considerable number of "pirates" in these municipalities. Of the total 'registered' metropolitan fleet, 56% is made out of models 1992 and earlier, meaning that they do not have any anti-pollutant systems and are thought to contribute about 158,000 tons of pollutants annually.1 It is estimated that in the DF close to 90% of the vehicles ride under the modality of "free taxis" and only the other 10% belongs to one of the more organized modalities: Radio Taxi, Stand Taxi or Tourist Taxi.

Characteristics of the fleet and service

Taxis are very important not only for the public service they provide to the occasional and habitual users, but also for the employment and income source they represent for a large sector of the city's society. It is calculated that around half a million Mexicans depend on this activity. But also, the vehicles used for this service are important consumers of fossil fuels and, due to the age of its fleet and to the particular operational an organizational conditions, have an important impact on the environment of the metropolis, as they represent only 2.9% of the metropolitan fleet, but contribute with 13.3% of the main air pollutant emissions generated from the passenger transportation fleet. It is beyond doubt that the taxi sector needs an urgent modernization in various aspects for the benefit of the environment, as well as that of the taxi-operator, the concessionaries, its organizations and the people in general.

Presently, there are 324 taxi organizations in the DF. From this total, 94% (305) have adopted the form of Civil Association (Asociación Civil), and the other 6% (19) have turned into an organization under the form of a Mercantile Association (Sociedad Mercantil).

As Table 2, the evolution of the taxi vehicle fleet has been vertiginous between 1988 and 2000, growing more than double in only 12 years, a period in which the DF slowed down its demographic growth rate and even expelled population from its territory. This is why we underlined above that taxis, besides being a strategic service, has also represented an opportunity for self employment, particularly during the years of "economic adjustment" when hundreds of thousands of jobs were eliminated in the formal sector.

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Table 1.	Daily	Trips and	Vehicle Fleet	of Public ⁻	Transportation	in the DF.
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TRANSPORT	TRIPS PERSON / D/	UNITS (% OF FLEET)			
Metro	4,278,243 (18%)	(2.0%)		
Electric vehicles*	262,909 (01%)	(0.3%)		
Buses	573,619 (02%)	(0.8%)		
Microbuses & Combis	17,495,385 (73%)	(22.2%)		
Taxis	1,314,544 (06%)	(74.7%)		
τοται	23,924	,700	119,943 (
IUIAL	(10)0%)	100.0%)		

Source: Secretaría de Transporte y Vialidad, GDF, 1999.

Trolley bus and light train.

What about the "pirates"?

One of the biggest questions in the sector is the large number of "pirate" units in this activity. As part of the UAM- MIT project, we were able to make an approximation through a counting method of the number of "pirate" taxis circulating in the DF: in a period of one week, we made 30 surveillance between 2:00 and 7:00 pm at a fixed crossroad in the city, counting 1500 taxis.

Out of this total, 224 units did not have the attributes that could certify them as regulars, and 1276 were registered as legal. This means that practically 15% of the units were irregular (14.9%), which, if extrapolated to the total number of taxis in the DF would represent the existence of 15,000 irregular vehicles. However, the total number of irregular taxis might be a bit larger, around 18,000, as they are generally located around the bus terminals and in the border with the neighboring municipalities. However, because of the same nature of the service they provide, taxis end up running through the main roads of the city.

A larger concentration of irregular taxis was observed during the evening in the counting exercise, at which the percentage of irregular taxis fluctuated between 22 and 24%.

Taxis and the environment

The contribution of pollutants from taxis is, in order of importance, the third within the transportation of people, and fourth if we include cargo transportation. As shown in Table 3, for the year 2001, taxis contributed 8.82% of pollutants included, but represent only 4.4% of the total number of trips in the MCMA. Also, the negative impact of used tires and oils on water and soil should be added, as a large percentage of the fleet gets their maintenance not in shops but in public roads.

The disproportionate impact of taxis is related mostly to the age of its fleet, oversupply of service, and its particular forms of exploitation.

Public actions for improving the taxi service

Probably due to the described characteristics, a number of public policies to improve taxi service had been decided by December 2000, trying, at the same time, to improve its environmental impacts. Among the actions that stand out, we find:

- Suspension of new concessions
- Substitution of obsolete vehicles with new cars equipped catalytic converter and four doors
- Establishment of more taxi stands in order to minimize roaming without passengers
- Campaigns against pirates

Table 2. Evolution of Fleet of Free and Stand Taxi Service in DF.

