

Task 9: Reduce Harmful Air Emissions

Emission Reduction Opportunities and Recommendations



Prepared for: **Broward County Aviation Department**
Fort Lauderdale, Florida

October 2007



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NOTE: Archive photo on the cover was not taken at Ft. Lauderdale Hollywood International Airport and is not typical for any commercial aircraft now in operation. It was used as an extreme example of aircraft air emissions. Today's aircraft and airport operations are considerably cleaner than those of that era.

Task 9: Reduce Harmful Air Emissions

Prepared for

Broward County Aviation Department

Ft. Lauderdale, Florida

Prepared by

Clean Airport Partnership, Inc.

Environmental Consulting Group, Inc.

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Final Report

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ACRONYMS

APU – Auxiliary Power Unit

BCAD – Broward County Aviation Department

BCC – Broward County Board of County Commissioners

CAP – Clean Airport Partnership, Inc.

CO – Carbon Monoxide

CO₂ – Carbon Dioxide

DOT – US Department of Transportation

EPA – US Environmental Protection Agency

EDMS – Emissions and Dispersion Modeling System

FAA – US Federal Aviation Administration

FDEP – Florida Department of Environmental Protection

FDOT – Florida Department of Transportation

FLL – Ft. Lauderdale-Hollywood International Airport

IM – Impact Metric

LTO – Landing and Take Off

NO_x – Nitrogen Oxides

SO_x – Sulfur Oxides

VOC – Volatile Organic Compounds

1. Executive Summary

The Clean Airport Partnership (CAP) and its team of subcontractors reviewed a wide range of operations at Ft. Lauderdale-Hollywood International Airport (FLL) to characterize the airport's environmental impacts. For this report, air emissions from aircraft, ground support equipment, and auxiliary power units were quantified. Estimates of emissions from the cars, trucks, buses, and other highway vehicles that operate on the landside of the airport were also developed. Opportunities to reduce these emissions were subsequently evaluated.

Broward County does not have a serious air quality problem currently although airport air emissions are expected to increase in the future with growing demand for air travel. Aircraft operations, ground service equipment, and landside vehicles present significant opportunities for further improving air quality at FLL.

Aircraft operations are the dominant source of mobile emissions, but they are not under the direct control of BCAD. For that reason, the CAP team recommends BCAD establish an airport-wide policy for all operating entities to identify and follow industry best practices for reducing emissions and fuel use. BCAD should then lead a multi-step, collaborative process, working with representatives of all tenant airlines, FAA, and researchers and academicians with expertise in aviation emissions to establish best operating practices for reducing emissions and fuel use.

Many airlines already practice fuel saving/emission reducing measures and find the fuel savings pay for pilot training and any other costs associated with their implementation. On that basis, it is likely that all major carriers would similarly be able to implement the best practices at little or, more probably, no net cost, achieving significant emissions reductions for no net investment.

Ground service equipment, including baggage tugs, tows, and service vehicles, contribute significant pollution disproportionate to their numbers because of their long operating life, their long daily operating schedule, and their inefficient stop/start operating cycle. The CAP team evaluated several alternative fuels for GSE that would have a positive environmental impact, including compressed natural gas, electricity, and biodiesel.

As with the aircraft, most of the GSE at FLL are owned and operated by the primary tenant airlines and most of the GSE fueling is done under contract with a third-party service company. Based on the analysis of the various alternatives for reducing air emissions from GSE at FLL, the CAP team recommends using B20 biodiesel to fuel all diesel GSE. Since B20 is a drop in replacement for essentially all diesel engines, this is expected to be a relatively simple strategy, at competitive cost, that will have meaningful environmental benefits. This is one of the two primary recommendations of this report.

Landside vehicle pollution comes from fuel combustion with minor evaporative fuel emissions. Combustion emissions are generated during start-up, driving, and idling, while evaporative emissions occur primarily when the vehicle is parked. Strategies for controlling emissions from landside vehicles include those to reduce the number of vehicle miles traveled, ease congestion, or convert to less polluting vehicles or fuel.

Several recommendations are made to reduce or eliminate trips and miles traveled, update vehicle fleets, reduce congestion, and encourage low emission operating practices. Targets for these recommendations include airport fleets, roadways, and facilities like parking lots, employee vehicles, passenger vehicles, and commercial vehicles that operate regularly at the airport. The second primary recommendation of this report is the implementation of an automated vehicle identification system (AVI) to manage commercial traffic circulating through the airport roadway, which would reduce both congestion and emissions. The third primary recommendation is to examine the viability of consolidating hotel shuttle services to further reduce vehicle trips and pollution.

Combined, the recommendations made in this report will substantially reduce air emissions from airport activities and reduce the use of petroleum-based fuel. Most recommendations can be achieved at nominal cost.

2. Air Quality Improvements at FLL

2.1. Introduction

This report is one of several that collectively comprise the Green Airport Initiative (GAI) at Ft. Lauderdale-Hollywood International Airport (FLL). The GAI is designed to help FLL improve environmental quality and operational efficiency, and become a community model for sustainable development.

Evaluating strategies to reduce air emissions at the airport is one of the important goals of the GAI. Air emissions from aircraft, auxiliary power units, ground support equipment, and from the cars, trucks, buses, and other highway vehicles that operate on the landside of the airport were evaluated along with strategies for mitigating or reducing their emissions. This report presents that analysis. Three primary recommendations made in this report are:

- Change from conventional diesel fuel to B20, a fuel blend of conventional diesel and 20% biodiesel, to reduce emissions from ground support equipment.
- Implement an AVI system to reduce the amount of circulating commercial traffic moving through the airport to reduce landside congestion and to reduce emissions from the commercial vehicles.
- Consolidate hotel shuttle services to reduce vehicle miles traveled and concomitant pollution.

Several other recommendations also made to reduce air emissions are included in this report:

- Provide a forum for airlines to learn about and discuss best practices for environmentally sensitive operations.
- Adopt policies to encourage best practices by airlines in their ground operations for reducing aircraft fuel burn and emissions.
- Participate in FAA and other Federal agency projects that demonstrate technologies and operating procedures for reducing aircraft fuel burn and emissions.

- Adopt a series of strategies focused on improving traffic flow, ride sharing, and expanding the use of clean operating vehicles on landside operations.

Broward County does not have a serious air quality problem currently although airport air emissions are expected to increase in the future with growing demand for air travel and federal and state regulatory limits are often reduced. Initiating the recommendations in this report will be important first steps to managing air quality impacts in the future.

2.2. Purpose

The purpose of this project is to provide the Broward County Aviation Department (BCAD) with guidelines for working with tenants, passengers, and other airport customers to reduce air emissions that result from airport activity but are not under the direct control of the airport.

2.3. Scope

The project team evaluated air emissions from the largest sources that operate at FLL airport. The analysis focused on commercial aircraft operations and the ground support equipment that support them. Emission mitigation strategies used at other airports and best practices from similar operations were identified and evaluated. Operations of landside vehicles also were studied for private passenger vehicles, passenger-oriented commercial vehicles, employee vehicles, airport fleets, construction vehicles, and delivery and service vehicles.

2.4. Report Organization

This report presents analyses of airport air emissions and strategies to mitigate or avoid them. Section 3 addresses aircraft operations at the gate, on the ground, and in terminal area airspace. Section 4 describes the use of ground support equipment and means for reducing their emissions. Section 5 discusses strategies to reduce emissions from landside vehicle operations. Recommendations for mitigating emissions are made in each section.

3. Aircraft Operations at FLL

3.1. Introduction

Population increases and rising per capita income stimulate demand for air travel over time. Local factors like the increasing cruise business operating out of Port Everglades also drive demand for air travel into the Ft. Lauderdale area. While air travel makes a significant contribution to the south Florida economy, it also is the source of a range of environmental impacts, including air emissions.

Primary sources of air emissions at FLL include aircraft and their auxiliary power units (APU), ground support equipment (GSE), which service aircraft, and landside (or airport access) vehicles. The latter category includes traffic to and from the airport and shuttle buses and vans serving passengers. Other emissions sources at the airport include auxiliary power units providing electricity and air conditioning to aircraft parked at airport terminal gates, stationary airport power sources, construction equipment operating on the airport, maintenance activities such as painting, and fuel tanks. Aircraft are the most significant source of air emissions at the airport.

The U.S. Clean Air Act establishes National Ambient Air Quality Standards (NAAQS). These standards are based on extensive research to define concentrations of pollutants deemed to be healthy. Because FLL is located with large expanses of preserved, undeveloped lands of the Everglades on the west and the Atlantic Ocean to the east, the Ft. Lauderdale area does not have serious air quality problems, as do many other U.S. cities of similar size. There are still two or three days a year, however, when smog exceeds the NAAQS. This often occurs when pollutants released in the morning by cars, aircraft, power plants, lawnmowers, cruise ships, and boats of all sizes are blown offshore to “cook” all day only to be blown back onshore in the evenings.

With any major expansion, the airport must ensure it conforms to Federal local air quality regulations and does not cause any air quality impairment. Under current forecasts, air emissions at FLL are projected to be within Federal limits, however, there still are air quality concerns that must be considered in airport operations and planning. To do their share to preserve the health and environmental quality of the region and to allow future growth it is important for FLL to reduce emissions from airport operations where

feasible. The following section describes opportunities for FLL and its tenants to reduce their air emissions.

3.2. Air Emissions from Aircraft Operations

Aircraft jet engines and most other vehicle engines produce carbon dioxide (CO₂), water vapor (H₂O), nitrogen oxides (NO_x), carbon monoxide (CO), oxides of sulfur (SO_x), unburned or partially combusted hydrocarbons (HC) (also known as volatile organic compounds (VOCs)), particulates, and other trace compounds. A small subset of the VOCs and particulates are considered hazardous air pollutants (HAPs). Aircraft engine emissions are roughly composed of about 70 percent CO₂, a little less than 30 percent H₂O, and less than 1 percent each of NO_x, CO, SO_x, VOC, particulates, and other trace components including HAPs. Emissions of carbon dioxide (CO₂), the most prevalent greenhouse gas, contribute to global climate change, which could eventually contribute to warming of the atmosphere with subsequent sea level rise. Even modest sea level rise and increased storm intensity due to climate

Emissions from Combustion Processes

CO₂ – Carbon dioxide is the product of complete combustion of hydrocarbon fuels like gasoline, jet fuel, and diesel. Carbon in fuel combines with oxygen in the air to produce CO₂.

H₂O – Water vapor is the other product of complete combustion as hydrogen in the fuel combines with oxygen in the air to produce H₂O.

NO_x – Nitrogen oxides are produced when air passes through high temperature/high pressure combustion and nitrogen and oxygen present in the air combine to form NO_x.

HC – Hydrocarbons are emitted due to incomplete fuel combustion. They are also referred to as volatile organic compounds (VOCs) and these terms are used interchangeably in this report. Many VOCs are also hazardous air pollutants.

CO – Carbon monoxide is formed due to the incomplete combustion of the carbon in the fuel.

SO_x – Sulfur oxides are produced when small quantities of sulfur, present in essentially all hydrocarbon fuels, combine with oxygen from the air during combustion.

Particulates – Small particles that form as a result of incomplete combustion, and are small enough to be inhaled, are referred to as particulates. Particulates can be solid or liquid.

Ozone – O₃ is not emitted directly into the air but is formed by the reaction of VOCs and NO_x in the presence of heat and sunlight. Ozone forms readily in the atmosphere and is the primary constituent of smog. For this reason it is an important consideration in the environmental impact of aviation.

change could have serious consequences for the area. This report does not address CO₂ emissions since its primary focus is on local air quality.

Landside vehicle emissions are primarily considered local air quality pollutants. Hot spots of carbon monoxide (CO), primarily from landside vehicles, can occur in confined areas around the terminals like parking lots and covered roadways as well as near congested intersections. Aircraft emissions, depending on whether they occur near the ground or at altitude, are primarily considered local air quality pollutants or greenhouse gases, respectively. Water in the aircraft exhaust at altitude may have a greenhouse effect, and occasionally this water produces contrails, which also may have a greenhouse effect. About 10 percent of aircraft emissions of all types, except hydrocarbons and CO, are produced during airport ground level operations and during landing and takeoff. The bulk of aircraft emissions (90 percent) occur at higher altitudes. For hydrocarbons and CO, the split is closer to 30 percent ground level emissions and 70 percent at higher altitudes.

