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Report to Congressional Requesters

April 2007

COMMERCIAL AVIATION

Potential Safety and Capacity Issues Associated with the Introduction of the New A380 Aircraft

GAO-07-483

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Highlights

Highlights of GAO-07-483, a report to congressional requesters

Why GAO Did This Study

Airbus S.A.S. (Airbus), a European aircraft manufacturer, is introducing a new aircraft designated as the A380, which is expected to enter service in late 2007. The A380 will be the largest passenger aircraft in the world, with a wingspan of about 262 feet, a tail fin reaching 80 feet high, and a maximum takeoff weight of 1.2 million pounds. The A380 has a double deck and could seat up to 853 passengers.

GAO was asked to examine the impact of the A380 on U.S. airports. In May 2006, GAO issued a report that estimated the costs of infrastructure changes at U.S. airports to accommodate the A380. This report discusses (1) the safety issues associated with introducing the A380 at U.S. airports, (2) the potential impact of A380 operations on the capacity of U.S. airports, and (3) how selected foreign airports are preparing to accommodate the A380. To address these issues, GAO reviewed studies on operational and safety issues related to the A380 and conducted site visits to the 18 U.S. airports and 11 Asian, Canadian, and European airports preparing to receive the A380.

GAO provided the Federal Aviation Administration (FAA) and Airbus a copy of the draft report for review. Both generally agreed with the report's findings. FAA and Airbus also provided technical clarifications, which were incorporated as appropriate.

www.gao.gov/cgi-bin/getrpt?GAO-07-483.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Gerald L. Dillingham at (202) 512-2834 or dillinghamg@gao.gov.

What GAO Found

The A380 will be the first of a new category of large passenger aircraft introduced into the national airspace system in the coming years. The size of the A380 poses some potential safety challenges for U.S. airports. As a result, airports expecting A380 service may need to modify their infrastructure or impose operating restrictions, such as restrictions on runway use, on the A380 and other aircraft to ensure an acceptable level of safety. In addition, increased separation between the A380 and other aircraft during landing and departure is also required because research data indicate that the air turbulence created by the A380's wake is stronger than the largest aircraft in use today. The A380 also poses challenges for fire and rescue officials due to its larger size, upper deck, fuel capacity, and the number of passengers. FAA, Airbus, airports, and other organizations have taken several steps to mitigate these safety challenges. For example, the A380 is equipped with some safety enhancements, such as materials designed to reduce flammability and an external camera taxiing system to enhance pilot vision on the ground.

The impact of A380 operations on capacity is uncertain. The A380 was designed, in part, to help alleviate capacity constraints faced by many large airports in the United States and around the world by accommodating more passengers and freight on each flight than any aircraft currently in use. However, potential operating restrictions and the increased separation requirements imposed to ensure the safety of the A380 and other aircraft at airports and during flight could reduce the number of flights that airports can accommodate. The extent to which possible operating restrictions, increased separation, and gate utilization impact capacity would depend on the time of day, the number of A380 operations, and the volume of overall airport traffic.

Selected foreign airports that GAO visited have taken different approaches than U.S. airports in preparing for the introduction of the A380. These differences reflect the expected level of A380 traffic at the airports—and in some cases, the anticipated economic benefits of the A380 flights. The different approaches include adopting alternative airport design standards, making significant investment in existing infrastructure, and designing airports that allow for new large aircraft. By implementing these approaches, officials from the foreign airports that GAO visited do not anticipate that the introduction of the A380 will result in delays or disruptions at their airports, despite higher levels of expected A380 traffic compared to most U.S. airports.

Inaugural Airbus A380 Visit to Singapore Changi Airport

Source: Courtesy of Civil Aviation Authority of Singapore.

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Abbreviations

AACG	A380 Airports Compatibility Group
DOT	Department of Transportation
EASA	European Aviation Safety Agency
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organization
NAS	National Academy of Sciences

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GAO
Accountability * Integrity * Reliability

United States Government Accountability Office
Washington, DC 20548

April 20, 2007

The Honorable John L. Mica
Ranking Member
Committee on Transportation and Infrastructure
House of Representatives

The Honorable Thomas E. Petri
Ranking Member
Subcommittee on Aviation
Committee on Transportation and Infrastructure
House of Representatives

Airbus S.A.S. (Airbus), a European aircraft manufacturer, is introducing a new large aircraft designated as the A380. When the A380 enters service—which is currently expected in late 2007—it will be the largest passenger aircraft in the world, with a wingspan of about 262 feet, a tail fin reaching 80 feet high, and a maximum takeoff weight of 1.2 million pounds.[1] The A380 has a double deck and could seat up to 853 passengers, depending on the cabin configuration.[2] In comparison, the largest passenger aircraft currently in operation, the Boeing 747-400, can seat up to 660 passengers. While the A380 will be the first of this new category of large passenger aircraft, it will not be the last. For instance, Boeing received orders in December 2006 for its 747-8 passenger aircraft, which will be in the same category as the A380, and is expected to enter service in late 2010.[3]

[1]The freight version of the aircraft, the A380F, has been delayed and the first delivery is to be determined.

[2]The A380 has a typical seating capacity for 555 passengers, but is certified for a maximum of 853 passengers. According to Airbus, the seating capacity for the A380s currently on order range from about 480 to 650.

[3]The freight version of the 747-8 is expected to be delivered in the third quarter of 2009; the passenger version of the 747-8 is scheduled for delivery beginning in 2010.

Figure 1: Inaugural Airbus A380 Visit to Singapore Changi Airport

Source: Courtesy of Civil Aviation Authority of Singapore.

