PLANE SMOG:

AN ASSESSMENT OF THE SOURCES AND EFFECTS

OF LAX AIR POLLUTION

ON THE LOCAL AND GLOBAL ENVIRONMENT

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I. LAX OPERATIONS

Los Angeles International Airport, or LAX, is one of the country's busiest airports. In 1996, the Federal Aviation Administration (FAA) ranked LAX the 4th busiest airport in the US in terms of total operations (the number of times planes take-off and land), and second in freight and mail tonnage.[1] In 1997, LAX again set new records in both cargo and passenger volume (LAX News release, 1998). In terms of statistics, the commercial carriers at Los Angeles International Airport boarded close to 23 million passengers and over 700 thousand tons of freight and mail in 1996 (FAA, 1998).[2]

This volume of passengers and flight operations, and the support required, has made LAX a powerful economic engine in Southern California. The airport directly employs over 50,000 people in various support roles for its flight, cargo and passenger operations. It also claims indirect responsibility for another 390,000 jobs throughout the region. In fact, the Los Angeles World Airport Authority estimates that one in 20 jobs in Southern California is attributed to LAX operations (LAWA, 1998).

The operations at LAX also constitute the largest single source of air pollution in what has long been the nation's worst air quality region. In fact, the LA Basin exceeded one or more federal air-quality standards on nearly one third of the days of the year in 1995, earning it the status as a "non-attainment" area (SCAQMD, 1997). This status is reserved for areas in the nation that fail to reduce air pollution levels to prescribed federal standards, or meet certain reduction targets.

This section seeks to summarize the issues associated with the air pollution generated by LAX. It begins with a brief review of the pollutants. It is followed by a discussion of the sources of contaminants that result from the airport's operations, and then presents estimates of the emissions from LAX. Next is a discussion of the health risks posed by these pollutants, as well as, their effects on the environment. Finally, the public policy issues regarding the air pollution at LAX and its control are summarized.

II. BACKGROUND – AIR POLLUTION ISSUES

For most people, the issue of noise pollution from airports immediately strikes a chord, especially for those in communities adjacent to, or directly under an airport's flight paths. At or near an airport as busy as LAX, aircraft noise is pervasive: noise from aircraft in holding pattern, approaching, landing, braking, taxiing, docking, undocking, waiting, accelerating, taking off, and leveling out. What few people realize is that a less palpable but no less harmful form of pollution – air pollution – also accompanies the noise pollution in these stages of aircraft and ground operations. The larger the

[1] There is some confusion regarding the estimated number of passengers passing through the airport annually. The FAA only counted the number of passengers that boarded a commercial flight from LAX, this number did not include charter, taxi, private and military passengers, or the number of passengers that deplaned at LAX.

[2] To put this volume of traffic in perspective, the amount of traveling passengers that departed via LAX in 1996 is more than the entire population of the State of Texas. To look at this number in another way, it is almost equal to the number of people currently living in Alaska, Arkansas, Delaware, the District of Columbia, Hawaii, Idaho, Iowa, Kansas, Maine, Montana, Nebraska, Nevada, New Hampshire, New Mexico, North and South Dakota, Rhode Island and Vermont (US Bureau of the Census, 1997).

airport's scope, in terms of passengers, freight tonnage and planes arriving or departing, the more air pollution is generated as a result (EEA, 1995).[3]

Although the issues of airport noise and air pollution share some similarities, such as their direct detrimental impacts on the surrounding communities, air pollution from airports can be a much more complex issue. Noise pollution, which acts upon the mental health of people living and working in the high-decibel areas, can be more localized in effects. For people living outside of the immediate flight paths, noise pollution is more of a quality of life issue. This is not the case with air pollution. Emissions from airports consist of many pollutants that adversely act upon humans and their environment locally, regionally and globally (EPA 1996a). Also, air travel is expected to have a higher growth rate than all other transportation modes in the coming decade, which will further exacerbate air travel's impact on the environment, mostly in the form of increased air pollution (VROM, 1997).

Due to the many sources of emissions, types of pollutants emitted, and the difficulty in their characterization, controlling the pollutants generated by an airport's operations is an extremely complex, multi-faceted issue (EPA 1997e, NRDC, 1996b). While a single federal agency is responsible for promulgating regulations to control noise levels from aircraft, no less than half a dozen federal, state and regional agencies are responsible for addressing the issue of air pollution in the LA basin. Existing federal and state jurisdictional delineation have exempted airports from meeting annual emissions reduction targets or reporting their air releases, unlike other local sources of air pollution. Because of this current emissions control regime, the air quality in the LA Basin is likely to further degrade as the number of flights and passengers at LAX continue to set new records each year (LAX News Release).[4]

The lack of information on air pollutants' impacts also hampers efforts to control them. Currently, strategies to address a particular air pollutant are dependent upon its type, source, and what is known about its effects. Furthermore, researchers are just now becoming aware of other potentially harmful pollutants from aircraft and airport operations, but because not much is known about their formation and long-term effects, their regulation has yet to be defined (EPA, 1997e). Finally, regulators are only beginning to grasp the cumulative impacts of air pollutants, the way they interact with one another, and how chronic exposure to multiple airborne chemicals harms human health.

III. AIRPORT EMISSIONS

Most people enjoying a spectacularly fiery red sunset from the beaches of Santa Monica are blissfully unaware that the agents helping to enhance the colors in this scene belong to the same group of air pollutants that are responsible for the unsightly haze over the LA Basin. While the ingredients contributing to this "chemical soup" are released at ground level by a number of sources, aircraft are unique in that their emissions occur at both ground level and while in flight (LA Times, 1996). Analysis

[3] Under the current mix of aircraft, an increase in airport operations will result in increased pollution from both aircraft and ground transport. Future aircraft mixes may see reduced emissions from an individual aircraft, but net emissions may increase nevertheless due to an increase in the total number of flights.

[4] According to the latest South Coast AQMD report using data gathered in 1995, the LA Basin exceeded federal and state standards for ozone, particulates, and carbon monoxide on a regular basis. The basin also exceeded the state standard for sulfate and visibility (SCAQMD, 1997).

of available data indicates that emissions from planes include as many smog components as emissions from some of the local industries (EPA, 1997a).

Air emissions by airports come from a variety of different sources. Aircraft operations, which includes activities from commercial, private and military aircraft engines on the ground, at the gate and in the air, account for the plurality of aircraft-sourced pollutants at LAX and at other airports (EPA, 1997a).[5] The other sources of emissions include exhaust from aircraft auxiliary power units (APUs)[6], and ground support equipment – baggage and people movers, aircraft tows, refueling and catering vehicles, etc. (LAX Communications, 1997; EPA, 1997b).

Aircraft engines, like other fossil fuel-based engines, burn a prescribed mixture of fuel and outside air inside their combustion chambers. Under ideal conditions, the outcome of this fuel and oxygen explosion is heat, which is harnessed for thrust, plus carbon dioxide and water vapor, with no other by-products, thereby generating little pollution. Because of other compounds and elements present in air and fuel, as well as variability in the oxidation process, combustion in the real world produces not only heat, water vapor, and carbon dioxide, but also a host of other not-so-desirable by-products (EEA, 1995).[7]

Surprisingly, a large part of the air pollutants from airports comes not from aircraft but cars and trucks. The daily vehicular traffic that carry arriving and departing passengers at a busy airport contributes significantly to an airport's pollutant pool, as do the many light, medium, and heavy trucks that carry freight and mail to and from airports (LAX Communications, 1997; EPA, 1997b). Finally, a small amount of air emissions come from the refueling operations, spillage and evaporation, pre-flight checks, and dust generated by all of these processes (CRH Consulting, 1994).

The five identified major air pollutant species from aircraft operations are volatile organic compounds (VOCs), nitrogen oxides (NOx), soot or particulate matter (PM), carbon monoxide (CO), and sulfur dioxide (SOx). These five air pollutants are also present in automobile and truck exhaust gases. Along with these five are other compounds whose effects are just beginning to be investigated, and are far from fully understood.[8]

Regardless of the sources of emissions, the two most significant of these five air pollutants (both in volume and effects) that LAX and its operations are responsible for, are VOC and NOx. These two pollutants are particularly problematic for three reasons:

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[5] The Federal Aviation Administration defines four categories of aircraft operations at airports: commercial, general, taxi, and military. Most of the available FAA data on airport operations are of commercial aircraft.

[6] APUs are mall jet engines that supply the aircraft with electricity, climate control and other necessities while parked.

[7] Carbon dioxide is harmless to humans at ground level. It is the increasing volume of carbon dioxide in the atmosphere from human activities, and its ability to trap and reflect additional heat onto the earth's surface that is of concern.

[8] Currently, not enough is known about the pollutant types resulting from the combustion of jet fuel or their health effects . We were not able to identify a comprehensive risk-assessment of airport air pollution during the course of this research. Studies identifying toxic and carcinogenic air pollutants from airport operations have mostly relied on actual sampling of the air around airports such as Chicago's O'Hare and Midway.

1. These chemicals are extremely harmful pollutants by themselves;
2. They belong in a class of chemicals known as "ozone precursors" or, more specifically, "ground-level ozone precursors," because they contribute to the formation of hazardous tropospheric ozone (O_3) a significant urban air pollutant and the primary component of smog; and,
3. The presence of these pollutants in urban air is expected to increase in the near future despite the current control regime (EPA, 1997d).[9]

A more in depth discussion of the pollutants and their effects on human health and the environment can be found in Appendix A.

In addition to the five criteria pollutants described above, the combustion of fossil fuels for transport activities and other human uses results in the release of various compounds into the atmosphere. Of great concern are the "greenhouse gases" – compounds that can contribute to global climate change due to their interactions in the upper atmosphere. These gases include carbon dioxide, methane, water vapor, and nitrous oxide. The potential effects of these gases on the global climate are further explored in the discussions on environmental effects (EPA, 1994; VROM, 1997).

Scientists are also concerned with the emissions of NOx and particulates that are released in the upper atmosphere by commercial, military, and private planes. Many commercial airliners cruise at altitudes over 30,000 feet, at the boundary of the troposphere and stratosphere. There have been indications that NOx and particulate emissions in this region of the atmosphere undergo complex interactions that can reduce the ozone layer's effectiveness, thereby allowing more ultraviolet radiation to reach the earth's surface (EDF, 1994; EO, 1998).

IV. ESTIMATION/INVENTORY OF AIR EMISSIONS

The amount of pollutants released daily by an airport, especially an airport with the operational scale of LAX, can be immense. Because of their nature, air pollutants can physically blanket the surrounding communities and the airport itself, yet remain physically intangible, making their discharge and potential effects extremely difficult to characterize. Thus, in order to provide a better understanding of the significance of this pollution, a means is needed to help quantify the volume of air emissions – both from air and ground operations – at LAX on a daily and annual basis. This quantification makes three things possible:

[9] According to the US EPA, the current control regime will no longer be effective in the future due to a combination of factors, the primary ones being the projected increase in ground and air traffic, urban growth, and lack of new control technologies. This projected increase applies for all US urban areas.

1. It identifies the sources (and their magnitude) of air pollutants;
2. It provides a snapshot of the levels of air pollutants generated from current operations, thereby providing a reference for future emissions estimation or any reduction efforts; and,
3. It allows an observer to place LAX's emissions in context by enabling a comparison to other sources of pollution in the LA Basin or the state.

