

SUSTAINABLE PROJECTIONS FOR AIRCRAFT EMISSIONS – WHAT’S THE FUTURE FOR OUR SKIES?

By

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Section I - Introduction

In 2011 the Federal Aviation Administration (“FAA”) reported that the airline industry flew 713 million passengers in 2010 with an anticipated increase of 2.8 percent annually over the next twenty years to a projected 1.27 billion annual fliers by 2031.¹ According to the Director General and CEO of the International Air Transport Association (“IATA”), the airline industry’s global net profit is expected to reach \$8.6 billion in 2011.² This profit accounts for approximately fifteen million jobs worldwide³ and contributes to \$13.2 trillion of the U.S. gross domestic product (“GDP”).⁴

The FAA forecasts that the total United States mainline and regional air carriers will increase from 704 million in 2009 to 1.2 billion in 2030, which equates to an average annual rate increase of 2.6 percent each year.⁵ Further, the total number of airline passengers traveling to and from the U.S. is projected to increase at an annual growth rate of 4.2 percent between 2009 and 2030, with passenger numbers increasing from 147 million to 348 million in 2030.⁶

In light of the above numbers generating from the commercial airline industry, one of the biggest queries for its future is what is being done to minimize the aviation industry’s impact on the environment? In an industry where growth is forecast, the potential for continued climate change due to aircraft emissions is frightening. However, amidst the current growing concerns pertaining to aircraft-generated pollution, it is clear that national and international agencies and organizations, both governmentally-run and privately-operated, are working together to better understand the airline industry’s footprint on the environment and develop solutions for sustainability.

Between the implementation of rigorous commercial aircraft regulations and the aviation sector’s commitment to reaching noble environmental goals, the impact which the commercial aviation industry has on the environment seems to be the cornerstone of this industry’s commitment to reduce aircraft emissions in our skies. To better understand the impact of commercial airline emissions on the environment and its future impact on the environment, this paper offers a synopsis of the evolution of commercial air travel, an evaluation of the core aircraft atmospheric emissions and their effects on the environment, a study of the regulatory standards currently in place regarding aircraft emissions as well as the private sector’s commitment to meet such regulations, a projection of the future environmental impact of the aircraft industry, and a review of the judicial system’s influence on aircraft emissions.

Section II - The Historical Evolution of Commercial Air Travel

While mankind entered unchartered airspace as early as 1783 with the launch of the first hot air balloon in Paris,⁷ commercial air transportation did not begin until the early nineteenth hundreds in Europe.⁸ Germany launched the first official passenger service airline – *Deutsche Luft-Reederei* – on February 5, 1919⁹, thus officially beginning the evolution of the commercial aircraft industry.

With the inception of the Air Commerce Act of 1926, the U.S. persuaded the public that flying was safe, and encouraged the formation of private commercial airline companies.¹⁰ The earliest U.S. airlines included Northwest Airways, Inc. (“NWA”) in 1926¹¹, Eastern Airways¹², Pan American Airways (“Pan Am”)¹³, and the Boeing Air Transport Company (“Boeing”) in 1927¹⁴, Delta Air Service (“Delta”) in 1928¹⁵, American Airways, Inc. (“American”) in 1930¹⁶ and Trans World Airlines (“TWA”) in 1931.¹⁷ By 1931, passengers could travel via commercial aircraft between all major American cities.¹⁸

By the 1930s, aircraft design combat between the Douglas Aircraft Company (hereinafter, Douglas) and the Boeing Company (hereinafter, Boeing) resulted in mass production of aircraft designs which revolutionized passenger-carrying

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performance.¹⁹ In the span of the 1930's, numerous upgrades were made to commercial aircraft, including luxury sleeping²⁰, multi-engine aircraft²¹, and pressurized, heated and sound-proofed cabins²².

While few if any of the commercial airline companies made profits in the early days of commercial flight²³, the 1930's aircraft boom resulted in profits from passenger operations alone.²⁴ By the end of the decade, U.S. airliners were carrying three million passengers a year.²⁵

International travel gained recognition in the mid-1930's with the advent of the sea plane.²⁶ Pan Am took the American lead with this invention and in 1935 began scheduling flights across the Pacific Ocean.²⁷ While numerous seaplane designs graced the air²⁸, the Boeing B-314 Clipper was the last and largest of the commercial seaplanes designed, carrying a maximum of seventy four passengers and flying at a top cruising speed of one hundred eighty three miles per hour.²⁹ This aircraft was the precursor to the modern day land-plane.³⁰

The 1940s, the end of World War II, and the 1950's welcomed the new era of commercial air travel, particularly non-stop air travel on a domestic and international scale.³¹ Pan Am launched the Boeing 377 Statocruiser, a luxury aircraft which could carry up to one hundred and twelve passengers, into the commercial aircraft industry in 1949.³² However, heavy competition among design competitors Lockheed and Douglas set the stage for newer, faster and more cost-efficient aircraft.³³ By 1957 the Lockheed 1649 Starliner could fly from Los Angeles to London nonstop in nineteen hours.³⁴

The post World War II era in commercial aviation brought with it another generation of evolutionary design – specifically to the aircraft engine.³⁵ Early jet engines used large quantities of fuel and required heavy demands on maintenance staff.³⁶ The advent of the turboprop engine, which used hot gas inside a jet engine to drive propellers, offered much better fuel economy than the original turbojet engines.³⁷ However, the 1950's turbojet engine design followed by the turbo-fan engine of the 1960's became standard models in jet aircraft due to their fuel-efficiency and long-distance travel range.³⁸

The 1960's marked yet another era in aircraft engine design – that of the cost efficient aircraft. American airlines were in need of aircraft to operate on shorter routes.³⁹ New engine designs were required to offset the economics of shorter flight lengths – operating costs were required to be low enough to offset the number of passengers an aircraft could carry.⁴⁰ Douglas produced the DC-9 which offered aft-mounted engine designs, but the Boeing 727⁴¹ which offered a three-mounted rear-engine design, and the smaller two-mounted under-wing engine designed Boeing 737 eroded the DC-9 market.⁴²

The growth of passenger air travel during this decade was remarkable – TWA's figures rose from 4.6 billion in 1958 to 19.1 billion in 1969; and Pan Am growth rose from 3.8 billion in 1958 to 17.1 billion in 1969.⁴³ With growth on the rise, not only were aircraft designs required to accommodate such numbers, but so were airports and air traffic control management requirements.⁴⁴ Essentially, the world needed to accommodate the newest inception of jet aircraft including the likes of the Boeing 747 "Jumbo Jet" in 1965 and the Concorde in 1976.⁴⁵ However, amidst the glamour and stylishness of the latest aircraft designs, the ecology movement began to take shape against airlines claiming that aircraft use was damaging the ozone layer.⁴⁶

Commercial aircraft designs after the 1970's have varied only marginally, until the recent vision of the super-jumbo jet which is capable of carrying up to eight hundred passengers.⁴⁷ The Boeing 787 Dreamliner, a recent vision in wide-body aircraft design, is anticipated to provide airlines with unmatched fuel efficiency for comparable missions than the current similarly sized airplane, while maintaining travel speeds similar to the current fastest wide-body aircraft.⁴⁸

The ultimate question for the future of commercial air travel largely lies in the quest for environmentally acceptable aircraft designs. The greatest threat to the future of air travel is likely the growing sensitivity to environmental damage caused by aircraft.⁴⁹ Governments and agencies, including the FAA, Environmental Protection Agency ("EPA"), National Aeronautics and Space Administration ("NASA"), the International Civil Aviation Organization ("ICAO") and International Air Transport Association ("IATA") are working in tandem with aircraft manufacturers in an effort to combat global warming.⁵⁰ The rise or fall of commercial air transportation in the future is undoubtedly linked to the next generation of aircraft design.

Section III - Aircraft Emissions and the Environmental Concerns

Pollution and Transportation

Transportation⁵¹ is described as being the world's most serious environmental villain.⁵² As a major consumer of non-renewable energy resources including fossil fuels, transportation is among one of the world's most prominent polluters⁵³ and is deemed the largest end-use source of carbon dioxide.⁵⁴ According to the EPA, in 2008 transportation sources contributed approximately twenty seven percent of the total U.S. greenhouse gas emissions.⁵⁵ Transportation is also found to be the fastest growing source of greenhouse gas emissions in the U.S.⁵⁶

Aircraft release gasses and particulate emissions directly into the atmosphere, both at the ground level and into the upper atmosphere.⁵⁷ While air transportation contributes to a relatively small share of the total pollutants in our environment⁵⁸, it is the only industry which discharges harmful emissions directly into the upper atmosphere.⁵⁹

The Intergovernmental Panel on Climate Change ("IPCC") has determined that two major global environmental issues emerging from the field of aviation may have potentially important consequences: climate change, including changes to weather patterns, and stratospheric ozone depletion and the resulting increase in ultraviolet B ("UV-B") radiation at the Earth's surface.⁶⁰ Thus, concerns about the consumption of non-renewable resources, including fossil fuels, global warming, and acid rain, as well as air and noise pollution, urban sprawl, congestion, and safety warrant a closer examination of the role of transportation in making planet Earth less habitable.⁶¹ As commercial aircraft emissions are a growing concern in the transportation emissions inventory, especially considering that the FAA has reported that flights of commercial air carriers increased by nine percent from 2002 to 2010 and will increase by thirty four percent from 2002 to 2020,⁶² a closer look at the types of pollutants which are emitted into the atmosphere by aircraft is imperative in order to critically assess the future of "green aircraft".

Critical Pollutants

The EPA has identified certain critical pollutants which cause or contribute to air pollution and which can endanger the public health or welfare.⁶³ Those key pollutants are: Ozone (O₃), Carbon monoxide (CO), Particulates (PM-10), Sulfur dioxide (SO₂), Nitrogen dioxide (NO₂) and Lead (Pb).⁶⁴

The Glenn Research Center, NASA's lead center for aer propulsion, documents that modern jet fuel is primarily kerosene, which is a flammable hydrocarbon oil and fossil fuel.⁶⁵ Burning fossil fuels primarily produces CO₂ and water vapor (H₂O).⁶⁶ Other major emissions include nitric oxide (NO) and NO₂, which are collectively referred to as NO_x, SO₂, and soot.⁶⁷ Each of these listed pollutants is emitted in and around airports and/ or into the upper atmosphere during actual aircraft use. A brief discussion of these pollutants, along with an understanding of how aircraft engine emissions of these pollutants affect life on Earth and the world as we know it, follows as it is integral to the pursuit of finding a way to reduce such emissions in the future.