Year	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Taxis	51,906	51,906	55,717	59,051	59,211	56,180	63,935	80,869	82,770 85.437*	87,499	93,332	97,455	104,418
F.T.T.P.1)	93,941	93,941	98,282	101,173	101,707	109,719	109,931	155,927	111,700*	_	_	_	
%T.C.R.F.T.P.+	55.25	55.25	56.69	58.36	58.21	51.20	58.15	51.86	76.48				
Free taxis	27,017	27,675	30,742	33,947	34,034	32,851	36,859	60,935	75,733*	78,778	84,086	87,881	92,139
%+	52.05	53.31	37.22	57.48	57.47	58.47	57.65	75.35	88.64	90.03	90.09	90.17	
Stand taxis	24,889	24,231	24,973	25,104	25,177	23,329	27,076	19,934	9,704*	8,721	9,246	9,574	9,971
%+	47.95	46.69	62.78	42.52	42.53	41.53	42.35	24.63	11.36	9.97	9.91	9.83	
Stands	154	154	154	154	165	165	165	_	_	_	_	_	_

%TCRFTP: Porcentaje total con respecto a la flota total de pasajeros. 1) FTTP: Flota total transporte concesionado de pasajeros: Sedán, Combi y Minibús. Source: Anuarios Estadísticos de Transporte y Vialidad, SCT, 1990 a 2000. *Source: Estrategia Integral de Transporte y Calidad del Aire, Estudio 8, Felipe Ochoa y Asociados, 1997, pp. 20, con base en Dirección

Table 3. Means of Transportation and Pollutant Contributions to the Environment in MC
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Source/pollutants	PM10 ton	%	SO ₂ ton	%	CO ton	%	NOx ton	%	HC ton	%	Total/ton	%
Private autos	701	10.31	2,000	48.67	822,477	55.66	47,380	32.36	81,705	50.19		53.08
Taxis	199	2.93	567	13.80	131,453	8.90	11,093	7.58	15,310	9.40	158,622	8.82
Combis	10	0.15	28	0.68	20,448	1.38	930	0.64	1,945	1.19	23,361	1.30
Microbuses	59	0.87	166	4.04	216,740	14.67	9,524	6.50	19,761	12.14	246,250	13.70
Diesel buses	1,174	17.26	214	5.21	9,270	0.63	11,640	7.95	3,853	2.37	26,151	1.45
Motorcycles	22	0.32	63	1.53	22,729	1.54	215	0.15	4,742	2.91	27,771	1.54
Diesel trucks	1,990	29.26	363	8.83	16,675	1.13	22,678	15.49	7,587	4.66	49,293	2.74
Diesel trucks (> 3 t)	2,562	37.67	468	11.39	20,956	1.42	27,662	18.89	9,205	5.65	60,853	3.38
Trucks (gas)	84	1.24	240	5.84	216,865	14.68	15,297	10.45	18,683	11.48	251,169	13.97
TOTAL	6,801	100.00	4,109	100.00	1,477,613	100.00	146,419	100.00	162,791	100.00	1,797,733	100.00

Source: Elaboración propia con base en el Programa para Mejorar la Calidad del Aire de la Zona Metropolitana del Valle de México, 2002-2010. DDF, Gobierno. Edo. México, Secretaría. del Medio Ambiente Recursos Naturales y Pesca, Secretaría. de Salud, CAM. (2002).

These important policies have had important advances but have also found severe limitations that are inherent to the characteristics of the sector.

This way, for example, the suspension of new concessions has been limited with the "pirates," as well as by the management of the concessions by powerful groups and corruption. The vehicle substitution faces the challenge of credit accessibility needed to buy new cars and the oversupply of the taxi service. As for the campaigns against the "pirates," these have to fight corporatism, judicial gaps and ambiguities, as well as corruption.

Conclusions

- The current exploitation rate and obsolescence of the vehicular fleet of the taxi service result in important environmental impacts, as shown above. The acceleration of the renovation of the vehicles and the reorganization of the exploitation and also the coherent implementation of the above-mentioned measures will have a direct benefit on the improvement of air quality, as well as the service to benefit the users and the people in general.
- Taxi service has a metropolitan dimension, for which the design of policies must involve close collaboration among the various authorities involved with problems of agglomeration, Governments of the State of Mexico, DF and Federal, overall those related to its environmental impact, as well as with its representations, and local and federal congress.



Francisco Guardado and Ed Dunlea in hot pursuit to measure exhaust emissions from taxi during the MCMA-2003 campaign.