This section aims to provide a detailed summary of emissions estimates from operational sources at LAX, based on available inventories and/or information. LAX's sources of pollutant emission covered in this section include:

Emissions from aircraft

- main engines (landing, takeoff, and taxiing operations)
- auxiliary power units (gate operations)
- evaporative emissions (fueling operations)

Emissions from vehicles

- Ground support vehicles (aircraft tugs, baggage tractors, and cargo moving equipment, etc.)
- Ground access vehicles (passenger cars, buses, vans, and other service vehicles, etc.)
- Cargo transport (light, medium and heavy duty trucks used for mail and cargo transport)

The inventory estimates presented here are summarized from a number of origins, and are not all complete or specific to LAX operations.[10] Nevertheless, from these inventories, we were able to construct a rough picture for VOC and NOx emissions from activities at LAX for 1993, the latest year for which the most complete inventory data is available. In the case of PM, SOx or CO, it was not possible for us to build a complete emissions inventory for these air pollutants, due to the fact that emission data for certain activities are not complete or not available. See Table 1 on next page.

[10] Some of the available inventories consulted provided information concerning specific categories, such as commercial air activities at LAX; while others only account for automobile or stationary sources, and are therefore not specific to LAX. For example, inventories of vehicle emissions that we examined were not prepared for the specific purpose of estimating emissions from LAX's operations, but rather as part of the inventory of emissions from mobile sources (cars & trucks) in the LA Basin. In the case of emissions from cargo transport, we had to develop an estimate from available statistics because no LAX-specific estimates were available from the SCAQMD or from LAWA.

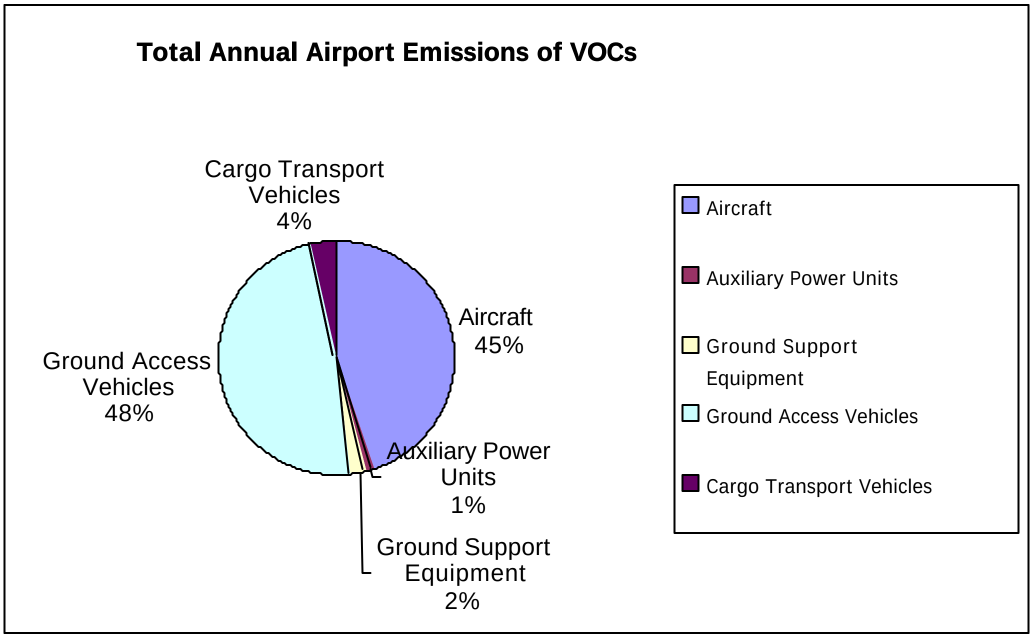
Table 1. Emissions from Airport Operations, Estimates for 1993

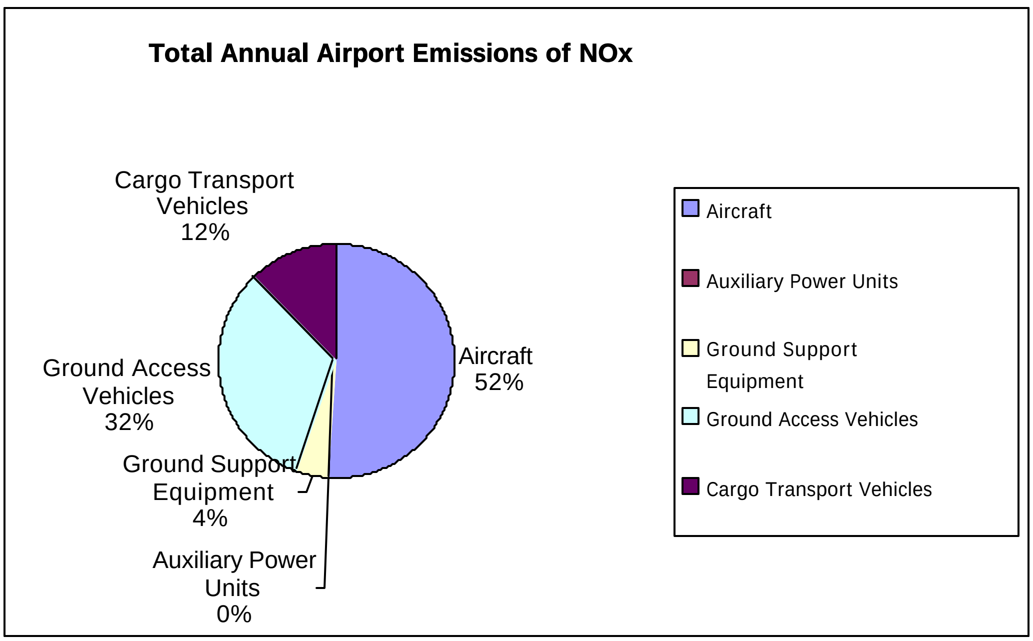
Emissions Category	**VOCs (Tons)**	**NOx (Tons)**	**CO (Tons)**	**SOx (Tons)**	**PM (Tons)**
Aircraft (Main Engines) *% of Airport Total*	2,226.5 *41%*	3,255.8 *50%*	8,249.0 *79%*	211.7 *NA*	2.2 *4%*
Auxiliary Power Units *% of Airport Total*	65.7 *1.2%*	3.7 *0.01%*	NA	NA	NA
Evaporation [1] *% of Airport Total*	363.8 *6.7%*	-	-	-	-
Ground Service Vehicles *% of Airport Total*	105.9 *2%*	292.0 *4%*	NA	NA	NA
Ground Access Vehicles *% of Airport Total*	2,460.1 *45%*	2,190.0 *34%*	NA	NA	NA
Cargo Transport Vehicles[2] *% of Airport Total*	182.9 *3%*	773.8 *12%*	2,180.7 *21%*	NA	59.8 *96%*
Total Aircraft Emissions	2,656.0	3,259.5	8,249.0	211.7	2.2
Total Ground Emissions	2,748.9	3,255.8	2,180.7	NA	59.8
Airport Total	**5,413.0**	**6,522.1**	**10,429.7**	**211.7**	**62.0**

Source: Emissions estimates are from SCAQMD Planning Office, except for Evaporation, which is derived using data from CRH Consulting, Inc., 1994; and Cargo Transport, which is estimated using available data from a number of sources.

Notes: 1. Emissions from evaporation are assumed to consist mostly of hydrocarbons (HC).
2. Estimated from LAX cargo tonnage.
NA: Not available.

Refer to Appendix B for a detailed discussion on emissions estimates.


Total Annual Airport Emissions of VOCs
Cargo Transport Vehicles 4%
Aircraft 45%
Ground Access Vehicles 48%
Auxiliary Power Units 1%
Ground Support Equipment 2%
Aircraft
Auxiliary Power Units
Ground Support Equipment
Ground Access Vehicles
Cargo Transport Vehicles


Total Annual Airport Emissions of NOx
Cargo Transport Vehicles 12%
Aircraft 52%
Ground Access Vehicles 32%
Ground Support Equipment 4%
Auxiliary Power Units 0%
Aircraft
Auxiliary Power Units
Ground Support Equipment
Ground Access Vehicles
Cargo Transport Vehicles

As seen from the 1993 emissions inventory breakdown, aircraft are responsible for approximately half of the airport's total NOx emissions (3,259 tons), and about 41 percent of the total VOC emission at LAX (2,656 tons). The inventory also shows that ground access vehicles (GAVs) are responsible for about 31 percent of the airport's annual NOx emissions (2,190 tons) and about 45 percent of the total VOCs emission (2,460 tons). More significantly, ground vehicles actually contribute a larger portion of VOCs to the annual airport VOCs emission total than aircraft. In addition to cars and light trucks, cargo transport vehicles are responsible for a notable portion of the airport's total NOx emissions (about 12 percent), and a little over 3 percent of the total VOC. (Note: although emissions estimates are available for CO and PM from aircraft, no comparison to the airport totals can be made for these pollutants due to a lack of estimates from other categories).

Role of LAX in the Local Air Pollution Inventory & Future Emissions

The aggregate summary of NOx and VOC emissions from the operations at LAX confirmed the fact that the airport is currently one of the largest (if not the largest) sources of these pollutants in the LA Basin.[11] The current NOx emissions at LAX alone constitute about 1 percent of the LA Basin's annual NOx emissions. To put the airport's emissions of VOC and NOx in perspective, LAX's 6,522 tons of NOx emissions in 1993 places it as the top emitter of this pollutant in the LA Basin, well ahead of second place Mobil Oil Corporation (2,731 tons), and third place Chevron Corporation (1,921 tons). In fact, aircraft engines alone emitted enough NOx in 1993 to provide each of LAX's 50,000 employees with 130 pounds of this pollutant. With regards to VOC, the airport's 1993 VOC emissions is almost three times the emissions from the Basin's largest oil refinery, and more than ten times the VOC emissions from Santa Ana's John Wayne – the next largest airport in the South Coast area (SCAQMD, 1997). Thus, even with its present growth in operations (without the planned expansion), it will still be far and away the largest source of these pollutants in the near future. [12]

Along with its magnitude, the emissions from LAX are significant for a number of other reasons. First and foremost, the current air quality control regime in the Basin is not targeting LAX aircraft operations, nor are the emissions at LAX targeted for significant reduction, for reasons discussed in the public policy issues section that follows. Therefore, emissions from the airport will continue to grow even as other large sources in the Basin are being controlled.[13] Unless adequate measures to address the growth in emissions are found, any expansion of LAX's operations in the near future will serve to grossly exacerbate the current situation at hand.

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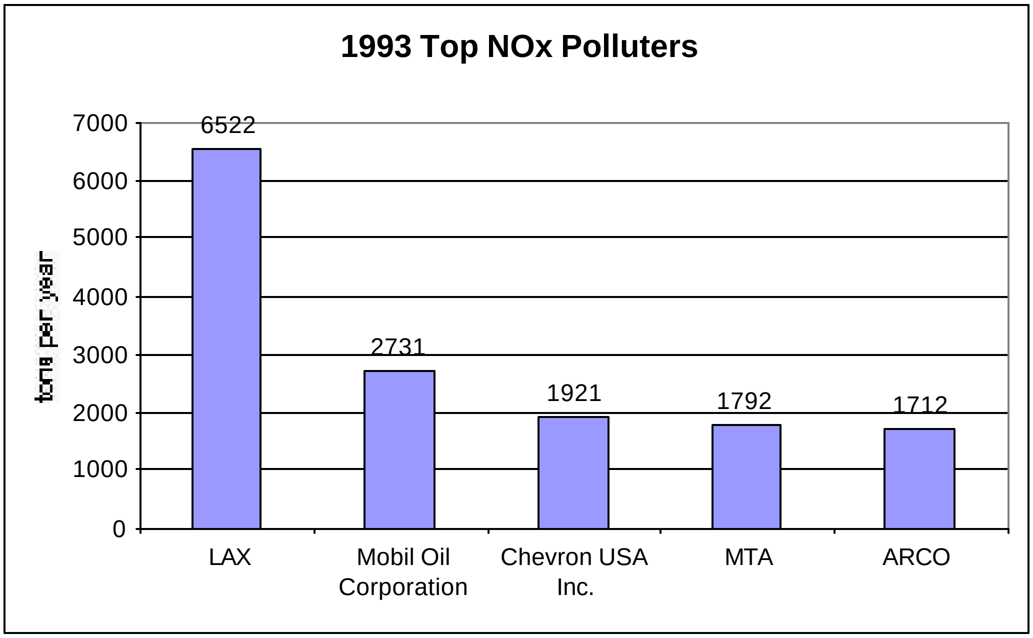
[11] Note that the emissions inventory uses 1993 data. Current emission numbers would have grown at a rate of about 1.7 percent per year, or about 10 to 12 percent more as compared with 1993 emission totals.

