Mobile Source Emission Estimates using Remote Sensing Data from Mexican Cities

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ABSTRACT

In Mexico, mobile source emission inventories are traditionally calculated using emission factors and deterioration rates developed by the US-EPA for the US vehicle fleet, fuels and driving conditions. While this method might prove useful to obtain rough estimates of mobile source emissions, it is assumed that these inventories entail a high (and still unidentified) level of uncertainty, which makes it essential to enhance these inventories with the use of field data on vehicle characteristics, driving patterns and fuels prevalent in Mexico.

During the past two years, the National Institute of Ecology in Mexico (INE) has worked to improve mobile source emissions inventory tools and information. As part of this effort, INE has performed several field campaigns (using remote sensing equipment and surveys) to gather local data on vehicle fleet characteristics and activity patterns in various cities along the US-Mexico Border and in other urban areas with large motor vehicle population.

This paper focuses on the analysis of the data obtained from these field campaigns and how it has been used to expand the IVE Model for Mexican cities; to estimate conventional pollutants and GHG emissions from mobiles sources in several cities, and to provide environmental authorities at the local and federal level with data on the environmental performance of the vehicle fleet in Mexico.

This work offers information and analyses previously not available in urban areas outside the Mexico City Metropolitan Area. This will prove useful both to inventory developers working on the update of the national emissions inventory and to policy makers driving emission control measures at the local and federal levels.

INTRODUCTION

Emissions inventories are a basic tool to identify the sources of emissions which impact air quality, and therefore, these tools are used to design suitable strategies to tackle air quality deterioration[1]. According to the National Emissions Inventory of Mexico-1999, transport is the main source of anthropogenic emissions of nitrogen oxides (NOx) and volatile organic compounds (VOCs) which are ozone precursors[2]. These sources also release particulate matter (PM) and carbon monoxide. Although the emissions come from fossil fuels (e.g. gasoline, diesel, LPG, etc.) use, there are other factors that determine the amount of emissions from a vehicle such as the technology, the use and driving modes as well as maintenance[3].

In Mexico, mobile source emission inventories are traditionally calculated using emission factors and deterioration rates developed by the US-EPA for the US vehicle fleet, fuels and driving conditions. While this method might prove useful to obtain rough estimates of mobile source emissions, it is assumed that these inventories entail a high (and still unidentified) level of uncertainty, which makes it essential to enhance these inventories with the use of field data on vehicle characteristics, driving patterns and fuels prevalent in Mexico.

Additionally, according to the North America Free Trade Agreement (NAFTA), appendix 300-A.2, starting in January 2009, Mexico may not maintain a ban or restriction on the importation of vehicles manufactured in Canada or the U.S. which are at least 10 years old[4]. When restrictions are removed, it is expected that these vehicles produce significant changes in the vehicular fleet in Mexican cities and, consequently, increase their emissions. Vehicle sales reported by the Mexican association of Vehicles Distributors (AMDA) and reports from the Mexican Tax Management Service (SAT), belonging to the Ministry of Treasury and Public Credit (SHCP), show that from October 2005 to January 2007, in average, two million imported vehicles from Canada and U.S. were legalized. This yields a ratio of two second-hand imported vehicles per each new car sold in Mexico. These vehicles are additional to the non-registered vehicles that were introduced into Mexican territory before 2005 and that are called "*chocolate*", from which there is no information available[5].

Despite all the progress made in regulating new vehicle emissions and fuel quality, the understanding of the environmental performance of in-use vehicles has been rather poor in Mexico; in this matter, some questions arise to overcome this problem:

- What are the real-world emission characteristics of vehicles actually on the roads in Mexico?
- How do vehicle emissions worsen over time?
- What are the emission contributions of different vehicle categories in a city?
- How do vehicle technologies, traffic conditions, and fuel quality influence the total amount of mobile emissions in a city?

It is evident that such knowledge is essential for developing effective strategies to improve urban air quality by controlling on-road vehicle emissions systematically and cost-effectively. However, part of this information remains unavailable. Due to the lack of reliable information, during the past two years, the National Institute of Ecology in Mexico (INE) has worked to improve mobile source emissions inventory tools and information. As part of this effort, INE has performed several field campaigns (using remote sensing equipment and surveys) to gather local data on vehicle fleet characteristics and activity patterns in various cities along the US-Mexico Border and in other urban areas with large motor vehicle population.

The aim of this document is to show the results obtained in this study of emissions and vehicular activity carried out in the Monterrey Metropolitan Area (hereafter MMA). We attempt to achieve the following goals through this project:

- Obtain emission factors for in-use vehicles in the MMA.
- Assess the emission characteristics of in-use vehicle fleet, in terms of vehicle age and vehicle characteristics.
- Derivate a fuel-based emissions inventory based on information gathered through the use of a remote sensing device and surveys.
- Provide national policymakers and city officials with input for decision making.

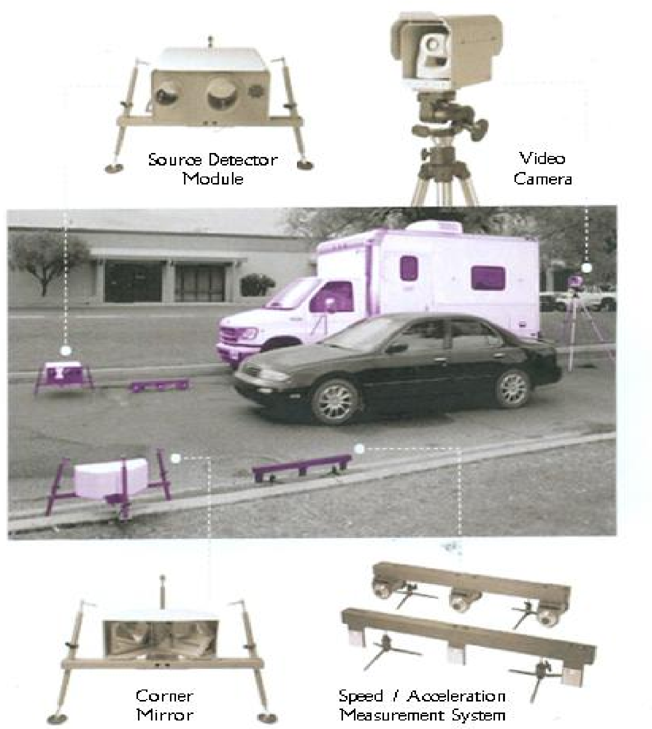
- Compare the resulting emissions inventory with that calculated using MOBILE and the International Vehicle Emissions (IVE) model, if possible.