Ozone, commonly known as smog, is caused by a photochemical reaction between NO_x and VOCs in the atmosphere. Ozone pollution is often the most significant air quality concern for urban areas. For this reason, it is useful to focus on emissions of NO_x and VOCs when considering the source of airport air emissions. Figure 3-1 shows the primary sources of NO_x emissions at FLL.

Figure 3-1: FLL Airport NO_x Emission Sources

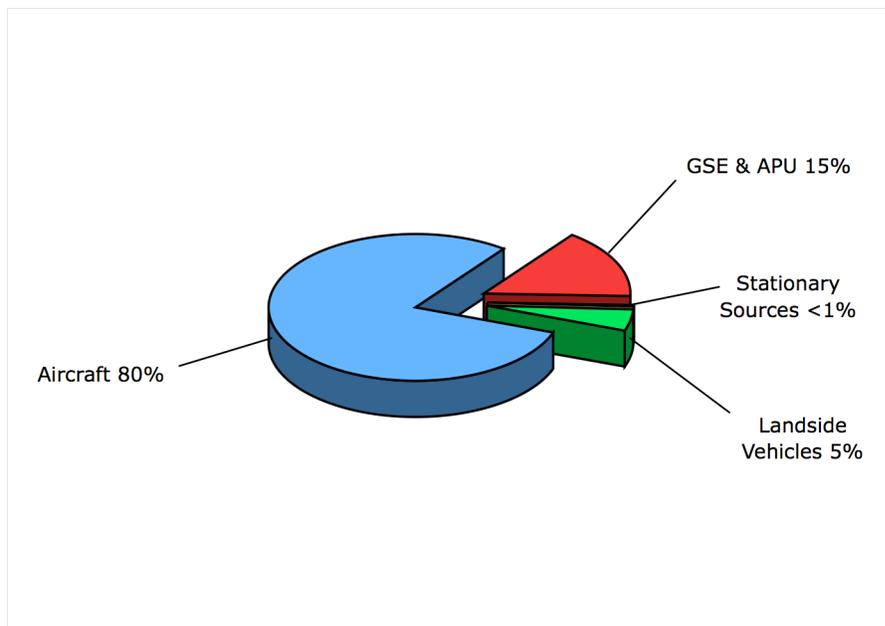
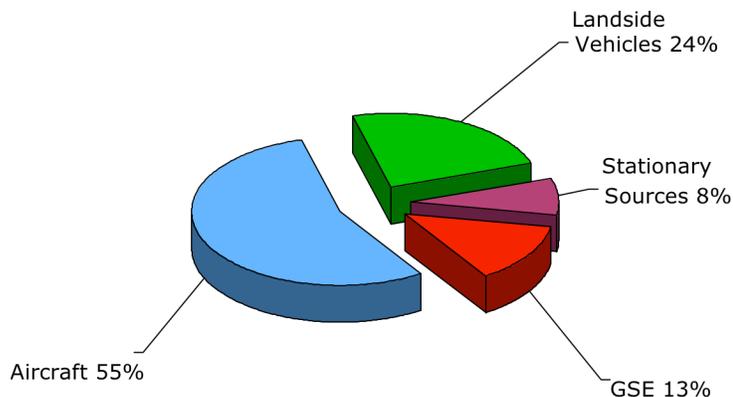


Figure 3-2: FLL Airport VOC Emission Sources



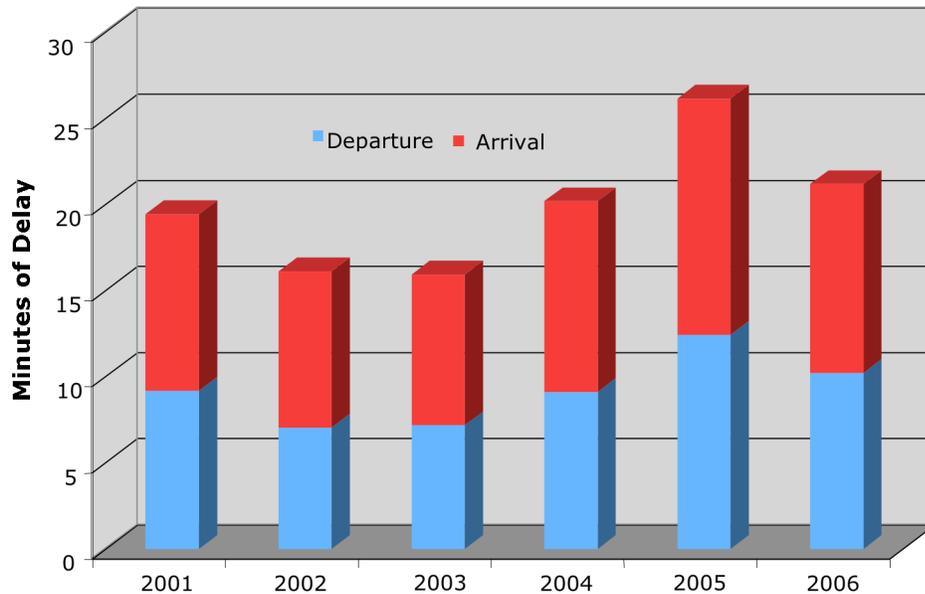
This report addresses emissions from aircraft and auxiliary power units (APU) in Section 3, ground support equipment (GSE) in Section 4, and landside vehicles in Section 5 because of their significance in total air emissions. Each source is discussed in turn. With regard to aircraft, our focus is on commercial aircraft, which dominate the aircraft emissions segment. In this same section we include APU, which are small jet turbine engines that provide power and air conditioning to aircraft. GSE include all equipment operating in support of the aircraft. Landside vehicles include vehicles used by passengers, rental car companies, and delivery services, trucks, limousines, shuttle vehicles, and buses that travel to and from the airport and are certified for highway travel.

Emissions Mitigation

Robust growth not only leads to more flights and more emissions but it also leads to congestion on both the airport airside and landside. Aircraft may wait in line to takeoff and, upon arrival, wait for an empty gate. Congestion can also occur in the terminal airspace as aircraft are staged to arrive and land and must coordinate with aircraft departures. During peak periods, passenger traffic to the airport can overload the access road, adjacent highways, and parking facilities as well. Delays and congestion lead to “excess” emissions as aircraft and vehicles idle and burn fuel while they wait.

FLL is among the most congested airports in the country. Figure 3-3 shows average delays for flights at FLL for the past several years.

Figure 3-3: Flight Delays at FLL



The dip in 2002-2003 reflects the drop in flight activity following the 9/11/2001 terrorist actions. Delays again began increasing until 2006 when the Delta Airlines bankruptcy forced the airline to reduce its number of flights. In 2004 and 2005, FLL was in the top five among large airports in the country with the lowest on-time arrival rates, ranking third in 2004 and second in 2005. FAA has said delays at FLL have caused delays to cascade across the country.

Aircraft operating at FLL include large commercial jets, smaller commuter aircraft powered by jet engines as well as turboprop engines, private jets, and piston-engine general aviation aircraft. This report primarily focuses on strategies to reduce emissions from commercial jets since their emissions represent the largest portion of the total aircraft emissions inventory. However, strategies that are beneficial for large commercial jets often are beneficial for smaller aircraft as well.

Large aircraft have two sources of air emissions: the engines and the auxiliary power unit (APU). The engines are a much larger emissions source than the APU, which is a small turbine engine on-board the aircraft designed to supply the electrical, ventilation, and air starting needs of the aircraft.

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While airport activities and emissions are increasing, FLL is limited in its ability to mitigate the emissions. Aircraft operations are within Federal jurisdiction. For safety considerations, the aircraft pilot in command must have flexibility to determine how to operate the aircraft in a wide range of traffic and weather conditions. However, the airport can set policies and operating goals that guide airfield development, for example, through its master plan, and can define best operating practices for aircraft and encourage tenant airlines to work collaboratively toward these goals.

In identifying targets for mitigating aircraft emissions it is important to understand the source or cause of pollutant emissions. The basis for evaluating aircraft emissions is the landing and takeoff (LTO) cycle. An LTO includes the aircraft operation from the time the aircraft starts its engines, taxis to the runway, takes off, and climbs out toward cruise altitude as well as the approach, landing, and taxi in to the gate where the engines are shut down. HC and CO emissions are very high during the taxi/idle operations when aircraft engines are at low power and operate at less than optimum efficiency. These emissions fall, on a per pound of fuel basis, as the aircraft moves into the higher power operating modes of the LTO cycle. Thus, operation in the taxi/idle mode, when aircraft are on the ground at low power, is a significant factor for HC and CO emissions. When considering mitigation methods for HC and CO, the objective is to minimize the aircraft operation at idle and low power taxi.

NO_x emissions are low when engine power and combustion temperature are low but increase as the power level is increased and combustion temperature rises. Therefore, the takeoff and climb out modes have the highest NO_x emission rates.

Particulate emissions¹ come in two forms: solid, non-volatile carbon or soot particles and condensed, volatile particles that form in the exhaust plume as the exhaust gases cool. Both types of particles are quite small; on the order of 0.25 micrometers. At this small size, they are quite inhaleable and thus a potential cause for concern for human exposure. The carbon component of the particulate emissions is higher at low power rates and the volatile particles are higher at high power settings as are total particulate emissions.

¹ For more information about aircraft particulate emissions in the vicinity of FLL, see the report *Task 5: Investigating Air Emission Impact on the Community, Particle Deposition from Airport Activity*, Clean Airport Partnership, November 2006.

Other aircraft engine emissions, including SO_x and CO₂, are directly related to fuel use so are highest at high power operations.

In addition to knowing how pollutants are emitted from aircraft, it is important to anticipate changes to the overall fleet since newer aircraft generally have lower HC and CO emissions and higher NO_x emissions. The two primary factors driving changes to the fleet currently are fuel cost and growth. As oil prices increase, airline operating costs increase since fuel costs are the second or third largest expense for airlines. In the past two years, oil prices have doubled, which in turn has caused airline fuel costs to increase substantially. With newer aircraft considerably more fuel-efficient than older aircraft, airlines have placed orders for the latest models. New aircraft have also been ordered to meet the need for new capacity to accommodate demand growth.

3.3. Emissions Reducing Strategies and Technologies

This section discusses air emission mitigation measures that potentially apply to aircraft. Mitigation measures that are targeted to HC and CO emissions usually focus on relieving congestion on the airside of the airports and in the terminal airspace. Congestion relief and emission mitigation measures include:

- Upgraded instrumentation and air traffic control procedures to minimize spacing between incoming aircraft and to better coordinate landings and takeoffs
- Controlling aircraft departures through gate-hold procedures
- Taxiing on one engine
- Towing aircraft to the end of the runway
- Using gate power and preconditioned air rather than running the aircraft's auxiliary power unit (APU)

Mitigation measures that address NO_x are much more limited because takeoff and climb out times are relatively short and must take place at very narrow engine power ranges. Alternatives include:

- Derated takeoff
- Reduced use of reverse thrust
- Prohibiting power back

Mitigation measures that reduce fuel use generally tend to result in fewer air emissions including CO, HC, NO_x, PM, SO_x, and CO₂. Initiatives airlines have undertaken to reduce fuel use also are discussed.

Perhaps the best strategy to reduce NO_x emissions is inherent in engine design. Jet engine manufacturers are constantly working to improve the performance of their products. On average, fleet NO_x emissions fall about 1%/year. However, engine design changes are beyond the scope of this report.

Terminal Area Spacing

Several strategies for improving terminal area operations include more efficient climb and descent procedures, reduced horizontal separation, improved routing, more efficient approach procedures, and more efficient ground movement procedures. These strategies depend on aircraft instrumentation, air traffic control instrumentation and procedures, or airport procedures, or a combination of these.

More efficient descent procedures – Moving into and out of congested airport airspace often requires step changes in altitude and speed to ensure safe transit. Following a glide descent is more efficient and consequently reduces fuel burn and noise. Controlled descent approach (CDA) is designed to allow a glide descent to final approach at the aircraft. CDA saves fuel and reduces noise in moderate noise exposure areas (outside of 65 DNL contour).

Reduced horizontal separation – Aircraft must be separated horizontally to ensure safe operation, keeping aircraft from trying to occupy the same airspace at the same time. Separation is often lengthened due to weather or on-ground delays reducing the number of operations during a given time. Required Navigation Performance (RNP) is one of the new navigation technologies that will allow closer spacing with greater precision, even in low visibility conditions.

Preferred routing – Many flight paths are indirect, for example, flights along the coast that could fly directly over water if the aircraft were properly equipped. This lengthens the distance of the flight. This is an important consideration for flights from FLL north to New York and Boston and west to New Orleans and Houston. Area navigation (RNAV) procedures allow aircraft to fly more direct routes, instead of ones that track over a series of navigation beacons on the ground or along the coast.