[12] While some sources have projected LAX's average growth rate to be about 1.7 percent (ICF, Inc. 1998) for the next 10 years, we have calculated that in the past 10 years, LAX's operations have been averaging about 3.5% annual increase in passengers and 6.5% in freight (LAWA, 1999).

[13] Currently, emissions sources in the LA Basin are targeted for reduction through the State Implementation Plan (SIP). But, LAX is not included in the SIP, so its emissions are expected to grow significantly. In fact, at current growth rates (based on past trends, not on expansion projections) in air travel and cargo volume, growth at LAX is expected to be about 1.7 percent annually for the next 10 years (ICF, 1998). Air pollution growth is likely to exceed this pace, as congestion in and around the airport exacerbates emissions rates.



Opportunities to Control Aircraft Emissions

Some changes can be made in the aircraft operational procedures to reduce the emissions of NOx and VOC today. (For example, changes in engine power settings or delaying main engine starts). However, substantial emissions control will have to take place with new engine designs and new emission standards. Effective emissions controls for the near term would have to include a combination of changes in aircraft operational procedures and the use of today's most fuel-efficient, cleaner emitting aircraft. To date, little has been done to address this issue.

There are also opportunities to reduce auxiliary power unit emissions, and airport authority has taken significant steps to control APU emissions by beginning to provide aircraft with an alternative source for electricity and other services at the gate, thereby lessening the duration of APU use. This measure will go a long way towards reducing current APU emissions. However, like aircraft emissions, APU emissions can be most effectively reduced through stricter standards and improved operational procedures.

Opportunities to Control Vehicle Emissions

As a group, ground vehicles do contribute significantly to an airport's emissions. In fact, as can be seen from the 1993 inventory, ground access vehicle emission, even when cargo trucks are excluded, is as large a source of certain types of air pollutants as aircraft at LAX. However, in the case of LAX and the LA Basin, efforts have been underway to reduce emissions from ground service and ground access equipment. These efforts include the electrification of gate service vehicles, increased use of natural gas vehicles, as well as the conversion of transfer buses to liquefied natural gas (see Box).

Efforts to Control Emissions from Airport Ground Vehicles at LAX

Aside from providing aircraft with electricity and other services at the gates to reduce APU emissions, the LA Department of Airport is also implementing a $320 million program to reduce emissions from airport ground service vehicles.

A major focus of this effort is the use of alternative fuel vehicles. Currently, 14 of the passenger parking shuttle buses are powered by liquid natural gas (LNG). These buses can be up to 97 percent cleaner than diesel buses, since LNG vehicles are much cleaner burning. Another 18 LNG buses are on order and will be phased into service in the near future. In addition to these buses, LAX also has a fleet of 30 compressed natural gas vehicles (CNG) and electric powered cars.

Another focus of the emissions reduction effort involves the use of alternative work schedules (for example, 9day/80 hours two-week work schedule), public transportation and ride-sharing programs to reduce emissions from airport employee vehicles.

Source: LAWA

The Department of Airport is also in the process of requiring all shuttle services to use alternatively fueled vehicles as a condition of their license. These efforts will go a long way towards emissions reduction from vehicles. Once again, as in the case of aircraft emissions, the effectiveness of these emission control measures will have to be considered in light of the projected operations and cargo increases for LAX, which may render these efforts to be less than successful. In addition, the vast majority of emissions from ground access vehicles come from vehicles owned by employees or passengers, which can not be controlled by the airport. Thus, if not addressed, we can expect that air pollutants from surface transportation will continue to be a major problem at LAX.

V. IMPACTS OF AIR POLLUTION

a. Impacts of Air Pollution on Public Health

Air pollution has serious health implications for the people who are exposed to it. Unfortunately, citizens who are concerned with the potentially adverse health effects of living near LAX or under the flight path have very little primary research available to help them understand the facility's impacts. Because an epidemiological study of the LAX region has never been performed, the only health conclusions that can be drawn are based on a growing body of research that is now available from airports around the world. These health conclusions point not to any one type of pollutant, but groups of pollutants of concern: the so called "criteria pollutants" which were discussed earlier – VOC, NOx, PM, CO and SOx – and other pollutants from jet fuel combustion, as well as, gasoline and diesel ground vehicle exhaust.

The net effect of emissions from airport operations can be difficult to fully assess. Although the effects of individual pollutants can be (and some have been) studied and catalogued, the additive effects of daily exposure by humans and the environment to all of these pollutants are yet unknown. The cumulative health impacts of these pollutants on humans have rarely been studied. In other words, the medical community currently understands what happens when the body is exposed to each of these chemicals individually, but scientists are collectively in the dark about what happens to people when they are exposed to these chemicals in combination. The difficulty in estimating the volumes of emissions can also hamper this assessment (EPA 1997b). As LAX is one of the world's busiest airports, and is already the largest single source of air pollution in Southern California, it is imperative that its impacts on the hundreds of thousands of people who are immediately exposed to its contaminants be fully investigated and understood.

Criteria Pollutant Health Risks

The significance of ground-level ozone, criteria pollutants, particulate matter, and their health effects are briefly summarized below from available scientific literature. A more in-depth discussion of these pollutants and their effects can be found in Appendix A.

Ground-level Ozone or tropospheric ozone (O_3) is a significant urban air pollutant, and is the primary component of smog. It is not a direct product of fuel combustion, rather, it is formed in a complex, photo-chemically non-linear process from other compounds that are by-products of combustion.[14] To explain simply, ground-level ozone is formed when volatile organic and nitrogen oxide compounds are transformed by sunlight. (SCAQMD, 1997). Humans exposed to ground-level ozone in the short-term can experience acute health effects such as changes in breathing pattern, reduction of breathing capacity, and inflammation of lung tissues. Groups at increased risk from high ozone concentration include active children and older adults, as well as outdoor workers and individuals with asthma or other obstructive lung conditions (SCAQMD, 1997).

VOC is the name given to a class of several hundred carbon-based chemical compounds that evaporate easily into the air. VOCs sources include fuel additives, fuel evaporation, and incomplete combustion. Some VOCs have little or no known direct human health effects, while others are extremely toxic and/or carcinogenic. Very little is known about how various VOCs combine in the atmosphere or in the human body, or what the cumulative impacts of exposure might be.

NOx, consisting primarily of NO_2 and NO gases, are also a result of fuel combustion processes. NOx is also a source of some of the particulate matter found in urban air.[15] People with asthma are especially sensitive to NOx, and animal studies have suggested that exposure to NO_2 can impair respiratory defense mechanisms and increase susceptibility to infection; chronic exposure may cause structural changes in the lungs.[16] While cars, trucks, and buses are California's primary source of NOx, the

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[14] The troposphere, as used here, defines the portion of the atmosphere from the ground up to about 16 km, or about 48,000 feet (this ceiling varies – it is lower at the poles and higher at the equator). The stratosphere begins at this point.

[15] Airborne particles derived from NOx emissions react in the atmosphere to form various nitrogen-containing compounds, some of which may cause mutation. Examples of NOx-related particulate products thought to contribute to increased mutagenicity include the nitrate radical, peroxyacetyl nitrates, nitroarenes, and nitrosamines (EPA, 1997e).

[16] The severity of lung tissue damage increases when animals are exposed to a combination of ozone and NO_2 (NRC, 1992; SCAQMD, 1997).

contribution from aircraft activities is expected to be the fastest growing source of urban NOx in the future (NRDC, 1996b).

Carbon Monoxide (CO) is a product of incomplete combustion. It is an odorless gas that has no direct effect on the lungs. Instead, CO interferes with the oxygen carrying capacity of blood and weakens the contraction of the heart. Its actions reduce the volume of blood and oxygen delivered to various parts of the body. In a healthy person, CO can significantly reduce the ability to perform physical activities. In persons with chronic heart conditions, this effect can be life threatening. Adverse effects have been observed in individuals with heart conditions who are exposed to areas of heavy CO concentration, such as heavy traffic conditions. Exposure to CO has also been associated with increased incidence of heart failure among the elderly (SCAQMD, 1997).

Sulfur Dioxide (SO_2) is formed when the sulfur in fossil fuels combines with oxygen at high temperature. Like NOx, sulfur dioxide is a potent air pollutant. All asthmatics are sensitive to the effects of sulfur dioxide. Animal studies suggest that SO_2 does not cause substantial health effects at ambient concentrations. However, at very high levels of exposure, it can cause lung edema (fluid accumulation), lung tissue damage, and sloughing off of cells lining the respiratory tract. Some population-based studies indicate that human health effects associated with fine particles show a similar association with ambient SO_2 levels (SCAQMD, 1997).

Particulate matter, or "PM," is a class of chemically diverse, air-borne solid and liquid particles. Particulates that are on the nation's "criteria pollutant" list are those with an aerodynamic diameter less than or equal to 10 micrometers, hence the name "PM10."[17] PM from airport operations may either be produced directly from fossil fuel combustion, especially by diesel-fueled vehicles (in the form of soot), or formed in the atmosphere through chemical interactions of combustion by-products. PM is also a result of dust from various activities, passing vehicles, and also friction from components such as tires, brakes, etc. (NRDC, 1996a).[18] Recent epidemiological studies on the impacts of particulate air pollution, and diesel exhaust have also linked these forms of air pollution to toxic exposure and premature deaths from heart and lung disease, as discussed below (NRDC, 1998).

Diesel Exhaust Health Risks

In addition to the health effects from aircraft and auto emissions, the high volume of cargo at LAX also exposes the people in the surrounding communities to the exhausts of diesel trucks and buses that move mail, cargo, and people to and from the airport. There is growing evidence that the emissions from these vehicles not only contributes to smog and visibility problems, but that many of the components of diesel exhaust are extremely toxic, affecting the health of nearly everyone exposed to them (NRDC, 1996a).

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[17] A micrometer is one millionth of a meter, or about one thousandth the thickness of a human hair.

[18] An SCAQMD monitoring station found traces of combusted soot particles greater than 50 microns in size, which are believed to be from ascending and descending aircraft. The health effects of these particles is not yet understood (SCQAMD, 2000).

Diesel exhaust is a complex mixture of fine particles and organic materials, with hundreds of constituent materials. Components of this mixture have been found to be toxic, carcinogenic, and hazardous to reproductive systems (NRDC).[19] The State of California in 1990 identified diesel exhaust as "known to the state of California to cause cancer" and listed it under Proposition 65.[20] NIOSH, the National Institute of Occupational Safety and Health, has also considered diesel exhaust to be a probable cancer-causing agent. Most recently, the California Air Resources Board officially listed diesel particulates as a "toxic air contaminant (TAC)" and has begun the process of determining whether additional control measures are necessary to reduce human exposure.

In addition to its cancer causing agents, diesel exhaust is the major source of sooty particles from vehicles. Compared to gasoline engines, diesels put out about 100 times more soot under the same load conditions – exhaust from heavy-duty diesel engines can contain up to 200 times more small particles (PM2.5) than gasoline engine exhaust. In California, diesel exhaust accounts for 26 percent of total PM from all combustion and 66 percent of the total PM 10 from traffic. Long-term exposure to PM pollution can negatively affect human health (discussed below). Furthermore, a recent NRDC study found that diesel exhaust is also responsible for 20 percent of the total NOx from transportation in the US (NRDC, 1997).