¹ Gobiernos del Distrito Federal, Estado de México y Federación. *Programa para el Mejoramiento de la Calidad del Aire de la ZMVM 2002-2010*. México, 2003, 8-20.

Experts Conferred on Improving Emissions Inventory

Contributed by Gerardo Mejía, Francisco Obregon and Robert Slott

The Integrated Program on Urban, Regional and Global Air Pollution organized the "Workshop on Mexico Emissions Inventory" at the Hotel Royal Pedregal, México D.F., México on February 25 and 26, 2003. The purpose of this workshop was to bring experts from both the United States and from Mexico to discuss the current state of knowledge in emissions inventories and to help improve the development of the Mexico emission inventory. Better defining the emission inventory in the Mexico City metropolitan area (MCMA) is of particular importance due to the large population exposed to air pollutants that often exceed the national standards. The workshop was sponsored by the North American Commission for Environmental Cooperation, the Mexican Ministry of Environment and Natural Resources (SEMARNAT) and the Mexican Metropolitan Environmental Commission (CAM).

Uncontrolled air pollution in our modern age can lead to serious adverse health effects, threaten the viability of ecosystems and contribute significantly to global climate change. Studies have shown that increased morbidity and mortality accompany air pollution that exceeds air quality standards. Pollutants may be directly emitted from air pollution sources and other pollutants may be formed in the atmosphere as a result of reactions often catalyzed by sunlight. Establishing the appropriate control strategy portfolio requires understanding how secondary air pollutants are formed, especially ozone, and particulate matter.

Reducing air pollution requires controlling emission sources. An accurate emission inventory is needed to help design and monitor the emission control program by defining the important emission sources and watching air pollution trends. Emission inventories can be approached by measuring source emissions (bottom-up) or monitoring pollutants in the atmosphere using ambient concentrations, source receptor analysis, or other methods (top-down). Air pollutant concentrations vary in time (time of day, day of the week, season of the year) and space. Because many of the sources are difficult to measure and monitoring cannot take place everywhere, every emission inventory should be considered as a best estimate with an associated uncertainty. Methods of estimating the accuracy and uncertainty of emission inventories are important.

The workshop was divided into six sessions:

- 1. Emission Inventory Applications, Uncertainties, and Data Requirements
- 2. Mexico Emissions Inventory
- 3. Innovative Techniques for Measuring Emissions
- 4. Bottom-up Methods
- 5. Top-Down Methods
- 6. Wrap up Session

In the Welcome / Introduction, Luisa and Mario Molina gave an

overview of the research and education activities of the Integrated Program's Mexico City Case Study (hereafter referred as Mexico City Project). A review of the 1998 Mexico City Emission Inventory is included in a book published in 2002 (Air Quality in the Mexico Megacity: An Integrated Assessment, edited by L.T. Molina and M.J. Molina). The Project used emissions information from the 1997 IMADA measurement campaign to calculate the ambient ozone concentration as a function of time and location. The ambient ozone measurements did not agree with the air modeling calculation unless the hydrocarbon concentrations were multiplied by a factor of two to three. The Project conducted an exploratory field study in the MCMA to gather additional emissions measurements in February 2002 in preparation for an intensive field measurement campaign in the MCMA in April 2003. More than two dozens institutions from the US, Europe and Mexico, involving more than a hundred investigators will participate in this campaign. The 2003 effort adds a significant number of new state-of-the-art instruments, some on the Aerodyne Inc. mobile lab and some on a supersite installed at CENICA (Centro Nacional de Capacitación Ambiental), as well as in the boundary sites of the MCMA. We expect to generate lots of information that will enable us to further elucidate the atmospheric chemistry of the Mexico City Valley and reduce uncertainties in emission inventories. The insight obtained will be crucial for protecting human health and ecosystem viability in Mexico City as well as other megacities around the world.

Another important activity of the Project is the integrated scenarios analysis. While we cannot predict the future, we can estimate what might happen if Mexico City continues to grow and if different severity of control strategies are implemented. One of the unique features of the Project is the close collaboration with the Mexican government officials, so that our research findings can provide the scientific foundation for the decision making. Communicating to the public on how their actions can improve air quality is also part of the outreach program that is an important component of the Project.