As of March 2007, Airbus has orders from 14 customers for 156 A380 passenger aircraft.[4] Air carriers plan to operate the A380 at select airports throughout the world, including certain U.S. airports. As a result, the A380 must comply with standards set by individual countries from around the world. The International Civil Aviation Organization (ICAO) promulgates international standards and recommended practices, among other things, in an effort to harmonize global aviation standards. In the United States, the Federal Aviation Administration (FAA) is responsible for regulating the safety of civil aviation and also establishes the standards and recommendations for the design and development of civil airports.

You asked us to assess the impact of the Airbus A380 on U.S. airports. In May 2006, we issued a report that estimated the costs of infrastructure

[4]Fourteen customers have firm orders for 156 A380 passenger aircraft. No U.S. air carrier has ordered the A380 aircraft. However, International Lease Finance Corporation, a U.S. company, ordered 10 A380 passenger aircraft and plans to lease these aircraft to air carriers across the world.

changes that U.S. airports plan to make to accommodate the A380.[5] This report discusses (1) the safety issues associated with the introduction of the A380 at U.S. airports, (2) the potential impact of A380 operations on the capacity of U.S. airports, and (3) how selected foreign airports are preparing to accommodate the A380. To address these issues, we reviewed FAA and ICAO guidance and standards. We also reviewed studies on operational issues related to the A380 and on aircraft fire and rescue equipment and tactics, A380 emergency evacuations, pavement strength issues for the A380's weight, and other safety-related issues. We also analyzed capacity impact studies for some U.S. airports that anticipate receiving the new aircraft. We interviewed FAA, ICAO, Airbus, and aviation trade association officials. In addition, we conducted semi-structured interviews with 17 aviation experts, identified by the National Academy of Sciences, to obtain their views on the impact of the A380 on airport operations and capacity, and potential safety issues.[6] We conducted site visits to the 18 U.S. airports that are making infrastructure improvements to accommodate the A380 and 11 Asian, Canadian, and European airports that will be receiving the A380. During these site visits, we interviewed airport officials, including airport management, air traffic controllers, and fire and rescue personnel, and toured the airport facilities. This study built upon the work performed for the May 2006 report and therefore we performed our work from May 2005 to March 2007 in accordance with generally accepted auditing standards. Additional details on our scope and methodology can be found in appendix I.

Results in Brief

The A380 will be the first of a new category of large passenger aircraft introduced in the coming years. The size of these aircraft poses a number of potential safety challenges for U.S. airports. Most U.S. airports were not designed to receive aircraft the size of the A380 and therefore the width of their runways and taxiways do not meet FAA safety standards for such aircraft. As a result, airports expecting A380 service may need to modify their infrastructure or impose operating restrictions, such as restrictions on runway or taxiway use, on the A380 and other aircraft to maintain an

[5]GAO, *Commercial Aviation: Costs and Major Factors Influencing Infrastructure Changes at U.S. Airports to Accommodate the New A380 Aircraft*, GAO-06-571 (Washington, D.C.: May 19, 2006).

[6]The aviation experts we interviewed were not selected randomly. Therefore, their views and opinions cannot be generalized to the larger population of experts and aviation officials.

acceptable level of safety. Increased separation between the A380 and other aircraft during landing and departure is also required because research indicated that the air turbulence created by the A380's wake is stronger than the largest aircraft in use today. The A380 is equipped with some safety enhancements, such as internal and exterior materials designed to reduce flammability. However, it will still pose challenges for fire and rescue officials due to its large size, upper deck, fuel capacity, and number of passengers. Some fire and rescue officials at the airports we visited were confident in their ability to respond to an A380 incident. However, several of them identified additional equipment, personnel, or training needs that would improve their ability to respond to emergencies involving large aircraft, such as the A380. Similar concerns were raised for the Boeing 747 aircraft when it was introduced to the market, and these potential safety challenges would likely be present for other similarly-sized aircraft introduced in the future. FAA, ICAO, Airbus, and airports have taken several steps to mitigate these safety challenges.

The impact of A380 operations on capacity is uncertain and depends on multiple factors. Airport capacity is generally measured by the maximum number of takeoffs and landings. The A380 was designed, in part, to help alleviate capacity constraints faced by many large airports in the United States and around the world as passenger and cargo air traffic continues to increase. According to Airbus, the A380 will accomplish this by accommodating about 35 percent more passengers and 50 percent more cargo volume on the freighter aircraft per flight than aircraft currently in use. Thus, the A380 could reduce the number of flights required to carry the same number of passengers or the same amount of freight. However, potential operating restrictions and the increased separation requirements imposed to ensure the safety of the A380 and other aircraft at airports and during flight could reduce the number of flights that airports can accommodate. Furthermore, gate availability, restricted use of gates adjacent to A380 gates, and potential congestion issues could reduce gate utilization and flexibility at some airports—which could also lead to fewer flights at an airport. The extent to which possible operating restrictions, increased separation, and gate utilization impact airport capacity would depend on the time of day, the number of A380 operations, and the volume of overall airport traffic. Many airport officials and aviation experts stated that as long as the number of A380 flights per day remains low, the impact of the A380 on airport capacity should not be significant, but would likely increase as the number of A380 flights increases.