The current efforts to improve air quality through the requirements of cleaner, less polluting people and cargo transport will go far toward reducing the health effects of diesel exhaust, helping to reduce exposures by residents living near to effects of air pollution from both aircraft and ground transport.[21] However, any increases in future LAX cargo volume are likely to offset these gains.

Heath Risks from Exposure to Particulates

A number of studies since 1987 have connected particulate pollution at concentrations below current health standards to increased hospital and emergency room admissions, reduction in lung functions, and premature deaths. These studies have also shown a correlation between short-term exposure to air pollution and increases in respiratory illnesses.

Of particular concern are fine particles less than 10 microns in size; specifically, those measuring 2.5 microns or less that are especially associated with the operation of diesel fueled vehicles. There is a growing consensus that these particles (PM2.5) are too small to be filtered, are not easily purged by the human respiratory system, and can lodge deep in the recesses of human lungs. Evidence has accumulated in recent years that fine particulate matter is the most acutely pernicious and dangerous of the many hazardous pollutants human activity spews into the atmosphere. The elderly, people with

[19] Components of diesel exhaust are believed to be endocrine disruptors, a class of chemicals that can mimic and affect hormone interactions in mammalian reproductive systems.

[20] Proposition 65 is otherwise known as the "Safe Drinking Water and Toxic Enforcement Act of 1986." The law prohibits the discharge of any chemical that is a carcinogen or reproductive toxicant into sources of drinking water, and the exposure of any persons to these chemicals without prior warning. The law also requires the Governor to list chemicals that are known to cause cancer or reproductive harm. Diesel exhaust was listed by the Governor of California as "known to cause cancer" in 1990.

[21] A recent monitoring study by the SCAQMD found lower levels of diesel particulates north and south of LAX as compared to east of airport, indicating PM pollution of these communities is influenced by prevailing wind pattern and vehicular traffic on Aviation Blvd. & I-405 (SCAQMD, 2000).

existing respiratory or cardiovascular diseases, and children are susceptible to the effects of PM (NRDC 1996a).

In March of 1995, the American Cancer Society (ACS) released a landmark study that came to similar conclusions. The ACS looked at ambient air pollution data from 151 U.S. metropolitan areas and correlated it with their health data on 1.2 million adults. The study tracked the health of over 550,000 people between 1982 and 1989 living in cities where air pollution data was also available for analysis. The ACS found that people living in cities with the dirtiest air had as much as a 17 percent greater mortality rate than people living in the least polluted cities. The study's findings suggested serious, chronic health risks connected with particle pollution at concentrations well below current health standards. In short, the study concluded that modest exposures to air pollution, especially particulate pollution, are reducing lives by several years (ACS, 1995).

A Natural Resources Defense Council (NRDC) study that soon followed the ACS effort gathered data on the average annual mean concentration of particulates for a number of U.S. metropolitan areas between 1990 and 1994. The NRDC compared reported cardiopulmonary death data in these regions, and estimated the number of deaths attributable to particulate air pollution. The study concluded that, for the seven California regions with the highest annual mean PM concentrations, between 8,082 and 23,812 deaths could be attributable to fine particulate pollution.

What these results suggest is that the annual death rate attributable to air pollution for citizens living in the communities surrounding LAX (the LA-Long Beach area in the above study results) could be as high as 79 deaths per 100,000 people currently. As more pollution is generated in this region from increased operations and traffic at LAX, there is an increased possibility that more cardiopulmonary deaths may occur as a direct result of the increase in air pollution, especially the particulate matter concentrations.

Health Risks from Toxic Emissions

In addition to the known risks that travelers, airport workers, and the residents of the communities that surround LAX face, a 1993 US EPA study brought to light new worries. This study, which focused on the atmospheric emissions of 30 carcinogenic air pollutants in the Southwest Chicago and Midway Airport area, raised some significant concerns about other toxic air contaminants found in the air around airports.

The EPA study concluded that, of the air pollutants that are present in the ambient air in Southwest Chicago, emissions resulting from cars, trucks, buses and trains (fossil-fueled engine exhaust) may account for about one fourth of the total estimated cancer cases in the area. In addition, emissions from aircraft and lawn mowers may have accounted for another 11 percent of the cases (EPA, 1994). (Note: The report did not emphasize the fact that most of the area under study is in an industrialized part of Chicago. Thus, emissions from lawnmowers or other small engines is likely insignificant.)

Since the airport is the primary destination for auto, bus and truck trips in the Southwest Chicago area, it is reasonable to conclude that, in addition to the pollutants that come directly from aircraft, a significant portion of the region's inventory of toxic air contaminants are a direct result of the airport traffic. Similar conclusions can be extended to other large airports, such as LAX.[22]

Heath Risks from Exposure to Jet Fuel

Jet fuel may be released into the environment by in-flight jettisoning of fuel, and from spills or leaks to soil during its use, storage and transportation. Jet fuel released in flight can be dispersed and transported over a wide area. Some of it can be transformed into ozone or other components of smog. Even in the case of accidental ground spills of jet fuel, most evaporates into the air. This is also true of the lighter components of jet fuel that are present on the ground. In fact, one of the primary methods used to "treat" soil contaminated with Jet fuel is to expose it to air, which gasifies the volatile organic compounds in the fuel.

The Agency for Toxic Substances and Disease Registry (ATSDR) finds that exposure to jet fuel carries significant human and environmental risks. Breathing large amounts of fuel vapor in a short time can cause suffocation and can affect the breathing process. Moderate amounts of fuel vapor can affect the capacity to taste and smell; it also causes nausea, eye irritation, loss of appetite, poor coordination and elevated blood pressure.

The health danger is considerable for instances of direct contact with skin or ingestion (through the refueling process or contaminated soil and drinking water). However, people living and working near where jet fuel is being used are more likely to risk exposure to its evaporated components, especially where there are large amounts of fuel being handled daily. Hazardous chemical compounds generally found in all jet fuel include benzene, toluene, and xylene – all are known to be toxic or carcinogenic agents. The ATSDR believes that long-term exposure to fuel vapor can affect the nervous and reproductive systems. Direct exposure to jet fuel has also been linked to skin and liver cancer in laboratory animals (ATSDR, 1997).

b. Impacts of Air Pollution on the Natural Environment

The chemicals of air pollution that harm humans also can adversely affect both the local and global environment. Locally, and regionally, air pollution impacts can range from poor visibility, weakened trees and other plant life, to the eutrophication of rivers, lakes and other water bodies. Globally, air pollution can wreak havoc with entire ecosystems by reducing the earth's UV protection, or disrupt the temperature balance of the earth's surface. Following is a summary of the effects; additional discussions can be found in Appendix A.

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[22] Efforts are underway by concerned citizens around Chicago's O'Hare airport to advocate for a comprehensive study of the risks posed by pollutants from aircraft using the airport.

Impacts of Air Pollution on the Natural Environment

The chemicals of air pollution that harm humans also can adversely affect both the local and global environment. Below is a brief summary of the effects. Additional discussions can be found in Appendix A.

Visibility
Most visibility and haze problems can be traced to airborne particles in the atmosphere that include carbon compounds, NOx, SOx, and soil dust.

Botanical Impacts
Air pollutants also harm trees and other plant life in the same way they affect humans: by reducing their respiration capacity and increasing their susceptibility to diseases and insect attacks.

Acid Deposition
Regionally, SO_2 and NOx are the two key air pollutants that cause acid deposition. (These are also agents of acid rain, a more serious problem in areas with higher precipitation levels than LA). Acid deposition results in adverse effects on aquatic as well as terrestrial ecosystems. Nitric acid (from NOx deposition) plays a dominant role in the acid pulses associated with the fish kills observed during the springtime melt of the snow pack in sensitive watersheds, lakes, and estuaries. High levels of nitrate in surface and drinking water are a health hazard to all living creatures, especially for human infants and other young animals. Atmospheric nitrogen deposition increases stream water nitrate and can be transported long distances downstream. NOx emissions also contribute directly to the eutrophication of US coastal waters and estuaries: increased levels of nitrogen results in accelerated algae and aquatic plant growth, causing adverse ecological effects and economic impacts that range from nuisance algal bloom and fish kills.

Ozone Depletion
Scientists are also concerned with the emissions of NOx and particulates in the upper atmosphere, where many commercial airliners cruise (over 30,000 feet). There have been indications that NOx and particulate emissions in the upper atmosphere can reduce the ozone layer's effectiveness, thereby allowing more ultraviolet radiation to reach the earth's surface and causing ecological damage. Aircraft are responsible for 2 to 3 million metric tons of NOx emitted into the atmosphere in 1993, which is about 4 percent of worldwide NOx emissions from human activities. Increased levels of UV radiation reaching the earth's surface can disrupt many ecological processes and adversely affect human health. For example, increased levels of UV have been linked to a number of mutations and increased infant mortality in amphibians at high altitude, where their eggs are more exposed. High levels of UV radiation levels are also implicated in elevated incidences of human skin cancer and cataract (Science News, 1998; Natural History, 1996).

Global Climate Change
As more fossil fuels are used in human activities, greater and greater quantities of carbon dioxide, oxides of nitrogen, water vapor, and methane along with other pollutants are being produced. These are known as "greenhouse gases", i.e. they help to trap the sun's energy and increase the amount of heat in the atmosphere. Because these gases are produced in direct proportion to the volume of fuels used, concentrations of greenhouse gases in the atmosphere have steadily increased for the last century. Although there are isolated skeptics, the vast majority of atmospheric scientists have concluded that human activity is affecting the world's climate. Effects include increased storm power and frequency, drought, the possible inundation of low lying coastal areas and island nations due to sea level rise, and a general increase in the incidence of severe weather. According to the Intergovernmental Panel on Climate Change (IPCC), changes in the earth's clime have manifested themselves in the high temperatures recorded over the last half century (IPCC, 1997).

VI. PUBLIC POLICY ISSUES RELATED TO AIR POLLUTION FROM LAX

LAX is particularly well situated to avoid much of the adverse impacts of its own operations. Whereas the concentrations of ozone and fine particulate matter in ambient air over LAX may not be significant, it is primarily because the pollution generated by the airport impacts communities to the east. Prevailing onshore winds carry both the ozone-forming compounds and other air contaminants over the LA basin, where they combine with Southern California's plentiful sunlight to make this area into a region of high air pollution potential.[23]

In addition to the topography and climate, issues of jurisdiction, data collection and reporting processes, as well as the resistance of certain parties to increased emissions controls, figure prominently in efforts to prevent pollution. These issues and their implications are summarized in the discussions below.

a. Regulation Entities

Due to the serious threat to many urban communities from air pollution, the 1990 Clean Air Act Amendments focused on ozone reduction and established health-based standards for NOx, ozone and other criteria pollutants. States with areas that fail to meet the standard – "non-attainment areas" – are required by law to clean up their air according to a set timetable. These states are required to develop State Implementation Plans (SIPs), outlining efforts to reduce emissions in these non-attainment areas to more healthful levels. These plans target ozone-precursor sources of all sizes – from power plants to gas stations, automobiles to consumer products.

There are numerous agencies responsible for air quality in the LA Basin. In conjunction with the US EPA at the Federal level, the Air Resources Board (ARB), at the state level, oversees on-road vehicle emission standards, fuel specifications, some off-road sources and consumer product standards.[24] At the regional level, the South Coast Air Quality Management District (SCAQMD) is responsible for stationary sources and some mobile sources. In addition, the SCAQMD has lead responsibility for the development and adoption of the region's air quality management plan (AQMP). Lastly, at the local level, the Southern California Association of Governments (SCAG) is responsible for providing projections for planning, developing land use and transportation control measures, and coordinating efforts to reduce pollution.