Ozone (O₃)

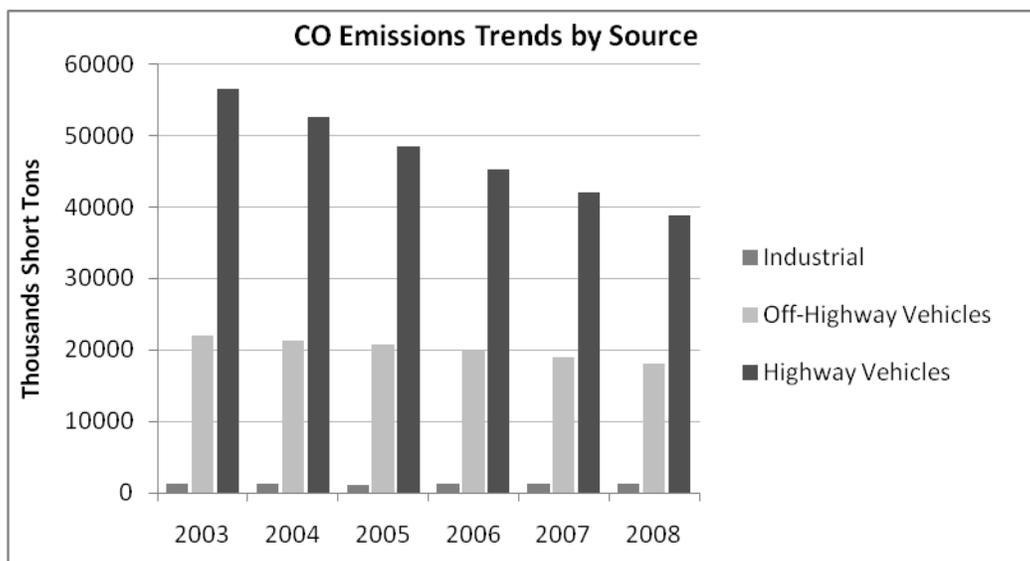
Ozone is a highly reactive gas composed of three oxygen atoms. It is both a natural and man-made product that occurs in the Earth's upper and lower atmospheres.⁶⁸ Ozone forms as a result of volatile organic compounds (VOCs) and oxides of nitrogen (NO_x) reacting in the presence of sunlight in the atmosphere.⁶⁹ VOCs are emitted at airports and where aircraft, ground support equipment, and ground access vehicles are located.⁷⁰ While NO_x are emitted in and around airports,⁷¹ significant NO_x emissions are produced during aircraft takeoff and climbout⁷² when fossil fuels are burned at extremely high temperatures.⁷³

At higher altitudes, increases in NO_x lead to decreases in the stratospheric ozone layer.⁷⁴ Ozone is the Earth's natural sunscreen which acts as a shield against excessive amounts of ultraviolet radiation.⁷⁵ In a 2010 report prepared by the science advisors to the Montreal Protocol, an international treaty to phase out ozone-depleting chemicals, it was determined that the impact of the Antarctic ozone hole on the Earth's surface climate is becoming evident in surface temperature and wind patterns.⁷⁶

Health risks pertaining to the inhalation of ozone emissions include damage to lung tissue and a reduction of proper lung function.⁷⁷ Evidence suggests that ambient levels of ozone not only affect those with impaired respiratory systems, but also healthy individuals.⁷⁸ Further, increasing occurrences of skin cancer are now attributed to the shrinking of the Earth's ozone layer.⁷⁹

Carbon Monoxide

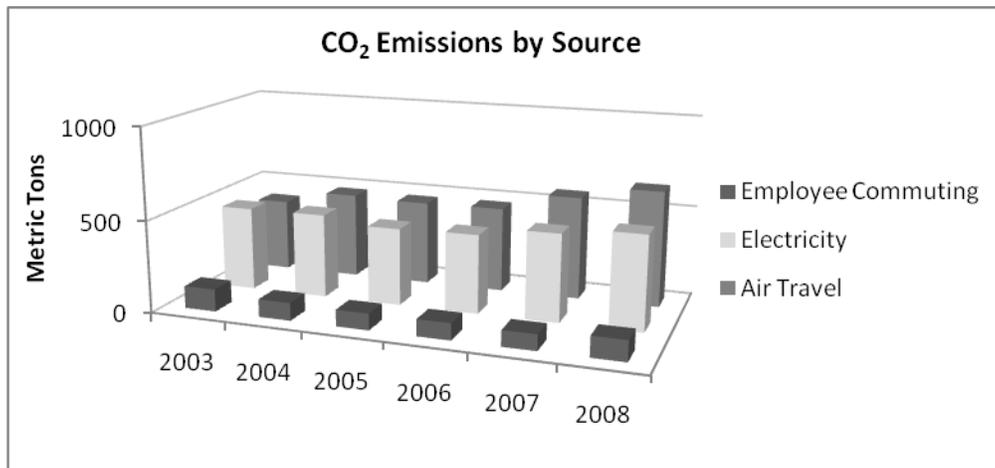
Carbon Monoxide (CO), an odorless, colorless, and poisonous gas, is largely emitted by aircraft and ground access vehicles inside airport settings.⁸⁰ CO emissions reach peak levels during idling and low speed aircraft and ground access vehicle operations.⁸¹ The following graph identifies CO emissions by source.⁸²



When CO enters the bloodstream, it reduces oxygen delivery to the body's organs and tissues, and may produce adverse health effects including headaches, work capacity impairment, learning ability impairment, dizziness, weakness, nausea, vomiting, loss of muscular control, increase and decrease in respiratory rates, collapse, unconsciousness or death.⁸³

Carbon Dioxide

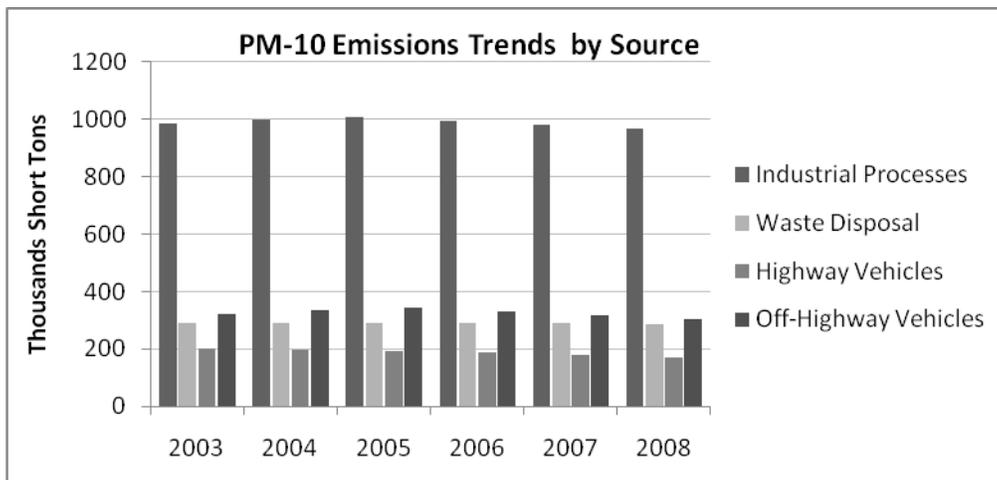
Carbon Dioxide (CO_2) is a greenhouse gas produced by human activities, primarily through the combustion of fossil fuels.⁸⁴ Global warming is caused by the emission of greenhouse gases. Because seventy two percent of all emitted greenhouse gases is CO_2 , its emission is the most important cause of global warming.⁸⁵ Since the Industrial Revolution in the 1700's, human activities have increased CO_2 concentrations in the atmosphere.⁸⁶ In 2005, global atmospheric concentrations of CO_2 were thirty-five percent higher than they were before the Industrial Revolution.⁸⁷ Aircraft produce about two percent of the annual global CO_2 emissions from fossil fuels both at the Earth's surface and at higher altitudes.⁸⁸ The following graph depicts the growing CO_2 emissions by air travel as compared to other major sources of CO_2 emissions:⁸⁹



While naturally occurring CO₂ helps keep the Earth warm enough to sustain plant life, increased amounts of greenhouse gases will eventually result in warmer Earth temperatures, thus causing excessive global warming.⁹⁰ The negative results of global warming include the melting of Polar ice caps, rising ocean levels, and flooding of coastal areas.⁹¹

Particulate Matter

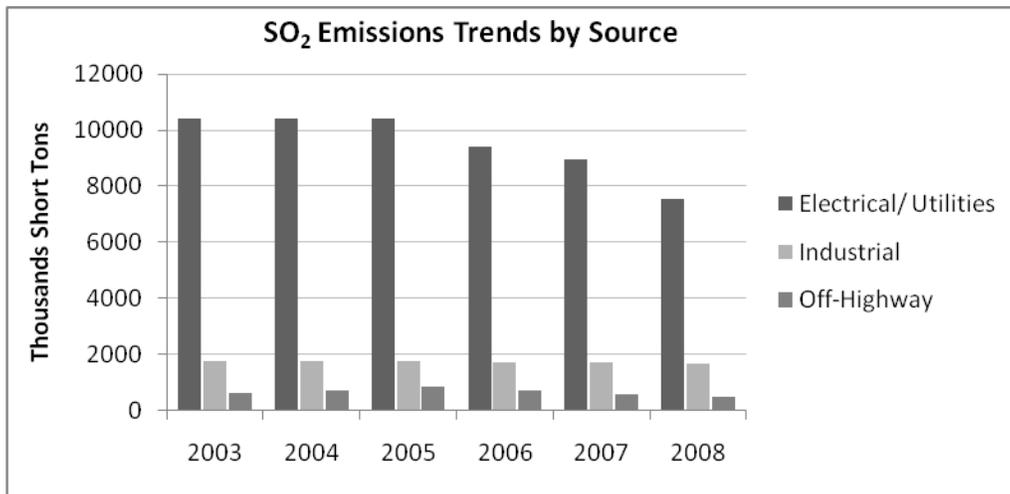
Particulate matter (PM-10) includes both solid and liquid material suspended in the earth's atmosphere.⁹² While some particulates are too large to be inhaled into the lungs, PM-10 are finer, smaller particulates which cannot easily be filtered from the body, thus resulting in easy inhalation.⁹³ Examples of PM-10 include dust, fog and fumes.⁹⁴ Aircraft are the main source of PM-10 emissions in and around airports, but are not the main source of such emissions from all sources.⁹⁵ The following graph depicts some of the main sources of PM-10 emissions:⁹⁶



Adverse health effects resulting from PM-10 inhalation include respiratory and cardiovascular disease, alterations in the body's defense systems against foreign materials, lung tissue damage, carcinogenesis, and premature mortality.⁹⁷

Sulfur Dioxide

Sulfur oxides (SO_x) are gases produced from industrial processes, including the burning of sulfur-containing fuels including coal and oil.⁹⁸ The extent of SO_x emissions depends entirely upon the amount of sulfur content in the fuel.⁹⁹ About ninety-five percent of all SO_x are sulfur dioxide (SO₂), which is a stable, colorless gas with a strong odor.¹⁰⁰ Only a minimal amount of SO₂ is emitted from any aviation emission source.¹⁰¹ The following graph depicts some of the main sources of SO₂ emissions:¹⁰²



Both SO₂ and soot particles from aircraft exhaust are aerosols, which are microscopic particles suspended in the air.¹⁰³ Water molecules condense or freeze on these particles, resulting in cloud particles.¹⁰⁴ Aircraft exhaust produces contrails, which are condensation trails located in the atmosphere about five miles above the Earth's surface.¹⁰⁵ Contrails which last longer than a few minutes develop into cirrus clouds.¹⁰⁶ Both contrails and cirrus clouds reflect sunlight which would otherwise warm the Earth's surface, as well as absorb heat from the ground in lieu of allowing it to escape.¹⁰⁷