Session 1: Emission Inventory Applications, Uncertainties, and Data Requirements

Bill Kuykendahl, US Environmental Protection Agency (EPA), described the emission inventory and air modeling requirements for states in the US that did not meet the National Ambient Air Quality Standards (NAAQS) to demonstrate that their control strategies were indeed working to reduce air pollution. The public in the US has access to these studies. The rules were established in the Clean Air Act. However, the Clean Air Act failed to account for the importance of pollutant transport from one state to another. Transport is especially a problem for long-lived pollutants and secondary pollutants such as ozone and particulate matter. Regional control strategies are now also important in the US. Jim Wilson, Pechan, described the shift from state to regional emission inventories. In the US power plant emissions are closely followed; hourly emissions are reported to the EPA. J. David Mobley, EPA, described the new NARSTO assessment on particulate matter to be released in March 2003. Robert Harley, University of California at Berkeley, and David Allen, University of Texas at Austin, each talked about the criteria for emission inventories that will be used as

Gerardo Mejía is a Professor and Francisco Obregon is a graduate student at Inst. Tecnológico de Monterrey (ITESM). Robert Slott is a Visiting Engineer with the Integrated Program on Urban, Regional, and Global Air Pollution.

sources of information for air quality modeling. For air quality modeling emissions must be specified spatially and temporally. Spatial coordinates are a few square kilometers in area in a three-dimensional grid. Times are specified as hours of the day, days of the week, and seasons of the year. Particulate matter inventories need to account for size and chemical composition of the pollutant. Based on studies in Houston, TX, extreme values of point source hydrocarbon emissions from chemical plants and refineries can have a large effect on the ozone concentrations. Intermittent high hydrocarbon emission events caused an underestimation of the point source hydrocarbon emission inventory by factors of five to ten. This illustrates the critical role that field measurements play in the development and performance evaluation of emissions inventory.

Session 2: Mexico Emissions Inventory

Adrian Fernandez, INE/SEMARNAT, described the Mexico National Emission Inventory Project, which started in 1996 with the support of US EPA and the Western Governors Association (WGA), later with help from the North American Commission for Environmental Cooperation (NACEC). The national emission inventory is starting in the border area for the cities of Aguascalientes, Mexicali and Tijuana, but will cover the entire country. Richard Halvey, WGA, described the decision making process in forming an emission inventory and the importance of the public having access to the information. Gathering emissions inventory information in Mexico presents unique challenges: jurisdictional issues, confidentiality laws, reporting requirements, data availability must all be considered during the planning and implementation portions of any project.

Session 3: Innovative Techniques for Measuring Emissions

Charles Kolb, Aerodyne Research Inc., talked about new opportunities for emission information by using new measurement tools. He illustrated this with some on-road formaldehyde data obtained in 2002 in real time in both Boston and Mexico City. The much higher formaldehyde concentrations and their association with carbon dioxide indicated much of the increase in formaldehyde in Mexico City could be due to primary emissions from automobiles. Brain Lamb, Washington State University, described the Urban Tower Flux Experiments to be established near CENICA and the instruments that will be used in the MCMA-2003 field campaign. Gene Tierney, US EPA, mentioned that EPA is promoting the development and commercialization of Portable Emissions Measurement Systems (PEMS) because they offer many benefits over traditional laboratory measurement techniques.

Session 4: Bottom-up Methods

Rodrigo Perrusquía, Gobierno del Distrito Federal, reviewed the recommendations given by the MIT Mexico City Project to the 1998 emissions inventory. He said that the three most important recommendations for mobile sources are knowing better the number of vehicles, the distribution by modelyear and the emission factors used. He discussed the basis and uncertainties in the vehicle counts. Sandeep Kishan, ERG, described the adoption of the US EPA MOBILE6 to conditions in Mexico. Matt Barth, University of California at Riverside, discussed the history and recent advances in mobile

source emission modeling. He described in some details the Comprehensive Modal Emissions Model (CMEM) and the International Vehicle Emission (IVE) Model developed at UC Riverside. The later has been successfully developed and applied to locations outside the U.S., including Chile, Kenya, India, and China. Gene Tierney pointed out that EPA's upcoming mobile source emissions model, MOVES, will be based much more on on-road vehicle emissions and will have the capability to make a life cycle analysis. Robert Harley commented to gain confidence in the estimates of emissions we need to make multiple independent estimates. His research activities use a highway tunnel as a laboratory to measure changes in vehicle emissions over a number of years. Vehicle emissions are estimated from emissions per fuel used multiplied by the amount of fuel sold in the area. The results from 1994 to 2001 showed an emission decrease of about 50% for NOx, 62% for CO and to 67% for VOC even though the amount of fuel used was increasing. The vehicle emission reduction is caused by better vehicle emission control equipment, especially better catalytic converters.