METHOD

On-road emissions monitoring using RSD

Remote sensing technique is a reliable way to measure pollution levels of vehicle emissions without interrupting traffic flow[6, 7, 8]. Unlike most equipment used to measure emissions, remote sensing devices (RSD) do not need to be connected to vehicles. Thus, it is possible to measure emissions from one vehicle in less than one second[9]. When a RSD instrument is deployed at a proper site with continuous traffic flow, it can measure emissions of thousands of vehicles in a few hours. The design of the RSD is illustrated in Figure 1.

Figure 1. The typical deploy of the remote sensing detection system[10].



This technique has US-EPA approval and it can complement traditional mobile source emission control programs when used to identify gross emitters, screen clean vehicles, evaluate the effectiveness of I/M programs, and assess overall emission characteristics of a fleet of interest[11].

For this study, a RSD4600 system from Environmental System Products is used to characterize and evaluate the overall emissions of the light-duty-vehicle fleet in MMA.

The RSD system operated under the following conditions:

- Fuel specific concentrations of HC, CO and NO, as well as smoke in the vehicle exhaust are calculated based on the absorption bandwidth of 3.3, 4.6 and 4.3µm. of IR/UV light. The gas analyzer was calibrated daily with a mixture of certified gases, (CO, propane and NO). The HC measurements were expressed in terms of the "n-hexane ppm equivalent"[6].

- Studies developed by the University of Denver, CO; sponsored by the California Air Resources Board and General Motors Research Laboratories have shown that the remote sensor is capable of CO measurements that are correct to within ±5% of the values reported by an on-board gas analyzer, and within ±15% for HC and NO, test were carried out to determine that Tests involving a late-model low-emitting vehicle indicate a detection limit (±3_) of 25 ppm for NO, with an error measurement of ±5% of the reading at higher concentrations. Considering these specifications, it has been declare the next criteria for valid/invalid data. The CO tolerance was 10% or 0.25% (whichever was greater) for all expected concentrations below 3.0%, and 15% for all CO expected concentrations above 3.0%. In the case of HC, the tolerance was 150ppm or 15% of the expressed HC concentration (whichever was greater) throughout the range of HC concentrations. The NO tolerance was 250ppm or 15% of the expected NO concentration (whichever was greater) throughout the range of the NO concentration[6,7,11].

- Vehicles passed through the detectors by restricting vehicle flow to one lane, to obtain vehicle speeds of 30 to 40 km/h[6].

- Vehicle characteristics were obtained using the license plate number and matching it with vehicle registries provided by local authorities.

Only valid readings (according to standard criteria)[12] were used for further analysis.

Site selection

Measurements were carried out from 9:00 to 15:00 hrs, from May 27 to June 5, 2008 (10 days). Each day we installed the RSD at a different monitoring site. The following criteria were considered for selecting the sites, based on previous experience in monitoring on-road vehicle emissions with RSD[12]:

1) Regional specifications: The selected sites should belong to a wide variety of socio-economic levels, to account variability in vehicle characteristics due to this factor.

2) Traffic specification: The vehicle count at the selected sites should range between 200 and 2,000 per hour; average vehicle speed should range between 5-65 mph, the difference between maximum and minimum vehicle speed should not exceed 10 mph (for camera settings); vehicles should be under slight acceleration; and there should not be plume overlapping (i.e., vehicles are not too close to each other).

3) Lane specifications: Traffic flow should be only in one direction preferably, a one-line road with a width between 4 and 6 meters; monitoring sites should have wide curbs, if possible dustless, with solid shoulders to ensure the safety of the operator and equipment.

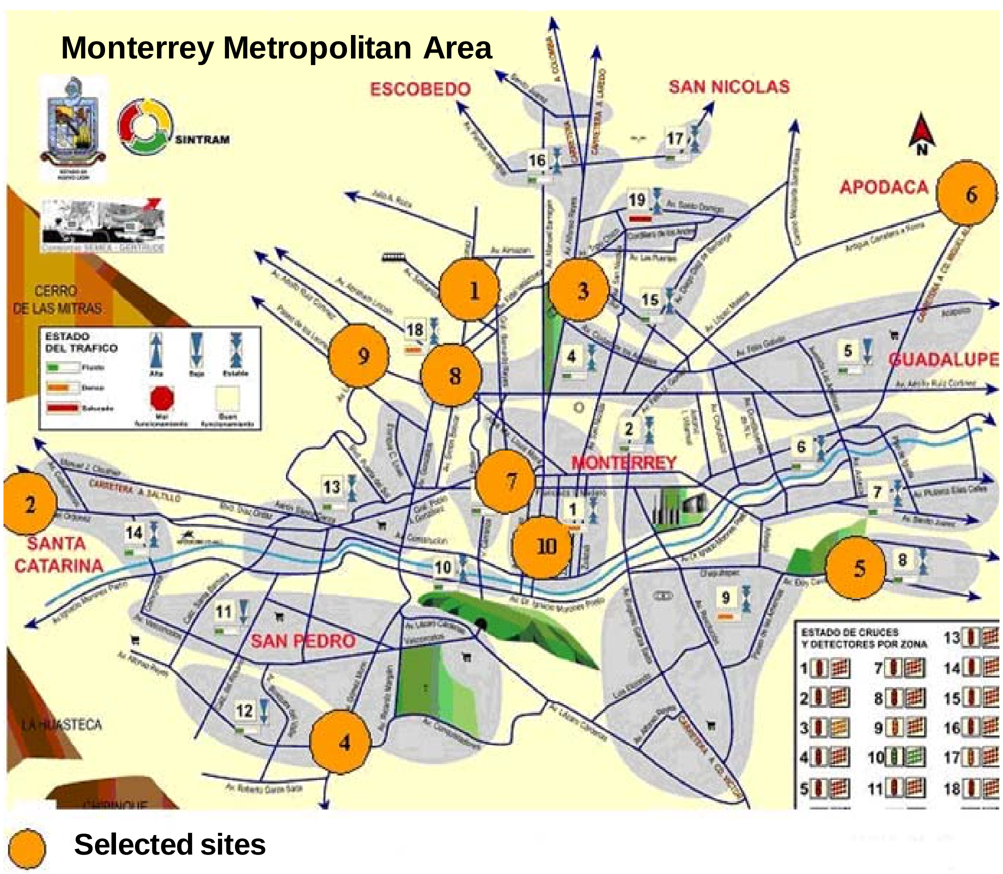
4) Ambient conditions: Humidity should range between 0% and 90%. No condensation or rain should occur during measurement.