Selected foreign airports we visited have taken different approaches than U.S. airports in preparing for the introduction of the A380. These

differences reflect the age of the airports, the expected level of A380 traffic at the airports, and the anticipated economic benefits of the A380 flights. Foreign approaches include adopting alternative airport design standards to accommodate new large aircraft, making significant investments in existing infrastructure, and designing airports that allow for new large aircraft. For example, airport officials at London Heathrow airport indicated that their investment to accommodate the A380 was about $885 million, which is a little less than the combined investment of all 18 of the U.S. airports expecting to receive the A380. The different levels of investment made by U.S. and foreign airports reflect the varying levels of expected A380 traffic—that is, most of the foreign airports we visited expect higher levels of A380 traffic compared to U.S. airports. As a result, foreign airports, in particular European airports, are investing more in terminal and gate improvements to accommodate the A380 than U.S. airports. Another foreign approach is designing airports that allow for new large aircraft. For example, seven of the eight Asian and Canadian airports we visited were designed for future expansion or were built to allow new large aircraft, such as the A380. As a result, these airports will not have to impose operating restrictions on the A380 to the extent of U.S. airports. In general, by implementing these different approaches, officials from the foreign airports we visited do not anticipate that the introduction of the A380 will result in delays or disruptions at their airports, despite the expected high level of A380 traffic.

We provided a draft of this report to the Department of Transportation and Airbus North America Holdings, Inc. (Airbus) for review and comment. FAA officials generally agreed with the report's findings. Airbus generally agreed that GAO correctly identified potential safety and capacity issues for the introduction of the A380 into service. However, regarding our discussion on capacity issues, Airbus expressed concern that we overemphasized the operational constraints imposed on or by the A380 and should include information on passenger throughput, noting that we use only one definition of capacity. Therefore, we provided more balance regarding the potential benefits that new large aircraft, such as the A380, could provide to help alleviate capacity constrained U.S. airports and additional information on the A380's potential impact on passenger throughput on the basis of Airbus' comments. FAA and Airbus also provided technical clarifications, which were incorporated as appropriate.

Background

FAA, airports, and aircraft manufacturers have worked to meet the demands of continued growth in passenger and cargo traffic in different ways. FAA has worked to improve the capacity and efficiency of the

national airspace system to accommodate a greater number and variety of aircraft by, for example, improving air traffic management systems and implementing domestic reduced vertical separation minimums.[7] FAA is also currently working on the transformation of the nation's current air traffic control system to the next generation air transportation system—a system intended to accommodate the expected growth in air traffic.[8] However, the full implementation of the next generation air transportation system is years away. To accommodate increased traffic, airports have expanded the number of available runways and gates to service additional aircraft and in some cases new airports have been built. However, airports cannot always accommodate increased air traffic by expanding their infrastructure for a variety of reasons, including the lack of physical space to build additional runways or terminals. Aircraft manufacturers have developed larger and more efficient aircraft to meet growing passenger and freight demand. For example, Boeing introduced the first wide-body aircraft in 1969, the 747-100, which significantly changed the aviation market and was much larger than currently operated aircraft. According to Airbus, the 747-100 had roughly two and a half times more seating capacity than the largest aircraft operating at the time.[9] Since then, other wide-bodied aircraft have been introduced to accommodate the increasing emphasis and demand placed on international service.

The Airbus A380 represents another generational change in aircraft size and seating capacity. Specifically, the A380 is much larger than other aircraft, with a wingspan of about 262 feet, a tail fin reaching almost 80 feet high, a maximum takeoff weight in excess of 1.2 million pounds, and seating between 555 and 853 passengers. In comparison, the largest commercial aircraft in use today, the Boeing 747-400, has a wingspan of

[7]Domestic reduced vertical separation minimums permit air traffic controllers to reduce minimum vertical separation from 2,000 feet to 1,000 feet at altitudes between 29,000 and 41,000 feet for aircraft that are equipped with dual altimeter systems and autopilots. Theoretically, by reducing the vertical separation minimums, the airspace system could accommodate more aircraft at any given time.

[8]For more information about the next generation air transportation system, see GAO, *Next Generation Air Transportation System: Preliminary Analysis of Progress and Challenges Associated with the Transformation of the National Airspace System*, GAO-06-915T (Washington, D.C.: July 25, 2006).

[9]In 1970, the increase in maximum passenger capacity from the Boeing 707-320B (189 passengers) to the Boeing 747-100 (452 passengers) was about 139 percent.

211 feet, a tail fin about 64 feet high, a maximum takeoff weight of 875,000 pounds, and can seat between 416 and 660 passengers.[10]

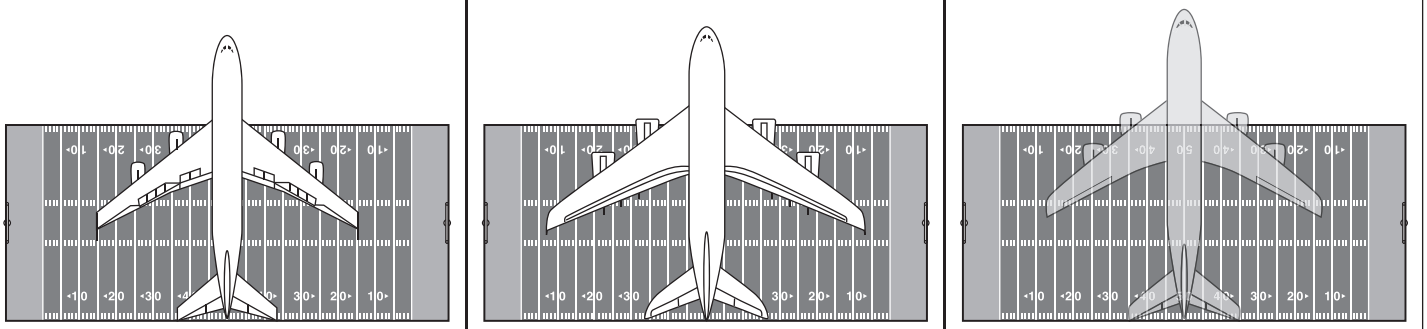
Although the A380 will be the first in the new category of large passenger aircraft, it will likely not be the last. In December 2006, Boeing announced that it received orders for its 747-8 passenger aircraft. The Boeing 747-8 is anticipated to have a wingspan of about 225 feet, a tail fin about 64 feet high, a maximum takeoff weight of about 970,000 pounds, and typically seats 467 passengers in a 3-class configuration. These dimensions place this aircraft in the same category as the A380. (Figure 2 shows the dimensions of the Boeing 747-400, Airbus A380, and Boeing 747-8 aircraft.) Airbus anticipates there will be a continued demand for larger aircraft that can connect busy and congested hubs in the future. According to its analysis, Airbus estimated that new large passenger and freight aircraft would make up about 10 percent of the overall fleet from 2004 to 2023. In contrast, Boeing, while conceding the demand for a small number of very large aircraft, projects a greater demand for smaller-sized aircraft, such as the Boeing 787, which can provide point-to-point service, especially in long distance markets.[11]