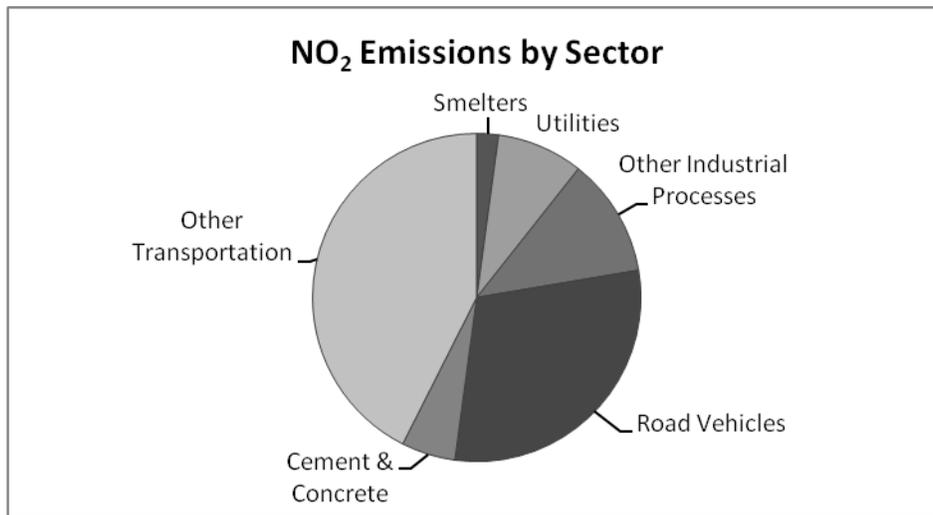
Contrails and cirrus clouds are known to contribute to "global change".¹⁰⁸ It has been observed that over the past forty years cloudiness over the Earth has increased, which may lead to global climate change as it will change the amount of radiation entering and leaving Earth's atmosphere.¹⁰⁹

Exposure to high levels of SO₂ could result in adverse health effects including throat and lung irritation, swelling and accumulation of fluid in the lungs and throat, nasal bleeding, and aggravation of existing respiratory and cardiovascular disease.¹¹⁰

Nitrogen Dioxide

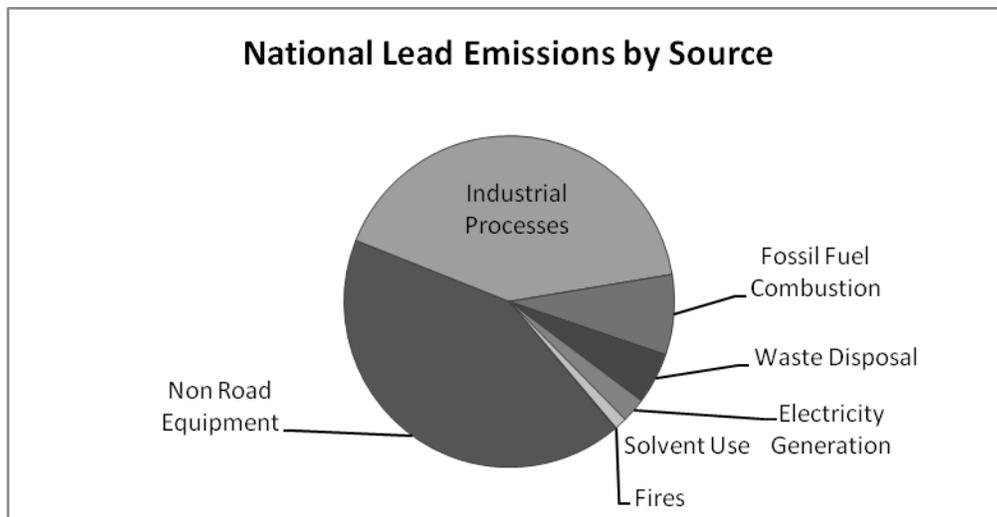
Nitrogen Dioxide (NO₂), a poisonous, brown gas with an irritating odor, is emitted at airports from sources including aircraft operations.¹¹¹ NO₂ emissions are highest during high-temperature combustion, including when an aircraft is in take-off mode.¹¹²

In addition to contributing to the formation of ground-level ozone, and fine particle pollution, NO₂ is linked with a number of adverse effects on the respiratory system including nose and throat irritations, coughing, choking, headaches, nausea, stomach pains, chest pains, and lung inflammations.¹¹³ The following graph depicts an example of the main sources of NO₂ emissions:¹¹⁴



Lead

Lead (Pb), a heavy metal solid, occurs in the atmosphere as lead oxide aerosol or lead dust.¹¹⁵ The main source of Pb at airports is the combustion of leaded aviation gasoline in piston-engine aircraft.¹¹⁶ Lead accumulates in soils and sediments through deposition from air sources, direct discharge of waste streams to water bodies, mining, and erosion.¹¹⁷ Ecosystems near point sources of lead demonstrate a wide range of adverse effects including losses in biodiversity, changes in community composition, decreased growth and reproductive rates in plants and animals, and neurological effects in vertebrates.¹¹⁸ The following graph depicts an example of the main sources of Pb emissions:¹¹⁹



Adverse health effects of lead accumulation in blood, bone and soft tissue may lead to fatigue, sleep disturbance, headache, aching bones and muscles, constipation, abdominal pains, decreased appetite, and permanent nerve system damage.¹²⁰ Significant exposure to Pb can lead to seizures, coma and death.¹²¹

Section IV - Sustainability of Air Traffic and the Environment

Regulatory Standards

The aviation industry lies at the heart of today's modern economy. As indicated by the FAA in February 2011, the airline industry anticipates a 2.8 percent increase in passenger growth annually over the next twenty years to a projected 1.27 billion

passengers flying annually by 2031.¹²² The airline industry's global net profit is expected to reach \$8.6 billion in 2011,¹²³ and the industry currently accounts for fifteen million jobs worldwide.¹²⁴

Amidst these staggering numbers the airline industry generates only about two percent of the world-wide CO₂ emissions.¹²⁵ However, with air traffic increasing annually and the airline industry growing as a business enterprise, it is imperative that national and international agencies and organizations focus on the current state of the environment and the pollution attributable to aircraft usage, and work with the private sector to reduce the airline industry's carbon footprint. As such, this section documents the regulatory standards currently in place in a number of agencies worldwide.

Federal Aviation Administration (FAA)

The FAA, through its Office of Environment and Energy (AEE), recognizes that the aviation industry impacts the environment and acknowledges that more focus must be placed on aircraft emissions.¹²⁶ As such, the Office of Environment and Energy, in collaboration with the EPA's Office of Transportation and Air Quality (OTAQ), have issued recommended best practices for the quantification of organic gas emissions from aircraft.¹²⁷ The measurement of air emissions associated with aircraft engines is an evolving process that is still under development and can only be refined vis-à-vis future research and additional attention to this issue.¹²⁸ This collaborative effort is an initial attempt, and both the FAA and the EPA have affirmed their dedication to further develop these quantitative measures.¹²⁹

It is important to note that currently there are no Federal regulatory guidelines specific to hazardous air pollutants (HAPs) emissions from aircraft.¹³⁰ Thus, these best practices serve as only mere suggestions for addressing potential legislative action at the federal level.¹³¹ However, until upper atmospheric aircraft emissions can be effectively quantified, the hope for important federal legislation remains in its infancy.¹³² More specifically, twenty-nine percent of organic gas (OG) associated with the exhaust from tested commercial aircraft emissions are presently unidentified.¹³³ Both the FAA and the EPA recognize that the advanced atmospheric photochemical models used to simulate the transport, dispersion, and reactivity of aircraft engine emissions will benefit from the best available accounting of OGs.¹³⁴

Unlike emissions from other transportation sources, international certification standards require that OG emissions from newly certified aircraft engines be reported in units of methane equivalency.¹³⁵ The specific conversion factors are highly technical and are beyond the scope of this paper. However, based on these conversion factors, the FAA in tandem with the EPA have recommended specific steps in order to prepare an emission inventory of speciated OGs for aircraft equipped with turbofan, turbojet, and turboprop engines.¹³⁶

Certain specific aircraft operational characteristics are of primary significance in preparing an emissions inventory of pollutants.¹³⁷ Such characteristics include the number of aircraft operations (i.e. landings and takeoffs) by aircraft type, the type and number of engines, and times-in-mode for each of the aircraft operational modes (i.e. approach, taxi-in, taxi-out, idle (delay), take-off and climbout).¹³⁸ These characteristics are used collectively to calculate the levels of total hydrocarbons (THC), VOCs and non-methane organic gas (NMOG).¹³⁹

Another revolutionary endeavor in the FAA's effort to minimize aircraft emissions is its project entitled The Next Generation Air Transportation System (NextGen). NextGen is the FAA's plan to modernize the National Airspace System (NAS) through the year 2025.¹⁴⁰ Via NextGen, the FAA addresses the impact of air traffic growth by increasing NAS capacity and efficiency while at the same time improving safety, reducing environmental impacts, and increasing user access to the NAS.¹⁴¹ To achieve these goals, the FAA is implementing new Performance-Based Navigation (PBN) routes and procedures that leverage emerging technologies and aircraft navigation capabilities.¹⁴²

Several NextGen milestones are currently in the works to be implemented by 2025.¹⁴³ First, a new, cleaner-burning fuel is expected to be approved for use by commercial aircraft by the end of 2011.¹⁴⁴ Second, NextGen aims to reduce airline delays (both in-flight and on the ground) by thirty-five percent by the year 2018, thereby saving approximately 1.4 billion gallons of aviation fuel and reducing CO₂ emissions by 14 million tons during this period.¹⁴⁵ Third, the implementation of several new technologies, including the Automatic Dependent Surveillance-Broadcast (ADS-B), Data Communications (Data Comm) and PBN will further aid in reducing aircraft emissions.

ADS-B is the FAA's satellite-based successor to radar which more accurately tracks air traffic. ADS-B offers increased situational awareness by providing free in-cockpit traffic and weather information.¹⁴⁶ Data Comm will provide pre-departure clearances that allow amendments to flight plans.¹⁴⁷ On the ground, the flight crew's situational awareness will improve via flight-deck displays portraying aircraft and surface vehicle movement.¹⁴⁸ Improved ground systems, including surface-movement displays, will also be available in the tower to enable controllers to more efficiently manage the use of taxiways and runways.¹⁴⁹

The FAA reports that the implementation of PBN procedures, which encompass a set of enablers with the capability to construct flight paths which are not constrained by the location of ground navigation aids, has already saved hundreds of thousands of gallons of fuel, thereby reducing thousands of tons of CO₂ and other air pollutants.¹⁵⁰ PBN procedures reduce fuel use, emissions and miles flown at high altitude.¹⁵¹ In 2010 the FAA's production of PBN routes and procedures exceeded its fiscal year goal.¹⁵²

As demonstrated by the FAA's role in creating healthier skies, there are two key primary components to this agency's effort to reduce aircraft emissions – (1) a consistent method for quantifying the amount of emissions and (2) the introduction and adaption of technology in order to reduce fuel consumption by aircraft. Collectively, these two approaches will help to reduce the airline industry's carbon footprint.