Sergio Sánchez, SEMARNAT, said all industries in Mexico are required to provide data related to general information of the industry, processes, raw material and inputs, air, water and soil emissions and pollutant transfers. Information about proprietary processes is confidential similar to US regulations. There is a list of 104 substances and the criteria pollutants are included as well as greenhouse gases. Jesús Contreras, SEMARNAT, gave an introduction to the stationary emissions inventory efforts in previous years and the air quality programs. The last EI is the 1998 estimate. Following the recommendation from Mario Molina's team at MIT, several techniques were used in refining the 1998 EI: source monitoring, emission factors, materials balance, and extrapolation. A large effort is being made to reduce uncertainties in the estimation of emissions. The focus is on NOx, HC, PM10 and PM2.5 emissions. Jim Wilson talked about similarities between data registered in the US and Mexico and about differences in confidentiality of information. He discussed uncertainty analysis results found by the National Academy of Science (NAS). Proper characterization of uncertainty is essential; most analyses underestimate uncertainties, thus giving decision makers a false sense of confidence.

Rocío Reves and Cuitlahuac Cruz, Secretaría de Ecología del Estado de México, reviewed the biogenic emission inventory for the Valley of Mexico. These talks included a description of the data requirements to be used in the Biogenic Emissions Inventory System (BEIS) model developed by EPA. Thev included climatology, humid and dry seasons, and land use, and emissions of isoprene, terpenes, VOC, and NOx. Luis Gerardo Ruiz Suárez, Centro de Ciencias de la Atmósfera, UNAM, discussed limitations in the use of the PC BEIS and in the use of the data for modeling. There is also no uncertainty analysis or validation with other methodologies. Thomas Pierce, National Oceanic and Atmospheric Administration (NOAA), described the evolution and advances of the BEIS and its application to air quality simulation modeling within the United States. Biogenic emissions are estimated to contribute more than 50% of VOC emissions in the US. However, depending on the methodology used, large differences in isoprene emissions may be estimated. He recommended ways to improve the estimation of biogenic emissions.

Jorge Sarmiento, Gobierno del Distrito Federal commented on the air quality problems and the efforts to estimate emissions inventories in the MCMA. The goal is to have a new estimate every 2 years. Mobile and area sources were considered the most important. The PM10 estimate is known to be low because it does not include emissions from either paved or unpaved roads. Many sources were not included in the 1998 EI due to lack of data and uncertainty about their reliability, especially in the informal sector (e.g., street vendors).

Session 5: Top-Down Methods.

Rafael Ramos, Gobierno del Distrito Federal, described the current Mexico City Air Quality Monitoring Network. The cost of the monitoring operation is in the order of 2 million dollars per year. David Allen talked about the use of the results of an air quality study to assess the accuracy of the EI using aircraft data and its application to areas of Texas. Results of ozone formation and HC reactivity in Houston showed that VOC emissions are underestimated. Interaction with stakeholder and community leaders has increased the confidence on policy-making and the value of scientific partnerships. Eric Fujita, Desert Research Institute, talked about how tunnel studies have shown that gasoline and heavy-duty diesel vehicle emissions have been greatly reduced over time except for particle emissions, which have shown only a small decrease. He discussed how emissions could be traced to their source using chemical composition.

Sixth Workshop

Continued from Page 2

growth; and Francisco Barnés of the Secretaria de Energia paralleled Mr. Grumet's discussion with a similar analysis in Mexico, highlighting the shift towards natural gas and PEMEX's efforts to modernize its equipment and reduce emissions. After a panel discussion, the debate shifted to fuel quality and vehicle technologies.

Jose Luis Jaramillo, PEMEX, said to reduce the level of sulfur in the refining process, it is necessary to upgrade the infrastructure of the refinery. PEMEX estimated the cost to produce ultra low sulfur gasoline to be as high as 2.3 billion dollars, or from 6 cents to 12 cents per gallon. Tim Johnson, Corning Environmental Technologies, stated that combining the newest vehicle emission control technologies available with ultra-low sulfur fuels, vehicles are capable of literally "cleaning the air" from what it is today. However, this is only possible by taking a total vehicle/ fuel approach, that is, the engine, catalytic converter, and fuel content must all be designed to work together. Cesar Flores, the president of the Mexican Automobile Industry Association



Panelists for Fuel Quality and Vehicle Technologies: Robert Slott (moderator), Sergio Sánchez, Luis Barojas, Tim Belian, José Luis Jaramillo, Arturo Massuttier Morales, Ramón Carlos Torres, Timothy Johnson.