SCAQMD has jurisdiction over approximately 12,000 square miles. However, the Air District's current purview does not include any of the airports in the LA area. In fact, nationwide, none of the SIPs currently include plans for emission reduction from airports, even though 30 of the US's busiest airports are located in ozone non-attainment areas. The South Coast Air Basin, currently the worst non-attainment area in the nation, contains three of these top airports. This is because Congress has purposefully left the Federal Aviation Administration, the agency responsible for certifying aircraft and developing airport operational procedures, out of the State Implementation Plan process, to prevent potential interstate commerce conflicts. This omission has serious consequences in efforts to reduce air

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[23] A recent study by SCAQMD (MATES II), consisting of a comprehensive monitoring program and inventory of toxic air contaminants, found that south-central and east-central LA have the highest risks from mobile sources. The study also showed elevated cancer risks for Huntington Beach and Pico Rivera (SCAQMD, 2000b).

[24] The U.S. Environmental Protection Agency (US EPA), at the Federal level, is charged with regulation of on-road motor vehicle standards; trains and ships; non-road engines; and offshore oil development.

pollution. Because the FAA is not directly involved in the SIP planning process, and emissions from aircraft cannot be addressed by the LA basin's SIP, state and local regulators must find ways to reduce emissions elsewhere.[25] This means that other ozone precursor sources in the region must be reduced drastically in order to compensate for the emissions generated by aircraft and airport operations.

Furthermore, as aircraft and airport operations increase, and they are projected to do so in the near future, local regulators must implement ever-stricter measures to compensate for the additional emissions from increased airport operations. One direct impact of this omission in the air quality planning process is economic – stationary or other sources in the area that would otherwise be compliant, will be forced by air quality regulators to spend additional resources to offset emissions from LAX. This could lead to a situation of diminishing returns, where it will cost more to achieve less pollution reduction.

b. Aggregate Emissions and Impacts

The FAA's primary concern is aviation; thus its regulations tend to not take the environment into account. Although prototypes of aircraft engines must meet certain FAA requirements for VOC, NOx and smoke standards before placed in operations, the FAA's current emission standards do not take into account any of the health or environmental effects of the pollutants that are released by aircraft. Even the current ICAO (International Civil Aviation Organization) standards that have been recommended for FAA adoption by the US EPA were not developed based on air quality impacts.[26]

Because FAA regulations do not address environmental effects of aircraft emissions and aircraft operations, one issue that is not being addressed by any regulations is the issue of aggregate emissions. This is the total impact of emissions from hundreds of thousands of jet engines that pass through LAX's and other airports' ground and airspace annually. In other words, while the FAA may regulate the pollution that comes out of each engine model, and the EPA may have some input into these regulations – neither agency is addressing the cumulative environmental impact aircraft have on the communities in which they operate. This is an area where the agencies do not have a clear mandate (NRDC, 1996b; LA Times).

Current Federal law preempts all other federal, state, and local agencies from establishing measures to reduce emissions from aircraft. Because of these regulatory disconnects, local regulators who are on the front-line of the air pollution battle cannot address a large and growing source of air pollution in their district. The same regulatory regime is preventing local and regional officials from addressing the issue of cumulative pollution from increased airport operations.

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[25] Recently, the FAA and EPA have begun to coordinate efforts to regulate emissions of certain pollutants in the next generation of aircraft engines. However, there are some changes in aircraft operational procedures on the ground that can help lower current and future emissions, but states and local governments do not have the jurisdiction to implement them because the FAA still has the final say over aircraft and airport operating procedures.

[26] The new ICAO standards were designed to reduce the emissions of certain pollutants from the new generation of engines, specifically NOx and VOC. However, these standards do not cover other pollutants from jet fuel combustion, nor were they based on risk assessment studies (NRDC 1996b).

c. Resistance to Emissions Reduction Measures

In addition to the regulatory barriers, any emissions reduction measures affecting aircraft and airport operations will face other hurdles, among them groups representing airports and airlines. In fact, a number of these groups have successfully resisted a recent initiative by the EPA to bring affected parties into a discussion regarding how to reduce emissions from airline operations.

In 1994, the EPA solicited input on its proposal to limit "dirty planes" from the LA Basin. The agency proposed to allow only planes with lower emissions per passenger to land in California's worst ozone-attainment areas. Two groups representing airports, the AAAE (American Association of Airport Executives) and the ACI-NA (Airport Council International - North America), responded that such action to isolate a "clean fleet" would violate other statutes. They went on to say that such action could only be the responsibility of the Department of Transportation and the FAA. The proposal, which was part of the now voided Federal Implementation Plan, was never implemented. Thus, even if the FAA becomes involved in the LAX pollution reduction process, it will require sufficient resources to address such resistances.

d. Omissions

Missing from the available emissions inventory for LAX (and other airports) are estimates of emissions from aircraft belonging to foreign countries or governments. This omission can make it harder to estimate and address airport emissions. There are several reasons for this omission:

1) The FAA currently does not publish flight data or detailed statistics for planes in this category;
2) Available information does not provide sufficient details (plane type, engine specifications, flight pattern, and time-in-mode information) for emissions inventory purposes.

Sufficient information is available, however, to tell us that emissions from this "forgotten" category may be another significant contributor to the overall airport emissions. For example, the NRDC study on airports found that about 7% of all flights from the airports in the NY City area belonged to this category. Given the importance of LAX as an international hub, we can only surmise that LAX would be host to at least the same amount of traffic, if not more.[27] It is also likely that a number of these foreign-owned aircraft may be older, less-efficient aircraft, since a number of foreign charter and cargo traffic tend to use planes retired from US commercial carrier fleets in order to keep costs low.

It is likely that activities by foreign-owned aircraft will increase in the near future, like other air transport activities. In fact, Department of Airport (DoA) officials report that international flights are increasing as a percentage of the total number of flights in and out of LAX. If so, their contribution to the air emissions at LAX will also increase. Currently, local, state or regional air pollution control agencies not only don't track these emissions, they can do nothing about them. Because of the lack of an available inventory for emissions from foreign-owned aircraft, the issue cannot be addressed in any meaningful way.

e. Reporting of Airport Emissions

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[27] Conversation with FAA and Department of Transportation staff has indicated that the statistics are extremely mingled, due to the cross listing of flights by commercial airlines as well as other data collection difficulties. Based on these conversations, we have estimated that this portion of operations comprise about 7 to 10 percent of LAX's flights.

Under the Emergency Planning and Community Right-to-Know act of 1986 (EPCRA), manufacturing facilities meeting specific activity thresholds or industry criteria must annually report their estimates of both transfers and discharges of listed toxic chemicals to EPA.[28] Facilities are required to file reports on their air, water or land releases and transfer of over 300 chemicals in 20 chemical classes. With this law, Congress intended to identify significant polluters as well as allowing communities access to knowledge that would not be available to them otherwise.

California's own "Proposition 65," otherwise known as the "Safe Drinking Water and Toxic Enforcement Act of 1986," also requires pollution reporting. This California law prohibits the discharge of any chemical that is a carcinogen or reproductive toxicant into sources of drinking water, and the exposure of any persons to these chemicals without prior warning. The law also requires the Governor to list chemicals that are known to cause cancer or reproductive harm.

A significant omission by these laws is the fact that airports are not included on the list of facilities that have to report emissions. This is because airports do not belong in a specific industry category, with industry-specific releases. If the laws considered volume and types of releases instead of process- or industry-related releases, then airports, with their volume of hazardous air pollutants as well as toxic chemical releases, would be considered for reporting.[29] Because airports are not required to report their air or other emissions, the surrounding communities have no way of knowing what types of pollutants their inhabitants are being exposed to daily.[30]

This is an example of a "free ride," where airports are currently not being subjected to the environmental regulations to which everyone else is subjected, even though they contribute significantly to the air quality problems. In addition, until airports are required to compile and list their own emission inventories, communities that surround them will not have the needed information to act; nor can agencies charged with maintaining regional air quality implement any meaningful programs without knowing about, and controlling emissions from airports.

f. Responsible Federal Agencies

New aircraft introduced in the last several years are more energy-efficient, and may emit less of certain pollutants than the ones in service a decade ago. However, an aircraft's long service life of twenty or more years means that the current aircraft population still contains a high number of less efficient aircraft. This less than efficient mix, along with the growth in the number of routes, passengers and freight, has resulted in a considerable increase in fuel consumption by the air transport sector. Furthermore, increases in the volume of air passenger and freight projected for the next decade means that fuel consumption, and the associated pollution, will remain high. However, as discussed earlier, neither fuel

[28] The EPA downloads this data in to a publicly available database called the Toxic Release Inventory, or TRI.

[29] For example, diesel exhaust – a major component of LAX's emissions – was listed by the Governor of California as "known to cause cancer" in 1990, yet its emissions are not being reported.

[30] The 1995 TRI for California listed nitrate compounds as one of the top 5 industrial air pollutant releases in the state. Our research indicates that the current volume of NOx releases by LAX alone is over four thousand times the total TRI-reported air release for nitrates for industrial sources in the State of California in 1995.

efficiency nor environmental protection is the focus of FAA, the agency that controls aircraft and engine certification.

In contrast, the EPA, the agency that is responsible for the control of other mobile pollution sources, has managed to work with the auto industry to reduce air pollutant from automobiles without significantly compromising their safety. Indeed, the EPA has recommended that the US adopt standards for aircraft emissions matching ICAO, the international industry group responsible for aircraft emission issues.[31] Yet, because regulating aircraft emissions does not come under the EPA's purview, the agency can only suggest that the FAA adopt these standards, without any right of enforcement.[32] Until this situation is changed, the issue of cleaner, more efficient aircraft will remain elusive, leaving communities seeking other less effective, possibly more expensive, control strategies.

g. Communities in the Impact Zone

Because of the unique topography of the area and layout of the airport, the pollution generated is carried away by prevailing winds. According to the AQMD, the winds in this area tend to blow south and/or southeast, away from the city of Los Angeles.

This wind-borne pollution creates yet another "free rider" issue specific to LAX. While LAX is part of the City of Los Angeles, its physical location places it closer to the communities of El Segundo and Hawthorne, as well as Gardena & Compton – further to the south and east, rather than the city of Los Angeles. Because of this, the communities closest to, and the communities most likely to be affected by the operations at LAX, are not within the City of Los Angeles.

The communities that are most directly affected by its pollution are smaller and less politically powerful than the City of Los Angeles. Their economic status affords them fewer resources to deal with the noise, air pollution, and other issues related to the quality of life in their communities. Even if they can afford the resources to wrestle with these issues, the separation of jurisdiction ensures that these issues may not be accorded the same importance as if these issues were to happen in the city of LA itself.

[31] Currently, international aircraft emissions are proposed through the ICAO (International Civil Aviation Organization), an organization affiliated with the United Nations. ICAO increased its existing aircraft NOx emissions standard by 20 percent on January 1996. It is also considering tightening it a further 16 percent. The European Union is supporting the tighter standards.

[32] According to the EPA, although the new standards are stricter than the old ones, they were not set based upon air quality impact studies. Instead, they were arrived upon based on what is currently believed to be practicable.

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APPENDIX A: AIRPORT EMISSIONS AND THEIR IMPACTS

1. General Air Pollution Health Risks

In its 1997 plan for air quality improvement (Air Quality Improvement Plan, or AQMP), the South Coast Air Quality Management District (SCAQMD) concluded that air pollution is, and remains, a major public health concern in general and for the LA basin in particular:

"The vast body of scientific evidence shows that the adverse impacts of air pollution in human and animal health are clear. A considerable number of population-based and laboratory studies have established a link between increased morbidity and in some instances, earlier mortality and air pollution." (SCAQMD, 1997)

The AQMP did not isolate any single air pollutant as the culprit for its concerns, rather, the report identified emissions from fuel combustion sources are a major component of air pollution in the LA basin.