Environmental Protection Agency (EPA)

The sole mission of the EPA is to protect human health and the environment.¹⁵³ In keeping with this mission, the EPA ensures that national efforts are made to reduce environmental risks based on the best scientific information available.¹⁵⁴ Studying various air pollutant emissions created by the aviation industry and implementing regulations to reduce aircraft emissions is high on the EPA's priority list, and as such the Agency has drafted key regulations and guidance to help reduce the airline industry's carbon footprint.¹⁵⁵

The Clean Air Act¹⁵⁶, which was signed in 1970 by Richard Nixon and enacted by Congress in 1990, defines the EPA's responsibilities for protecting and enhancing the United States' air resources and preventing air pollution.¹⁵⁷ Title II of the Clean Air Act specifically targets aircraft emissions standards¹⁵⁸, documenting both the establishment of aircraft emissions standards as well as the enforcement of those standards.

The Clean Air Act requires the EPA to set National Ambient Air Quality Standards (NAAQS)¹⁵⁹ for those pollutants which are considered harmful to public health and to the environment.¹⁶⁰ Those pollutants identified include carbon monoxide, lead, nitrogen dioxide, particulate matter, ozone, and sulphur dioxide.¹⁶¹ In December 2010 the EPA finalized revisions to the ambient monitoring requirements for measuring lead in the air, which included the monitoring of airports emitting lead in order to better assess the EPA's compliance with NAAQS.¹⁶²

In 2010 the EPA also issued an *Advance Notice of Proposed Rulemaking* (ANPR)¹⁶³ on lead emissions from piston-engine aircraft using leaded aviation gasoline as petitioned by Friends of the Earth, an organization which in 2006 requested that the EPA find that aircraft lead emissions endanger public health and welfare and issue a proposed emissions standard for lead from general aviation aircraft.¹⁶⁴

In 2008 the EPA's Office of Transportation Air Quality (OTAQ) and the FAA's Office of Environment and Energy (AEE) prepared a *Quality Assurance Project Plan For the Development of a Commercial Aircraft Hazardous Air Pollutants Emission Inventory Methodology*¹⁶⁵, a profile which uses the most recent data sets available for studying emission inventories of aircraft equipped with certain engine types fueled with kerosene-based fuel.¹⁶⁶ The EPA also amended its 2005 emission standards for nitrogen oxides¹⁶⁷ for new commercial aircraft engines in order to parallel the nitrogen oxides emission standards of the ICAO, thus bringing U.S. aircraft standards into alignment with the international standards.¹⁶⁸

As working in tandem with other agencies and organizations is critical to the goal of reducing aircraft emissions, the EPA works with both the FAA and the ICAO in developing international aircraft emission standards.¹⁶⁹ The FAA's role in this endeavor is to enforce the aircraft emissions standards established by the EPA, and the ICAO's role is to ensure safety, equality, and consistency among international air transport services, including developing standards and procedures for aircraft emissions.¹⁷⁰ In its rulemaking, the EPA has historically and will continue to adopt standards equivalent to the ICAO standards.¹⁷¹

International Civil Aviation Organization (ICAO)

In 1944 the Convention on International Civil Aviation (also known as Chicago Convention) was signed by fifty-two countries, thereby establishing the first world-wide effort to unify international aviation.¹⁷² Since its inception, nine editions of the document have followed, with the most recent published in 2006. Three years after the original version of the Chicago Convention was signed, the ICAO was created as a specialized agency of the United Nations linked to Economic and Social Council (ECOSOC).¹⁷³ The purpose of the ICAO is to develop international civil aviation in a safe and orderly manner and to establish international air transport services on the basis of equality of opportunity and operated soundly and economically.¹⁷⁴

Along with other world-wide agencies and organizations, the ICAO has become the leading international organization pursuing measures to reduce civil aviation's impact on the environment across the globe.¹⁷⁵ The ICAO Council's Committee on Aviation Environmental Protection (CAEP), which consists of Members and Observers from States, intergovernmental and non-governmental organizations representing aviation industry and environmental interest, undertakes massive efforts to meet major environmental goals.¹⁷⁶

In 2004, the ICAO, through the CAEP, adopted three critical environmental goals to coincide with its purpose – (1) to limit or reduce the number of people affected by significant aircraft noise; (2) to limit or reduce the impact of aviation emissions on local air quality, and (3) to limit or reduce the impact of aviation greenhouse gas emissions on the global climate.¹⁷⁷ To address these goals, a *Consolidated Statement of Continuing ICAO Policies and Practices Related to Environmental Protection* was prepared, and such document is revised and updated by the CAEP every three years.¹⁷⁸ The purpose of this Statement and subsequent revisions is to reflect developments that have taken place in the field of aircraft noise and engine emissions, including taking initiatives to promote information on scientific understanding of aviation's impact and action undertaken to address aviation emissions and finding resolutions that will reduce aircraft engine emissions without negatively impacting the growth of air transport especially in developing economies.¹⁷⁹

In 1999, the *Special Report on Aviation and the Global Atmosphere*¹⁸⁰ was prepared by the IPCC at the request of the ICAO.¹⁸¹ Among numerous findings, the *Report* documented that aircraft emissions alter the atmospheric concentration of greenhouse gases, trigger the formation of contrails, and may increase cirrus cloudiness – all of which contribute to climate change¹⁸², and that aircraft contribute approximately 3.5 percent of the total radiative forcing (a measure of climate change) by all human activities and that such percentage is expected to grow.¹⁸³

In 2007 the ICAO requested the IPCC to update the main findings of the 1999 Report in its Fourth Assessment Report.¹⁸⁴ The findings in this report included data indicating that global warming is evident¹⁸⁵ the total CO₂ emissions grew by about eighty percent between 1970 and 2004¹⁸⁶; that global increases in CO₂ concentrations are due primarily to fossil fuel use,¹⁸⁷ and that there is much evidence to suggest that global emissions will continue to grow over the next few decades¹⁸⁸. The Fifth Assessment Report is expected to be completed in 2014 and will address the scientific understanding of aviation's impacts on global climate.¹⁸⁹

Drafted in 1998, the *Kyoto Protocol to the United Nations Framework Convention on Climate Change*¹⁹⁰ (Kyoto Protocol) clearly identified the international role of the ICAO to limit or reduce emissions of greenhouse gases from aviation fuels.¹⁹¹ The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change,¹⁹² and requires certain industrialized nations¹⁹³ to reduce their collective emissions of six specific greenhouse gases.¹⁹⁴

While the ICAO works actively with many worldwide agencies and organizations including the EPA and FAA to improve the environmental performance of aviation, it maintains close relations with United Nations ("UN") policy-making bodies which have expressed an interest in civil aviation.¹⁹⁵

The Private Sector

As previously noted, certain national and international governmental agencies and organizations including the FAA, the EPA and the ICAO are major players in the hunt for a greener aviation industry. However, the national and international private sector plays no small role in creating policies to reduce aviation emissions. The following examples provide a glimpse at the private sector's role in improving the aviation industry's impact on the environment.

International Air Transport Association (IATA)

IATA was incorporated in 1945 in order to represent, lead and serve the airline industry.¹⁹⁶ IATA represents 230 international member airlines in over 115 different countries.¹⁹⁷ One of IATA's main priorities in working amidst the standards required by the ICAO is to achieve carbon neutral-growth in the short term and to build a plane that produces zero emissions within the next fifty years.¹⁹⁸ IATA has designed a strategy¹⁹⁹ whereby carbon-neutral growth beginning in 2020 followed by a carbon-free future is achievable by cutting emissions within the airline industry or by financing projects to cut

an equivalent amount of emissions in other industries.²⁰⁰ In coordination with this Strategy, IATA also developed a recommended policy approach for adoption by governments which will support the efforts to meet the global challenge of climate change.²⁰¹

The Boeing Company

The Boeing Company²⁰² (hereinafter Boeing) is the world's largest aerospace company and leading manufacturer of commercial jetliners and defense, space and security systems.²⁰³ In recognizing the environmental challenges facing the ecosystem, Boeing is instrumental in pioneering new technologies for environmentally progressive products and services.²⁰⁴

As part of its pursuit to reduce emissions of greenhouse gases from its facilities and products, Boeing is constantly working to develop new technology to improve global transportation, increase its research to improve efficiencies throughout the system – including the introduction of sustainable advanced-generation biofuels, accelerate the adoption of environmentally progressive products and services, and reduce carbon dioxide emissions by fifteen percent with each new generation of commercial aircraft.²⁰⁵ In keeping with these goals, Boeing is working with NASA on the Environmentally Responsible Aviation (ERA) Project which explores and documents the feasibility, benefits and technical risk of vehicle concepts and enabling technologies which will reduce the impact of aviation on the environment.²⁰⁶

Airbus

Airbus²⁰⁷ is a global leader in aerospace, defense and related services. Since its inception, Airbus has made environmental performance its highest priority and has adhered to the philosophy of increasing the number of passengers (freight) per flight, while reducing overall energy consumption.²⁰⁸

To meet its environmental goals, Airbus has created its own Vision 2020 guidelines which outline the company's environmental approach, social practices and economic performance.²⁰⁹ In December 2010 Airbus also published its *Airbus Global Market Forecast 2010 – 2029* which not only documents the aviation industry's anticipation of growth through innovation, but also discusses the Company's intent to reduce environmental impact by way of new engine designs.²¹⁰

Airbus also partners with numerous organizations in order to proactively work towards a more sustainable aviation sector. Airbus is part of the Air Transport Action Group (ATAG) which advocates the environmentally responsible development of aviation infrastructure.²¹¹ In 2011, Airbus launched its ProSky subsidiary in order to focus on enhancing the development and support of modern air traffic management systems.²¹² The Company also lobbies with international bodies including the European Commission, promoting the idea that use of sustainable bio-fuels should be reserved for aviation and developed for its use as soon as possible.²¹³ Finally, Airbus has also partnered with Lufthansa to launch the first daily commercial passenger service using bio-fuels.²¹⁴

Section V Sustainability of Air Traffic and the Environment

Projections for Future Improvements

With the growing concerns emerging regarding the impact of aircraft emissions on the environment, what can society expect of the next generation of aircraft? As this paper has already addressed, numerous regulatory standards are now in place world-wide to help mitigate the environmental impact of aircraft use. However, putting these regulations into practice requires new aircraft and engine designs, and new infrastructure in the airline industry.