More efficient ground movement procedures – Traffic and dispatch delays, limited gate availability, uncoordinated taxi traffic, and low-speed

taxiing due to weather all add to taxi time and consequently emissions. Controller pilot data link (CPDLC), which is like an email system between pilots and controllers, and automatic dependent surveillance-broadcast (ADS-B), which allows pilots to monitor the speed, direction, and identification of other aircraft, are two of the new air traffic control systems that will allow more efficient dispatch and operations both on the ground and in the terminal airspace.

Today's air traffic control system, on which these procedures depend, is designed to prevent collisions and expedite and maintain an orderly flow of air traffic. The capabilities and limitations of the system determine how effectively and efficiently the system functions. In the coming years, the air traffic control system is to be modernized to increase system capacity by a factor of three by 2025 according to the US Department of Transportation. Design of the next generation air transportation system (NGATS) is currently underway by the Joint Planning and Development Office (JPDO), which was established by the Century of Aviation Reauthorization Act (PL 108-176) in December 2003. JPDO was established within the FAA and includes the Department of Transportation (DOT), Department of Defense (DOD), Department of Homeland Security (DHS), Department of Commerce (DOC), National Aeronautics and Space Administration (NASA), and the Office of Science and Technology Policy (OSTP). CDA, RNP, RNAV, CPDLC, and ADS-B are all being developed and demonstrated with the coordination of the JPDO.

To estimate the emission benefits from new technology and procedures, a methodology was developed to compute emissions per minute for different operations, which could be converted into total emissions benefits depending on the specific procedure. It provides a relative measure for comparison and is not intended to be a precise measure of emissions reduction. Flight simulation modeling based on a well-defined system and operational scenario would be required to quantify emissions precisely.

The following table summarizes the annual fuel savings benefits in gallons for three aircraft types that operate at FLL that represent approximately 38% of all commercial airline flights in 2004.

Table 3-1: Fuel Savings Benefits from Reduced Spacing

	B737-300	B757-200	A320
More efficient descent procedures	344,734	1,080,845	545,574
Reduced horizontal separation	46,529	1,393,947	698,205
Preferred routing	919,996	2,830,784	1,477,597
More efficient ground movement procedures	174,482	439,629	227,323

To illustrate the potential emissions benefits from advanced ATC procedures the following table summarizes the annual NOx emission reductions in tons for the same three aircraft types.

Table 3-2: Emissions Reductions from Reduced Spacing

	B737-300	B757-200	A320
More efficient descent procedures*	29	120	61
Reduced horizontal separation*	16	56	26
Preferred routing*	40	175	83
More efficient ground movement procedures	3	7	4

*Only a portion of these benefits will be achieved within the local air quality area. A majority of the reemission reductions will be above 3,000 feet.

There are many opportunities for FLL to participate in demonstration programs with JPDO, which will allow FLL to be among the first airports in the country to take advantage of the new technologies that will reduce both

emissions as well as fuel use. Demonstration projects that have a research component will likely be eligible for funding through the Airport Improvement Program (AIP) under the FAA Reauthorization legislation expected in early 2007. Up to 50% funding to a limit of \$5 million per project is anticipated.

Ground Operations

There are a variety of strategies for reducing emissions from aircraft ground operations that must be left under the control of the pilot in command of the aircraft. These tend to be situational and depend on many factors, safety among them, that must be considered whenever they are invoked. The following discusses strategies that airlines can pursue to reduce aircraft air emissions at FLL.

Single Engine Taxiing - Large commercial aircraft have two, three, or four engines. Since low thrust is needed to taxi an aircraft, one or more engines can be shutdown during taxiing. Not only does shutting down an engine reduce the emissions from the engine(s) shut down, the remaining engine(s) operates at higher RPM. This results in more efficient operation and lowers the HC and CO emissions per pound of fuel consumed. It also results in higher engine exhaust velocity. Single engine taxiing (also referred to as reduced engine taxiing or engine-out taxiing) only affects the taxi mode emissions. In addition to emission reduction benefits, this measure also conserves fuel.

The number and placement of engines on an aircraft influences how many engines are required to taxi. Large commercial aircraft have two, three, or four engines that can be mounted in various combinations on the wing or mounted on the rear fuselage. The engine(s) that remains running during single engine taxiing must enable the pilot to operate the aircraft safely and with adequate control. For some aircraft, single engine taxiing results in power being supplied from only one side of the aircraft. For example, a Boeing 747, which has four engines, may require a minimum of two engines since a single engine may put too much thrust on one side of the aircraft, making steering difficult. When the power is unbalanced, the pilot uses the brakes to control and steer the aircraft. For certain aircraft, taxiing with one engine may not provide sufficient control. Aircraft control is further constrained along narrow taxiways or where there may be obstructions, such as other aircraft. A pilot may need to operate with a greater number of engines to aid maneuverability on narrow taxiways and turns or to reduce

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potential problems from jet blast. Using brakes to control and steer the aircraft may be difficult in inclement weather. Generally airlines leave the decision for using single engine taxiing to the discretion of the pilot in command. However, Delta airlines, for example, practices single engine taxiing as a matter of corporate policy and it is practiced for a large majority of flights.

Another consideration for using single engine taxiing is that immediately prior to takeoff, all engines must run for at least two minutes to achieve thermal stability. Two minutes at idle also is necessary for engine cool down. At FLL, taxi-out is generally longer than taxi-in as aircraft are typically dispatched from Runway 9L/27R and must taxi from the terminal to the west side of the airport. Given the relatively clean layout of FLL, its generally open taxiways, and the distance from the terminal to the most frequent runway end for takeoff (west end of the airport for dispatch on Runway 9L/27R), FLL is well suited for airlines to practice single engine taxiing for departure most of the time. Arriving aircraft taxi directly to a terminal gate from their landing position, which is typically on the terminal end (east) of the airport and the opportunity for single engine taxiing is more limited.

Average taxi times at FLL exceed 40 minutes through much of the year. Emissions reductions were calculated for using single engine taxiing regularly at FLL based on the following assumptions:

- 70% of all flights apply single engine taxi on takeoff
- 0% of all flights apply single engine taxi on arrival
- all flights run all engines run for a minimum of 2 minutes prior to takeoff

Based on these assumptions the following benefits would be achieved.

Table 3-3: Emissions Benefits from Single Engine Taxiing (tons/yr)

Emissions	Baseline emissions	Emissions with Single Engine taxiing	Emission Reduction
VOC	251.14	169.44	32%
CO	2,414.20	1,798.51	26%
NO_x	1,219.70	1,097.40	10%

Airlines operating at FLL would be responsible for implementing this emissions reduction strategy. It apparently can be implemented under few constraints since it already is policy at some airports and for some airlines. FAA Advisory Circular No 91-41 (Appendix B) addresses this procedure, recommending only that it not be made mandatory at any time.

Tow Aircraft to Runway - Aircraft typically are pushed back from the gate using a tow tractor, which maneuvers the aircraft in a position to safely start its engines and taxi forward to the runway for departure. Instead of taxiing, a departing aircraft can be towed from the terminal gate to the departure end of the runway. Towing aircraft can substantially decrease the time the engines idle. Aircraft taxi at inefficient power settings and have relatively high HC and CO emissions. The tradeoff is between aircraft engine exhaust emissions and emissions from the tow tractor and the aircraft's APU. The APU must be run while the aircraft is being towed to provide electricity and interior ventilation, as well as compressed air to start the engines away from the gate.

Tow tractors are available with varying maximum towing speeds. High-speed tractors tow aircraft quickly through runway and taxiway intersections, alleviating the need for intermittent stopping and reducing time to reach the runway. As a result, HC and CO emissions are reduced further. In addition to emission reduction benefits, towing aircraft to the runway also conserves fuel.

Possible constraints to aircraft towing include hook-up, emissions, safety, and speed. Traditional tractors hook-up to and tow an aircraft by means of a connecting bar or towbar. The towbar places a horizontal stress on the nosegear as opposed to the vertical stress the nosegear experience during landing. The nosegear is designed for infrequent towing for pushback from the gate or towing to a maintenance hangar rather than frequent, long distance towing for each LTO. The additional towing means more frequent maintenance and parts replacement on the nosegear. Some new tractors avoid this by actually lifting the nosegear to tow the aircraft and completely avoid towbars. These tractors may not reduce the nosegear life appreciably.

The emissions from the tractor and APU offset the savings from towing an aircraft but this is not very significant (tractor and APU emissions are approximately half those of taxiing aircraft). Safety is also an important

consideration for extensive aircraft towing. Crosswinds and standing water can be hazards to towing and may limit the amount of time this can be practiced.

Conventional towing can be quite slow and more tugs would be required to implement this strategy than are currently used. Airline experience indicates that about 2.5 times as many tugs would be required as are now used. This would result in an increased amount of ground traffic with tractors shuttling between the gate and runway, which could increase on-ground congestion without careful planning. New high-speed (greater than 20 mph) tractors are available that can tow significantly faster than conventional tractors or aircraft taxi speeds. However, these high-speed tractors are quite expensive (e.g., up to \$1 million per unit). The initial investment of a high-speed tractor is offset in part by savings in ground support labor and fuel costs and aircraft engine hours. Some airlines have found high-speed tractors to be economical, with a three-year payback in specific applications such as towing to maintenance areas. An offsetting cost consideration is cabin and cockpit labor costs. These employees typically are paid for all time the aircraft is away from the gate. If towing takes longer than taxiing, labor costs will increase.

An aircraft staging area also is needed near the runway end where aircraft can be disconnected from the tow tractor and engines can be run to reach thermal stability. At FLL this would only be needed at the west end of runway 9L/27R since operations to the west would not use this procedure because the runway departure end is so close to the terminals in that configuration.

Virgin Atlantic Airlines recently announced plans for towing aircraft to the end of the runway. They began testing the concept at Heathrow and Gatwick airports in late 2006 with more extensive testing planned for early 2007. They also hope to test the concept at airports in New York, San Francisco, and Los Angeles. Virgin estimates that in New York they could cut fuel used for ground operations by 25%. Long haul aircraft currently take 60 minutes from the gate to takeoff and burn almost 2,000 gallons of jet fuel. They anticipate saving 10% of that fuel by towing the aircraft.

For the future, Boeing has begun investigating a similar strategy by adding an electric motor to an aircraft's nose gear. They successfully tested such a system on an Air Canada B-767 and found the concept was feasible. They used the electric motor to taxi the aircraft from the gate to the runway, where

the engines were started and allowed to warm up just prior to takeoff. One challenge is to design the system so the net change in weight is minimal but Boeing anticipates this is feasible. Electrically powered nose wheels will not be available in the immediate future but would eventually contribute to reduced fuel burn and emissions from aircraft taxiing.

To determine the potential benefit from towing aircraft to the runway, the following assumptions were made:

- high-spiced towbar-less tractors would be used for all towing operations
- all aircraft engines are off during towing and the APU is in operation at full power
- all aircraft engines are run for at least 2 minutes before takeoff to achieve thermal stability
- there is no increase in ground congestion

Table 3-4: Emissions Benefits from Towing Aircraft to the Runway (tons/yr)

Emissions	Baseline emissions	Emissions with Aircraft Towing	Emission Reductions
VOC	251.14	126.89	49%
CO	2,414.20	1,516.81	37%
NO_x	1,219.70	1,047.87	14%

Implementing this emissions reduction strategy would require the close cooperation of BCAD and all airlines operating at FLL. It also requires modifications to the airfield (i.e., addition of a holding area at the end of the runway), which should be developed as a component of the airport master plan.

Reduce APU Use - As noted above, APUs are small turbine engines on-board aircraft that generate 400 Hz electricity and compressed air to operate the aircraft’s instruments, lights, ventilation, and other equipment. They mostly are operated when the aircraft is on the ground with its main engines shut

down. *ICAO Circular 303-AN/176 – Operational Opportunities to Minimize Fuel Use and Reduce Emissions* recommends using preconditioned air (PCA) and 400 Hz power at gates and maintenance areas to reduce or eliminate APU use.

The fixed systems that provide power to aircraft supply electricity from the local electric power grid. It first is converted from 480 volt, 60Hz power to 120/208 volt, 400 Hz power, which is used on aircraft. This is typically done with solid-state static inverters. The electric power supplied by the utility is produced much more efficiently than that generated by an APU so fewer air emissions are produced.