Selection of sites was conducted in agreement with local environmental and traffic authorities. Table 1 shows the location of the selected sites, the dates when the RSD was installed in each site and the type of economic activity carried out in each one. All the sites have a slight upward slope of approximately 0.2 degrees in average[13,14]. The location of the sites is shown in Figure 2.

Table 1. Summary of the monitoring points in the MMA.

Number	Date	Municipality	location	Zone type
1	27-May-08	Escobedo	Av. Raúl Salinas Lozano	Business & services
2	28-May-08	Santa Catarina	Av. Manuel Ordóñez	Commercial/ Urban
3	29-May-08	Escobedo/ San Nicolás	Av. Sendero	Commercial/ Industrial
4	30-May-08	San Pedro Garza García	Av. Gómez Morín	Residential area
5	31-May-08	Guadalupe	Av. Eloy Cavazos	Commercial/ Urban
6	01-June-08	Apodaca	Carretera Santa Rosa	Industrial
7	02-June-08	Monterrey	Av. Alfonso Reyes	Commercial/ Urban
8	03-June-08	Monterrey	Av. Rangel Frías	Commercial/ Urban
9	04-June-08	Monterrey	Av. Ruiz Cortínez	Commercial/ Urban
10	05-June-208	Monterrey	Av. Serafín Peña	Urban

Figure 2. Selected monitoring sites in the MMA[13].



Fleet composition and activity data

Two sets of data were used to identify the fleet composition in the MMA: the information gathered by the RSD and the data collected through surveys in gas stations. When matched with registration data, RSD information is a very useful resource to understand what vehicle types (automobiles, SUVs, pick up trucks, minivans, etc.) are predominant on the roads, as well as their age and, if the databases allow it, other characteristics such as number of cylinders, type of emissions control technologies, etc. In this study, we consider that the group of vehicles registered by the RSD is a representative sample of the whole population of vehicles in the MMA, because of the criteria used for site selection (see *Site selection*).

Additionally, a contractor (The Sustainable Transport and Emissions Services Company - *TSTES*) was employed to survey 1,000 drivers at gasoline stations and carry out vehicle counts at crossroads located near the RSD sampling points (to preserve the representativeness of the sample). Surveys were conducted at selected service stations in five different municipalities within the MMA from November 4 through 8. Counting was carried out each 20 minutes from 8:00 to 18:00 hrs[15]. The surveys provided complementary information on the average activity of the fleet (VKT) per vehicle type and the percentage of used cars imported from the USA. The vehicle counts were also useful inputs (along with local vehicle sales statistics) to estimate the actual size of the on-road fleet in the MMA and were used to validate the data obtained from the license plates[15].

Emissions inventory

For the estimation of emission inventory we use the following equation:

Equation (1) $E_{ijk} = EF_{ijk} \times VKT_{ik} \times N_{ik}$

where
E_{ijk} = Emission per type of vehicle (i), pollutant (j) and stratum (k), (g/year)
EF_{ijk} = Emission factor per type of vehicle (i), pollutant (j) and stratum (k), (g/km)
VKT_{ijk} = Vehicle kilometer traveled per type of vehicle (i) and stratum (k), (km)
N = Number of vehicles per type (i) and vehicular stratum (k)

From the data collected by the RSD, it is possible to derive emission factors per vehicle type. This information, along with fuel economy data (per vehicle type, as well) is critical in building emissions inventories using this technique. In addition, from data collected through surveys we obtained the vehicle kilometers traveled by type of vehicle. The actual size of the on-road fleet in the MMA was estimated with local vehicles sales statistics.

Fuel-based emission factors

The readings were converted into mass emissions per gallon of fuel using equations (2), (3) and (4).

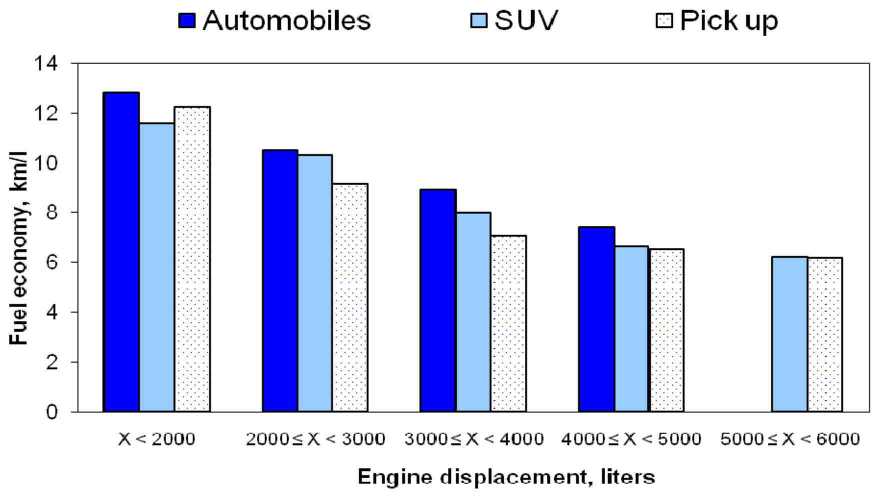
Equation (2) g CO/gallon = 5506 x %CO/(15+0.285 x %CO + 2.87 x %HC)
Equation (3) g HC/gallon = 8644 x %HC/(15+0.285 x %CO + 2.87 x %HC)
Equation (4) g NO/gallon = 5900 x %NO/(15+0.285 x %CO + 2.87 x %HC)

where
%CO = %v exhaust concentration of CO
%HC = %v exhaust concentration of HC
%NO = %v exhaust concentration of NO

The %HC measurement is a factor of two smaller than an equivalent measurement by an FID instrument[3]. In order to calculate mass emissions, the %HC values in the equations (2), (3) and (4) were multiplied by 2[16]. To transform the emission factors of mass/volume to mass/distance, we use information of fuel economy. Fuel economy data per vehicle type and per engine displacement were estimated from two databases available in Mexico: the inspection and maintenance program of Mexico

City Metropolitan Area (MCMA) and the National Commission for the Efficient Use of Energy. We analyzed data on vehicles with engine displacement ranging from 1 to 6 liters, and derived fuel economy for each vehicle type (automobile, SUV and pick up). Figure 3 shows a plot of fuel economy (km/l) versus engine displacement for each vehicle type.