ICAO

The ICAO facilitates the promotion and harmonization of initiatives encouraging and supporting the development of sustainable alternative fuels for international aviation.²¹⁵ The organization not only provides forums for education and outreach on sustainable alternative fuels for aviation, but facilitates the exchange of information on financing and incentives for sustainable alternative fuels, and facilitates the establishment of a regulatory framework assuring that sufficient quantities of sustainable alternative fuels are made available to the aviation sector.²¹⁶

The ICAO has also mandated that aircraft meet the engine certification standards adopted by the Council of ICAO.²¹⁷ Such standards establish limits for emissions of nitrogen oxides, carbon monoxide, unburned hydrocarbons, smoke and vented fuel.²¹⁸ Such standards also limit emissions at altitude, with particular attention paid to nitrogen oxides which at altitude is a greenhouse gas.²¹⁹ The standard for nitrogen oxides, which was first adopted in 1981, was made more stringent

in subsequent years as recent as 2010. The most recent standard will improve the current standard by up to fifteen percent with an effective date of 2013.²²⁰

IATA

As discussed earlier, IATA has designed a Vision for the airline industry to build a zero emissions commercial aircraft within the next fifty years.²²¹ While admittedly the engineering solution to this goal is not yet available, IATA is keen on meeting this goal through the use of building blocks, including creating new materials and engine designs and seeking the use of alternative fuel sources in order to reduce CO₂ emissions.²²² To reduce aircraft emissions, IATA has created a four-pillar building-block strategy: (1) Investing in technology, (2) Improving operational efficiency, (3) Building and using efficient infrastructure, and (4) Positive economic instrument provide incentives.²²³

Under Pillar One, the advent of newer, more radical technology will provide the best prospects for reducing aviation emissions, including new aircraft designs, new composite lightweight materials, new engine advances, and the development of biofuels.²²⁴ The goal of implementing these new technologies includes airlines spending \$1.5 trillion dollars on new aircraft by 2020 as well as the aviation industry replacing 5,500 aircraft by that same year, thus resulting in a twenty-one percent reduction in CO₂ emissions.²²⁵

Regarding Pillar Two, IATA developed Green Teams which consist of experts that visit airlines and advise them on fuel and emissions savings measures and best practices.²²⁶ The goal of these Green Teams is to improve operational practices, utilizing more efficient flight procedures, and finding measures to reduce aircraft weight in order to achieve three percent emissions reductions by 2020.²²⁷

The goal of Pillar Three is to make the air transport infrastructure more efficient. To meet this goal, measures will be implemented including developing programs across the globe to reduce route extensions and flight delays.²²⁸

Pillar Four entails utilizing economic measures to close the gap, or more precisely advocating for a global sectoral approach to reducing emissions.²²⁹ Under Pillar Four, IATA would act as the appropriate UN body for developing and implementing a global sectoral approach to address aviation emissions.²³⁰

In keeping with its goal to reduce aviation emissions, IATA is working with the entire airline industry, including manufacturers, airports, air navigation and others to turn such vision into reality.²³¹

Aircraft Manufacturers

Because the environmental impact of commercial aircraft has become a fundamental component of the aeronautics industry, aircraft manufacturers must constantly keep abreast of the latest agency regulations pertaining to aircraft emission standards. To meet the goals set by various organizations, manufacturers must continuously strive to design and build more fuel efficient aircraft.

Boeing is currently flight-testing two new commercial aircraft, the 787-8 Dreamliner (hereafter, “787”) and the 747-8.²³² The 787, which seats up to three hundred passengers, is designed to be twenty percent more fuel-efficient than other comparable-sized aircraft.²³³ The 747-8, a wide-body jumbo jet seating up to five hundred passengers, is designed to be sixteen percent more fuel-efficient than previous generation jumbo jets.²³⁴

Boeing also announced performance enhancements to the Next-Generation 737 (hereafter, “737NG”), a short to medium range aircraft, to improve fuel efficiency of the world’s most popular airplane by two percent.²³⁵ Structural improvements on this aircraft will result in an increase in fuel efficiency by approximately one percent, and hardware changes will contribute another one percent fuel savings.²³⁶

In keeping with ICAO regulations, Boeing details that compared to the Boeing 707, Douglas DC-8 and other early jetliners, today’s commercial airplanes generate seventy percent fewer emissions.²³⁷ Boeing further acknowledges that it is committed to delivering at least a fifteen percent improvement in fuel and carbon dioxide efficiency with each new generation of commercial airplanes.²³⁸

Over ninety percent of Airbus' annual research and development budget is dedicated to environmental benefits for current-generation and future aircraft.²³⁹ In 2010 Airbus unveiled its ideal of what air transport may look like in 2050 with the Airbus Concept Plane, an aircraft characterized by its ultra long and slim wings, semi-embedded engines, a U-shaped tail and light-weight "intelligent" body.²⁴⁰ This aircraft would improve environmental performance of air transportation, deliver lower fueled consumption and significantly reduce emissions.²⁴¹

Two of the smaller commercial global aircraft manufacturers – Canadian-based Bombardier Aerospace²⁴² (hereinafter Bombardier) and Brazilian-based Embraer²⁴³ - are both looking to future innovations and investments in commercial aircraft in order to reduce aircraft emissions. Bombardier's Learjet 85 aircraft program will be the first business or commercial aircraft to be built primarily from composites.²⁴⁴ Bombardier's CSeries family of commercial aircraft²⁴⁵ will use leading-edge technology and proven methods to meet commercial airline needs in 2013 and beyond.²⁴⁶ This CSeries aircraft family is set to launch in 2013 and will use twenty percent less CO₂ and fifty percent less NO_x than other similar aircraft models on the market.²⁴⁷ For its part, Embraer boasts being the first manufacturer to build a certified ethanol-fueled airplane.²⁴⁸ Further, in 2009 Embraer partnered with Azul Airlines, General Electric and Amyris to work on a joint project to study the technical aspects and sustainability of a renewable jet fuel derived from fermented sugar cane.²⁴⁹

Airlines

Certain airlines across the globe are doing their part to reduce aircraft emissions. On its website, United Continental Holdings (hereafter, "Continental Airlines") lists certain environmental accomplishments to include thirty-two percent improvement in fuel efficiency through investing in a modern, fuel-efficient fleet and equipment and aircraft orders that will deliver a greater than twenty percent improvement in fuel efficiency comprised of fifty Boeing 787s and twenty five Airbus A350s.²⁵⁰ In recognition of its environmental commitments, Continental Airlines won the Design for Environmental Stewardship Award from the EPA in 2008.²⁵¹

In 2008, The Lufthansa Group (hereafter, "Lufthansa") established fifteen guidelines, based on its Strategic Environmental Programme, to make crucial environmental progress by 2020.²⁵² These guidelines include reducing and cutting carbon and Nitrogen oxides emissions, modernizing its current fleet, promoting alternative fuels, and implementing emissions trading on a global scale.²⁵³ Lofty goals for this company include reducing its specific carbon dioxide emissions by 2020 by twenty-five percent as compared to 2006 levels, and cutting nitrous oxide levels by eighty percent relative to 2000.²⁵⁴

Virgin Atlantic Airways (hereafter, "Virgin Atlantic") has partnered with Boeing to assist the Company in its quest to become the most sustainable airline in the world.²⁵⁵ Virgin Atlantic ordered fifteen 787s from Boeing, and participated in a biofuel demonstration with Boeing, Virgin Fuels and General Electric Aviation.²⁵⁶ Further, in 2008 Virgin flew its Boeing 747-400 aircraft using twenty percent biofuel (a mixture of coconut and babassu oil) and eighty percent conventional jet fuel.²⁵⁷ Virgin Atlantic's environmental goal is to achieve a target of improving its fuel efficiency per revenue tone kilometer by thirty percent by 2020.²⁵⁸

Section VI – The Judicial System's Impact

Setting regulatory standards and implementing new aircraft designs may be the answer to solving the airline industry's impact on the environment. However, implementation of standards goes hand in hand with judicial interpretations. As such, lawsuits surrounding the aviation industry, with particular emphasis on emissions standards, have come forward both nationally and internationally.

In *National Association of Clean Air Agencies [NACAA] v. EPA*²⁵⁹, the Court sided with the EPA on its interpretation of the Clean Air Act with respect to the EPA's ability to study, investigate and adopt regulations on aircraft emissions.²⁶⁰ In its discussion of the facts surrounding this case, the Court discussed *West Virginia v. EPA*²⁶¹ where petitioners sought review of EPA rules requiring various states to revise implementation plans as to NO_x emissions and establishing emission limits for major NO_x sources.²⁶² In both cases the Court found that petitioners had demonstrated injury where the EPA lowered states' total NO_x emissions budgets, thus requiring states to revise and impose additional controls.²⁶³ However, in the NACAA case the Court determined that the EPA's construction of the Clean Air Act was appropriate.²⁶⁴

In a case against the FAA, County of Rockland, New York lost on appeal on the issue of the FAA's analysis of environmental impacts on the redesign of New York, New Jersey, and Philadelphia airspace.²⁶⁵ This case is intriguing because the Court found that the Petitioner had not been harmed by the FAA's determination that the redesign would in fact reduce emissions in the redesign study area.²⁶⁶ In its analysis of whether the airspace redesign would harm any local property via aircraft emissions, the FAA relied on a fuel burn analysis which showed that the redesign would reduce fuel consumption in the study area.²⁶⁷ Petitioners argued that notwithstanding the results of the fuel burn analysis, the FAA failed to calculate "the total of direct and indirect emissions" resulting from the project.²⁶⁸ While the Petitioner lost this case, it was clear that it demanded higher standards of emissions inspection than that which was conducted by the FAA under the Clean Air Act.

Looking internationally, in 2009 The Air Transport Association of America (ATA) and three member carriers - American Airlines, Continental and United - brought suit against the UK Secretary of State for Energy and Climate Change²⁶⁹ on the legality of the European Union's plan to apply its Emissions Trading Scheme (ETS) to non-EU airlines. ATA's view is that the unilateral approach taken under the EU ETS violates critical international law principles and imposes costly policies on international aviation.²⁷⁰ Regarding this case, ATA's Vice President of Environmental Affairs stated, "The U.S. airline industry has adopted a set of measures and targets as part of the worldwide aviation industry commitment to a global framework on aviation emissions. Through this commitment, the U.S. airlines alone will save more than sixteen billion metric tons of greenhouse gas emissions through 2050 on top of substantial savings already achieved."²⁷¹

In the midst of this pending case, in May 2011 U.S.-based airlines and the China Air Transport Association officially challenged the EU's efforts to implement the ETS for the aviation sector.²⁷² This ETS requires that beginning January 2012, all airlines flying to and from Europe will be required to reduce their carbon emissions.²⁷³ Airlines will be issued emission permits; those airlines which overshoot their emission targets will be required to buy emission permits from those airlines which have complied and have surplus emission permits.²⁷⁴ The China Air Transport Association stated it and its airline members do not acknowledge the EU's ETS, claiming that it would cost them billions of Yuan each year.²⁷⁵

While the above cases are not inclusive, they represent the notion that the judicial system plays a definite role in the impact of the airline industry's past and future carbon footprint.

Section VII – Conclusion

The great question for the future of aviation is simply – are all of these regulations and goals enough to minimize the aviation industry's impact on the environment? It is impossible to answer such question in the present. In an industry where growth is guaranteed, and with growth comes an increase in aircraft use, the potential for continued climate change due to aircraft use is quite possible. However, amidst the growing concerns pertaining to aircraft emissions, it is clear that a myriad of agencies and organizations, both governmentally-run and privately-owned, covering an international scale, are working together to better understand the airline industry's footprint on the environment. With the creation of hefty regulations coupled with the aviation sector's commitment to reaching lofty environmental goals, the impact which the aviation sector has on the environment is at the very least the cornerstone of this industry's commitment to reduce aircraft emissions in our skies.

¹ See FAA Forecast Fact Sheet (2011), available at http://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=12440.