Although U.S. deaths associated with air pollution have been documented as early as 1948 in Donora, Pennsylvania, deaths associated with acute air pollution are now unlikely in the United States (NRDC 1996a). Unfortunately, air pollution is still identified as a cause of respiratory illnesses and increased death rates among urban population. According to current scientific data, adverse human health effects associated with air pollution include:

a) Increased hospitalization, physician and emergency room visits (and health care costs)
b) Increased respiratory illnesses
c) Reduction in life-span
d) Increased risk of developing certain forms of cancer
e) Decreased breathing capacity
f) Lung inflammation
g) Potential immunological changes
h) Increased airway reactivity to a known chemical exposure - a method used in laboratories to evaluate the tendency of airways to have an increased possibility of developing an asthmatic response
i) A decreased tolerance for exercise.

Although individuals in affected communities inhale a mixture of pollutants, scientists have focused on specific pollutants because the regulatory framework and the control measures are mostly pollutant-specific. Even with an increasing number of studies focusing on the mechanisms and specific pollutant(s) responsible for individual effects, these effects are still not always clearly understood (SCAQMD, 1997).

Long-term effects of exposure to air pollution, being more difficult to identify and measure, require further research and evaluation. However, results from a number of recent studies on aggregated effects of air pollutants have raised doubts about the adequacy of the current National Ambient Air Quality Standards (NAAQS) for ozone and PM10 in protecting public health (EPA, 1997e).

2. Pollutant Emissions from Airport and Aircraft Operations

a. Ground-Level Ozone

Ground-level (tropospheric) ozone (O3), is not a direct product of fuel combustion. Instead, it is a reactive oxidant gas formed from other compounds that are by-products of combustion processes, known as "ozone precursors." Ozone is formed and accumulates in the lower atmosphere (troposphere) in a complex, photo-chemically non-linear process. To explain simply, ground-level ozone is formed when volatile organic and nitrogen oxide compounds are transformed by sunlight. Ground-level ozone is also a significant urban air pollutant and is the primary component of smog (SCAQMD, 1997). In fact, in its report on urban ozone, the National Research Council stated:

> "Ozone in urban and regional air pollution represents one of this country's most pervasive and stubborn environmental problems. Despite more than two decades of massive and costly efforts to bring this problem under control, the lack of abatement progress in many areas of the country has been disappointing and perplexing" (NRC, 1992).

Unlike the stratospheric ozone layer, which lies several miles above ground and protects the earth's surface from harmful ultraviolet radiation, ground-level ozone does not provide any health or environmental benefits. Instead, humans exposed to ground-level ozone in the short-term can experience acute health effects such as changes in breathing pattern, reduction of breathing capacity, and inflammation of lung tissues. Short-term exposure to ground-level ozone also increases susceptibility to respiratory infection. Long-term exposure effects include chronic inflammation and structural damage to lung tissue and decline in lung functions. Groups at increased risk include active children and older adults, as well as outdoor workers and individuals with asthma or other obstructive lung conditions (SCAQMD, 1997).

Ground-level ozone interferes with the ability of plants to produce and store food, thereby compromising growth, reproduction and overall plant health. Crops, plants and trees in this weakened state are more susceptible to diseases, insect attack and adverse weather (drought). Ozone also damages tree leaves, causing them to brown or fall off prematurely (NRDC 1996b). As a result of ozone exposure, agricultural yields of important food crops in the Basin and elsewhere such as oranges, soybean, wheat, and other crops (such as cotton) may be reduced or lower in quality (SCAQMD, 1997).

b. VOC

VOC, sometimes used interchangeably to describe hydrocarbons (HC) or reactive organic gases (ROG), is the name given to a class of several hundred carbon-based chemical compounds that evaporate easily into the air at ambient air temperatures. This class of compounds comes from a variety of sources: fuel additives, fuel evaporation, incomplete combustion and other processes that are not fully understood. Most often, they arise as a result of fuel combustion or evaporation.

Some VOCs have little or no known direct health effects, while others in the same class, such as benzene and hexane, are extremely toxic and/or carcinogenic. In sufficient quantity or exposure, VOCs can cause eye and respiratory tract irritation, headaches, dizziness, visual disorders and memory impairment. Depending on the type and quantity, VOCs can also cause a variety of environmental effects - high levels of VOC can damage plants, crops, buildings and materials (ICF, 1998). In addition, very little is known about how various VOCs combine in the atmosphere or in the human body, or what the cumulative impacts of exposure to multiple airborne toxic compounds might be.

c. NOx

NOx, consisting primarily of NO_2 and NO gases, are also a result of fuel combustion processes. Healthy humans exposed to high levels of NOx for a short duration (less than three hours) can experience respiratory problems. People with asthma are especially sensitive to NOx even at low concentrations. A number of animal studies have suggested that NO_2 can impair respiratory defense mechanisms and increase susceptibility to infection. Other animal studies have also shown that chronic exposure to NO_2 at relative low levels may cause structural changes in the lungs. In addition, the severity of lung tissue damage increases when animals are exposed to a combination of ozone and NO_2 (NRC, 1992; LA Times).

NOx is also a source of some of the particulate matter found in urban air. Airborne particles derived from NOx emissions react in the atmosphere to form various nitrogen containing compounds, some of which may be mutagenic (causing cell mutation). Examples of NOx-related particulate products thought to contribute to increased mutagenicity include the nitrate radical, peroxyacetyl nitrates, nitroarenes, and nitrosamines (EPA, 1997e).

In the environment, NOx is the key compound in a number of damaging chemical processes. It has an important role in the formation of acid rain, which harms both terrestrial and aquatic systems. Acid rain can damage trees, especially at higher elevation, and causes the acidification of surface water; excess nitrogen in water bodies is also a cause of algal blooms. Acid rain also accelerates the decay of buildings, statues and other man-made as well as natural structures (ICF, 1998). (Is Acid Rain a West Coast problem? Should we even be bringing it up?)

NOx itself is a brown colored gas that greatly contributes to the reduced visibility problems in many of the metropolitan areas of the US and around the world. In the presence of sunlight and other chemical compounds, NOx is a primary ingredient in the formation of tropospheric ozone. Released into the upper atmosphere, NO2 can also be a potent greenhouse gas (EPA 1997d).

Unlike a number of other air pollutants, whose control strategies seem to be working, future trends for NOx control is not particularly encouraging. According to a recent EPA estimates, the amount of NOx released into the environment may decrease slightly in the near term, but will increase again in the future:

> "Despite increases in vehicle miles traveled, total on-road vehicle emissions will likely continue to decline through 2005 as per vehicle NOx emissions decrease due to tighter tailpipe standards...Soon after the year 2002, overall NOx emissions are projected to begin to increase and continue to increase in the foreseeable future due to increased economic (especially transportation) activity."

Mobile emissions (emissions from transport activities) are one of the most significant contributors to the NOx problem on a nation wide basis. Cars, trucks, and buses are California's primary source of NOx. The contribution of aircraft, however, is expected to be the fastest growing source of NOx in the future (NRDC, 1996).

d. Particulate Matter

Particulate matter, or "PM," as the name implies, is a class of chemically diverse, air-borne solid and liquid particles of varying sizes. Particulates that are on the nation's "criteria pollutant" list are particles with an aerodynamic diameter less than or equal to 10 micrometers (PM10). PM from airport operations may either be produced directly from fossil fuel combustion (in the form of soot) or formed in the atmosphere through chemical interactions of combustion by-products, such as VOC, NOx or sulfur oxides. PM is also a result of dust from passing vehicles and also friction from components such as tires, brakes, etc. (NRDC, 1996a).

PM physical and chemical characteristics vary with environmental conditions and sources. Of particular concern are fine particles less than 10 microns in size, specifically those 2.5 microns or less. There is a growing consensus that these particles (PM2.5) are too small to be filtered, are not easily purged by the human respiratory system, and can lodge deep in the recesses of human lungs. The difficulties in characterizing their properties also have hampered the assessment of their heath and environmental effects.

Evidence has accumulated in recent years that fine particulate matter is the most acutely pernicious and dangerous of the many hazardous pollutants human activity spews into the atmosphere. A consistent correlation between elevated ambient PM levels and an increase in mortality rates, respiratory infection, number and severity of asthma attacks has been observed. Studies have also associated long term PM exposure with increased mortality, reduction in life span, and possibly increased cancer incidences. The elderly, people with existing respiratory or cardiovascular diseases and children are susceptible to the effects of PM (NRDC 1996a).

Virtually all combustion creates PM, but fine particulate matter is especially associated with the operation of diesel fueled vehicles, such as trucks and buses. This has led air quality regulators to become particularly aggressive in their efforts recently to reduce human exposure to diesel exhaust.

e. Carbon Monoxide

Carbon Monoxide (CO) is a product of incomplete combustion. It is an odorless gas that has no direct effect on the lungs. Instead, CO interferes with the oxygen carrying capacity of blood and weakens the contraction of the heart. Its actions reduce the volume of blood and oxygen delivered to various parts of the body. In a healthy person, CO can significantly reduce the ability to perform physical activities. In persons with chronic heart conditions, this effect can be life threatening. Adverse effects have been observed in individuals with heart conditions who are exposed to areas of heavy CO concentration, such as heavy traffic conditions Exposure to CO has also been associated with increased incidence of heart failure among the elderly (SCAQMD, 1997).

g. Sulfur Dioxide

Like NOx, sulfur dioxide (SO_2) is formed when the sulfur in fossil fuels combine with oxygen at high temperature. And like NOx, sulfur dioxide is a potent air pollutant. An exposure of a few minutes to low levels of SO_2 can result in airway constriction in some asthmatics; in fact, all asthmatics are sensitive to the effects of sulfur dioxide. Severe breathing difficulties are generally observed in asthmatics after acute exposure to SO_2. However, healthy individuals do not exhibit similar acute responses even after exposure to higher concentrations of SO_2.

Animal studies suggest that despite SO_2 being a respiratory irritant, it does not cause substantial acute or chronic toxicity at ambient concentrations. At very high levels of exposure, however, it can cause lung edema (fluid accumulation), lung tissue damage, and sloughing off of cells lining the respiratory tract. Some population-based studies indicate that the mortality and morbidity effects associated with fine particles show a similar association with ambient SO_2 levels. Efforts of studies to separate the effects of SO_2 from fine particles have not been successful. Thus, it is not clear whether the two pollutants act synergistically or whether one pollutant alone is the predominant actor.

SO_2 is also a major source of acid rain, although this is not a problem in the Western States because of its aridity. SO_2 is one of the few air pollutants which has been successfully been reduced in Southern California.

h. Greenhouse Gases and Other Emissions from Aircraft and Airport Operations

Greenhouse Gases

In addition to the five criteria pollutants described above, the combustion of fossil fuels for transport activities and other human uses results in the release of other compounds into the atmosphere. Of great concerns are the “greenhouse gases” – compounds that can contribute to global climate change due to their interactions in the upper atmosphere. These gases include carbon dioxide, methane, water vapor, and nitrous oxide. The potential effects of these gases on the global climate are further explored in the discussions of environmental effects following this section.
(EPA, 1994; VROM, 1997).

Ozone-Depleting Gases

Scientists are also concerned with the emissions of NOx and particulates that are released in the upper atmosphere by commercial, military, and private planes. Many commercial airliners cruise at altitudes over 30,000 feet, at the boundary of the troposphere and stratosphere. There have been indications that NOx and particulate emissions in this region of the atmosphere undergo complex interactions that can reduce the ozone layer’s effectiveness, thereby allowing more ultraviolet radiation to reach the earth’s surface (EDF, 1994; EO, 1998).