Figure 3. Fuel economy versus engine displacement.



RESULTS AND DISCUSSION

On-road emissions monitoring using RSD

Table 2 shows the total number of readings per day and the valid readings with matching license plate information. A total of 42,959 readings were collected during the ten days, of which 27,248 were actually valid for future processing (63.4%).

Table 2. Number of readings per sampling site in the MMA.

Date	Site	Total readings	Valid readings with matching plate
27-May-08	Av. Raúl Salinas Lozano	5,171	2,922
28-May-08	Av. Manuel Ordóñez	4,375	2,337
29-May-08	Av. Sendero	4,801	2,882
30-May-08	Av. Gómez Morín	3,966	2,727
31-May-08	Av. Eloy Cavazos	4,513	3,025
01-June08	Carretera Santa Rosa	3,045	1,884
02-June-08	Av. Alfonso Reyes	6,123	4,274
03-June-08	Av. Rangel Frías	3,767	2,169
04-June-08	Av. Ruiz Cortínez	4,966	3,326
05-June-08	Av. Serafín Peña	2,232	981
	Total	42,959	26,527
	Readings used for the analysis (%)		61.75

Ideally, the measurement of vehicular emissions should be carried out when the vehicle experiences a light increment in the speed, preferable on a road whit a slight slope. In the case of CO and especially for HC, emissions can increase with the load on the engine from moderate to high, that is, when the vehicle increases its speed from moderate to high. HC emissions can also increase during decelerations[8]. NO is primarily formed in the post-flame of the gases during the combustion process into the cylinder engine. The kinetic of this reaction is highly dependant of the temperature of the gas; high temperatures favour the rate of formation of NO[17]. Nitrogen oxide emissions can also be increased when there is a load on the engine and with a high air/fuel mixture[1]. Table 2 shows the summary of the average and standard deviation of the emissions data as well as speed and acceleration

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Table 3. Summary of speed, acceleration and emissions in the MMA.

Parameter	CO (vol %)	HC (ppm)	NO (ppm)	Speed (km/h)	Accel. (km h^{-1} s^{-1})
Average	0.97	490.66	736.96	27.63	1.48
SD	1.88	1,349.96	1,009.77	7.13	1.59

The averaged emission per pollutant is shown in Table 3 as well as the standard deviation of the emissions of the measured pollutants, as table SD are greater, this is due to the diversity of the tested vehicles, here, the whole sample has been evaluated and for that reason high variability is observed, this is also presented in next results. The speed and acceleration of vehicles recorded with the RSD instrument are shown in Figure 4 and 5. These results indicate that vehicles in the MMA were driven between 20 to 35 km/hr, and approximately 50% of the vehicles were driven between 25 to 30 km/hr, as it can be seen in Figure 4. Figure 5 shows that about 7% of the sample was driven in deceleration mode, about 85% in acceleration mode while 8% were in cruising mode. This behavior of speed and velocity is consistent with other studies[3, 8].

Figure 4. Speed distributions of vehicles recorded with the RSD instrument.

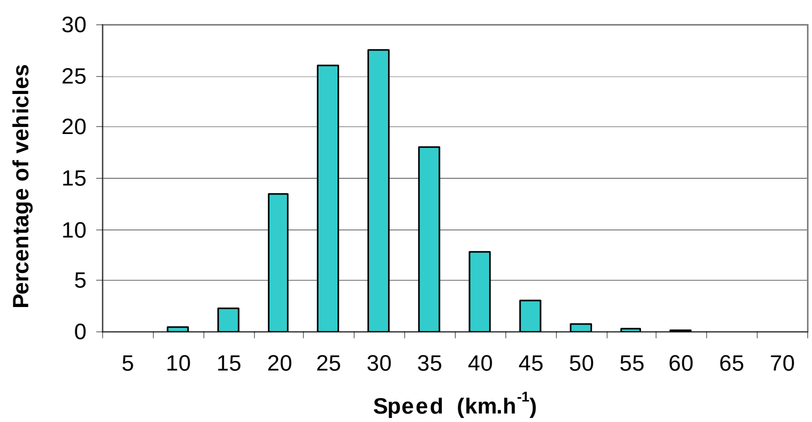
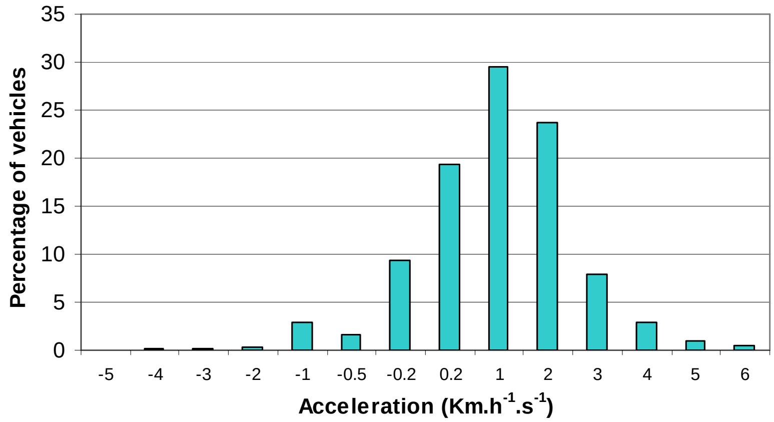


Figure 5. Acceleration distributions of vehicles recorded with the RSD instrument.



Emissions vs. age

To estimate the influence of age and emissions control equipment in emissions levels in the MMA vehicle fleet, we grouped vehicles, according to the model-year, in different *technology strata* based on regulatory requirements of emission control equipment in Mexico. Hence, four strata were defined as follows:

- 1990 and previous model-years: vehicles with no emission control systems (these vehicles have carburetors and no catalyst).
- 1991-1992 model-years: vehicles with two-way catalytic converters (new regulation issued in Mexico).
- 1993 and onwards: this group includes, vehicles with three-way catalytic converters, electronic fuel injection, more sophisticated emission-control system are installed in models after this year, however, this improvements can be included in this group[19].