[10]The 747-400 typically seats 416 passengers in a 3-class cabin configuration but certified to seat a maximum of 660 passengers. In addition, a newer version of the Boeing 747-400 aircraft was approved with a maximum takeoff weight of 910,000 pounds through a design change.

[11]The 787-8 Dreamliner will carry 210 to 250 passengers on routes of 7,650 to 8,200 nautical miles; the 787-9 Dreamliner will carry 250 to 290 passengers on routes of 8,000 to 8,500 nautical miles; and the 787-3 Dreamliner will accommodate 290 to 330 passengers and optimized for routes of 2,500 to 3,050 nautical miles.

Figure 2: Comparison of the Boeing 747-400, Airbus A380, and Boeing 747-8

BOEING 747-400 (currently in operation):		AIRBUS A380 (in production):		BOEING 747-8 (planned):	
Wingspan:	211.4 feet	Wingspan:	261.7 feet	Wingspan:	224.6 feet
Length:	231.8 feet	Length:	239.3 feet	Length:	250.7 feet
Height:	63.7 feet	Height:	79.6 feet	Height:	64.2 feet
Max takeoff weight:	.875 million pounds	Max takeoff weight:	1.235 million pounds	Max takeoff weight:	.970 million pounds
Number of seats:	416–660	Number of seats:	555–853	Number of seats:	467
Max fuel capacity:	57,285 gallons	Max fuel capacity:	81,890 gallons	Max fuel capacity:	64,225 gallons



Source: GAO.

The air carriers that have ordered the A380 plan to operate at airports throughout the world, including certain U.S. airports. As a result, the A380 must comply with aviation standards set by individual countries from around the world. ICAO is the international body that seeks to harmonize global aviation standards so that worldwide civil aviation can benefit from a seamless air transportation network. Its members or contracting states, including the United States, are not legally bound to act in accordance with the ICAO standards and recommended practices.[12] Rather, contracting states decide whether to transform the standards and recommended practices into national laws or regulations. In some cases, contracting states deviate from the ICAO standards and recommended practices, or do not implement them at all.[13] Although ICAO has no enforcement powers and only establishes standards and recommended

[12]ICAO has a sovereign body, consisting of 189 contracting states (members). Each contracting state is entitled to one vote, and decisions are determined by a majority of the votes cast.

[13]Contracting states are obligated to notify ICAO of differences if they choose not to implement the ICAO standards.

practices, air carriers that use airports that do not comply with them may be subject to increased insurance costs. The A380 falls under ICAO's design standards for the largest aircraft (Code F), which require at least 60-meter-wide runways (about 200 feet) and 25-meter-wide taxiways (about 82 feet). In addition, ICAO has also established varying in-flight, landing, and takeoff separation standards for the different classes of aircraft.

In the United States, FAA, an agency of the Department of Transportation (DOT), is responsible for regulating the safety of civil aviation and also establishes the standards and recommendations for the design and development of civil airports. FAA's role as a regulator is to foster aviation safety by overseeing manufacturers and operators to enforce full compliance with safety requirements. To this end, FAA must certify any new aircraft design before that aircraft can be registered in the U.S. for operations by domestic airlines. This design certification is the foundation for many other FAA approvals, including operational approvals. When domestic aircraft manufacturers request approval of a new aircraft design, FAA uses the type certification process to ensure that the design complies with applicable requirements or airworthiness standards. Type validation is the type certification process that FAA uses for foreign or imported products, such as the A380, to ensure that the design complies with applicable FAA standards. The A380 was validated by FAA and issued a type certificate in December 2006. Also, in March 2007, Airbus completed a series of airline route proving and airport compatibility flights, which were designed to demonstrate the A380's ability to operate at airports around the world. As part of these flights, the A380 visited four U.S. airports, including New York John F. Kennedy, Chicago O'Hare, Los Angeles, and Washington Dulles International Airports.

FAA also establishes standards and recommendations for airport planning and design. Due to the size of the A380, it is subject to the FAA's design standards for the largest aircraft (Airplane Design Group VI standards). To be in compliance with these design standards, airports are required to have 200-foot-wide runways, 100-foot-wide taxiways, and appropriate separation distances.[14] Table 1 shows the wing span criteria for the airplane design groups and examples of aircraft that fall into each

[14]FAA Advisory Circular, *Airport Design* 150/5300-13. According to FAA, these design standards are required for new federally-funded construction or reconstruction projects at U.S. airports.

category. These design standards group aircraft by wingspan and set ranges for which the aircraft that fall within each group could operate without limitations. According to FAA standards, the A380 could operate at U.S. airports built to Design Group VI standards without the imposition of operating restrictions to the airport or aircraft. However, most U.S. airports that anticipate receiving A380 service are not built to Design Group VI standards. When airports do not or cannot meet the required FAA design standards to accommodate certain aircraft, airport officials can apply for Modifications to Standards through FAA. This would allow certain aircraft to be operated at airports under certain conditions as long as the airport can provide an acceptable level of safety comparable to that of an airport meeting Design Group VI standards. The use of Modifications to Standards is a process to provide U.S. airports flexibility when the required design group standards cannot be met to accommodate certain operations, as long as an acceptable level of safety can be maintained.