FLL makes utility power available at every gate. Since individual airlines lease gates from the airport, they have the discretion to add the necessary equipment for converting the power and using it on their aircraft if they choose.

Aircraft parked at FLL gates require air conditioning essentially year round to keep the cabin cool for passengers and crew. All large commercial aircraft have on-board air conditioning units that are powered by compressed air from the APU. Alternatively, preconditioned air (PCA) can be supplied at the gate. At FLL, airlines tend to rely on point-of-use air conditioning systems mounted on jet bridges at each gate. They are powered by the standard utility power (480 volts, 60 Hz) and are connected to the aircraft using large, standard hoses.

The fixed electrical and air conditioning systems are not always used even when they are available. The APU must be started to provide the volume of pressurized air needed to start the main engine. The engines of typical narrow body aircraft require 90 pounds per minute of air pressurized to 42 psi and wide-body aircraft require approximately 120 pounds per minute at 42 psi. APUs require 5-10 minutes to warm up and start one or more engines. Alternatively, a ground air start unit can be used to start the aircraft engines. This type of unit typically uses a diesel engine and a screw compressor to provide the volume of compressed air needed. Many airlines prefer to use air start units only when the APU is out of service.

Sometimes when aircraft are scheduled to park at a gate for a quick turn-around (of 30 minutes or less) pilots prefer to just leave the APU running. Also, if power is available but PCA is not, the APU is operated to provide air

conditioning to the cabin. For these reasons it is not feasible to eliminate APU use entirely. However, minimizing APU run time reduces air emissions and saves the airlines substantial maintenance costs since APU, which in fact are jet engines, must be maintained by qualified mechanics based on time of use.

Many airlines have targeted APU use across their entire network to reduce maintenance costs, fuel use, and as a result air emissions. For example, United launched a program in early 2003 to reduce average APU run time during each turn around, that is time between flights. In the first year of the program they reduced average APU run time by 11 minutes, which saved \$368,000 in fuel cost and \$265,000 in maintenance expenses in one month. The airline plans to reduce APU run time every year with a goal of saving \$12 million or more annually.

Derated Takeoff - Aircraft are designed to takeoff fully loaded on a hot day with enough of a safety factor to ensure safe operation. Full engine thrust is needed only under extreme conditions. The maximum thrust is not needed under more typical operations when the aircraft is not fully loaded and weather conditions are normal. With a derated takeoff, the engine thrust can be reduced from maximum thrust to the minimum safe level necessary given the aircraft weight and atmospheric conditions. As an aircraft's thrust is reduced, the NO_x emissions are reduced. Therefore derated takeoff can reduce the total NO_x emissions during takeoff. As an added benefit, derated takeoff can reduce wear on the engines, which can save airlines substantial maintenance costs.

The higher an aircraft's thrust, the faster it clears the runway and local airspace. During a period of high activity use of derated takeoff may be undesirable because it could increase congestion around the airport, however, the difference in time to clear the terminal airspace is relatively small. It also takes somewhat longer to rise above the level where emissions no longer have an impact on local air quality (for south Florida this is approximately 3,000 feet). This would result in an approximately 15% fuel penalty for the takeoff portion of the flight, which would represent less than a 1% increase for the entire flight's fuel consumption. Also, noise reduction requirements may not permit low power takeoff because the flight path may take the aircraft over residences at a lower altitude, for example, when airport operations are towards the west.

~~ Task 9: Reduce Harmful Air Emissions~~

To determine the potential benefit from derated takeoff, the following assumptions were made:

- derated takeoff will be used 90% of the time to allow for maximum weight operations for the balance of flights
- the aircraft will remain below 3,000 feet approximately 34 seconds longer than under 100% thrust takeoff
- takeoff thrust is equivalent to normal climb out thrust
- derated takeoff will not affect normal airport operations

Table 3-5: Emissions Benefits from Derated Takeoff (tons/yr)

Emissions	Baseline emissions	Emissions with Derated Takeoff	Emission Reduction
VOC	251.14	248.74	1.0%
CO	2,414.20	2,414.03	0.0%
NO_x	1,219.70	1,189.2	2.5%

This NO_x emissions reduction strategy would be the responsibility of individual airlines and, in fact, many airlines practice this as a technique for reducing aircraft and engine maintenance costs, which can amount to \$millions annually for an airline's entire fleet.

Reverse Thrust Reduction - Upon landing, aircraft often use reverse thrust to slow down. Reverse thrusters, engaged by the pilot, are mechanical devices that deflect engine exhaust forward. This operation generally lasts approximately 15 seconds. The breaking effect is proportional to the thrust applied so that maximum breaking effect is achieved with maximum thrust. As a result of the high thrust, NO_x emissions are high. It also generates a great deal of noise. The alternative to reverse thrust is use of the aircraft's wheel brakes, which, by design, are adequate to slow and stop an aircraft without resorting to reverse thrust under normal conditions.

FLL's primary arrival runway for commercial aircraft is runway 9L/27 R, which is 9,000 feet long. For essentially all aircraft types operating at FLL this is

ample length to allow for the use of brakes alone. Of course, safety is always a prime consideration and there are times when reverse thrust is appropriate, such as during adverse weather, when an aircraft is landing near maximum weight, or for especially large aircraft like the Boeing 747, which operates only infrequently at FLL.

To determine the potential benefit from reducing the use of reverse thrust, the following assumptions were made:

- reverse thrust is employed on 50% of all landings
- reverse thrust can be avoided on 75% of all flights that currently employ it when landing
- thrust is reversed for 15 seconds
- reverse thrust is equivalent to normal takeoff thrust
- reducing the use of reverse thrust will not affect normal airport operations

Table 3-6: Emissions Benefits from Reduced Reverse Thrust (tons/yr)

Emissions	Baseline emissions	Reducing Use of Reverse Thrust	Emission Reduction
VOC	251.14	246.24	2.0%
CO	2414.20	2,340.26	3.1%
NO_x	1219.70	1,167.60	4.2%

This NO_x emissions reduction strategy must be left to the discretion of the pilot in command and must be implemented by individual airlines.

Prohibiting Power Back Operations - In addition to slowing an aircraft, reverse thrust can be used to back an aircraft away from a gate rather than the more common method of being pushed by a tow tractor. Power back is a high power operation that generates significant NO_x emissions and can pose safety concern for both personnel and equipment on the ramp. Many U.S. and foreign airports as well as many airlines have policies against using power back. FLL allows powerback at concourses E and F at the discretion of

~~ Task 9: Reduce Harmful Air Emissions~~

individual airlines. Certain additional procedures are required to ensure the safety of personnel and equipment. Airlines that use power back to depart the gate leave more quickly and save on the number of pushback tugs needed.

To determine the potential benefit from prohibiting power back, the following assumptions were made:

- power back is used for 2% of departures of commercial jets equal to or larger than a B737
- power back operations last 30 seconds under 100% thrust

Table 3-7: Emissions Benefits from Prohibiting Power Back (tons/yr)

Emissions	Baseline emissions	Emissions with Derated Takeoff	Emission Reduction
VOC	251.14	248.54	1.0%
CO	2414.20	2,374.90	1.6%
NO_x	1219.70	1,192.00	2.3%

Implementing this emissions reduction strategy would be the responsibility of individual airlines.

Since single engine taxiing, derated takeoff, reduced reverse thrust use, and prohibition of power back must all be left to the discretion of the pilot in command, it is up to airlines to implement policies to encourage their use. As part of a broad sustainability initiative, it would be appropriate for BCAD to establish an airport-wide policy for airlines to follow industry best practices for reducing emissions and fuel use and recommend they follow these practices. Other airports have implemented policies similar to those proposed here; see Appendix B for an example policy from Phoenix Sky Harbor Airport that prohibits power back operations without prior airport approval. Changes such as these can be implemented at very low cost if they are phased in over 1-2 years, which would allow the airlines to implement them through their routine pilot training and recertification programs. No new technology or special equipment is required.

Fuel Saving Strategies for Airlines

In addition to the previous emission reduction strategies, there are many opportunities that airlines have for saving fuel, which in turn reduce their emissions, especially of CO₂, the primary aviation global warming gas emission. This section describes several actions airlines have taken in the recent past as fuel costs increased substantially, more than doubling during a one-year period.

Reduce Aircraft Weight – Many airlines have reduced the amount of drinking water they carry onboard. Some have replaced glass mirrors with acrylic ones. Cooking equipment from galleys such as ovens has been removed since airlines rarely serve meals, especially on domestic flights. Some airlines have reduced the number of magazines they carry as well as reduced the weight of manuals pilots are required to carry. Some airlines have removed seatback phones while others are considering ways to reduce the amount of paint used on their aircraft. United Airlines has removed excess electronic equipment and curtains. America West Airlines, American Airlines, and Continental Airlines have reduced fuel reserves loaded onto their aircraft to the minimum required by FAA for safe operation. British Airways changed duty-free alcohol sold onboard from glass to plastic bottles.

Winglets – Uprturned tip-extensions to aircraft wings increase the wingspan and decrease drag. Southwest Airlines is adding winglets to more than 170 Boeing 737-700s expecting to save 3% of fuel use. Continental Airlines is adding winglets to 11 Boeing 737-800s and 11 Boeing 757-200s.

Variable Schedule – America West Airlines has instituted “variable speed schedule” for fuel savings, where they slow down if wind and weather conditions allow them to slow and stay on time.

Pilot Training – United Airlines has added fuel use reduction to its pilot and dispatcher training programs.

Direct Routing – Southwest Airlines has added life vests to many of their aircraft to allow them to operate over open water, for example between Ft. Lauderdale and Houston or Ft. Lauderdale and New York, which shortens the routes and consequently fuel burn. Singapore Airlines and Air France have found that plotting optimum trajectories allow for shorter, more direct flights, which in turn save on fuel.

Most of these emission reduction strategies can be implemented by any airline. For that reason it would be beneficial for BCAD to encourage all airlines to pursue these best operating strategies for fuel conservation. Not only could BCAD establish a policy to encourage them but it could also convene a forum for airlines to share their ideas and experiences. Often discussing ideas with peers in a non-competitive setting will allow progress that might not otherwise be possible. BCAD already hosts regular meetings with its airline tenants, such as the MII technical committee meetings.

3.4. Recommendation to BCAD

Aircraft are the largest source of air emissions at FLL yet are not under the direct control of the airport. Their operations are controlled by the pilots in command who ensure the safety of passengers, crew, and the aircraft. They follow the overall guidance established by individual airlines through their operating procedures and reinforced through pilot training programs. However, BCAD can influence aircraft operations through airport policies established in the context of the Green Airport Initiative.

Working collaboratively with representatives of all tenant airlines to establish best operating practices for reducing emissions and fuel use is recommended. Implementing this recommendation would be a multi-step, collaborative process, led by BCAD, and including the airlines, FAA, and researchers and academicians who study aviation emissions.

First, BCAD, working through the Broward County Commission, should establish an airport-wide policy for all operating entities to identify and follow industry best practices for reducing emissions and fuel use. Among other things, this likely would entail the airport implementing many of the recommendations made in this and other technical reports that comprise the Green Airport Initiative at FLL.

Second, BCAD should establish a forum for evaluating various aircraft-specific emission reduction opportunities identified in this report, both airfield procedures and fuel saving strategies. This could potentially be initiated in an existing forum involved in operational initiatives.. This would provide a focal point for educating BCAD staff and airline representatives on the many opportunities to save fuel and reduce emissions. Initially each meeting could address a single topic, with a knowledgeable expert (including experts from airlines) presenting an overview of a procedure, single engine taxiing for

example, with a discussion of procedural details, an illustration of the potential emission reductions and fuel savings, and information on the data or other information necessary to implement the procedure. Time should be allotted to the airlines to discuss the implications for their operations and voice any safety, training, or other concerns. The airlines response to the proposed best practice could be presented at a subsequent meeting. Not all procedures will apply to all airlines. For example, winglets are very expensive retrofit technology and are not available on all aircraft models so may not be appropriate or cost effective for all carriers. Similarly, not all carriers fly to destinations where over the ocean capabilities would provide a benefit. Also, towing aircraft to the runway prior to takeoff as a routine procedure will require some modifications to the airfield, for example, construction of a large staging pad where tow vehicles can be disconnected and the aircraft can warm up their engines. After ample discussion, the procedure should be defined and codified as a best practice for aircraft operations at FLL.