3. Impacts of Air Pollution on the Natural Environment

Visibility

Locally, NOx emissions lead to the formation of compounds that can interfere with the transmission of light, limiting visual range and color discrimination. Most visibility and haze problems can be traced to airborne particles in the atmosphere that include carbon compounds, nitrate and sulfate aerosols, and soil dust.

Botanical Impacts

Air pollutants not only lower visibility and visual access to the earth's natural beauty, they also harm trees and other plant life in the same way they affect humans: reducing their respiration capacity and increasing their susceptibility to diseases and insect attacks. In many areas of the country, acute air pollution has contributed to the denuding of forests and plant life, thus removing an important link in the ecological web. At higher elevation, where less oxygen is available, these effects can be even more acute (NRDC, 1996b).

Acid Deposition

Regionally, sulfur dioxides and NOx are the two key air pollutants that cause acid deposition (wet and dry particles and gases). They are also agents of acid rain, a more serious problems in areas with higher precipitation levels than LA. Acid deposition results in adverse effects on aquatic as well as terrestrial ecosystems. Nitric acid deposition plays a dominant role in the acid pulses associated with the fish kills observed during the springtime melt of the snow pack in sensitive watersheds. Recently, these agents have also been identified as major contributors to chronic acidification of certain sensitive surface waters, such as alpine lakes and estuaries (EPA, 1997c).

Nitrates

High levels of nitrate in surface water are a health hazard to all living creatures, especially for human infants and other young animals. Atmospheric nitrogen deposition in sensitive watersheds (including areas already affected by other environmental stresses, such as logging or drought) can increase stream water nitrate concentrations; the added nitrate can remain in the water and be transported long distances downstream.

NOx emissions also contribute directly to the widespread acceleration of eutrophication of United States coastal waters and estuaries. Nitrogen is the nutrient that controls growth of algae in most coastal waters and estuaries. Thus, increased levels of nitrogen results in accelerated algae and aquatic plant growth, causing adverse ecological effects and economic impacts that range from nuisance algal blooms to oxygen depletion and fish kills. According to the EPA, atmospheric nitrogen deposition onto surface waters and deposition to watershed and subsequent transport into the tidal waters has been documented to contribute from 12 to 44 percent of the total nitrogen loading to United States coastal waters.

Global Climate Change

Globally, the consumption of fossil fuels results in an array of adverse environmental impacts. These impacts include environmental degradation and loss of cultural and ecological habitats due to oil exploration, extraction, transportation and refining, as well as air pollution, ozone depletion, and other associated impacts from the combustion of fossil fuels. These impacts are generally restricted to the geographic area in close proximity to the emissions source. In the case of global climate change, however, the impacts of air pollution affect the ecological health of the entire planet.

As more fossil fuels are used in human activities, greater and greater quantities of carbon dioxide, oxides of nitrogen, water vapor are being produced. These emissions are what are known as "greenhouse gases", i.e. they help to trap the sun's energy and increase the amount of heat in the atmosphere.

Because these gases are produced in direct proportion to the volume of fuels used, concentrations of greenhouse gases in the atmosphere have steadily increased for the last century. (IPCC, 1997). [33]

Along with CO_2, water vapor and methane, Nitrous oxide (N_2O) is also a greenhouse gas. Anthropogenic NO emissions in the United States (from fossil fuel consumption) contribute about 2 percent of the greenhouse effect, relative to total United States anthropogenic emissions of greenhouse gases.[34] In addition, emissions of NOx lead to the formation of tropospheric ozone, which is another greenhouse gas (EPA, 1997).

Although there are isolated skeptics, the vast majority of atmospheric scientists have concluded that human activity is affecting the world's climate. Effects include increased storm power and frequency, drought, the possible inundation of low lying coastal areas and island nations due to sea level rise, and a general increase in the incidence of severe weather. According to the Intergovernmental Panel on Climate Change (IPCC), changes in the earth's clime have manifested themselves in the high temperatures recorded over the last half century (IPCC, 1997).

Emissions from aircraft, specifically, NOx emissions in the upper troposphere, have been linked not only with one, but two environmentally adverse effects. Aircraft are responsible for 2 to 3 million metric tons of NOx emitted into the atmosphere in 1993, which is about 4 percent of worldwide NOx emissions from human activities. Not only do these emissions contribute to global climate change, but many scientists also believe that NOx released from aircraft at cruising altitudes rises to the upper stratosphere where is depletes the beneficial layer of ozone there, increasing the amount of harmful ultraviolet rays reaching the earth's surface.

Increased levels of UV radiation reaching the earth's surface can disrupt many ecological processes and adversely affect human health. For example, increased levels of UV have been linked to a number of mutations and increased infant mortality in amphibians at high altitude, where their eggs are more exposed. High levels of UV radiation levels are also implicated in elevated incidences of human skin cancer and cataract (Science News, 1998; Natural History, 1996).

Alternatively, the NOx released at cruising altitudes also pollutes a lower layer of the atmosphere where it contributes to concentrations of ozone in the upper troposphere. At this height, rather than blocking harmful UV radiation, the ozone helps to magnify the greenhouse effect. The net effects of aviation activities on the climate are still highly uncertain. However, since air travel is expected to grow rapidly through the next decade, the local and global environmental impacts are also likely to increase. At its current pace of growth, air travel is projected to account for 10 percent of all anthropogenic CO2 and NOx emissions, and any associated global climate change effects along with these emissions (NRDC, 1996b).

APPENDIX B: ESTIMATING EMISSIONS

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[33] 1 gallon of fuel (about 4 lbs.) produces about 20 to 21 lbs. of CO_2.

[34] N_2O is a more potent greenhouse gas than CO_2. If two volumes of NO_2 and CO_2 of equal mass are released into the atmosphere, the volume of N_2O can do more damage because it can trap more heat.

Sources of air pollution at LAX

a. Aircraft Emissions

Table B1. Emissions from Aircraft: Inventories for 1990, 1993 and 2010 (projected)

Emission Year	LTOs	NOx (Tons)	VOCs/THC (Tons)	CO (Tons)	SOx (Tons)	PM10 (Tons)
For 1990						
Daily	1,847	7.91	6.33	19.74	0.38	0.01
Annual	673,993	2,886.06	2,310.82	7,203.64	137.97	2.56
Annual (ICF)		4,202.68	1,958.73	5,321.53	168.69	NA
For 1993						
Daily	2,141	8.92	6.10	NA	0.58	NA
Annual	781,492	3,255.80	2,226.50	NA	211.7	NA
For 2010						
Daily	2,438	17.68	8.10	21.56	0.07	NA
Annual	889,720	6,454.80	2,956.80	7,870.28	27.30	NA

Sources:
1990: from CRH Consulting, 1994 and ICF, Inc. 1998. Note that the ICF calculations are for commercial operations only.
1993: from Planning Office, SCAQMD, 1998.
2010: from ICF, Inc. 1998. Note that this estimate was developed based ONLY on LAX's current growth rate of commercial operations.

Table B2. Aircraft Emissions as part of Airport Total, 1993

Aircraft Emissions	VOCs (Tons)	NOx (Tons)
Daily Emissions	6.10	8.92
Annual Emissions	2,226.50	3,255.80
% of Total Airport Emissions	41.13%	49.92%

Source: from Planning Office, SCAQMD, 1998.

Agencies responsible for the regulation and estimation of aircraft emissions have defined a "closed loop" under which aircraft emissions can be reasonably estimated: the landing and take-off cycle, or LTO. An LTO cycle begins with the aircraft's approach, subsequent landing, taxi in to the gate, then idling at the gate. The cycle continues with the preflight taxi out, taking off, and finally "climbing out" to cruising altitude. The LTO stages are defined such that they closely follow the power setting by aircraft during each mode. This approximation is extremely critical, since an engine's emissions of each pollutant type varies with its power setting.

This approximation also assumes that emissions from aircraft below a certain height, the "mixing height" are essentially the same as emissions on the ground.[35] Above this ceiling height, emissions from aircraft are assumed to be the same as at the cruising altitude, and do not belong as part of the ground emissions. The default mixing height for LAX is 3,000 feet (915 meters).

As seen from the 1993 emissions inventory breakdown, aircraft are responsible for approximately half of the airport's total NOx emissions, and about 41 percent of the total VOC emission at LAX. (Although emissions estimates are available for CO and PM from aircraft, no comparison to the airport totals can be made for these pollutants due to a lack of estimates from other categories).

Aircraft Emissions Estimation Methodology

Main Engines Emissions
The U.S. EPA's basic methodology for calculating aircraft emissions at any given airport during any given period involves six general steps:

1. Determine airport activities in terms of the numbers of LTO cycles.
2. Determine the mixing height to be used for an LTO cycle.
3. Define fleet make-up at airport.
4. Estimate time duration for the LTOs involved (TIM or time-in-mode).
5. Determine emission factors of the particular aircraft.
6. Calculate emissions based on the factors above.

For each type of aircraft using the airport, steps two through five are repeated. For the projected (future) emissions, adjustments are made in the calculations to account for changes in fleet make up, airport activities, and anticipated effects of any emissions measure (EPA, 1993).

APU (auxiliary power unit) Emissions
The procedure to estimate total APU emissions is similar to the procedure used to estimate main engine emissions. The differences, however, are that the average APU operational time is used instead of the time-in-mode, and APU emission factors are used instead of engine emission factors. Energy and Environmental Analysis, Inc. in its report to EPA, estimated an average APU operational duration for aircraft at LAX of 81.54 minutes, based on 1990 data. Unfortunately, APU are not subjected to the same regulatory scrutiny as main engines. Therefore, emission data are only available for hydrocarbons (of which VOC is a subset), NOx, and CO. Emissions data for PM and other pollutants are currently not available.

[35] The mixing height is based on meteorological data and can be highly variable - depending on the weather conditions, it can be as low as 500 feet or as high as 3300 feet (1000 m).

Auxiliary Power Units (APUs) Emissions

Table B3. APU Emissions for 1993 and Emissions as part of Aircraft and Airport Totals, 1993

APU Emissions	VOCs (Tons)	NOx (Tons)
Daily Emissions	0.18	0.01
Annual Emissions	65.70	3.65
% of Total Aircraft Emissions	2.95%	0.11%
% of Total Airport Emissions	1.12%	0.05%

Source: from Planning Office, SCAQMD.

When an aircraft is at the gate, its main engines are shut off. However, the aircraft still requires electricity and other services such as ventilation and air conditioning. The plane will also require assistance in starting the main engines and will need backup power during taxiing periods. Auxiliary power units (APU)- small turbines or jet engines that remain on while the aircraft's primary engines are down, provide power for these activities.

As seen from the 1993 emissions inventory, APUs are responsible for a small portion of the of the airport's total NOx emissions (less than 1 percent), and about 3 percent of the total VOC emission at LAX. (Although the APUs CO inventory is not available, we believe it may also be a significant portion of the airport's CO total –see example below).

The contribution of APU emissions (of certain pollutant species) can be significant. To illustrate, consider an example of APU emissions calculation below, based on the APU information of a Boeing 737-300 aircraft (a relatively new aircraft).

Table B4. APU Emissions: 737-300 Example

Pollutant	Operational time	Fuel flow rate (lbs./min)	APU Emission factor (lbs./1000 lbs.)	Emissions (lb.)
HC	81.54	3.92	1.03 lb/1000	0.33
CO	81.54	3.92	17.99lb/1000	5.75
NOx	81.54	3.92	4.75/lb/1000	1.52

Source: EEA, 1997.

Thus, in the average APU operational time of 81.54 minutes, a Boeing 737-300 arriving and departing LAX has left behind over 7.5 pounds of various pollutants. Carrying this exercise further, one can see that with close to a million LTOs a year, emissions from APUs alone can contribute up to seven million pounds (3,500 tons) of pollutants a year to the air of the LA Basin. For comparison, the amount of NOx released by the 737's APU in those 81.5 minutes is about the same amount that an average sport utility vehicle or light truck releases in over 1000 miles of driving.[36]

[36] This was estimated using the IPCC's standard emission factors for an SUV averaging 22 miles per gallons with advanced 3-way catalyst system, releasing 8.36 grams of NOx per kilogram of fuel burned.