² See Bisignani, Giovanni, IATA, *The Risks to Our Profit Forecast for 2011 Are Very Real* (Apr. 2011) available at <http://www.iata.org/pressroom/airlines-international/index/pages/comment.aspx> (last visited May 18, 2011).

³ See <http://www.airbus.com/company/environment/climate-change/> (last visited May 18, 2011).

⁴ See FAA Forecast Fact Sheet, *supra*.

⁵ *Id.*

⁶ *Id.*

⁷ R.G. GRANT, *FLIGHT THE COMPLETE HISTORY* 11 (2002, 2007).

⁸ *Id.* at 132. The first daily international air service transport began in August 1919 between Hounslow, London and Le Bourget, Paris.

⁹ *Id.* at 134.

¹⁰ *Id.* at 138.

¹¹ See http://www.nwahistory.org/about_nwa.htm (last visited May 18, 2011).

¹² See <http://www.pbs.org/kcet/chasingthesun/companies/eastern.html> (last visited May 18, 2011).

¹³ See <http://panam.com/default1.asp> (last visited May 18, 2011).

¹⁴ See <http://www.boeing.com/history/chronology/chron03.html> (last visited May 18, 2011).

¹⁵ See <http://news.delta.com/index.php?s=18&cat=39> (last visited May 18, 2011).

¹⁶ See <http://www.aa.com/i18n/amrcorp/corporateInformation/facts/history.jsp> (last visited May 18, 2011).

¹⁷ CHRISTY, JOE, *AMERICAN AVIATION AN ILLUSTRATED HISTORY* 135 (1987).

¹⁸ *Id.* at 136.

¹⁹ GRANT, *supra* at 132.at 146. With the inception of Boeing's Model 247, which was capable of carrying 10 passengers at a top cruising speed of 155 mph, as well as the Douglas Commercial DC-1, DC-2 (which could carry 14 passengers) and DC-3 (which could carry 21 passengers), U.S. commercial air transport launched into the 20th Century.

²⁰ *Id.* at 146.

²¹ *Id.* Boeing designed the first two-engine aircraft in 1921 – the Model 247, and the first four-engine aircraft – the B-307 Stratoliner, in 1938.

²² *Id.* at 149.

²³ CHRISTY, *supra* at 122. The average income per flight was approximately \$0.43 per mile, while operation costs began about \$0.50 per mile to upward of \$0.80 per mile.

²⁴ GRANT, *supra* at 147.

²⁵ *Id.*

²⁶ *Id.* at 157.

²⁷ CHRISTY, *supra* at 155. The maiden voyage of the *China Clipper*, a Martin M-130 captained by Ed Musick, occurred on November 22, 1935. The M-130 was capable of carrying up to 70 passengers and flew at a top cruising speed of 180 mph. See GRANT, *supra* at 165.

²⁸ See GRANT, *supra* at 164 – 165. Notable commercial models included the Caproni Ca 60 Transaero, which carried up to 100 passengers and flew at a top cruising speed of 81 mph; the Latécoère “Late” 521, which carried up to 70 passengers and flew at a top cruising speed of 132 mph; the Sikorsky S-38, which carried 8 passengers and flew at a top cruising speed of 110 mph, and the Sikorsky S-42 which carried up to 32 passengers and flew at a top cruising speed of 170 mph.

²⁹ *Id.* at 157. See also GRANT, *supra* at 163.

³⁰ GRANT, *supra* at 163.

³¹ GRANT, *supra* at 376.

³² *Id.* at 380. This aircraft flew at a top cruising speed of 340 mph. Due to high operational costs as compared to other competitors’ manufacturing costs, only 55 Model 377’s were built.

³³ See GRANT, *supra* at 379 – 381. The Lockheed 1049G Super Constellation, which carried up to 109 passengers and flew at a top cruising speed of 327 mph was considered one of the most graceful airliners of all time. The Douglas DC-7C Seven Seas four-engine jet used energy efficient Write Turbo Compound engines, and carried up to 105 passengers with a top cruising speed of 360 mph. The DC-7C was the last of the prop-driven planes in the Pam Am fleet. See CHRISTY, *supra* at 160.

³⁴ GRANT, *supra* at 380.

³⁵ See *id.*

³⁶ *Id.*

³⁷ See *id.* The first turboprop airliner, the Vickers Viscount, was a British aircraft and came into inception in 1950.

³⁸ See GRANT, *supra* at 383. The first commercial jet, the deHavilland Comet, entered the scene in 1952. However, due to certain in-flight disasters in the mid-1950’s, lost its edge in the technology era. The Boeing 707 came into service in 1958, and flew transatlantic routes from New York to Paris and London. The Boeing 707 flew at a maximum cruising speed of 600 mph, and launched the airline industry into the era of the jet-powered engine.

³⁹ *Id.* at 385.

⁴⁰ *Id.*

⁴¹ The Boeing 727 along with its rear mounted trijet engines, was also designed with a complex multiflap wing married to a spacious fuselage. This aircraft became the world’s best-selling jet transport with 1,831 build by 1984. See GRANT, *supra* at 388.

⁴² See CHRISTY, *supra* at 333 – 334.

⁴³ GRANT, *supra* at 386.

⁴⁴ *Id.*

⁴⁵ See *id.* at 390 – 395.

⁴⁶ See *id.* at 393.

⁴⁷ *Id.* at 399. The Airbus A3XX was the original design for the super-jumbo jet, but was redesigned the A380 and carries 550 passengers. Its maiden voyage was in April 2005.

⁴⁸ See http://www.boeing.com/aboutus/environment/environmental_report_09/_inc/flash-2-3-2.html (last visited May 18, 2011).

⁴⁹ GRANT, *supra* at 429.

⁵⁰ *Id.*

⁵¹ According to the EPA, the term “transportation” includes the following engine categories: aircraft, diesel boats and ships, non-diesel program, gasoline boats and personal watercraft, forklifts, generators, compressors, lawn and garden engines, locomotives, snowmobiles, dirt bikes, and ATV’s. See <http://epa.gov/nonroad/> (last visited May 24, 2011).

⁵² Dempsey, Paul Stephen, *Trade & Transport Policy in Inclement Skies – The Conflict Between Sustainable Air Transportation and Neo-Classical Economics*, 65 J. Air L. & Com. 639, 640 (2000).

⁵³ *Id.* at 642. According to the U.S. Energy Information Administration’s International Energy Outlook Highlights of 2010, transportation accounts for 30% of the world’s carbon dioxide (CO₂) emissions. See <http://www.eia.doe.gov/oiaf/ieo/highlights.html> (last visited May 24, 2011).

⁵⁴ See <http://www.epa.gov/otaq/climate/basicinfo.htm> (last visited May 24, 2011) which indicates that CO₂ is the most prevalent greenhouse gas.

⁵⁵ See <http://www.epa.gov/otaq/climate/basicinfo.htm> (last visited May 31, 2011).

⁵⁶ *Id.* According to the EPA, transportation accounts for 47% of the net increase in total U.S. emissions since 1990. See <http://www.epa.gov/otaq/climate/basicinfo.htm> (last visited May 24, 2011).

⁵⁷ See Reagan, Daniel B., *Note, Putting International Aviation Into the European Union Emissions Trading Scheme: Can Europe Do It Flying Solo?*, 35 B.C. Envtl. Aff. L. Rev., 349,349 (2008). See also Intergovernmental Panel on Climate Change [IPCC], *Aviation and the Global Atmosphere: Summary for Policy Makers*, at 3 (1999).

⁵⁸ Aircraft account for approximately 4% of the annual global CO₂ emissions from fossil fuels near the earth’s surface as well as at high altitudes. See <http://www.nasa.gov/centers/glenn/about/fs10grc.html> (last visited May 23, 2011).

⁵⁹ Dempsey *supra* at 643.

⁶⁰ IPCC, *Aviation and the Global Atmosphere: Summary for Policy Makers* Web Publication (2001) at Section 1.1., available at http://www.grida.no/publications/other/ipcc_sr/?src=/climate/ipcc/aviation/index.htm (last visited May 23, 2011). Ultraviolet B radiation (also known as UV-B) is the chief cause of skin reddening and sunburn, and tends to damage the skin’s more superficial epidermal layers. It plays a key role in the development of skin cancer. See <http://www.skincancer.org/understanding-uva-and-uvb.html> (last visited May 23, 2011).

⁶¹ Dempsey, *supra* at 640.

⁶² *Id.*

⁶³ See the Department of Transportation and FAA *Air Quality Procedures For Civilian Airports & Air Force Bases*, (1997) Appendix C: Key Pollutants at C-5. (hereinafter, “FAA Air Quality Procedures”).

⁶⁴ *Id.*

⁶⁵ See <http://www.nasa.gov/centers/glenn/about/fs10grc.html> (last visited May 11, 2011).

⁶⁶ *Id.*

⁶⁷ *Id.*

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- ⁶⁸ See <http://www.epa.gov/apti/ozonehealth/what.html> (last visited May 31, 2011).
- ⁶⁹ See FAA Air Quality Procedures *supra* at Appendix C: Key Pollutants at C-6, Section C1.1
- ⁷⁰ *Id.*
- ⁷¹ *Id.*
- ⁷² *Id.* at C-7. Note, the term “climbout” when used in aviation refers to the actual operation of increasing the altitude of an aircraft as well as the logical phase of an aircraft flight following take-off and preceding the aircraft reaching cruising altitude.
- ⁷³ See <http://www.nasa.gov/centers/glenn/about/fs10grc.html> (last visited May 13, 2011).
- ⁷⁴ See http://climatelab.org/Airplane_emissions under “Climate Impact” section (last visited May 11, 2011).
- ⁷⁵ See <http://earthobservatory.nasa.gov/IOTD/view.php?id=49040> (last visited May 12, 2011).
- ⁷⁶ *Id.*
- ⁷⁷ See FAA Air Quality Procedures *supra* at C-7, Section C1.2.
- ⁷⁸ *Id.*
- ⁷⁹ See <http://www.nasa.gov/centers/glenn/about/fs10grc.html> (last visited May 13, 2011).
- ⁸⁰ See FAA Air Quality Procedures *supra* at C-7, Section C1.2.
- ⁸¹ *Id.*
- ⁸² Note, the term “Off-Highway Vehicles” includes aircraft. Data accumulated from World Resources Institute – CO Inventory Report for Calendar Year 2008 (documenting CO Emissions Trends by Source, 2003 – 2008) *available at* http://pdf.wri.org/wri_co2_inventory_report_2008.pdf (last visited May 27, 2011).
- ⁸³ See FAA Air Quality Procedures *supra* at C-7, Section C1.2.
- ⁸⁴ See http://www.eoearth.org/article/Carbon_dioxide (last visited May 11, 2011).
- ⁸⁵ See <http://timeforchange.org/CO2-cause-of-global-warming> (last visited May 27, 2011).
- ⁸⁶ See <http://www.epa.gov/climatechange/emissions/co2.html> (last visited May 11, 2011).
- ⁸⁷ *Id.*
- ⁸⁸ See Intergovernmental Panel on Climate Change [IPCC] *Special Report on Aviation and the Global Atmosphere* (1999).
- ⁸⁹ Data accumulated from World Resources Institute – CO₂ Inventory Report for Calendar Year 2008 (for data accumulated during years 2003 – 2008) *available at* http://pdf.wri.org/wri_co2_inventory_report_2008.pdf (last visited May 27, 2011).
- ⁹⁰ See <http://www.epa.gov/climatechange/emissions/co2.html> (last visited May 11, 2011).
- ⁹¹ *Id.*
- ⁹² See FAA Air Quality Procedures *supra* at C-7, Section C1.3.
- ⁹³ *Id.*

⁹⁴ *Id.*

⁹⁵ *Id.* See also EPA National Emissions Inventory Air Pollutant Emissions Trend Data 1970 – 2008 available at <http://www.epa.gov/ttn/chieftrends/index.html> (last visited May 27, 2011).