Third, after establishing an airport-wide policy on using best practices and implementing one or two practices at a minimum, BCAD should approach FAA and ask to serve as a test facility for new, best practice air traffic control technologies, such as those identified as improvements to terminal area spacing. FAA is regularly conducting demonstration projects and testing potential new instrumentation and procedures and through its participation, FLL could demonstrate the capability and establish itself as an airport committed to best environmental practices at little or no cost since FAA will be providing primary funding. While FLL may not be an appropriate facility to demonstrate all new technologies and procedures, FAA and their researchers would welcome a cooperative airport for participating in demonstrating new capabilities.

The cost of implementing the initiatives proposed in this section to reduce emissions and fuel use are quite variable. The cost of implementing new air traffic control procedures and associated equipment cannot readily be defined since most are in demonstration or proof of concept stage, however, FAA underwrites most of the cost of installing and evaluating new procedures and the cost to the airport is primarily through the support of existing staff. Procedures such as CDA have been evaluated at a couple of airports on a limited basis already and they have not found it necessary to increase staff to

accommodate the tests. On that basis the fuel savings and emissions reductions are achieved at an extremely low cost.

With regard to many of the aircraft operating procedures, such as single engine taxiing, many airlines already practice them and find the fuel savings pay for pilot training and any other costs associated with their implementation. On that basis, it is likely that all major carriers would similarly be able to implement the best practices at little or, more probably, no net cost, achieving significant emissions reductions for no net cost.

3.5. Impact on FLL Environmental Footprint

Assuming all airlines implement the airfield procedures (excluding towing aircraft to the runway) to reduce fuel use and emissions for 70% of their flights and all aircraft use gate power and preconditioned air preferentially for 80% of their turn arounds, VOC emissions would be reduced by approximately 10% and NO_x emissions by 8%.

The baseline values for aircraft emissions used for the impact metrics to calculate the baseline footprint were 0.0342 lbs VOC/passenger and 0.1876 lbs NO_x/passenger. The new impact metrics after procedures to reduce fuel use and emissions would be 0.0308 lbs VOC/passenger and 0.1726 lbs NO_x/passenger.

4. Ground Support Equipment Operations at FLL

4.1. Introduction

A variety of equipment is used at airports to service aircraft. The types of equipment most commonly used by airlines at FLL include the following:

- **Baggage Tractors** haul baggage carts between the terminal and the aircraft.
- **Belt Loaders** are mobile conveyor belts used to lift baggage from the tarmac to the aircraft's hold.
- **Aircraft Tow Tractors** tow aircraft from the taxiway to the gate and push back the aircraft from the gate to the taxiway. They also are used to tow aircraft to hardstands for maintenance.
- **Cargo Lifts** are used to raise cargo containers from the tarmac to wide-body aircraft loading doors using scissor lifts.
- **Ground Power Units** are ground-based mobile generator sets. They supply electricity to aircraft while they are parked at the gate.
- **Air Conditioning Units** provide conditioned air to ventilate and cool parked aircraft.
- **Air Start Units** provide large volumes of compressed air used by the aircraft to start the engines.
- **Secondary GSE** includes lavatory servicing carts, air stairs, and maintenance carts.

Most GSE are owned and operated by the airlines to service their aircraft. BCAD owns some GSE for airport maintenance and some other companies operate GSE in support of cargo and other equipment movement.

4.2. Air Emissions from GSE

The majority of GSE at FLL operate on diesel fuel or gasoline although some of the secondary GSE use electricity. GSE represent approximately 13% of both NO_x and VOC emissions at the airport. Since GSE are used to support aircraft, their use, and consequently emissions, will increase as aircraft operations increase in the future.

GSE emissions are computed based on their fuel type, engine run time, and emission control equipment. Since GSE generally are not licensed for on-road operation they do not have to comply with national emissions standards and their uncontrolled emissions are 5 to 20 times higher than current on-highway engine emissions. Baggage tractors, belt loaders, aircraft tractors, and cargo lifts are built specifically for airport service and do not include catalytic converters and other emission control devices. These equipment types are the most important targets for an emissions reduction strategy.

4.3. Emissions Reducing Strategies

Two strategies for reducing GSE emissions are providing the services through alternative means such as fixed, electrically driven equipment or converting the equipment to alternative fuels such as compressed natural gas, low sulfur diesel including biodiesel, or electricity. In the former category, some airports, mostly in Europe, are being designed with vehicle free ramps. In addition to eliminating GSE as emission sources, the airports are attempting to enhance safety and security. For example, Arlanda Airport in Stockholm, Sweden was one of the first airports to try to eliminate GSE. Each gate at their domestic terminal is equipped with a service tunnel from which elevators rise approximately three feet to supply the aircraft with fuel, electric power, compressed air, water, and lavatory service. Catering supplies and cleaning equipment are stored in the passenger bridges. Passenger baggage is checked at the ticketing area in the terminal and transferred by conveyor belt directly to the aircraft hold. An electrically powered system is installed for moving aircraft to and from the gate. The system has a hydraulically powered chain link that moves a trolley along a track in the ramp surface to an arriving aircraft. The trolley then locks onto the nose wheel and pulls the aircraft to its park position. The process is reversed for departing aircraft. These types of systems must be incorporated into the airport at an early design stage as they are impractical to retrofit at an existing airport. For this reason it is not recommended for FLL.

Alternative Fuels

Alternative fuels offer a more practical approach to reducing GSE emissions at FLL. At FLL, baggage tractors are run on both gasoline and diesel. Aircraft tractors are predominantly diesel while belt loaders run on gasoline, diesel, or

electricity. Cargo lifts use diesel. The primary alternative fuel options include compressed natural gas, electricity, and low sulfur diesel.

Compressed natural gas – Converting a vehicle to using compressed natural gas (CNG) is relatively simple for gasoline (spark ignition) engines. Converting a diesel engine is much more complicated and requires major changes to the engine. Converting a gasoline engine only requires new fuel storage tanks for the CNG and a new fuel supply and metering system. The cost for such a conversion is in the \$4,000 to \$5,000 range per vehicle mostly due to the cost for a tank to store the high pressure gas (rated at 3,500 psi) and the pressure regulator. Converting a diesel vehicle would cost \$12,000 or more for a replacement engine with additional conversion costs driving the total conversion cost to more than twice that. Post-conversion fuel economy would generally be 10% lower for conversion from gasoline to 30% lower for conversion from diesel since current engines are designed for highest efficiency with the conventional fuels. Emissions benefits from converting to CNG can be significant with VOC emissions typically 65-70% lower and NO_x 25% lower compared to the unregulated conventional fueled engines.

While conversion to CNG offers substantial emissions benefits, this is not recommended for several reasons for FLL. First, the conversion costs are substantial and the use of CNG also requires some investment in fuel storage and supply infrastructure, which can be quite expensive. Also, since FLL only experiences a few poor air quality days each year the true cost-benefit of such a conversion is far from economical.

Electricity – Already several airlines use electric GSE, notably belt loaders. Electric GSE are available to replace the other primary types of equipment as well. The first cost for an electric baggage tractor or belt loader is comparable to a diesel version of the vehicle although the battery and charger would be an added cost that would increase the total cost by approximately 50%. To offset this higher initial cost, the fuel cost is substantially lower since electric vehicles do not use power while “idling.” With typical use, GSE are idling approximately half of their operating time. Given the difference between electricity cost and gasoline or diesel costs, an electric GSE would require about 10-20% of the fuel cost of conventional fuels. This fuel savings could pay for the initial cost difference within 2-3 years.

Using electric GSE produces no emissions at the airport and the emissions at the power plant for producing the electricity are small relative to conventionally fueled equipment since utility plants are generally well controlled. Thus a compelling case can be made for using electric GSE, especially when airlines are replacing existing equipment or adding new equipment to accommodate growth. Widespread use of electric equipment may eventually require an upgrade of the electricity supply to the airport but this would not be a technical challenge.

Biodiesel – Another alternative for GSE fueling is biodiesel. Biodiesel is a diesel substitute fuel made from plant or animal fat-based oils. It is a “drop-in” replacement fuel since diesel equipment does not require modification to use biodiesel. It is safe to handle and is compatible with existing pumping, storage, and other airport infrastructure. Its benefits include the fact that its use results in lower emissions and it is renewable since it can be made from agricultural products. Commercially biodiesel comes as essentially pure biodiesel and in blends with conventional diesel, usually 20% or 5% biodiesel. 100% biodiesel has solvent properties not found in conventional diesel and for that reason is usually handled separately from other diesel fuel. The blended fuels can be handled just as conventional diesel is without concern. Emissions reductions of VOC and particulate matter when using biodiesel can be significant. Emissions of NO_x usually increase slightly. Also, on a life-cycle basis, CO₂ emissions are lower since it is not a fossil fuel.

Biodiesel has been extensively tested and there are national and international specifications for biodiesel making its use of less concern than many other alternative fuels. It has been tested by US EPA to confirm its emissions benefits and by US DOE’s National Renewable Energy Laboratory to confirm its fuel properties in conventional diesel engines. It is used by several fleets in South Florida and is regularly available from several fuel suppliers.

The State of Florida is currently promoting the use of biodiesel as well as conducting a variety of demonstration projects. Special economic incentives have been proposed for biodiesel as well. And biodiesel is already in use at FLL by ShuttlePort buses, which has confirmed the ease of use of B20 (20% biodiesel blended into 80% conventional diesel) as a drop-in diesel replacement.

Biodiesel has been demonstrated as an effective GSE fuel at Munich Airport in Germany. Well over a third of the GSE operating at Munich Airport use biodiesel. Rapeseed is grown on fields surrounding the airport that is harvested and converted into biodiesel. This enables the airport to use biodiesel at a 30% savings over conventional diesel.

4.4. Analysis of Promising Strategies and Technologies

Benefit - As a result of the simplicity of using biodiesel to fuel GSE, its environmental benefits, and consistency with the goals of the State of Florida, biodiesel looks like a compelling opportunity for FLL. The following environmental benefits can be achieved by using the B20 blend of biodiesel when compared to conventional diesel.

- VOC reduction of 11-20%
- CO reduction of 12-13%
- PM reduction of 12-18%
- SO_x reduction of 20%
- CO₂ lifecycle reduction of 16%
- NO_x increase of 1-2%

Biodiesel also has a lower toxicity, both the fuel and its VOC emissions, than conventional diesel. Note that there is a slight increase in NO_x emissions. This is a small cost to gain significant reduction in other pollutants and to introduce a renewable material in place of a non-renewable petroleum product.

Expected environmental benefits resulting from a change from conventional diesel to B20 at FLL

- 10.18 tons/year VOC emissions reduction
- 174.3 tons/year CO emissions reduction
- 1.79 tons/year NO_x increase

Cost – Several costs must be considered when converting from conventional diesel to B20. These include fuel cost, handling costs, and equipment maintenance costs. Currently the cost of biodiesel is stable and essentially equal to the cost of ultra low sulfur diesel delivered to the airport. The price of B20 reflects the biofuels investment tax credit (Florida Statutes 220.192) and biofuels tax exemption (Florida Statutes 220.08) available in Florida. B20 is available in the quantity necessary to supply all GSE operating at the airport.

Also, there are multiple suppliers in Ft. Lauderdale for both 100% biodiesel as well as the recommended B20 blend, which is blended locally.

Fuel cost

- Average B20 price² (Lower Atlantic – March 2007) \$2.49/gallon
- Average diesel price³ (Lower Atlantic – March 2007) \$2.52/gallon

Onsite storage – existing tanks can be used since B20 is a drop-in replacement fuel. B20 could be introduced to the existing diesel storage tanks without modification and the fuel could be dispensed using existing practices and procedures.

Distribution – existing fuel trucks can be used since B20 is a drop-in replacement fuel

Equipment maintenance – experience is rapidly being developed with B20 in vehicle applications across the country; a benefit to the use of B20 is its added lubricity compared to ultra-low sulfur diesel, which is required for all off-road vehicles by 2010. Some older (20+ years old) may require gasket changes during scheduled engine rebuild but there will be no net cost to this change.

On this basis, there is no net cost to the replacement of diesel fuel at FLL with B20.