Session 6: Wrap up Session

As part of the project's outreach efforts, this session was transmitted via the Mexican Education Network (EDUSAT) to other cities in Mexico. Sergio Sánchez gave an introduction to the session and explained the importance of reaching other audiences. Mario Molina emphasized the importance of the emission inventory and how it fits under the study being developed for the MCMA. A very precise emission inventory is expensive to produce and update, so only the degree of precision that is necessary should be used. However, different approaches to the inventory, using independent data, should be made so that the uncertainty can be estimated. These include measurements, fuel consumption, levels of activities, etc. The wrap up session included questions addressed to a panel of speakers and other workshop participants by Mario Molina and follow-up questions and comments from the audience. Topics discussed include what kind of training is needed to compile and use emissions inventories; what can Mexico learn from the international experience; how should Mexico decide which emissions control strategies should be put in place and how do we know whether the control strategies are working; and finally what can average person do to reduce emissions and hence to help improve the air quality. Luisa Molina closed the workshop by thanking the speakers, the participants and the sponsors for a very productive workshop.

(AMIA) said we face the challenge of an aging fleet- out of 17 million units in all of Mexico, 60% are older than 10 years. If fuel quality is not improved, it will become difficult to comply with tougher emissions standards. But it is also important to control the entrance and exit of vehicles across the US/Mexico border. 100,000 pickup trucks older than 10 years have come into Mexico from the US. In the US, Industry/Government Automotive/Fuel Cooperative Research takes place through the Coordinating Research Council. Tim Belian explained that through collaboration and cost sharing more vehicle, fuel, and lubricant research can be conducted which helps put regulations on a scientific basis. All the results of this collaborative research are available to the government and to the public.

Air Quality and Health Impacts: From Chemistry to Urban Planning

The third plenary session took at once both a more technical and a broader view of implementation. Gerardo Mejia of ITESM oversaw the discussion on air quality measurements and modeling, highlighted by presentation by Peter Lunn



Plenary Discussion: Adrian Fernández (moderator), Gabriel Quadri, Jason Grumet, Francisco Barnés, Fernando Tudela, Odón de Buen.



Audience participants at the Sixth Workshop.

(US Department of Energy, DOE), who described the various components of the DOE Atmospheric Science Program, highlighting the value of airborne measurements and the interest in Mexico City air quality. Other presenters discussed the atmospheric chemistry of poly-aromatic hydrocarbons, how to measure regional haze, the challenge of water management, and the successes of the air pollution model developed at MIT for the project.

John Evans of the Harvard School of Public Health moderated the presentations on health impacts. Presenters focused on the risks of diesel emissions. James Hammitt (Harvard School of Public Health) presented the preliminary results of a benefitcost analysis of diesel particulate filters. Stanley Dawson (California EPA), Tony Cox (Cox Associates) and Eric Garshick (Harvard Medical School) led a stimulating, polemic discussion about the human toxicity of diesel exhaust. The health risk due to inhalation of fine particles (PM2.5) is considered to be the greatest threat from polluted air. Silvia Lask, UAM-Xochimilco, stated that although Mexico City does not currently have a monitoring network for PM2.5, one is planned to be implemented by June 2003. While the controversy surrounding the impacts of diesel exhaust remains unresolved, conference participants were better able to grasp the key arguments made on both sides of the issue.

Finally, Joseph Sussman moderated the presentations on mobility, land use, and urban development. In addition to presentations by government officials from the Federal District and the State of Mexico on transportation and traffic management and progress in implementing caps on urban development, Pablo Trivelli (Universidad de Chile, Santiago de Chile) noted that plans to cope with congestion and pollution have an impact on people's everyday lives, and therefore popular support is necessary for them to succeed. The Chilean government has made a great effort to collect information and develop tools and professional expertise in the areas of transportation, urban and environmental planning. Henry Malbran (Department of Transportation (SECTRA) in Santiago, Chile) described his country's experience with transportation planning, an initiative that focused on making transit more attractive, promoting nonmotorized trips, and implementing tax and toll schemes that more accurately aligned the use of automobiles with their external costs. Santiago's successes and continued challenges can serve as a model for policymakers in Mexico and the United States. In contrast to Santiago, Alfonso Iracheta (El Colegio Mexiquense) pointed out that MCMA is currently functioning as two cities, the DF and the State of Mexico. Many issues divide the DF and the State of Mexico, including water provision, population growth and urban expansion, distribution of resources, transportation and the environment. Iracheta discussed steps that need to be taken to move toward metropolitan planning that will improve the environment of the MCMA.