Emissions of CO (%vol.), HC (ppm) and NO (ppm) per technology stratum are presented in Figures 6, 7 and 8. These figures show how the median values per stratum decrease with time, most probably due to the improvement in the emission control systems. The exception is NO, which shows an almost constant behavior in the first three strata. This behavior is consistent with other studies carried out in Mexico[3].

The readings show more variability in the older strata, probably due to vehicle aging, different maintenance conditions and the lack of an inspection and maintenance program in the MMA. Non-controlled and carbureted vehicles (<=1990 and 1991-1992 strata) were the most polluting, with the median for the CO and HC emissions 3.09 and 2.14 times higher than the median of the emissions of the whole sample, while NO emissions remained in the same level. Vehicles with two-way catalytic converters (stratum 3) in average emitted 1.52 and 0.25 times less emissions than the previous two strata; vehicles with three-way catalytic converters and fuel injection (last stratum) were the cleanest vehicle group in the MMA. However, in the strata with better emission control technology (1993-1998 and >=1999) the RSD registered several vehicles with extremely high emission values, although these were not a large enough number and most of the vehicles showed emissions that were close to the median value.

Figure 6. CO emission per vehicular stratum in the MMA.

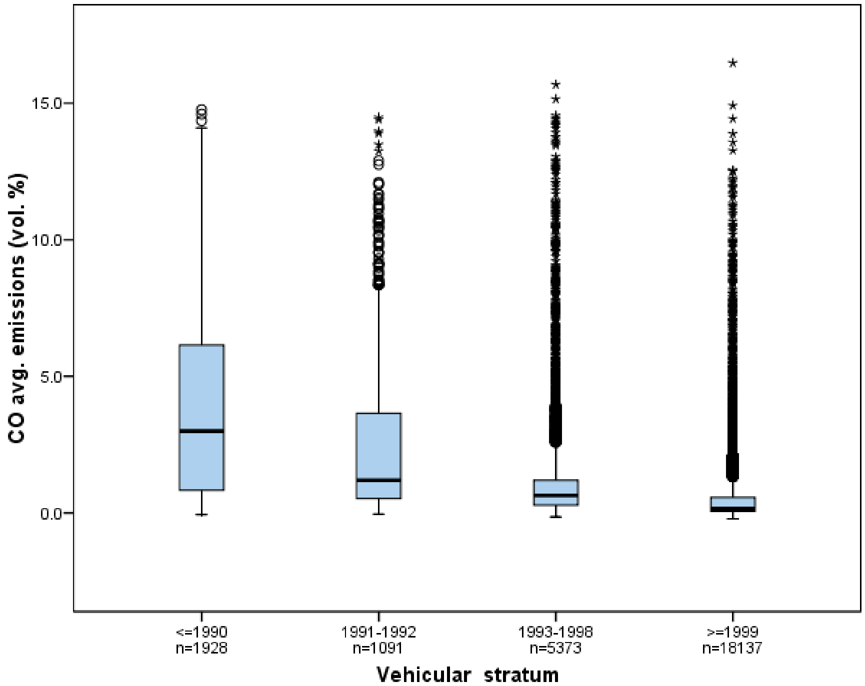


Figure 7. HC emission per vehicular stratum in the MMA.

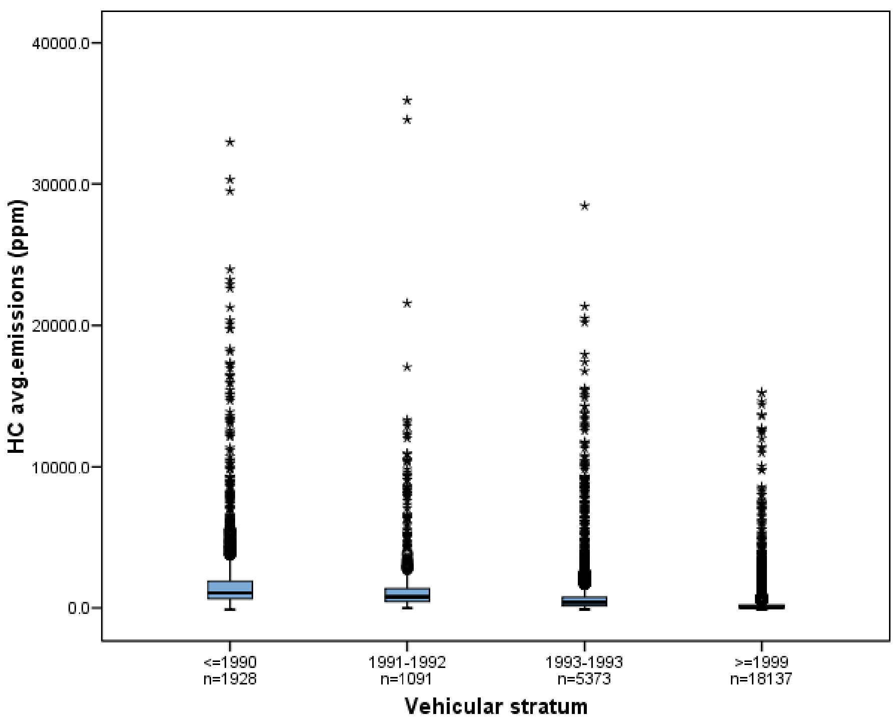
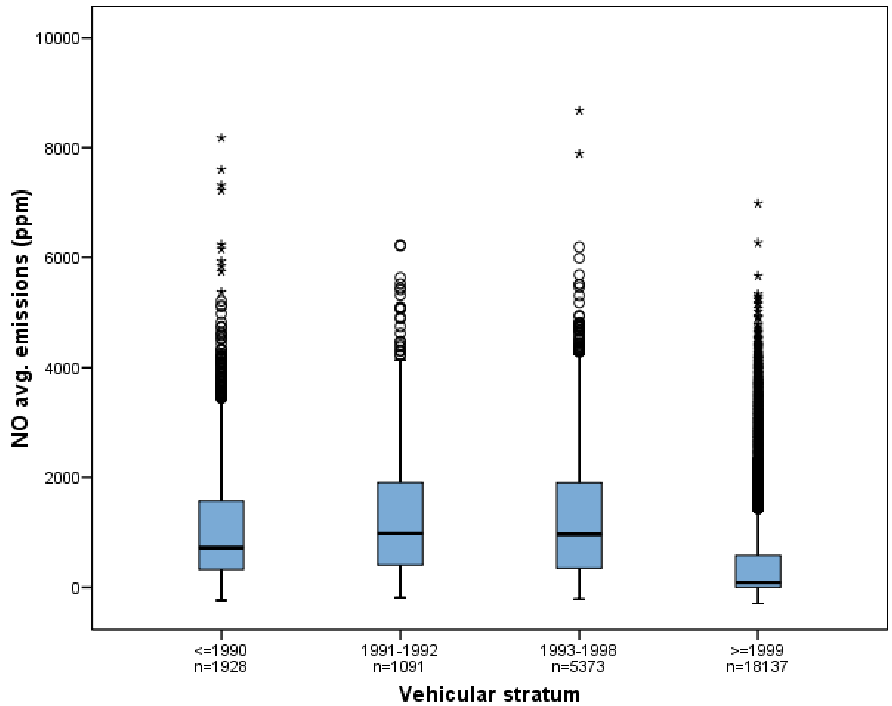