4.5. Recommendation to BCAD

Based on the analysis of the various alternatives for reducing air emissions from GSE at FLL, using B20 biodiesel to fuel all diesel GSE is recommended. Since most of the GSE at FLL is owned and operated by the primary tenant airlines and much of the GSE fuelling is done under contract to ASII, who operates the fuel farm, this recommendation will require the cooperation of a wide variety of operating entities. BCAD should develop a tenant awareness program to educate the various operating entities to the use of biodiesel and coordinate among them. The easiest strategy would be to simply replace the diesel storage maintained at FLL with B20, however, first it will be necessary to review all of the equipment that currently is fueled to ensure it is compatible with B20. Given the experience of most users to date, there are

² Clean Cities Alternative Fuel Price Report, U.S. Department of Energy, Energy Efficiency and Renewable Energy, March 2007.

no problems anticipated. There are no regulatory considerations, as long as the diesel blend stock is ultra-low sulfur diesel, and a new policy probably is not required, however, it is recommended that BCAD incorporate the use of B20 as the diesel fuel used at FLL as long as the price remains competitive with conventional diesel. For example, B20 should be used as long as its cost is no more than 5% more than conventional diesel delivered to the onsite storage tanks although that is a decision best left with the tenant airlines, ASIG, and BCAD as leader of a cooperative initiative.

Since the cost of B20 is stable and generally within \$0.05/gallon of the cost of ultra low sulfur diesel and it can be a drop-in replacement, the air quality benefits come at little or no cost to the operators.

4.6. Impact on FLL Environmental Footprint

Diesel represents more than 80% of the fuel used for GSE at FLL. If this is all replaced by B20, GSE VOC emissions would be reduced by 12% and NO_x emissions would increase by 2%. The baseline values for GSE emissions used for the impact metrics to calculate the baseline footprint were 0.0119 lbs VOC/passenger and 0.0358 lbs NO_x/passenger. The new impact metrics after conversion to B20 would be 0.0105 lbs VOC/passenger and 0.0365 lbs NO_x/passenger.

5. Landside Vehicle Operations at FLL

5.1. Introduction

Aircraft and landside vehicles are the dominant sources of air pollution at FLL and commercial airports. Passengers and employees traveling to and from the airport are the dominant sources of vehicle travel. The most effective way of reducing these emissions is through the provision of fixed rail or “airport express” shuttle services that maximize convenience and minimize travel time. For employees, travel allowances versus parking subsidies and aggressive van and car-pooling programs can also be influential in discouraging single occupant vehicle travel (SOV). The key to discouraging SOV is establishing and encouraging the use of attractive transit and ride-sharing alternatives.

5.2. Air Emissions from Landside Vehicles

Pollution from cars comes from both combustion and evaporative emissions. Combustion emissions are generated during start-up, driving, and idling, while evaporative emissions occur while vehicle is in operation and when parked. Transportation control measures seek to reduce vehicle miles traveled and ease congestion. They achieve the greatest reductions in vehicle emissions because they eliminate vehicle trips. Other landside strategies that focus upon cleaner operating vehicles generally achieve less emissions reduction on a per vehicle basis. Motor vehicles emit ozone causing hydrocarbon (HC) and nitrogen oxide (NO_x) emissions; carbon monoxide (CO), particulates (PM), and carbon dioxide (CO₂) emissions that contribute to climate change.

There are five primary sources of landside vehicle emissions:

- Private passenger vehicles
- Passenger oriented commercial vehicles
- Employee vehicles
- Airport fleets
- Construction vehicles
- Delivery and service vehicles

Passenger vehicles generate the greatest annual average vehicle miles traveled (VMT), followed by commercial vehicles, employees, and airport fleets. Passenger vehicles generate an average of three times more miles per

vehicle trip than employee operated vehicles.⁴ They are, however, the most difficult vehicle category to influence. Although little data is available on the contribution of commercial delivery and service vehicles, the operation of these vehicles is also difficult to influence because of the implications of restricting their access or attempting to compel the use of cleaner operating vehicles. For this reason, strategies for this sector are not addressed.

5.3. Data Collection and Analyses

Little data is currently available on the number of landside vehicle trips occurring on a daily, monthly, or annual basis at FLL; the types of vehicles that compose these trips; or average trip length. This information is essential to accurately project current emissions and the benefits of those strategies that have been implemented or remain available. To help estimate the magnitude of emissions achievable from available strategies, projections have been obtained from other airport sites, with those numbers adjusted based upon FLL's comparative number of employees or enplanements.

5.4. Emissions Reducing Strategies and Technologies

The analysis of strategies focused upon improving traffic flow, ride-sharing, and expanding the use of clean operating vehicles. In reviewing these strategies CAP relied heavily upon approaches that have been successfully and cost-effectively implemented at other sites; and their replicability at FLL, given its unique characteristics.

5.5. Analysis of Promising Strategies and Technologies

Strategies and technologies that follow are addressed in order of the sector contribution to landside vehicle emissions:

- Private passenger vehicles
- Passenger oriented commercial vehicles
- Employee vehicles
- Airport fleets
- Construction vehicles

Strategies for reducing VMT and improving traffic flow are examined first for each category and then followed with options for expanding the use of clean operating vehicles.

⁴ "Air Pollution Mitigation Measures for Airport Related Activities" (CA Air Resources Board, 2/05)

Private Passenger Vehicles

Trip Reduction and Operational Strategies

Parking pricing - Private vehicles discharging and loading passengers exacerbate VMT, since each home-based passenger generates two round-trips (versus one, for those parking at the airport). Research also shows that most of these trips to the curb are associated with leisure (versus business) travelers who cannot obtain reimbursement for parking fees.

Increasing public parking fees will provide incentive for alternative transit use if viable modes are available. Fee increases may, however, need to be significant to affect solo rider-ship and will disproportionately impact leisure travelers since business travelers can often obtain reimbursement from employers. Increased parking fees may also cause travelers to utilize other airports when competitive fares and lower parking fees are available from proximate airports. Because of the high relative proportion of leisure travelers and its current "lock" on discount travelers, increasing parking fees at FLL could influence solo travel **if** convenient, alternative modes of transit were readily available.

Pay-on-Foot (POF) - To improve customer service, reduce delays, and to minimize infrastructure and toll booth staffing needs, several airports including Seattle-Tacoma (SeaTac) and Salt Lake City (SLC) International Airports have implemented electronic parking payment programs. With POF programs, drivers receive a ticket upon entering the parking facility. Upon leaving the facility, drivers can utilize machines conveniently located in the terminal exit areas or parking garages to pay their fees prior to exiting. The machines typically allot thirty minutes of additional time so that users have ample time to exit the parking facility. In some cases, airports also enable automated payment by credit card upon exiting the parking facility. SeaTac analyses indicate that the costs of implementing the POF program was repaid within 18 months, through increased revenue and decreased personnel costs.⁵

In the summer of 2006, FLL implemented a pilot program testing the benefits of these automated programs to determine the viability of expanding the system airport-wide. There are currently 18 POF machines located on each

⁵ Communication between Steven Howards and Doug Holbrook, SeaTac (11/8/06)

level of the Cypress parking garage. Machines are located in the elevator vestibules and in the Hibiscus Garage, elevator vestibule area (near the pedestrian bridge to Terminal 1). FLL is also working with SunPass to see if these devices can be integrated to register parking fees and yield a combined bill for toll road and parking charges. POF and automated parking payment programs will improve air quality by improving traffic flow and reducing congestion.

Vehicle idling - In warm-weather climates like FLL, private motorists and commercial fleets can reduce pollution and save money by turning off their engines when they plan to remain idle for thirty seconds or more. Turning off engines may be more practical during non-summer months when constant air conditioning is not required for passenger comfort. Post 9-11 security requirements have limited the incidence of long-term idling at airport curbsides.

Vehicles idling on highway shoulders do, however, contribute to airport emissions and can pose a traffic hazard. To address this problem, FLL opened a cell phone lot in the fall of 2006. This lot accommodates up to 70 vehicles and is located alongside the parking garage under the access road. Monitors provide timely information on flight arrivals. Since this facility opened, FLL has prohibited shoulder idling and idling in the cell phone lot.

Commercial Passenger Vehicles

Congestion mitigation and trip reduction strategies

Hotel Shuttle Consolidation - Hotel and motel operators serving FLL do not currently pay a licensing fee to service the airport and there is no documentation of the number of shuttle trips. Each hotel operates its own independent shuttle which serves the airport as dispatched.

To reduce emissions from hotel shuttles, LAX has established a program to consolidate shuttle services. Prior to the consolidation, 9 hotels operated 53 vehicles that traveled in excess of 1.6 million miles annually. These vehicles consumed about 380,000 gallons of fuel annually and generated 277,000 vehicle trips per year. Together these vehicles emitted over 24 tons of air pollution annually.⁶

⁶ Internal memo from WestStart/CalStart to LAX with updates from Destination Shuttle (undated)

In establishing their consolidation program, LAX requires that hotels pool services so that each shuttle serves three neighboring hotels.⁷ Hotels using the shuttle service are located an average of approximately 3 miles from the airport.

The program adds a maximum of ten minutes to passengers targeting the last hotel on the route. The program has reduced the number of shuttle vehicles from 53 to 22 and is estimated to have reduced vehicle miles from 1.6 million to about 1,100,000 miles annually and from 277,000 to 123,000 vehicle trips per year (a 58% reduction). LAX licenses all commercial passenger vehicles that provide curbside service. By using licensing agreements to require hotels serving the airport to use dedicated natural gas versus gasoline and diesel powered vans, emissions have also decreased by over 60% from 24.33 to 15.67 tons annually.

Automated Vehicle Identification Systems (AVI) - One of the most effective ways to improve efficiency and to discourage VMT, is to charge vehicles each time they enter the airport. FLL does not have an AVI system, but seeks to minimize VMT by emphasizing the dispatch of vehicles based upon demand versus allowing vendors to “troll” for passengers. Fees imposed on taxis at FLL are based upon the number of deplaned passengers (.051 cents per passenger for B&L Taxi and .0461 cents for airport based curb-to-curb shuttles and limousines) and not actual vehicle trips.

An AVI system would afford FLL the opportunity to monitor the types of commercial vehicles serving the airport, the number of vehicle trips occurring, patterns of congestion, and to adjust fees based upon vehicle type (potentially providing discounts to clean operating vehicles). To maximize efficiency over 70 airports nationally use AVI systems to impose circuit fees for airport licensed, passenger-oriented commercial vehicles. When this program was instituted at LAX, shuttle trips through the airport were reduced by over one-third. At LAX, fees were increased over a 12 month period between 2006 and 2007. Fees are imposed by vehicle type and now vary between \$1.25 and \$5 per trip.⁸

Improved taxi ridership efficiency - Negotiating contracts to enable FLL based taxis to load passenger off-site could double the efficiency to taxi

⁷ LAX program was established by Destination Shuttle (Jack Lott; jlott@dss-lax.com/310-491-0447)

⁸ “Access Fees for LAX”, Landside Operations Division, LAX

operations and dramatically reduce vehicle miles traveled. Currently, for a variety of contractual and competitive reasons, airport licensed taxis are prohibited from loading passengers off-site, after they make their drops. Conversely, off-airport cabs are prohibited from loading passengers at FLL. As a result, taxis traveling from and to FLL make their return trips empty ("dead-heading"). This means that taxis generate twice the pollution, use twice the gasoline, and cause twice the congestion that would occur if these loading restrictions were absent.

Cleaner operating commercial passenger vehicles

Bus transport between the Port and FLL - During the cruise ship season (April to November), approximately 150 bus trips occur each Saturday and Sunday day between the Port and FLL. This number is reduced to about 35 per day Mondays through Fridays. During the off season (May-October), about 55 trips occur on Saturdays, 25 on Sundays, and only 1 or 2 trips per day Monday through Fridays. Most passengers travel from FLL to the Port via commercial vans or taxis. Bus trips between the Port and FLL are contracted by cruise ship operators with Greyhound being the dominant local operator.

In 2004, FLL met with the major cruise lines to explore whether cleaner service could be provided via the new ShuttlePort bus fleet. They concluded that because demand for transport was high during a relatively compressed season and portion of the week, efficient utilization of the ShuttlePort fleet was not practical.

Taxis and curb to curb vans - Vehicles operated by B&L Taxi (which holds the exclusive contract to load passengers at FLL), travel millions of miles annually. Their contract with Broward County was signed in 2002 and will be up for renewal in 2007. On a random day in August staff counted approximately 950 taxi pick-ups. They estimated an average round-trip length of 10-12 miles or about 10,500 miles per day. There is no way of accurately determining length, however, because the company is served by independent operators which pay a flat fee to the company for their services. For Yellow Cab, the company owned taxis are an average of 5 years old (2001) with 210,000 miles. For independent contractors, the vehicles are 9 years old on average. B&L's contract requires that vehicles be "clean, first class operable condition" but provides no other criteria affecting the age of the vehicles or emissions.