On the third day of the workshop, participants discussed the results of the negotiation exercise mentioned earlier in this article, and broke into working group sessions on integrated scenario analysis and strategies, atmospheric science and health studies, and transportation and urban planning. Participants in the scenario analysis session learned about progress at MIT in developing an effective method of communicating technical atmospheric and econometric data to policy makers. Scenario analysis uses a series of "future stories," or potential paths for the Mexican and world economies, which are used to describe impacts of different air quality mitigation efforts under uncertainty. The urban planning session focused on the Santiago experience, highlighting key differences and similarities between the two cases and developing bonds between researchers and politicians that will likely prove to be useful in the future. The participants in the atmospheric science working group listened to additional presentations and devote the bulk of the session discussing the upcoming MCMA-2003 Field Campaign.

On Thursday, it was time to adjourn. In the past four days, politicians, engineers, industrialists, and academics had had an opportunity to teach and to learn, to establish new relationships and to solidify old ones. Despite the almost overwhelming challenge, they had all pledged to combat. There was a sense of hope in the air, and an eagerness to work together for the benefit of the population of this beautiful city.

Field Campaign

continued from Page I



Investigators (J. Jiménez, B. Lamb, R. Volkamer) explaining the measurements to visitors from UNAM, NOAA, and NCAR.

The fixed "supersite" capability at CENICA was enhanced with state-of-the-art instrumentation contributed by many US and European teams. CENICA is housed in a building on the Iztapalapa campus of the Universidad Autónoma Metropolitana (UAM). CENICA maintains its own suite of routine (EPA level) air quality monitoring instruments for NO_x, CO, O_y, SO_y, and PM_{10} , and also has an automated sampling system for GC/FIDanalysis of volatile organic carbons (VOCs). In addition, the automatic monitoring network RAMA maintains two nearby air quality monitoring sites. When not involved in mobile off-site experiments, the mobile laboratory was sited at CENICA and its instrument suite contributed to the supersite's database.

During the MCMA-2003 campaign, a tall flux tower was erected on the roof top of CENICA for continuous micrometeorological flux measurements of carbon dioxide, water vapor and total olefins and periodic flux measurements of NOy, NO, NO, HNO, NH_a, H_aCO, and other trace gases using mobile laboratory fast response sensors. The CENICA site also hosted collaborative measurements from various US and European institutions, including i) OH concentrations and reactivity measurements by William Brune's team at Penn State; ii) a GC-based

peroxyalkylnitrate instrument, an open-path near infrared ammonia vapor instrument, a Luminol chemiluminescent instrument for semi-continuous olefin measurements, and an Andersen Aethelometer for black carbon determinations from Jeffrey Gaffney and Nancy Marley of the Department of Energy's Argonne National Laboratory (DOE/ANL); iii) nitro-PAH measurements by Roger Atkinson and Janet Arey's team at the University of California, Riverside; iv) an aerosol mass spectrometer from José Jiménez' team at the University of Colorado; v) a proton transfer reaction mass spectrometer (PTR-MS) and several radiometers and particle sampler from Pacific Northwest National Laboratory (PNNL); vi) two research lidars from Hubert van den Bergh and Valentin Simeonov's team at EPFL and from MIT/Free University of Berlin, and a



M. Castillejos, S. Lask, S. Zirath, V. Páramo and V. Gutierrez listening to Chuck Kolb inside the mobile lab.

commercial lidar from Elight; vii) a research grade visible/near ultraviolet differ-ential optical analysis spectroscopy (DOAS) instrument provided by the University of Heidelberg and operated by the MIT team; viii) mini DOAS and FTIR from Bo Galle's team at Chalmers University. A complete list of participating institutions is listed in the box.

A key feature of the spring MCMA-2003 campaign was the deployment of a new mobile laboratory designed and developed

MCMA-2003 Field Campaign Participating Institutions

Mexican Institutions

- Universidad Autónoma Metropolitana (UAM) •
- Instituto Mexicano del Petróleo (IMP)
- · Petróleos Mexicanos (PEMEX)
- Universidad Nacional Autónoma de México . (UNAM)
- Universidad Iberoamericana (UIA)
- Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT)
- Centro Nacional de Investigación y Capacitación Ambiental de Instituto Nacional de Ecología (CENICA/ (INE)
- Secretaría de M. Ambiente, Gobierno del Dist. Federal (SMA-GDF)
- Secretaría de Ecología, Gobierno del Estado de México (SEGEM)
- Instituto Nacional de Salud Pública (INSP)