Figure 8. NO emission per vehicular stratum in the MMA.



Likewise, averaged emissions obtained from the RSD (in %vol and ppm) against model-year are plotted in figures 9, 10 and 11, due to the small number of readings and its high variability observed into the oldest model-year, model-years from 1959 to 1979 were excluded in the analysis. As it can be seen, there is clear reducing trend for CO and HC and NO for newer model-year vehicles that have fuel injection, three way catalyst-equipped vehicles (1993 and newer)[3]. In addition, it is know the fuel based values are less sensitive to load than kilometers based ones, then CO is almost independent of load, HC is more dependent and HC is most dependent[20]. As observed in other studies, NO emissions show a curved behavior, from low emissions in old models to an increment within the earlier emission controlled vehicles to a decrease in the newer[3].

Figure 9. CO Averaged emission by model year of vehicles recorded with the RSD instrument.

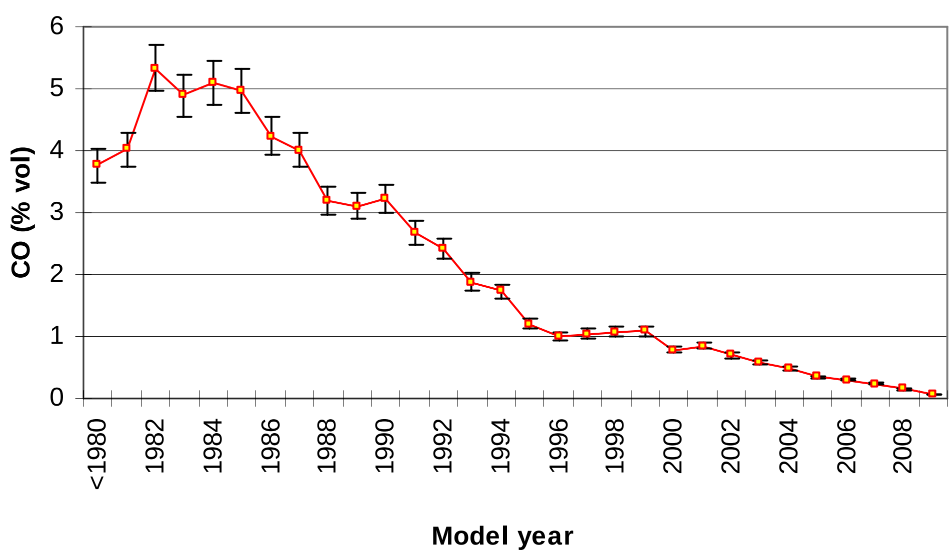


Figure 10. HC Averaged emission by model year of vehicles recorded with the RSD instrument.

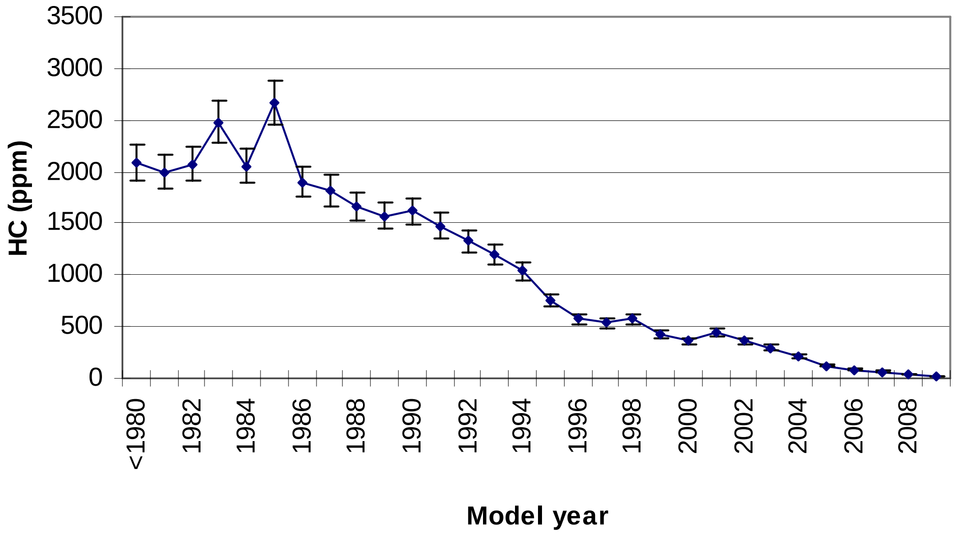
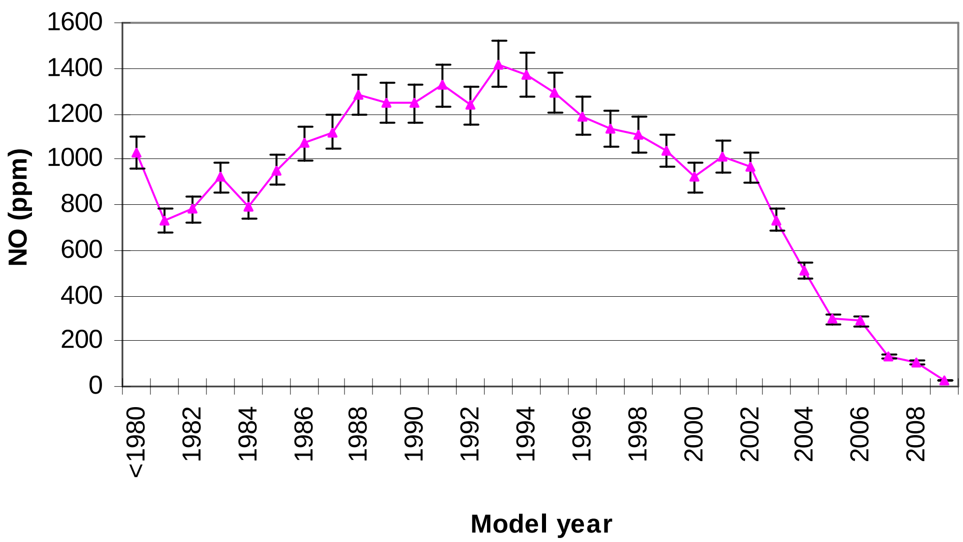


Figure 11. NO Averaged emission by model year of vehicles recorded with the RSD instrument.