⁹⁶ Note, the term “Off-Highway Vehicles” includes aircraft. Data accumulated from World Resources Institute – CO₂ Inventory Report for Calendar Year 2008 (data accumulated for years 2003 – 2008) available at http://pdf.wri.org/wri_co2_inventory_report_2008.pdf (last visited May 27, 2011). Data retrieved from PM-10 Emissions with Condensibles spreadsheet.

⁹⁷ See FAA Air Quality Procedures *supra* at C-7, Section C1.3.

⁹⁸ *Id.* at C-8, Section C1.4.

⁹⁹ *Id.*

¹⁰⁰ *Id.*

¹⁰¹ *Id.*

¹⁰² Note that “Off-Highway Vehicles” includes aircraft. Data accumulated from World Resources Institute – CO₂ Inventory Report for Calendar Year 2008 (data accumulated for years 2003 – 2008) available at http://pdf.wri.org/wri_co2_inventory_report_2008.pdf (last visited May 27, 2011).

¹⁰³ See <http://www.nasa.gov/centers/glenn/about/fs10grc.html> (last visited May 13, 2011).

¹⁰⁴ *Id.*

¹⁰⁵ *Id.*

¹⁰⁶ *Id.*

¹⁰⁷ *Id.*

¹⁰⁸ See <http://www.nasa.gov/centers/glenn/about/fs10grc.html> (last visited May 13, 2011).

¹⁰⁹ *Id.*

¹¹⁰ See FAA Air Quality Procedures *supra* at C-8, Section C1.4.

¹¹¹ See FAA Air Quality Procedure *supra* at Section C1.5.

¹¹² *Id.*

¹¹³ *Id.* See also <http://www.epa.gov/oaqps001/nitrogenoxides/> (last visited May 27, 2011).

¹¹⁴ Data accumulated from a 2006 study in Ontario, Canada which shows that two-thirds of all NO₂ emissions in that location come from the transportation sector. Data available at <http://www.airqualityontario.com/science/pollutants/nitrogen.cfm> (last visited May 27, 2011).

¹¹⁵ See FAA Air Quality Procedure *supra* at Section C1.6.

¹¹⁶ *Id.*

¹¹⁷ See <http://www.epa.gov/oaqps001/lead/health.html> (last visited May 27, 2011).

¹¹⁸ *Id.*

¹¹⁹ Data accumulated from a 2005 study by the EPA. Data *available at* <http://www.epa.gov/air/emissions/pb.htm> (last visited May 27, 2011).

¹²⁰ *See* FAA Air Quality Procedure *supra* at Section C1.6.

¹²¹ *Id.*

¹²² *See* FAA Forecast Fact Sheet (2011), *available at* http://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=12440 (last visited May 29, 2011).

¹²³ *See* Bisignani, Giovanni, IATA, *The Risks to Our Profit Forecast for 2011 Are Very Real* (Apr. 2011) *available at* <http://www.iata.org/pressroom/airlines-international/index/pages/comment.aspx> (last visited May 15, 2011).

¹²⁴ *See* <http://www.airbus.com/company/environment/climate-change/> (last visited May 18, 2011).

¹²⁵ *See* Intergovernmental Panel on Climate Change [IPCC] *Special Report on Aviation and the Global Atmosphere* (1999).

¹²⁶ *See* Aircraft & Emissions: A Primer *available at* http://www.faa.gov/regulations_policies/policy_guidance/envir_policy/media/AEPRIMER.pdf (last visited May 31, 2011).

¹²⁷ *See* Recommended Best Practice for Quantifying Speciated Organic Gas Emissions from Aircraft Equipped With Turbofan, Turbojet, and Turboprop Engines (hereinafter, Recommended Best Practice) *available at* http://www.faa.gov/regulations_policies/policy_guidance/envir_policy/media/AEPRIMER.pdf (last visited May 31, 2011).

¹²⁸ *Id.*

¹²⁹ *Id.*

¹³⁰ *Id.*

¹³¹ *Id.*

¹³² *Id.*

¹³³ *Id.*

¹³⁴ *Id.*

¹³⁵ *See* Procedures in the Emissions Certification of Aircraft Engines, Annex 16, Volume II, International Civil Aviation Organization *available at* <http://www.icao.int> (last visited May 31, 2011).

¹³⁶ *See* Recommended Best Practice, *supra*. Note that aircraft emissions are typically expressed in units of pounds per day or tons per year for each pollutant. Note further that the term “speciated”, when referring to OGs emitted from aircraft is essentially an advanced term used for quantifying the different gases (e.g., CO₂ and NO_x) emitted from various combustion engines (e.g., turbofan, turbojet and turboprop).

¹³⁷ *Id.*

¹³⁸ *Id.*

¹³⁹ *See id.*, pp. 14-17 for examples of these calculations.

¹⁴⁰ *See* http://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=8768 (last visited May 31, 2011).

¹⁴¹ *Id.*

¹⁴² *Id. Note*, during 2010 NextGen made flying safer by giving pilots nearly total access to stabilized approach procedures with three-dimensional precision using PBN. It made air transportation more efficient by moving aircraft in and out of airports faster and by making better use of airspace. It gave pilots and air traffic controllers new capabilities that allow them to see the exact location of surrounding aircraft. It reduced aviation's environmental impact from some operations using capabilities that allow aircraft to burn less fuel, emit fewer greenhouse gases and reduce noise. More information on NextGen's achievements *available at* http://www.faa.gov/nextgen/media/ng2011_implementation_plan.pdf (last visited May 31, 2011).

¹⁴³ *See* FAA's NextGen Implementation Plan (hereinafter NextGen Plan) (March 2011) at 6, *available at* http://www.faa.gov/nextgen/media/ng2011_implementation_plan.pdf (last visited May 31, 2011).

¹⁴⁴ *Id.* at 5.

¹⁴⁵ *Id.*

¹⁴⁶ Information on ADS-B *available at* NextGen Plan, *supra* at 8.

¹⁴⁷ *Id.* at 27.

¹⁴⁸ *Id.*

¹⁴⁹ *Id.*

¹⁵⁰ *Id.* at 7, 39.

¹⁵¹ *Id.* at 11.

¹⁵² *Id.*

¹⁵³ *See* <http://www.epa.gov/aboutepa/whatwedo.html> (last visited May 16, 2011).

¹⁵⁴ *Id.*

¹⁵⁵ *See* <http://www.epa.gov/otaq/aviation.htm> (last visited May 16, 2011).

¹⁵⁶ 42 U.S.C. §7401.

¹⁵⁷ *See id.* at §7401(b).

¹⁵⁸ *See id.* at §§7571 – 7574.

¹⁵⁹ 40 C.F.R. Part 50 (2008).

¹⁶⁰ 42 U.S.C. §7403(b)(6).

¹⁶¹ *Id.* at §7403(g)(1).

¹⁶² *See* 40 C.F.R. Part 58 [EPA-HQ-OAR-2006-0735; FRL-]. *Note*, three criteria were used to select airports for the lead monitoring study – (1) lead emissions with greater than or equal to 0.50 tons per year, (2) airport runway configuration and meteorology that lead to a greater frequency of operations from one or two runways, and (3) ambient air within 150 meters of the location(s) of maximum emissions *available at* <http://www.epa.gov/otaq/regs/nonroad/aviation/memo-selc-airport-monstdy.pdf> (last visited May 16, 2011).

¹⁶³ 40 C.F.R. Part 87 [EPA-HQ-OAR-2007-0294; FRL-9141-7].

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- ¹⁶⁴ Friends of the Earth October 3, 2006 Petition *available at* <http://www.epa.gov/otaq/regs/nonroad/aviation/foe-20060929.pdf>.
- ¹⁶⁵ Project Plan *available at* <http://www.epa.gov/otaq/regs/nonroad/aviation/420r09904.pdf>.
- ¹⁶⁶ *See* <http://www.epa.gov/otaq/aviation.htm> (last visited May 16, 2011).
- ¹⁶⁷ *See* <http://www.epa.gov/otaq/regs/nonroad/aviation/420r05004.pdf> (last visited May 16, 2011).
- ¹⁶⁸ *See* <http://www.epa.gov/otaq/aviation.htm> (last visited May 16, 2011).
- ¹⁶⁹ *See* <http://www.epa.gov/oms/regs/nonroad/aviation/420f05015.htm> (last visited May 17, 2011).
- ¹⁷⁰ *Id.*
- ¹⁷¹ *Id.*
- ¹⁷² Convention on International Civil Aviation, Apr. 4, 1947, T.I.A.S. No. 1591, 15 U.N.T.S. 295 [hereinafter Chicago Convention].
- ¹⁷³ *See* <http://www.icao.int/icao/net/dcs/7300.html> (last visited May 16, 2011).
- ¹⁷⁴ *Id.*
- ¹⁷⁵ *See* <http://www.icao.int/icao/en/env2010/Index.html> (last visited May 16, 2011).
- ¹⁷⁶ *Id.*
- ¹⁷⁷ *Id.*
- ¹⁷⁸ *See* Int'l Civil Aviation Org. [ICAO], *Consolidated Statement of Continuing ICAO Policies and Practices Related to Environmental Protection*, A37-WP/24. Resolutions A37-18 [hereinafter ICAO Resolution A37-18] and A37-19 [hereinafter ICAP Resolution A37-19] for the most recent updates in 2010 *available at* http://www.icao.int/icao/en/env2010/A37_Res18_en.pdf and http://www.icao.int/icao/en/env2010/A37_Res19_en.pdf.
- ¹⁷⁹ *See* ICAO Resolution *supra* A37-19.
- ¹⁸⁰ *See* Intergovernmental Panel on Climate Change [IPCC], *Aviation and the Global Atmosphere* (Nov. 2000).
- ¹⁸¹ *See id.* at Preface.
- ¹⁸² *See id.* at Summary for Policymakers, Section 2: How Do Aircraft Affect Climate Change.
- ¹⁸³ *See id.* at Summary for Policymakers - Section 4.8: What Are the Overall Climate Effects of Subsonic Aircraft?
- ¹⁸⁴ *See* Intergovernmental Panel on Climate Change [IPCC], c/o World Meteorological Organization (WMO), *Climate Change 2007 – Synthesis Report* (2008).
- ¹⁸⁵ *Id.* at Summary for Policymakers – Introduction - Section 1: Observed Changes in Climate and Their Effects.
- ¹⁸⁶ *See id.* at Introduction – Section 2: Causes of Change.
- ¹⁸⁷ *Id.*
- ¹⁸⁸ *Id.* at Summary for Policymakers - Introduction - Section 3: Projected Climate Change and Its Impact.
- ¹⁸⁹ *See* <http://www.icao.int/icao/en/Env2010/Aee.htm> (last visited May 17, 2011).