Table 1: FAA Airplane Design Groups

Design group	Wingspan	Examples of aircraft type
I	< 49 feet	Cessna 152-210, Beechcraft A36
II	49 – 79 feet	Saab 2000, EMB-120, Saab 340, Canadair RJ-100
III	79 – 118 feet	Boeing 737, MD-80, Airbus A320
IV	118 – 171 feet	Boeing 757, Boeing 767, Airbus A300
V	171 – 214 feet	Boeing 747-400, Boeing 777, MD-11, Airbus A340
VI	214 – 262 feet	Airbus A380 (in production), Boeing 747-8 (planned)

Source: FAA.

After reviewing the design specifications of the A380, FAA issued interim guidance in 2003 that allows the A380 to operate at airports with runways and taxiways that do not fully meet Design Group VI standards.[15] In order to avoid costly or impractical changes to upgrade runways and taxiway systems to Design Group VI and be approved for A380 operations under the interim guidance, FAA must approve an airport's request for Modifications to Standards when the standards are not met. These

[15]Engineering Brief 65 allows A380 operations on existing 150-foot-wide runways at airports by converting them to 200-foot-wide runways by adding 25 feet of pavement on each side at a lesser strength than required under Design Group VI standards and widening runway shoulders. Engineering Brief 63A allows the A380 aircraft to operate at airports with 75-foot-wide taxiways, if shoulders are widened and operating restrictions may need to be imposed.

modifications may include A380-specific operational restrictions or special operating procedures to ensure that existing non-standard infrastructure is providing an acceptable level of safety.

A380 Poses a Number of Potential Safety Challenges at Airports

The A380 will be the first of a new category of large passenger aircraft introduced into the national airspace system in the coming years. The size of the aircraft poses a number of potential safety challenges for airports. Most U.S. airports were not designed to receive aircraft the size of the A380 and therefore, the width of their runways and taxiways do not meet FAA safety standards. As a result, airports expecting A380 service need to modify their infrastructure or impose operating restrictions on the A380 and other aircraft to assure that safety is maintained. In addition, research data suggests that the wake turbulence created by the A380 is stronger than any aircraft in use today and would require greater separation from other aircraft during landing and takeoff. Although the A380 is equipped with some safety enhancements, such as new internal and exterior materials designed to reduce flammability and an external taxiing camera system to enhance pilot vision on the ground, the A380 poses safety challenges for fire and rescue officials due to its larger size, upper deck, fuel capacity, and the number of passengers. The fire and rescue officials at the airports we visited were confident in their ability to respond to an A380 incident, but almost all of them identified some equipment, personnel, or training needs that would improve their ability to respond to emergencies involving the A380. Similar concerns were raised for the Boeing 747 aircraft when it was introduced to the market, and these potential safety challenges would likely be present for other similarly-sized aircraft introduced in the future. FAA, ICAO, Airbus, and airports have taken a number of steps to mitigate potential safety challenges posed by the A380.

A380 Offers Some Safety Enhancements But Its Size Presents Potential Safety Challenges for Airports

The A380 offers air carriers and airports several safety enhancements over existing aircraft. For example, it has a cockpit with the latest advanced displays and avionics, and is equipped with an external taxiing camera system to assist flight crews in keeping the aircraft in the center of taxiways when moving on the airfield.[16] The cockpit was also designed to be much lower to the ground than other large aircraft to provide the flight

[16]Airbus refers to this camera system as the “external and taxiing camera system” or ETACS.

crew better visibility. Other technical advances include the aircraft's new external and internal materials that are designed to reduce flammability. A new material called Glare that is highly resistant to fatigue, is used in the external panels for the upper fuselage and provides a longer period of time preventing fire from penetrating into the passenger cabin—about 15 minutes compared to about a minute for standard aircraft aluminum. In addition, thermal acoustic insulation blankets, designed to extend the time before an external fire penetrates the fuselage, will be used inside the A380.[17] Combined, these materials could provide additional time for evacuation by delaying the entry of fire into the cabin. The interior materials used in the A380 will also have decreased flammability properties and the aircraft will be equipped with enhanced fire and smoke detection systems.

However, the size of the A380 also presents several potential safety challenges. These challenges include accommodating the A380 at airports that were not designed for aircraft as large as the A380, ensuring that the air turbulence caused by the A380 does not impact the flight of other aircraft, evacuating large numbers of passengers from the A380, and ensuring that airports have the necessary fire and rescue capabilities available.[18] These issues would likely be present for other similarly-sized aircraft that may be introduced in the future. FAA, ICAO, Airbus, and airports have taken several steps to mitigate these challenges.

U.S. Airports Typically Not Designed to Handle A380-sized Aircraft

The size of the A380 presents a safety challenge because most U.S. airports were not built to accommodate such large aircraft. FAA's design standards are intended to ensure the safety of the aircraft and passengers at the airport. For example, FAA's Design Group VI standards, which are applicable for the largest aircraft, including the A380, require that airports have 200-foot-wide runways. According to FAA officials, this standard helps ensure that pilots can safely operate large aircraft like the A380. Although the design standards do not govern aircraft operations, aircraft operators must seek FAA's approval for certain aircraft to use facilities and infrastructure that do not meet standards and demonstrate to FAA

[17]Thermal acoustic insulation is a fiberglass-type material used throughout the fuselage of commercial aircraft for reducing cabin noise from external sources and for maintaining comfortable cabin temperatures. FAA will begin requiring this improved insulation on all newly produced aircraft beginning in September 2009.