Fleet composition and activity data

Vehicle counts and sales data were used to estimate the total in-use vehicle fleet to be 960,062. Of these, it is estimated that 555,912 (58%) are automobiles; 204,547 (21%) are pick up trucks, and 199,603 (21%) are SUVs. These percentages were consistent in both the surveys and the RSD data. Using the RSD data, we assumed similar age distribution per vehicle type for the whole fleet.

Table 4 shows the estimated vehicle distribution by type, technology stratum and emission control technology. It was estimated that approximately 33% of the fleet are more than 10 years old, and 8% are not equipped with catalytic converters.

Table 4. Vehicle distribution by type, stratum, technology, number and VKT in the MMA.

Type of vehicle	Vehicular stratum*	Technology*	Number of vehicles **	Traveled km yr^{-1} (millions) **
Automobiles	<=1990	Carburetor, no emission control	33,004	1,167
	1991-1992	Carburetor, oxidative catalyst	19,014	672
	1993-1998	MPFI[a], TWC[b]	82,831	2,929
	>=1999	MPFI[a], TWC[b]	421,064	14,889
Pick up	<=1990	Carburetor, no emission control	34,560	814
	1991-1992	Carburetor, oxidative catalyst	14,489	341
	1993-1998	MPFI[a], TWC[b]	51,910	1,223
	>=1999	MPFI[a], TWC[b]	103,589	2,440
SUV	<=1990	Carburetor, no emission control	7,121	158
	1991-1992	Carburetor, oxidative catalyst	7,584	169
	1993-1998	MPFI[a], TWC[b]	63,769	1,419
	>=1999	MPFI[a], TWC[b]	121,129	2,696

[a] Multipoint injection; [b] Tree way catalyst
* Information obtained from references 13 and 19
** Information generated in this work (The Sustainable Transport and Emissions Services Company – *TSTES)*

Emissions inventory

Mean emission factors and their 95% confidence intervals per pollutant and per technology stratum are shown in figures 12, 13 and 14. As shown, emission factors not only increase with age, but are larger for pick ups and SUVs than for automobiles, regardless of age. Moreover, the two strata with newer vehicles shows significantly higher emission factors for pick ups than for automobiles or SUVs. This could be due to a more intensive use.

Figure 12. Emission factor of CO per vehicular stratum in the MMA.

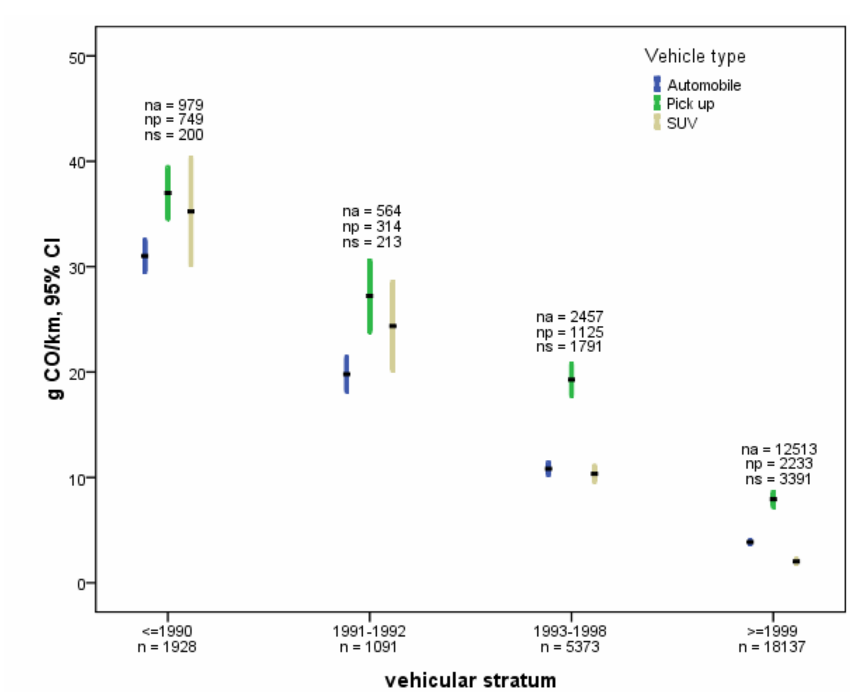


Figure 13. Emission factor of HC for vehicular stratum in the MMA.