While APU emission factors are different for different types of aircraft, and there are efforts currently underway at LAX to reduce APU use at the gate, three important factors need to be considered before dismissing the air quality impact of this aspect of aircraft operations.

1. At this time, there are no current emission standards for APUs;
2. It is not clear the extent to which emissions from APUs increase over time as the units age (newer aircraft tend to have more state-of-the-art APUs, which are cleaner); and,
3. With more and more flights projected to use LAX in the coming years, the sheer increase in the volume of APU use may make up for any emissions reductions from cleaner units or the use of gate power. It is therefore open to some question whether emissions from APUs will decrease much over time.

Evaporative Emissions

Table B5. Evaporative Hydrocarbon Emissions, 1990 & 1993, and Emissions as part of Aircraft and Airport Totals for 1993

HC Emissions	1990	1993*
Tons of HC emissions per day	0.86	0.99
Tons of HC emissions per year	312.59	363.8
% of Total Aircraft Emissions	NA	16.33%
% of Total Airport Emissions	NA	6.60%

Source: CRH Consulting, 1994.
* Note: The1993 emission estimates were derived from the 1990 figure.

Evaporative emissions happen during fuel transfers, taxi and general aviation pre-flight checks and diurnal/thermal expansion (escaping fuel vapor due to changes in temperature and pressure).[37] Due to jet fuel's lower volatility, most of these emissions have been attributed to fuel used in piston-driven engines only. These emissions are assumed to consist mainly of hydrocarbons, and a conversion factor was used to determine the VOC portion of these emissions. These factors also indicate that commercial and military aircraft HC emissions can result in a larger volume of VOC release, possibly due to the more reactive nature of the fuel vapors (CRH Consulting, 1994).

As seen from the 1993 evaporative emissions inventory, evaporative emissions are responsible for a significant portion (over 6 percent) of the of the airport's total annual VOC emissions.

b. Emissions from Vehicles

As discussed, airport vehicles also contribute a significant proportion of emissions from airport operations. These vehicles include air operations vehicles as well as buses, passenger cars and cargo trucks. In order to have a complete picture of the air quality impact of any airport, the emissions from airport-dependent vehicles must be included in the analysis. Therefore, their proportions of the airport's emissions are also estimated here. Unlike aircraft emissions, which are estimated from LTOs, vehicle

[37] During general aviation and taxi (mostly piston-driven engines) pre-flight checks, a small amount of fuel from the bottom of an aircraft's tanks are collected for a visual condensation check. This fuel is then discarded an allowed to evaporate.

emissions are estimated using vehicle miles traveled (VMT), or the time duration that they are used. The emissions are estimated by multiplying a vehicle's annual VMT or operational time by its emission factors, and summing these for all vehicles and equipment.

Ground Support Equipment (GSE)

A wide variety of equipment services commercial aircraft during the loading and unloading of passengers and freight at an airport gate. Air taxi, military, and smaller aircraft typically do not require this service equipment. As a group, the ground-support equipment (GSE) for commercial aircraft include primarily the following:

- Aircraft Tugs – Tow aircraft to and from the terminal gate area. They also tow aircraft to and from hangers for maintenance. There are two categories: narrow body aircraft tugs and wide body aircraft tugs.
- Baggage Tractors - Haul baggage between aircraft and terminals.
- Belt Loaders - Mobile conveyor belts used to move baggage between the ground and the aircraft hold.
- Cargo Moving Equipment - Equipment used to move baggage and other cargo around the airport and to and from aircraft. This category includes forklifts, lifts, and cargo loaders.
- Other - Small miscellaneous equipment commonly found on airports such as compressors, scrubbers, sweepers, and specialized units.

In addition, where available, the equipment below are used instead of the aircraft's APU.

- Air Start Units - Provide large volumes of compressed air to an aircraft's main engines for starting.
- Air-conditioning Units - Provide conditioned air to ventilate and cool parked aircraft.
- Ground Power Unit (GPU) - Mobile ground-based generator units that supply aircraft with electricity while they are parked at the airport.

Table B6. Ground Support Equipment Emissions, 1993 and Emissions as part of Aircraft and Airport Totals, 1993.

GSE Emissions	VOCs (Tons)	NOx (Tons)
Daily Emissions	0.29	0.01
Annual Emissions	105.85	3.65
% of Total Aircraft Emissions	4.75%	8.96%
% of Total Airport Emissions	1.92%	4.22%

Source: from Planning Office, SCAQMD, 1998.

As seen from the 1993 emissions inventory in Table B6, GSEs are responsible for over 4 percent of the airport's total NOx emissions, and about 2 percent of the total VOC emission at LAX.

Ground Access Vehicles (GAV)

Along with the equipment needed to service the aircraft, other vehicles are required for passenger and cargo transport. These include:

- Buses - Move personnel between airport locations.
- Cars or Pickup and Vans - Move personnel around the airport.
- Deicers - Vehicles used to transport, heat, and spray deicing fluid (for LAX, these are usually not needed).
- Service Vehicles - Specially modified vehicles to service aircraft at airports. This category includes fuel trucks, maintenance trucks, service trucks, lavatory trucks, and bobtail tractors (a truck body that has been modified to tow trailers and equipment).

Table B7. Ground Access Vehicle Emissions, 1993, and Emissions as Part of Aircraft and Airport Totals, 1993.

GAV Emissions	VOCs (Tons)	NOx (Tons)
Daily Emissions	6.74	6.00
Annual Emissions	2,460.10	2,190.00
% of Total Aircraft Emissions	110.49%	67.26%
% of Total Airport Emissions	44.69%	31.69%

Source: from Planning Office, SCAQMD, 1998.

As seen from the 1993 emissions inventory in Table 9, GAVs are also responsible for a significant portion of the of the airport's total NOx emissions (31 percent – about a third of the aircraft NOx total), and about 45 percent of the total VOCs emission at LAX. Ground access vehicles contributes a larger portion of VOCs to the airport VOCs emission total than aircraft.

Cargo Transport Vehicles

Aside from emissions from passenger and employees vehicles, another major source of LAX's vehicle emissions come from the many light, medium, and heavy duty trucks and vans that are used to move cargo daily to and from the airport. Currently, the emission inventories available do not make any distinction between airport service vehicles and passenger and cargo vehicles. In fact, we could find no emission inventories for LAX cargo transport. In the interest of completeness, we have attempted to come up with an approximate estimate using available cargo volume and truck emissions data.

Table B8. Cargo Transport Vehicle Emissions, 1993, and Emissions as part of Aircraft and Airport Totals, 1993

CTV Emissions	VOCs (Tons)	NOx (Tons)	CO (Tons)	PM (Tons)
Daily Emissions	0.50	2.12	5.97	0.16
Annual Emissions	182.9	773.8	2,180.7	59.8
% of Total Aircraft Emissions	8.21%	23.77%	26.44%	2730.27%
% of Total Airport Emissions	3.38%	11.86%	20.91%	96.47%

Source: Estimates based on data from LAX, EPA and IPCC.

As seen from the 1993 emissions inventory, cargo transport vehicles are responsible for a significant portion of the of the airport's total NOx emissions (about 12 percent), and a little over 3 percent of the total VOC emission at LAX. Most significantly, cargo transport vehicles are responsible for a very large amount of particulate emissions from the airport. Even though the total airport PM emissions lacks emissions from other ground vehicles, it still shows that emissions from all ground vehicles contribute a significant portion of the PM emissions.

Emissions from cargo transport were estimated using available data and based on a number of simplifications. Starting with the total amount of cargo moved through LAX in 1993 (1,288,503 tons), we determined the numbers and types of trucks that would be needed to move this tonnage, and the total time that these trucks would have to spend at LAX. These assumptions are contained in Table B9, below. The vehicle class distribution and brake horsepower are approximated from available US EPA data.

Table B9. Assumptions used in estimating emissions from cargo transport.

Vehicle Class	GVWR (lbs)	Vehicle class dist.	Total freight carried by each vehicle class (lbs)	# of Vehicles in class needed	Load time (hrs)	Total operating hours	Avg. vehicle bhp
Light Duty	6000	20%	515,401,200	107,375	1.50	161,062.88	140
Medium Duty	8500	10%	257,700,600	37,897	1.75	66,320.01	200
Light Heavy Duty	19500	10%	257,700,600	16,519	2.50	41,298.17	260
Medium Heavy Duty	33000	10%	257,700,600	9,761	4.00	39,045.55	320
Heavy Heavy Duty	80000	50%	1,288,503,000	20,132	9.00	181,195.73	380

Table B9 Legends:
GVWR: Gross vehicle weight rating
Vehicle class distribution: Approximate percentage of vehicles in each class
Load Time: Time required for each truck to travel through LAX, including time to load/unload cargo.
Average vehicle bhp: Average vehicle brake horsepower rating.

Once the operating hours is determined for each truck class, emission factors for each GVWR class are used to estimate the total emissions. Emission factors (for California trucks, EPA, 1997) for 1987 and

1993 are used to represent the best possible scenario (all new trucks that meet 1993 emission standards), and the worst possible scenario (old trucks that only meet 1987 emission standards). Emissions estimates for particulates, CO, VOC, and NOx are contained in table B10 in both pounds and tons emitted.

Table B10. Estimated PM, NOx, VOCs, and CO Emissions from Cargo Transport

	Emission factors		Emissions (lbs.)		
	1987 (max)	1993 (min)			
PM 1993	g/bhp-hr	g/bhp-hr	Max lbs	Min lbs	Average
LD	0.60	0.25	29,764.42	12,401.84	21,083.13
MD	0.60	0.25	17,508.48	7,295.20	12,401.84
LHD	0.60	0.25	14,173.53	5,905.64	10,039.59
MHD	0.60	0.25	16,492.84	6,872.02	11,682.43
HHD	0.60	0.25	90,887.78	37,869.91	64,378.84
Total PM (lbs)			168,827.05	70,344.61	119,585.83
Tons PM			84.41	35.17	59.79
NOx 1993					
LD	6.00	5.00	297,644.19	248,036.83	272,840.51
MD	6.00	5.00	175,084.82	145,904.02	160,494.42
LHD	6.00	5.00	141,735.33	118,112.78	129,924.05
MHD	6.00	5.00	164,928.38	137,440.32	151,184.35
HHD	6.00	5.00	908,877.80	757,398.17	833,137.99
Total NOx (lbs)			1,688,270.53	1,406,892.11	1,547,581.32
Tons NOx			844.14	703.45	773.79
VOCs 1993					
LD	1.30	1.30	64,489.58	64,489.58	64,489.58
MD	1.30	1.30	37,935.04	37,935.04	37,935.04
LHD	1.30	1.30	30,709.32	30,709.32	30,709.32
MHD	1.30	1.30	35,734.48	35,734.48	35,734.48
HHD	1.30	1.30	196,923.52	196,923.52	196,923.52
Total VOCs (lbs)			365,791.95	365,791.95	365,791.95
Tons VOCs			182.90	182.90	182.90
CO 1993					
LD	15.5	15.5	768,914.17	768,914.17	768,914.17
MD	15.5	15.5	452,302.45	452,302.45	452,302.45
LHD	15.5	15.5	366,149.60	366,149.60	366,149.60
MHD	15.5	15.5	426,064.99	426,064.99	426,064.99
HHD	15.5	15.5	2,347,934.33	2,347,934.33	2,347,934.33
Total CO (lbs)			4,361,365.54	4,361,365.54	4,361,365.54
Tons CO			2,180.68	2,180.68	2,180.68