[18]Aircraft create turbulence that forms behind them as they pass through the air.

that an acceptable level of safety is maintained.[19] A few airports, such as Dallas-Fort Worth, Denver, and Washington Dulles International Airports, meet some design standards for A380-sized aircraft; however, no U.S. airport is completely built to those standards.

To address this issue, airports have made or are making infrastructure changes to safely accommodate the A380. In May 2006, we reported that 18 U.S. airports were making preparations to receive the A380 and estimated that it would cost about $927 million to upgrade their infrastructure.[20] About 83 percent of the costs reported by airports were identified for runway or taxiway projects. Most projects widened existing runways or taxiways and, in some cases, relocated taxiways to increase separation. The remaining costs were for changes at gates, terminals, or support services. Although these changes to airport infrastructure were driven by the introduction of the A380, they will also benefit current aircraft and other new large aircraft that may be introduced in the future. Further, officials at some airports told us that the economic benefits from having A380 service at their airport will outweigh the costs associated with the infrastructure changes needed to accommodate the aircraft.

To safely accommodate the A380, many of the U.S. airports we visited that expect to receive this aircraft have requested Modifications to Standards from FAA.[21] The use of Modifications to Standards is an established process to provide U.S. airports flexibility when the required design group standards cannot be met to accommodate certain operations as long as an acceptable level of safety can be maintained. For example, if the separation between a runway and a taxiway at an airport is less than the established standards, a Modification to Standards can be granted by FAA

[19]To illustrate, FAA officials said that some Design Group VI category aircraft, such as the freighter Antanov 225 and military C-5A aircraft, operate on some 150-foot-wide runways in the U.S. today. However, airports that occasionally accommodate these aircraft and are not compliant with Design Group VI standards must request procedural waivers from FAA. FAA is still in the process of conducting an operational evaluation for the A380, expected to be completed by June 2007, and has not determined all operational restrictions.

[20]GAO, *Commercial Aviation: Costs and Major Factors Influencing Infrastructure Changes at U.S. Airports to Accommodate the New A380 Aircraft*, GAO-06-571 (Washington, D.C.: May 19, 2006).

[21]Modification to Standards means any change to FAA standards, other than dimensional standards for runway safety areas, applicable to an airport design, construction, or equipment procurement project that results in lower costs, greater efficiency, or is necessary to accommodate an unusual local condition on a specific project, when adopted on a case-by-case basis.

for not meeting the current standards when federal funds are being used for a planned improvement to that runway or taxiway and FAA determines that it is operationally safe. According to FAA, the use of Modifications to Standards at airports does not compromise safety. This process has been used by U.S. airports that do not fully meet the design standards for certain sized aircraft. However, FAA officials said the Modification to Standards process being applied to the A380 is seldom used because this process generally is not used to limit operations of a particular aircraft at an airport.[22]

Of the 18 U.S. airports we visited, 11 have applied for Modifications to Standards that would allow them to operate the A380. Of the remaining seven airports, officials indicated they were unsure if such modifications will be needed and will decide whether to request Modifications to Standards after FAA decides whether an A380 can safely operate on a 150-foot-wide runway or whether a 200-foot-wide runway will be required. According to FAA officials, a decision on runway width is expected in late summer of 2007.[23]

Finally, the airports also anticipate implementing some type of operating restrictions in order to safely accommodate the A380. Specifically, all 18 U.S. airports we visited anticipated imposing some type of operating restrictions on the A380 or on other aircraft that operate around the A380. The anticipated operating restrictions would generally affect runway and taxiway use. For example, officials at San Francisco Airport plan to restrict the movement of certain aircraft from using sections of parallel taxiways when an A380 is taxiing to and from the terminal because the taxiways are not far enough apart to meet the standards for taxiway separation required to safely operate the A380. FAA officials noted, however, that FAA is still conducting an operational evaluation for the A380, and therefore has not determined what, if any, operational restrictions for the A380 will be required. Thus, airports' planned operating restrictions are subject to change when FAA completes its operational evaluation, which is expected this summer. FAA officials said that, FAA

[22]FAA officials said the Modification to Standards process is not generally used to govern operations of a particular aircraft at an airport. Rather, the process is generally used for the justification of an investment of federal funds in construction projects for facilities that do not fully meet design standards for an aircraft design group and not necessarily issued for a particular aircraft.