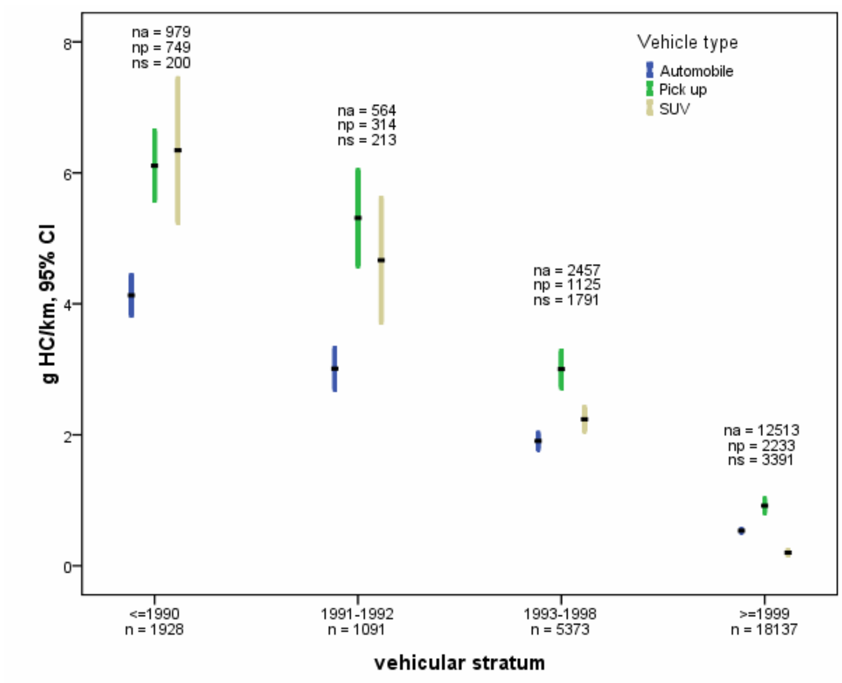


Figure 14. Emission factors of NO for vehicular stratum in the MMA

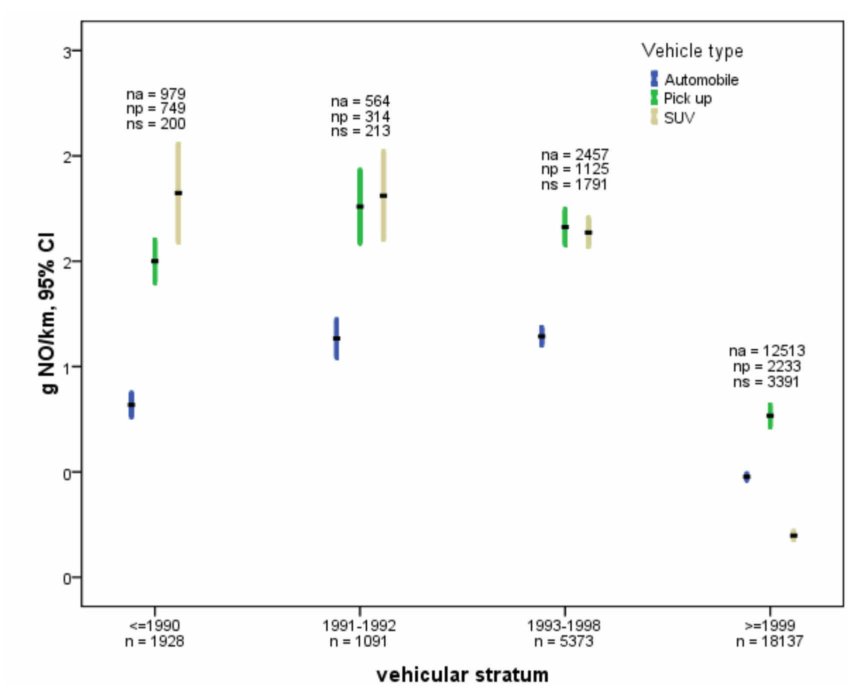


Table 5 shows the emissions inventory calculated for the MMA using the information on vehicle fleet and the emissions factors derived from this study. According to our estimates, vehicles with obsolete or no emissions control technologies amount only approximately one third of the fleet; yet, in average, these vehicles account for a large proportion of the emissions of all considered pollutants (67% of CO, 72% of HC and 56% of NO). Moreover, older vehicles with no emissions control technology (model-year 1990 or earlier) comprise less than 8% of the fleet but they are responsible for approximately 30% of CO and HC emissions and 10% of NO emissions.

Table 5. Mobile sources emission inventory per technology stratum in the MMA.

Vehicular stratum	Number	% of vehicles	Emission (Ton/year), contributions (%)					
			CO	%	HC	%	NO	%
≤1990	74,685	**8**	71,897±2,529	**28**	10,801±491	**28**	2,465±165	**12**
1991-1992	41,086	**4**	26,712±1,911	**11**	4,624±371	**12**	1,668±124	**8**
1993-1998	198,509	**21**	69,951±4,172	**28**	12,428±811	**32**	7,706±272	**36**
≥1999	645,781	**67**	82,216±7,464	**33**	10,747±1,450	**28**	9,511±486	**44**
Total	**960,062**	**100**	**250,776±16,076**	**100**	**38,600**±3,124	**100**	**21,350**±1,046	**100**

Table 6 shows the results distributed per vehicle type. Automobiles total 58% of the total fleet in MMA and account for a significant proportion of emissions of all pollutants.

Table 6. Mobile sources emission inventory per vehicle type in the MMA.

Type of vehicle	Vehicles in MMA		Emission (Ton/year)					
	Number	%	CO	%	HC	%	NO	%
Automobiles	555,912	**58**	138,730±8,336	**55**	20,402±1,620	**53**	12,183±543	**57**
Pick up	204,547	**21**	82,218±4,427	**33**	12,685±860	**33**	5,716±288	**27**
SUV	199,603	**21**	29,829±3,314	**12**	5,513±644	**14**	3,451±216	**16**
Total	**960,062**	**100**	**250,776±16,076**	**100**	**38,600±3,124**	**100**	**21,350±1,046**	**100**

CONCLUSIONS

This study is the first one carried out in Monterrey whereby emissions factors were derived and an emissions inventory for a group of vehicles was calculated using field data. The 95% confidence intervals of the average emission factors for automobiles indicate that there is less variability in this group that in the other vehicle groups (maybe due to sample size), especially in model-years 1992 and earlier. However, for model-years 1993 and later, the 95% confidence intervals of the average emission factors for all vehicle types indicate very little variability within each vehicle type. Considering the sample sizes of these strata, this increases our certainty about the average calculated values.

The inventory shows that even though the fraction of vehicles older than 10 years is not large, their contribution to emissions is quite significant. The differences in the emission factors calculated for pick-up trucks vs. SUVs and automobiles in the two newer strata suggest that emissions from pick-ups increase more rapidly with age, probably because pick-ups are mostly used for more intensive uses than SUVs and automobiles.

Considering that there is no I/M program in Monterrey, local officials should consider its implementation. This could be applied partially (to older vehicles only, or to intensive-use vehicles) or to the whole fleet. The amount of emissions due to older vehicles and pick-ups grant this consideration.

Future work includes comparing our results with existing mobile source emissions inventories in the MMA, compare emissions levels in the MMA with those measured in the Mexico City Metropolitan Area in a recent campaign (2008), use additional data collected during the MMA campaign as input for the International Vehicle Emissions (IVE) model and compare the resulting inventory with the inventory here presented and an inventory derived from MOBILE-6 Mexico.

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