US Institutions

- Washington State University (WSU)
- Montana State University (MSU)
- University of Colorado at Boulder (UC)
- Lawrence Berkelev Nat'l Laboratory (LBNL)
- Aerodyne Research Inc. (ARI)
- Department of Energy/Atmospheric Science Program (DOE/ASP)
- Argonne National Laboratory (ANL)
- Pacific Northwest Nat'l Laboratory (PNNL) ٠
- Los Alamos National Laboratory (LANL)
- Colorado State University (CSU)
- Pennsylvania State University (PSU)
- National Science Foundation (NSF) •
- University of California at Riverside (UCR) •
- · Nat'l Center for Atmos. Research (NCAR)

European Institutions

- Massachusetts Institute of Technology (MIT) Ecole Polytech Federal de Lausanne (EPFL)
 - ETH/Zurich (ETHZ)
 - University of Heidelberg (UH)
 - · Freie Universitaet Berlin (FUB)
 - · Chalmers University of Technology (CTH)
 - Elight Laser Systems (ELS)

Sponsors

- CAM
- US National Science Foundation
- MIT
- · Alliance for Global Sustainability (to partner institutions MIT, EPFL and Chalmers)
- PEMEX (to IMP)
- US Dep. of Energy (to participating DOE national laboratories)



Aerial view of CENICA supersite. Inset: Michel Grutter and Luisa Molina in helicopter cockpit.

by ARI. The new ARI mobile lab is larger and equipped with significantly more instruments than the original version deployed for the MCMA 2002 exploratory field measurements described in the last newsletter (Vol. 2, Fall 2002). Additional fast response (1 s) instruments included a quantum cascade tunable infrared laser differential absorption spectrometer (QC-TILDAS) to measure gaseous ammonia (NH_a) from ARI, a commercial total nitrogen oxide (NO.) from MIT, a fast response DustTrak fine particle surface area monitor also from MIT, and a second commercial non-dispersive infrared carbon dioxide monitor from ARI. Additionally, slower response (10-60 s) instruments included a commercial UV absorption SO₂ monitor from Washington State University, a commercial aethelometer on loan from the Lawrence Berkeley National Lab, a customized gas chromatographic instrument to measure peroxy acetyl nitrate (PAN) and related organic peroxynitrates from DOE/ ANL, and a customized impactor to collect fine particles for subsequent synchrotr on X-ray analysis provided by PNNL. The PTR-MS from Montana State University used for fast response oxygenated and aromatic VOC compound measurements was successfully reconfigured to be used in mobile mapping and vehicle chase experiments as well as at fixed site deployments.

These additional instruments, coupled with the fast response trace gas and fine particle instrumentation from the original ARI mobile laboratory allowed a wide range of experiments to be pursued during the MCMA-2003 campaign. These included selected vehicle chase experiments to measure total nitrogen oxides, formaldehyde, acetaldehyde, ammonia, and selected aromatic VOCs exhaust emission ratios from heavy-duty diesel trucks, diesel buses, colectivos, taxis, and selected light-duty trucks and cars. We also mapped background concentrations of these and other compounds in selected MCMA industrial, commercial, and residential districts, paying particular attention to the area around the CENICA supersite, where we carefully characterized rush hour traffic emissions and detected industrial plumes of toluene and ethyl acetate. Large plumes of ammonia, uncorrelated with CO₂ emissions, were also detected near CENICA and in other MCMA districts. Successful fixed site deployments were made to the Pedregal and La Merced RAMA monitoring sites and the Santa Ana boundary site.

An initial data analysis workshop will be held at MIT in August 2003 and a second workshop to discuss the preliminary results is scheduled for January 2004. Results of the field measurements will be communicated to the scientific community and decision makers through publications and conferences. It is anticipated that the insight obtained through the field measurements and analysis of the data will be crucial for protecting human health and ecosystem viability in the MCMA.

More than three dozen post-doctoral associates, graduate students and undergraduates from US and Mexican institutions were involved in the field measurement and data analysis. Working side by side, these researchers developed and used advanced methods for measuring pollutant emission fluxes and ambient concentrations. Thus, the MCMA-2003 campaign provides an excellent opportunity to build capacity for research, education, and policy in developing countries and contributes to international exchange.



Field campaign participants; some who were not available during the photo session were added electronically.



Terry Shirley and Robert Lesher explaining the OH measurements (mounted on flux tower platform) to Mario Molina.





Nancy Marley and John Hubbe working on the CENICA roof top. Lower right: Scene from the Fiesta Mexicana Farewell Party.

Please visit our website on the field campaign and contact us if you have any questions or comments at ltmolina@mit.edu.