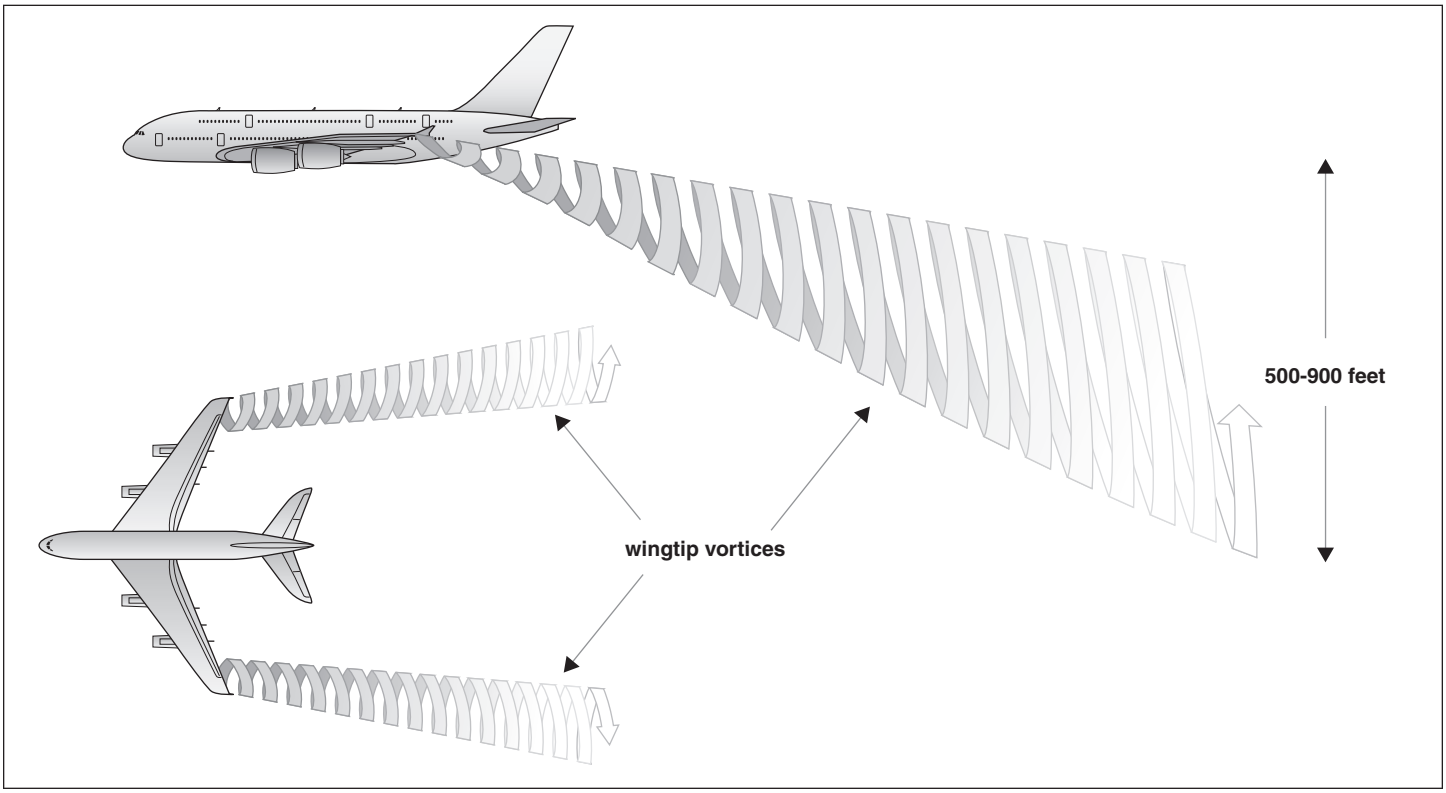
[23]As discussed later in the report, the European regulatory counterpart to FAA has certified the A380 to operate on 150-foot-wide (45 meters) runways.

will perform an operational evaluation similar to the evaluation used for the A380 for the Boeing 747-8 and other large aircraft when they enter service.

A380 Produces Greater Wake Turbulence Than Other Aircraft

The wake turbulence of the A380 and other large aircraft can create safety issues if appropriate wake turbulence separations are not applied. Wake turbulence is created behind aircraft and the strength of the turbulence is dependent on the wingspan, the weight of the aircraft, and its speed. In general, the bigger the aircraft, the greater the wake created. Wake turbulence can affect following aircraft during landing, takeoff, and in-flight. Figure 3 illustrates how wake turbulence is created by an aircraft and the direction it travels. FAA and ICAO have adopted standards for keeping aircraft separated from each other during landing, takeoff, and in-flight to avoid the adverse effects of wake turbulence.