¹⁹⁰ Kyoto Protocol to the United Nations Framework Convention on Climate Change, Dec. 10, 1997, 37 I.L.M. 22 [hereinafter, Kyoto Protocol].

¹⁹¹ *Id.* at art. 2.2. See also Daniel B. Reagan, *Note: Putting International Aviation into the European Union Emissions Trading Scheme: Can Europe Do it Flying Solo?*, 35 B.C. Envtl. Aff. L. Rev. 349, 356 (2008).

¹⁹² See http://unfccc.int/kyoto_protocol/items/2830.php (last visited May 24, 2011).

¹⁹³ Kyoto Protocol at Annex B.

¹⁹⁴ *Id.* at Annex A. The six identified gases are: Carbon Dioxide (CO₂), Methane (CH₄), Nitrous Oxide (N₂O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs) and Sulfurhexafluoride (SF₆).

¹⁹⁵ See <http://www.icao.int/icao/en/env2010/Index.html> (last visited May 17, 2011).

¹⁹⁶ See <http://www.iata.org/about/Pages/mission.aspx> (last visited May 17, 2011).

¹⁹⁷ See <http://www.iata.org/membership/Pages/airlines.aspx> (last visited May 17, 2011).

¹⁹⁸ See <http://www.iata.org/whatwedo/environment/Pages/index.aspx> (last visited May 17, 2011).

¹⁹⁹ International Air Transport Association [IATA], *A Global Approach To Reducing Aviation Emissions First Stop: Carbon-Neutral Growth From 2020* (2009).

²⁰⁰ *Id.* at IATA's Four Pillar Strategy.

²⁰¹ See International Air Transport Association [IATA], *Aviation and Climate Change Pathway to Carbon-Neutral Growth in 2020* (2009).

²⁰² The Boeing Company (hereinafter, Boeing) had 2010 net revenues of US\$64 billion in 2010 as compared to \$68 billion in 2009 per the Company's 4th Quarter and Full Year Results 2010 available at http://www.boeing.com/news/releases/2011/q1/110126a_nr.pdf (last visited May 28, 2011). Boeing employs more than 159,000 persons in 70 countries worldwide.

²⁰³ See <http://www.boeing.com/companyoffices/aboutus/brief.html> (last visited May 17, 2011).

²⁰⁴ See <http://www.boeing.com/aboutus/environment/index.htm> (last visited May 17, 2011).

²⁰⁵ See <http://www.boeing.com/aboutus/environment/policies.html> (last visited May 17, 2011).

²⁰⁶ Information on the ERA Project available at <http://www.aeronautics.nasa.gov/isrp/era/index.htm> (last visited May 17, 2011).

²⁰⁷ Airbus is a division of European Aeronautic Defense and Space Company (EADS). According to the EADS Annual Report 2010 available at <http://www.eads.com/eads/int/en/investor-relations/events-reports/annual-report/2010.html> (last visited May 18, 2011) Airbus' 2010 net revenue was €29.9 billion, up from the 2009 net revenue of €28 billion. Airbus employs 52,500 employees encompassing 80 nationalities.

²⁰⁸ See <http://www.airbus.com/company/environment/> (last visited May 17, 2011).

²⁰⁹ See <http://www.airbus.com/company/environment/climate-change/> (last visited May 17, 2011).

²¹⁰ See <http://www.airbus.com/company/market/gmf2010/> for a direct link to the pdf version of this *Forecast*.

²¹¹ See <http://www.airbus.com/company/environment/> and <http://www.atag.org/content/default.asp> (last visited May 18, 2011).

²¹² See <http://www.airbus.com/company/environment/climate-change/> (last visited May 18, 2011).

²¹³ *Id.*

²¹⁴ *Id.*

²¹⁵ See <http://www.icao.int/icao/en/Env2010/ClimateChange/AlternativeFuels.htm> (last visited May 19, 2011).

²¹⁶ *Id.*

²¹⁷ See Int'l Civil Aviation Org. [ICAO], *Annex 16 – Environmental Protection, Volume II – Aircraft Engine Emissions to the Convention on International Civil Aviation*, available at http://www.icao.int/eshop/pub/anx_info/an16_info_en.pdf

²¹⁸ *Id.*

²¹⁹ See <http://www.icao.int/icao/en/Env2010/TechnologyStandards.htm> (last visited May 19, 2011).

²²⁰ *Id.*

²²¹ International Air Transport Association [IATA], *A Global Approach To Reducing Aviation Emissions First Stop: Carbon-Neutral Growth From 2020* (2009,) available at http://www.iata.org/SiteCollectionDocuments/Documents/Global_Approach_Reducing_Emissions_251109web.pdf.

²²² *Id.*

²²³ *Id.*

²²⁴ *Id.* at Pillar 1 – Technology.

²²⁵ *Id.*

²²⁶ *Id.* at Pillar 2 – Operations.

²²⁷ *Id.* Note that in 2008 IATA's Green Team saved 1 million tons of CO₂.

²²⁸ *Id.* at Pillar 3 – Infrastructure.

²²⁹ *Id.* at Pillar 4 – Economic Measures.

²³⁰ *Id.*

²³¹ See <http://www.iata.org/whatwedo/environment/Pages/index.aspx> (last visited May 18, 2011).

²³² See http://www.boeing.com/aboutus/environment/environment_report_10/3_performance_pg_1.html (last visited May 18, 2011).

²³³ *Id.*

²³⁴ *Id.*

²³⁵ *Id.*

²³⁶ *Id.*

²³⁷ *Id.*

²³⁸ *Id.*

²³⁹ See <http://www.airbus.com/innovation/future-by-airbus/research-technology/> (last visited May 18, 2011).

²⁴⁰ See <http://www.airbus.com/innovation/future-by-airbus/concept-planes/> (last visited May 18, 2011).

²⁴¹ *Id.*

²⁴² Bombardier Aerospace (hereinafter, Bombardier) is a Canadian-based world leader in design, manufacture and support of innovative aviation products for the business, commercial, specialized and amphibious aircraft markets. According to Bombardier's 2011 Annual Report, net revenues were down in 2010 (US\$19,366 billion) as compared to 2009 (US\$19,721 billion). Of these numbers, US\$9.4 billion of the 2009 revenue was attributable to the aeronautics division of Bombardier as compared to US\$10 billion in 2008. Bombardier's 20 year forecast anticipates deliveries in the 100 – 149 seat mainland aircraft at 6,700 worth US\$393 billion. At present, Bombardier employs 28,700 permanent employees. Bombardier's 2011 Annual Report available at http://www.bombardier.com/files/en/supporting_docs/BI-Bombardier_Annual_Report_FY2010-11.pdf.

²⁴³ Embraer-Empresa Brasileira de Aeronáutica S.A. (hereinafter Embraer) is a Brazilian-based manufacturer of commercial, corporate and military aircraft. According to its 2009 Annual Report's Corporate Profile available at http://www1.embraer.com.br/relatorios_anuais/relatorio_2009/english/index.html, during the company's forty year history it has produced more than 5,000 aircraft which operate in 88 countries. According the Embraer's 2010 United States Securities and Exchange Commission Form 20-F available at http://ri.embraer.com.br/Embraer/ShowResultados.aspx?id_materia=NhgzWbS/o8oSOlow8ZzAeg==&id_vinculo=NhgzWbS/o8oSOlow8ZzAeg==&id_canal=yIPU%20SWBRqiRmJwFawb/Dg== (last visited May 28, 2011) at the close of 2010 Embraer's net revenue was US\$5497.8 as compared to US\$5364.1 in 2009.

²⁴⁴ See Bombardier 2011 Annual Report at 85.

²⁴⁵ The CSeries family of aircraft is Bombardier's entry into the 100 – 149 seat commercial aircraft market segment.

²⁴⁶ See <http://www.bombardier.com/en/aerospace/products/commercial-aircraft/cseries?docID=0901260d800091e6> (last visited May 18, 2011).

²⁴⁷ *Id.*

²⁴⁸ See Embraer Market Outlook 2010 – 2029 at 6.

²⁴⁹ *Id.*

²⁵⁰ See <http://www.continental.com/web/en-US/content/company/globalcitizenship/environment.aspx> (last visited May 18, 2011).

²⁵¹ See <http://www.continental.com/web/en-US/content/company/globalcitizenship/awards.aspx?Mobile=1> (last visited May 18, 2011).

²⁵² See <http://verantwortung.lufthansa.com/en/environment/environmental-strategy.html> (last visited May 18, 2011).

²⁵³ *Id.*

²⁵⁴ *Id.*

²⁵⁵ See <http://www.virgin-atlantic.com/en/us/allaboutus/environment/ouractions.jsp> (last visited May 18, 2011).

²⁵⁶ *Id.*

²⁵⁷ See http://www.seatguru.com/articles/green_aircraft_and_airlines.php (last visited May 18, 2011).

²⁵⁸ See <http://www.virgin-atlantic.com/en/us/allaboutus/pressoffice/faq/climatechange.jsp> (last visited May 18, 2011).

²⁵⁹ 489 F. 3d 1221; 376 U.S. App. D.C. 385 (D.C. App. 2007).

²⁶⁰ The Petitioner's argument specifically pertained to the EPA's interpretation of §231 of the Clean Air Act, 42 U.S.C.S. §7571 regarding increasing the stringency of certain emission standards applicable to newly certified commercial aircraft gas turbine engines.

²⁶¹ *West Virginia v. EPA*, 360 U.S. App. D.C. 419, 362 F.3d 861, 865 – 67 (D.C. Cir. 2004).

²⁶² *NACCA v. EPA supra* at 14.

²⁶³ *Id.* See also *West Virginia v. EPA supra* at 865 – 867. Note, the Court's discussion of the *West Virginia* case pertained to the issue of whether NACAA had standing to sue the EPA.

²⁶⁴ *Id.* at 22.

²⁶⁵ See *County of Rockland, New York, Et. Al v. FAA*, 335 Fed. Appx. 52 (D.C. Cir. 2009).

²⁶⁶ *Id.* at 12.

²⁶⁷ *Id.*

²⁶⁸ *Id.* at 13. See also 40 C.F.R. § 93.153(c)(1) of the Clean Air Act which requires that the FAA conduct a full-scale conformity determination of the project as to whether it will result in at most de minimis emissions of critical pollutants.

²⁶⁹ Case C-366/10. A discussion of this case available at http://www.airlines.org/News/Releases/Pages/news_5-27-10.aspx (last visited May 26, 2011).

²⁷⁰ See http://www.airlines.org/News/Releases/Pages/news_5-27-10.aspx (last visited May 26, 2011).

²⁷¹ *Id.*

²⁷² See <http://www.climate-connect.co.uk/Home/?q=node/663> (last visited May 26, 2011).

²⁷³ *Id.*

²⁷⁴ *Id.*

²⁷⁵ See http://www.chinadaily.com.cn/china/2011-05/10/content_12475857.htm (last visited May 26, 2011).