Tri-County Transportation operates Airport Express and is the exclusive shuttle van operator licensed to load passengers at FLL. They currently operate 50 Ford E-350, light-duty gasoline vans. These vans travel an average of 75,000 miles each per year between the airport and customer, areawide destinations.

Rental cars - There are approximately 30,000 sedans, pick-up trucks, and SUVs in the rental car inventory at FLL. These vehicles travel millions of miles annually in Broward County and throughout Southern Florida. While competition dictates that these vehicles be newer and cleaner model vehicles, their hybrid-electric counterparts typically emit less than half the pollution of current model vehicles. By familiarizing motorists with hybrid vehicles, FLL can help reduce emissions in the region while also accelerating the purchase and use of these vehicles by general consumers.

Employee Vehicles: Trip Reduction Strategies

While employee travel may comprise a significant portion of vehicle trips, their average trip length is typically much shorter than the average trip length for other vehicle sectors. At LAX for example, employees comprised 39% of total trips but 12% of total VMT.⁹

Ride-Sharing - In 2006, an estimated 10,000 individuals were employed at FLL which currently provides discounted parking for tenants and employees. Aviation Department employees pay \$10 per month for parking while other FLL employees pay \$35 per month. In contrast, public parking rates are \$36 a day for short-term parking and \$12 per day for long-term parking. Free or subsidized employee parking may serve to promote single occupant vehicle (SOV) travel.

Increasing parking fees or providing transit allowances can provide strong inducement for employees to find alternative transportation modes, although the benefits at FLL would be greater if mass transit options were more readily available. Case studies show that when increases in employee parking fees are implemented in coordination with travel allowances and the establishment of convenient commuting options (e.g., car-pooling, van-pooling, or mass transit), solo driving by employees has decreased by 12 to 25%.¹⁰ Recent spikes in gasoline prices will make alternatives to solo driving even more

⁹ Meeting between Steven Howards and Christy Sherrod, Landside Operations, LAX (9/15/06)

¹⁰ Ibid

economically attractive. In some areas, car pools have been found to be of marginal value since they have a tendency to attract a large percentage of former transit users. Because of limited transit availability, this would be a negligible issue at FLL.

South Florida Commuter Services (SFCS) coordinates van-pool services throughout Broward County in partnership with its sister agency, South Florida Vanpool Programs, which arranges the leases and insurance for these vehicles. Depending upon the number of passengers they carry, each van can take the place of 10 to 30 vehicle trips per day (5 to 15 round-trips). Currently, 1 shared ride employee van operates at FLL and 6 employee car pools.

SFCS estimates that each van costs approximately \$1,100 per month to operate which includes lease, fuel, insurance, depreciation, and maintenance. Currently, a variety of incentives are available to help offset these costs and include: \$100 per month subsidy for federal employees, a \$500 per month subsidy for any van-pool of 5 or more individuals, and a recent promotion that provides \$100 in free gas for each car-pool from September through November 2006. Due to the lack of transit options at FLL, car and van-pooling provide the best ride-sharing alternatives for FLL employees.

While the air quality benefits of FLL's current program have been limited, Los Angeles International Airport (LAX) has developed an aggressive ride-sharing program for its 20,000 employees. Their calculations on the projected air benefits of their car-pool, van-pool, and transit program notes that: 377 employees participate in their van program; 157 additional employees participate in their transit program; and 86 additional employees participate in their car pool program (622 employees total). In fiscal year 2005, these programs were projected to save approximately 25 tons of hydrocarbons, 196 tons of carbon monoxide, 3700 tons of carbon dioxide, and 120 tons of nitrogen oxide emissions; and over 450,000 gallons of gas.¹¹ The RideShare Program alone was estimated to reduce HC, NO_x, and CO emissions by almost 400 pounds daily and gas consumption by almost 6,500 gallons daily.¹²

¹¹ LAWA 2005 Annual Report Information

¹² 2006 EPA Clean Air Excellence Awards Nomination Fact Sheet

~~ Task 9: Reduce Harmful Air Emissions~~

LAX's 622 participating employees represent about 6% of FLL's workforce of over 10,000 employees. If FLL implemented a van and ridesharing program that attracted half of LAX's participation (311 employees), with all other assumptions being equal, FLL could reduce CO, NOx, and HC emissions by over 170 tons annually; and climate-change related CO2 emissions by 1,850 tons annually. If half of these 311 employees were transported via 10 passenger vans costing an average of \$28,000 a piece, and assuming the vans carried an average of 8 employees, the total cost of purchasing new vans would be about \$500,000. This assumes no subsidies and no administrative costs.

Transit - Broward County Transit serves FLL every 20 minutes through a city bound route that carries about 300 passengers to the airport and boards about 150 passengers from the airport on a week-day average. The Airport is also served by Tri-Rail which provides service from Miami Airport to Palm Beach County every sixty minutes. A free shuttle provides connections between the Griffin Road/I-95 station and FLL and is used by an average of 750 passengers per week. There is no data to distinguish the proportion of these trips attributable to FLL employees. What about the Tri-Rail BCAD shuttle?

Airport fleets

Congestion mitigation and trip reduction strategies

To minimize vehicle congestion and idling, in August 2006 FLL implemented a new program to reduce the queuing of ShuttlePort buses at the GTAs (General Transit Areas). Under this program, a ShuttlePort holding area will be established at the former Dollar Rent-a-Car ready return area. During slower periods, the supervisor will direct buses to this area where (weather permitting), drivers will turn-off their buses until they are dispatched back into operation. BCAD anticipates about 3 buses staging in the Dollar lot during slower periods. This will help reduce emissions from these vehicles and congestion. The idling of commercial buses and shuttles is also prohibited by the General Transit Administrator's that monitor these passenger loading areas.

Clean fuel - FLL currently operates an on-site fleet of over 150 vehicles comprised primarily of sedans and light duty pick-ups. Two vehicles are

hybrid-electric sedans and 10 are dual fueled natural gas. "Fleet Services" is the County agency responsible for purchasing and maintaining vehicles. Under the direction of the County Commission, Fleet Services is attempting to expand the purchase of alternative fuel, energy efficient vehicles. While FLL has a natural gas fueling station, the automakers have effectively terminated the manufacture of these light duty vehicles. The only exception is the natural gas Honda Civic. With the expanded availability of hybrids, purchasing has focused upon expanding this vehicle niche. Because these vehicles are difficult to obtain and command premium prices, Fleet Services cannot predict or guarantee the rate at which hybrids will expand at FLL.

ShuttlePort - ShuttlePort currently operates 5 hybrid-diesel buses and 56 diesel buses. Fifty-one of the diesels are 2004 model year, while 5 of the buses are older 30 foot Thomas's with high mileage that are scheduled for retirement. According to the manufacturer, the hybrids emit approximately 0.01 grams of particulates and 1.05 grams of combined non-methane hydrocarbons and nitrogen oxide emissions (NMHC/NOx) per brake horsepower hour (g/bhp-hr). In comparison, EPA standards allow ShuttlePort's 2004 diesel buses to emit up to 0.1 gram of particulates and 2.5 grams of NMHC per bhp-hr. By utilizing bio-diesel fuel, particulate emissions are reduced an additional 10%, NOx increases by about 2%, and PM is reduced an additional 15%. Beginning in 2007, new urban bus standards will tighten particulate standards from 0.1 to 0.01 g/bhp-hr.

Hybrid buses clearly emit less pollution than even the cleanest diesel vehicles burning bio-diesel fuel, but the incremental costs of the vehicles are also significantly greater (\$645,000 for a hybrid bus compared to \$400,000 for a new diesel bus).

Construction Vehicles

Clean On and Off-Road Equipment

About one-third of diesel powered construction equipment in use today were manufactured before emissions regulations were established. The equipment has a long operating life, often exceeding 30 years. In 2005, construction equipment was estimated to be responsible for approximately one-third of all

non-road PM10 (particulates 10 microns in diameter or less) and NOx emissions.¹³

Programs can be established to reduce emissions from construction vehicles associated with FLL's proposed expansion. For example, in 2002 SeaTac International Airport established a program requiring that all heavy duty construction vehicles be 1998 or newer model vehicles and that they be equipped with catalytic oxidizers to minimize particulate and NOx emissions. The year 1998 was used as the benchmark for heavy duty on-road equipment because the more stringent 4.0 NOx standards took affect that year. The SeaTac program also required use of low sulfur fuel which was necessary to avoid fouling the catalysts and that contractors submit letters of compliance prior to their initiation of work.¹⁴

In 2004, the Federal government implemented a more stringent NOx+HC standard of 2.5 g/bhp-hr. In 2007 these standards will again be lowered to 0.01 g/bhp-hr for PM and 0.20 g/bhp-hr for NOx. In order to achieve the 2007 standards, an ultra-low sulfur fuel (sulfur content 15 ppm) is required and after-market technology is available. This equipment includes catalyzed traps, oxidation catalysts, NOx absorbers, and selective catalytic reduction systems.¹⁵

Beginning on October 15, 2006, federal law requires that 80% of all diesel fuel sold for on-road vehicles meet the 15 ppm standard with 20% required to meet the previous 500 ppm standard. In 2010, all diesel fuel must meet the more stringent, 15 ppm ultra low standard. By 2007, EPA estimates that heavy duty diesel vehicle will emit about 1.6% of the particulate pollution of a 1988 model truck.

To reduce emissions associated with Boston's "Big Dig", a diesel retrofit program was established, with control systems and funding provided by a variety of outside sources. About 60 vehicles (25% of the total), were retrofitted with diesel oxidation catalysts or particulate filters. Retrofit costs averaged about \$2,500 per vehicle. Over a 4-5 year period, over 200 tons of

¹³ Mid-Atlantic Diesel Collaborative (PowerPoint presentation, October 2006)

¹⁴ "SeaTac on Road-Diesel Construction Vehicle Air Emissions Requirements"

¹⁵ Clean Air Fleets Emissions Standards (<http://www.cleanairfleets.org/standards.html>).

emissions were eliminated, which was the equivalent of removing 1,300 school buses from the road for a year.¹⁶

In 1998, Federal law also established Tier 1 standards for equipment under 50 hp and phased in more stringent Tier 2 and 3 standards from years 2000 to 2008. Requirements are met through advanced engine design with very little use of after-treatment oxidation catalysts. The Tier 3 NO_x+HC standard of 2.5 g/bhp-hr. (similar to the 2004 standard for highway engines) did not include a PM standard.

Even tighter Tier 4 standards will be phased in between years 2008 and 2015, further reducing PM and NO_x emissions by about 90%. To enable this equipment to operate efficiently, by 2010 all non-road diesel fuel must meet at 15 ppm sulfur content standard, although most fuel is expected to meet this requirement by 2007.¹⁷

5.6. Recommendations to BCAD

Private Passenger Vehicles

Pay-on-foot parking – FLL should proceed with its efforts to establish pay-on-foot (POF) parking throughout its terminal garage facilities. This is a proven program for improving traffic flow, reducing emissions, and reducing the costs associated with increased personnel and roadway infrastructure that would otherwise be required to serve a growing vehicle base. Sea-Tac International Airport has one of the oldest systems in the nation which has been in operation for almost a decade. While no figures are available on the period of payback, Sea-Tac is confident the program “has more than paid for itself” through lower personnel costs and reduced congestion.¹⁸

Clean fuel rental cars - Airport based rental cars travel millions of miles annually in Broward County and throughout Southern Florida. FLL should work cooperatively with airport based rental companies and encourage them to expand the availability of hybrid-electric vehicles. These are the cleanest gasoline vehicles now being manufactured. By familiarizing motorists with hybrid vehicles, FLL can help reduce emissions in the region while also accelerating the purchase and use of these vehicles by general consumers.

¹⁶ Mid-Atlantic Diesel Collaborative (October 2006)

¹⁷ Emission Standards USA: Non-Road Diesel Engines
(www.dieselnet.com/standards/us/offroad.html)

¹⁸ Conversation with Doug Holbrook, Manager of Utilities and Infrastructure, Sea-Tac (1/22/07)

Rental car companies are operating under long-term operating agreements with FLL (effective through 2015). Therefore, it may be most effective for FLL to seek voluntary commitments of support from rental car companies.

Because hybrid vehicles are more difficult to obtain and command an average 25% more than a comparably equipped vehicle, FLL may also wish to explore providing a fee rebate to rental car companies based upon the percentage of hybrid rental cars purchased and available.

While gasoline powered vehicles are becoming increasingly efficient with the phase-in of more stringent emission standards, in 2007 a hybrid electric-gasoline Toyota Camry will emit approximately half the emissions of the gasoline Camry on a per mile basis.¹⁹ Expanding the use of hybrid vehicles would both reduce airport and metro-wide emissions from FLL based rental fleets and also help familiarize drivers with hybrid vehicles, accelerating their private purchase.

Assuming each gasoline rental car is equivalent in emissions to a Toyota Camry and travels 40,000 miles per year, then each rental vehicle would emit approximately 6.25 pounds of NO_x; 8.04 pounds of non-methane organic gases (NMOG); 0.89 pounds of PM; 1.61 pound of hydrocarbons (HCHO); and 375 pounds of CO per year. Assuming that the rental car companies housed at the consolidated facility lease an average of 30,000 vehicles annually then these vehicles can be expected to emit over 11,753,700 pounds of pollution each year. If 10% or 3,000 were hybrid equivalents, pollution could be reduced by about 585,000 pounds annually. Approximately 96% of this total reduction would be CO with the remaining 4% (26,200) pounds composed of higher-priority smog forming emissions.

Passenger Oriented Commercial Vehicles

Hotel shuttle consolidation - FLL should encourage the consolidation of hotel shuttles to reduce congestion and improve air quality. One important step is organize and facilitate a meeting with representatives of area hotels to introduce them to experts that can help to apprise them of the costs and benefits of consolidation and case examples. FLL could also encourage

¹⁹ EPA emission standards for light duty vehicles are based upon “Bin” numbers. The gasoline Camry has a “Bin 5” ranking while its hybrid equivalent has a “Bin 3” ranking. For matrix of standards showing permissible emissions for each Bin, see: <http://www.epa.gov/greenvehicle/detailedchart.pdf>

participation by establishing concessionaire agreements for hotel shuttles that compel the use of consolidated services and the cleanest operating vehicles.

At least one company (Destination Shuttle, Inc.), specializes in conducting these types of feasibility analyses directly for hotels and providing consolidated shuttle services. Destination Shuttle estimates that their program reduces hotel shuttle costs to each hotel by an average of 25-30%, while reducing pollution and improving the quality of the vehicles providing services.²⁰

Based upon figures available from the Los Angeles World Airports, a shuttle program can reduce both pollution and operating costs. The costs and benefits of implementing a consolidated hotel shuttle program are determined by the number of hotels that currently provide shuttle services, the size of the hotels, and their proximity to one another. The larger the hotels are and the closer their proximity to one another and the airport, the greater the savings that can accrue. Consolidating 2-3 hotels with average of 200 or more rooms each is ideal from an efficiency and passenger convenience standpoint. The last passengers on the route would travel an average of 8-10 minutes more than a single-hotel, dedicated shuttle. More than 3 hotels would result in more than 10 minutes of additional travel time which is generally recognized as unacceptable.

Assuming an average trip length of 6 miles with participation of 9 hotels using the same type of natural gas shuttles, FLL could reduce air emissions by over 17.3 tons annually. The dedicated natural gas, 24 passenger shuttle buses cost about a third more than their gasoline or diesel counterpart (\$160,000 versus (\$100,000).²¹ This price differential is more than offset by Federal tax credits available for these vehicles (\$8,000) and reduced fuel costs which can exceed \$1 per gallon. At LAX, the consolidated shuttle program has enabled hotels to delegate the unwanted responsibilities of operating the service to an outside entity while reducing costs, pollution, and retaining high customer satisfaction.²²

Capital costs are negligible and primarily associated with administrative and contractual issues associated with conversion to a consolidated system.

²⁰ Communique from Jack Lott, CEO of Destination Shuttles (3/6/07)

²¹ Conversation between Steven Howards and Destination Shuttle (10/19/06)

²² Internal memo from WestStart/CalStart to LAX (undated)

Savings accrue from the reduced costs to hotels of administering their programs, paying drivers, and for vehicle maintenance.

AVI system - FLL can benefit by implementing an AVI system for curb-to-curb airport based shuttles, hotel shuttles, airport based taxis, Port buses, and other commercial companies licensed to load and discharge passengers at FLL. The ultimate cost of the system will be based upon the numbers and types of participating vehicles, the number of lanes monitored, and the sophistication of data the airport requires the system to collect.

The benefits of an AVI system includes enabling FLL to assess fees based upon the actual number of vehicle trips versus the surrogate deplanement formula currently utilized; and to distribute these fees over a broader base of commercial fleets. It would also allow FLL to monitor the number and types of vehicles loading at the airport, congestion patterns, to adjust rates to reduce peak congestion, and to encourage the use of cleaner operating vehicles. This could provide more direct market incentive for vendors to find ways of improving travel efficiency including the consolidation of services and maximization of vehicle ridership.

While costs vary based upon specific design factors, programs established for other airports and conversations with system contractors indicate that that a system for FLL can be established for approximately 1 million dollars. Depending upon the fee structure implemented, the system could generate in excess of .5 million dollars in annual *additional* revenue compared to FLL's current deplanement-based fee system (which generates approximately 1 million dollars in annual revenue). Fees are currently paid only by taxi and shared ride operators that have exclusive licenses to load passengers at the airport.

These additional funds would come from FLL's ability to impose fees on a broader array of commercial vehicles. Therefore, the incremental cost of an AVI system could be repaid in 2 years. After this "repayment" period, the system would generate about .5 million dollars in additional revenue (beyond the 1 million dollars currently provided annually). As an important secondary benefit, FLL would be able to obtain accurate data on the numbers and types of commercial vehicle trips occurring, which will enable the airport to more efficiently manage landside operations.

High efficiency taxis and shuttles - FLL licensed taxis, shuttles, and ShuttlePort buses purchased in the future, should be required to meet new vehicle standards representing the lowest emissions rate achievable and practicable through the use of conventional fuels. Regulators have historically preferred establishing emissions versus technology based standards to “push” technology and facilitate compliance by innovation. Because taxis and shuttles travel many miles annually, the air quality benefits to FLL and the region would be significant. This program would entail no incremental costs unless fleets would otherwise purchase used versus new replacement vehicles.

Taxis - FLL should require taxis serving the airport to meet an emissions standard based upon the “bin 5” requirements established for 2007 model light duty vehicles.²³ If FLL chooses to seek additional improvements from its taxi fleet beyond these 2007 gasoline vehicle standards, it should establish a fleet average requirement that is based upon emissions levels achievable through a combination of current year gasoline and hybrid-electric vehicle emission standards. As an alternative, FLL could also mandate that a certain portion of each rental car fleet be composed of hybrid-electric vehicles.

Additionally, FLL and Broward County should seek to implement a program for FLL and County licensed taxi fleets, which would discourage “dead-heading”. This would be a complicated issue to negotiate with taxi vendors, but would dramatically reduce vehicle miles traveled by empty cabs and concomitant congestion and emissions and result in cost savings to taxi operators.

Shuttles - FLL should analyze the air quality benefits of dedicated natural gas vans compared to their new model gasoline equivalents. Emissions standards for both light-duty gasoline and heavy duty diesel vans are becoming increasingly stringent. Unless the air quality benefits of natural gas vans are found to be significantly greater, FLL should implement a model year 2007 emissions based standard for airport based commercial shuttles which would tighten in accordance with Federal law as new vehicles are purchased. There would be no incremental cost associated with this program, unless fleets would otherwise purchase used versus new replacement equipment.

²³ Most light duty vehicles manufactured in 2007 will meet “Bin 5” standards. DFW, which is located in a serious air quality non-attainment region, has also chosen to go the emissions based route citing the handicaps of natural gas vehicles and very stringent 2007 gasoline vehicle emissions standards.

All of Tri-County Transportation's 50 FLL based curb-to-curb shuttles are light duty gasoline vans. If fleets should choose to comply with the standards that are designated by utilizing new vans converted from gasoline to natural gas, because of the significant Federal tax rebates and fuel cost savings available²⁴, these vehicles should be required to match the deterioration factors of OEMs. Purchase decisions by commercial fleets should be based upon emission requirements and market considerations—not technology mandates.

Employee Trip Reduction

Parking fees and allowances with expanded ride-sharing

FLL should establish a trip reduction goal for its employees and impose parking fees for single occupant drivers if these goals are not met. Waivers should be available for employees that work off-hours or have unpredictable schedules not conducive to alternative travel modes. The parking fees generated should be utilized to provide employees with convenient, transit and ride-share alternatives.

Non-Aviation Department FLL employers that pay parking fees to FLL on behalf of their employees should be encouraged to implement "cash-back" programs that provide employees with the option of receiving the parking fee paid to FLL in exchange for releasing their space. This provides financial motivation for employees to seek ride-sharing alternatives with no cash loss to employers.

These programs would require significant investment by Broward County in expanding ride-sharing services; providing adequate financial support to make these services economically attractive; and working with employees to familiarize them with these services and adapting them to maximize convenience to users.

To improve the use of these programs, FLL should consider establishing a part-time on-site ride-share coordinator and including materials in salary payment envelopes, provide postings and other updates in communiqués with

²⁴ The incremental cost of converting a light duty van from gasoline to natural gas costs about \$12,000. \$4,000 can be recovered through Federal tax credits available through 2010. Natural gas typically costs about one-third to one-half the price of a gasoline gallon equivalent. Thus, the incremental cost of the vehicle can typically be recovered within the first year of operation.

employees, promoting ride-sharing programs and advising employees of the significant cost savings that can be achieved compared to solo travel.

The ultimate cost of the program could range between \$50,000 and \$100,000, depending, upon the level of additional subsidies provided to employees and the proportion of salaried time devoted to an on-site ride-share coordinator.

Airport Fleets

FLL plans to request 2007 budget approval for the retirement of 3 of its 5 older diesel buses and their replacement with electric-hybrid vehicles. This is an important step in refining the efficiency of its already clean fleet. With the advent of tougher heavy duty diesel emission standards in 2007, FLL should also analyze the comparative benefits and cost-effectiveness of diesel versus hybrid-diesel buses to insure that the incremental cost of hybrid buses continue to be justified.

FLL should continue to shift its future clean vehicle purchasing emphasis from alternative fuel to electric hybrid vehicles. These vehicles are readily available, provide significant air quality benefits, can utilize available infrastructure, and realize a strong resale value.

Clean On-Road Construction Equipment and Off-Road Vehicle Standards

Construction of a new runway and new terminal facilities will result in extensive emissions generated by both on-road and off-road construction vehicles. These vehicles have a long operating life that can exceed 30 years. About one-third of diesel powered construction equipment, nationally, was manufactured before the introduction of emissions regulations.²⁵

According to EPA, in 2007 it will take 60 new model on-road heavy duty diesel trucks to emit the particulate emissions of 1 truck sold in 1988. To minimize these emissions, FLL should assess the feasibility of establishing standards requiring their contractors and sub-agents to utilize newer model on-road vehicles (emissions were tightening significantly in 1998, 2004, and 2007). FLL should also explore the implementation of policies requiring FLL and its contractors to use equipment that meets Tier 1-3 off-road diesel standards.

²⁵ Mid-Atlantic Diesel Collaborative (PowerPoint presentation, October 2006)

FLL should seek the assistance of the Southeast Diesel Collaborative which can provide technical and financial help in establishing diesel retrofit and other programs for reducing emissions from construction equipment. Additional information on funding options and diesel retrofits can be obtained at: www.dieselforum.org/retrofit.

Educate motorists to further reduce vehicle travel and idling

To help maximize traffic flow and minimize curbside idling, FLL should further publicize the location and convenience of the cell phone lot within the terminals and concourses.

As a separate but related issue, strategically located signage at curbside areas could help to educate passengers and motorists about opportunities to reduce vehicle idling and pollution, metro-wide.

- Many motorists persist in idling their vehicles when loading or discharging passengers off-site even with established restrictions.
- They believe that it is more efficient to idle vehicles than to turn off engines during short stops.
- Due to advances in light duty vehicle technology, pollution and fuel use are reduced if engines are turned off when anticipated idling exceeds thirty seconds.

Private motorists and commercial fleets can reduce pollution and health impacts throughout the region and save money by turning off engines when their vehicles are not moving.

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Appendix B – Example Policy Statements

The following pages provide example airport policies adopted by the City of Phoenix Aviation Department, under the authority of the Phoenix City Council and city laws, to:

- prohibit the use of aircraft powerback as well as other aircraft operating practices, without prior written permission of airport management
- report, clean-up, and document fuel spills at the airport, and
- storm water enforcement policies and requirements applied to all airport tenants.