Figure 3: Illustration of the Effects of Wake Turbulence



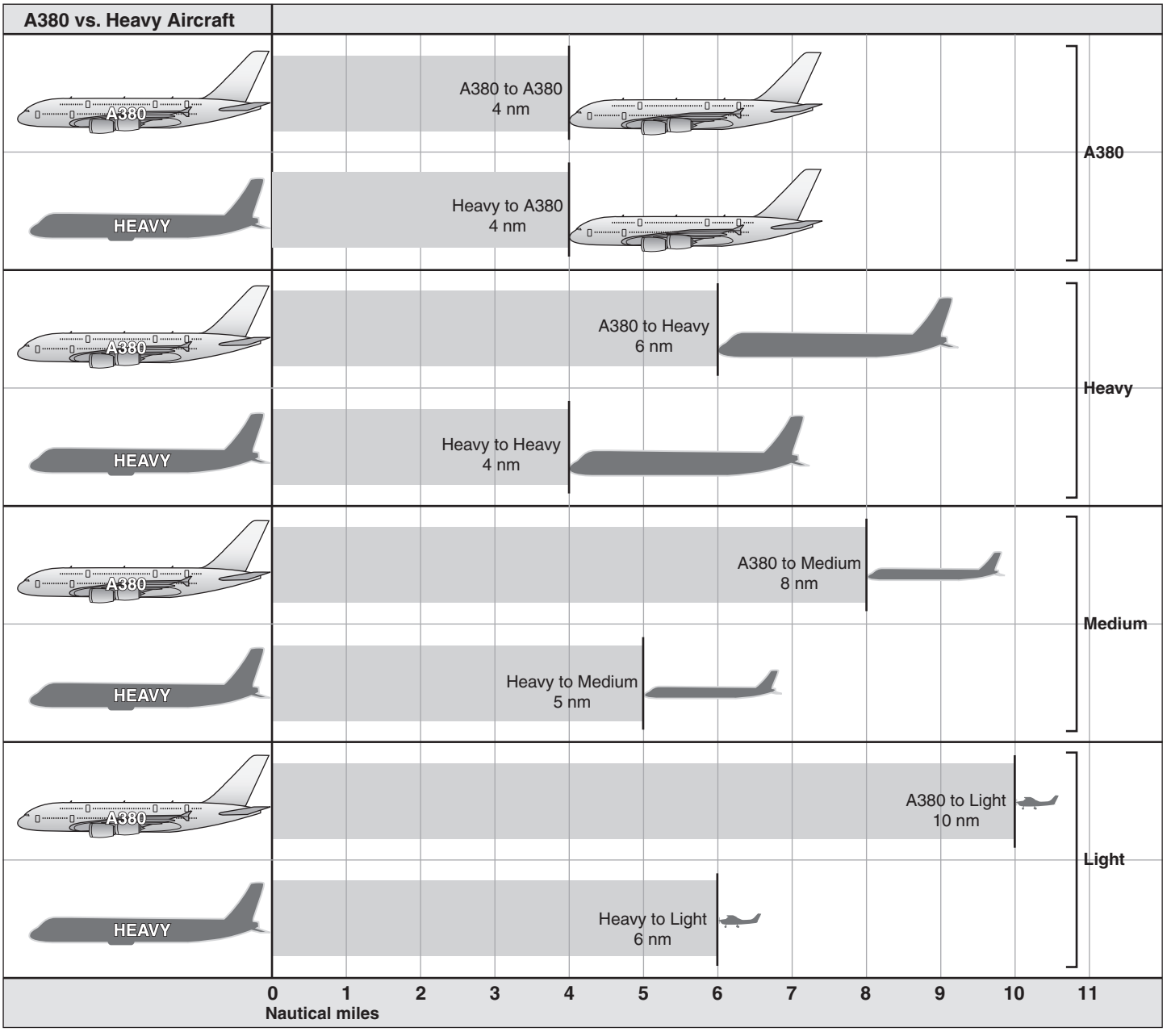
Source: GAO representation of FAA information.

Note: Flight tests have shown that the wake vortices from larger aircraft extend downward at a rate of several hundred feet per minute, slowing in descent and diminishing in strength with time and distance.

ICAO and FAA have studied whether the A380 needs greater separation than current standards require and determined that the A380 produces stronger wake turbulence than any aircraft in use today. On the basis of this data, ICAO issued new guidance on the separation required between the A380 and other aircraft during landing, takeoff, and in-flight in October 2006. ICAO officials acknowledged that the guidance could be more conservative than the final standards, noting that the initial flight separation standard for the Boeing 747-400 aircraft was also set conservatively, but later reduced. The separations for the A380 could be changed in the future on the basis of operational experience of the aircraft. However, while this guidance is in effect, there will be somewhat longer intervals for departures following an A380 than currently exist and greater distances between aircraft following an A380 during landings. Figure 4 illustrates the interim flight separation standards for the A380 compared to other heavy category aircraft, such as the Boeing 747-400 aircraft.[24]

[24]"Heavy" is an aircraft category used by air traffic officials when applying wake turbulence separations. The heavy category represents aircraft that weigh more than 299,800 pounds (136,000 kilograms).

Figure 4: Illustration of On-approach Landing Separation Distances for Aircraft Trailing an A380 and Heavy Aircraft



Source: GAO representation of ICAO information.

Note: Heavy, medium, and light are aircraft categories used by air traffic officials when applying wake turbulence separations. The heavy category represents aircraft that weigh more than 299,800 pounds (136,000 kilograms); medium for aircraft that weigh more than 15,430 pounds (7,000 kilograms) but less than or equal to 299,800 pounds; and light for aircraft that weigh less than or equal to 15,430 pounds.

One nautical mile is equal to 1.15 miles.

Greater Number of Passengers to Evacuate from A380 Compared to Other Aircraft

Another potential safety challenge is the large number of passengers to evacuate from an A380 during an emergency. The A380's maximum seating configuration can accommodate up to 853 passengers—193 more than carried by the maximum seating configuration of the Boeing 747-400. To obtain type certification, aircraft manufacturers must demonstrate that the aircraft can be evacuated within 90 seconds.[25] In March 2006, Airbus conducted the emergency evacuation demonstration for the A380. During the demonstration, 853 passengers and 20 crew members were successfully evacuated from the aircraft within 78 seconds. Airbus officials credited the design of the A380 for the successful evacuation demonstration.

A related concern of FAA officials, airport fire and rescue officials, and some experts with whom we spoke is how to handle the large numbers of people around the aircraft after evacuation is complete. In particular, some fire and rescue officials were concerned about their ability to control the crowd and how to treat injured people on-site prior to being moved to nearby hospitals. To address these concerns, airport fire and rescue officials are reexamining their equipment needs and emergency plans for treating a greater number of passengers. FAA guidance states that an airport's emergency plans should, to the extent practical, provide for medical services, including transportation and medical assistance, for the maximum number of people that can be carried on the largest aircraft that an airport reasonably can be expected to serve.[26] However, in most cases, airport fire and rescue officials said that they plan for reasonable worst-case scenarios in which about 50 percent of the passengers can be treated for injuries on the largest aircraft operated at the airport.

Size of A380 Could also Pose Airport Fire and Rescue Challenges

The advent of the A380 also may introduce a number of new fire and rescue safety issues for airports. For example:

[25]14 CFR Sec. 25.803.

[26]FAA Advisory Circular, *Airport Emergency Plan* 150/5200-31A.

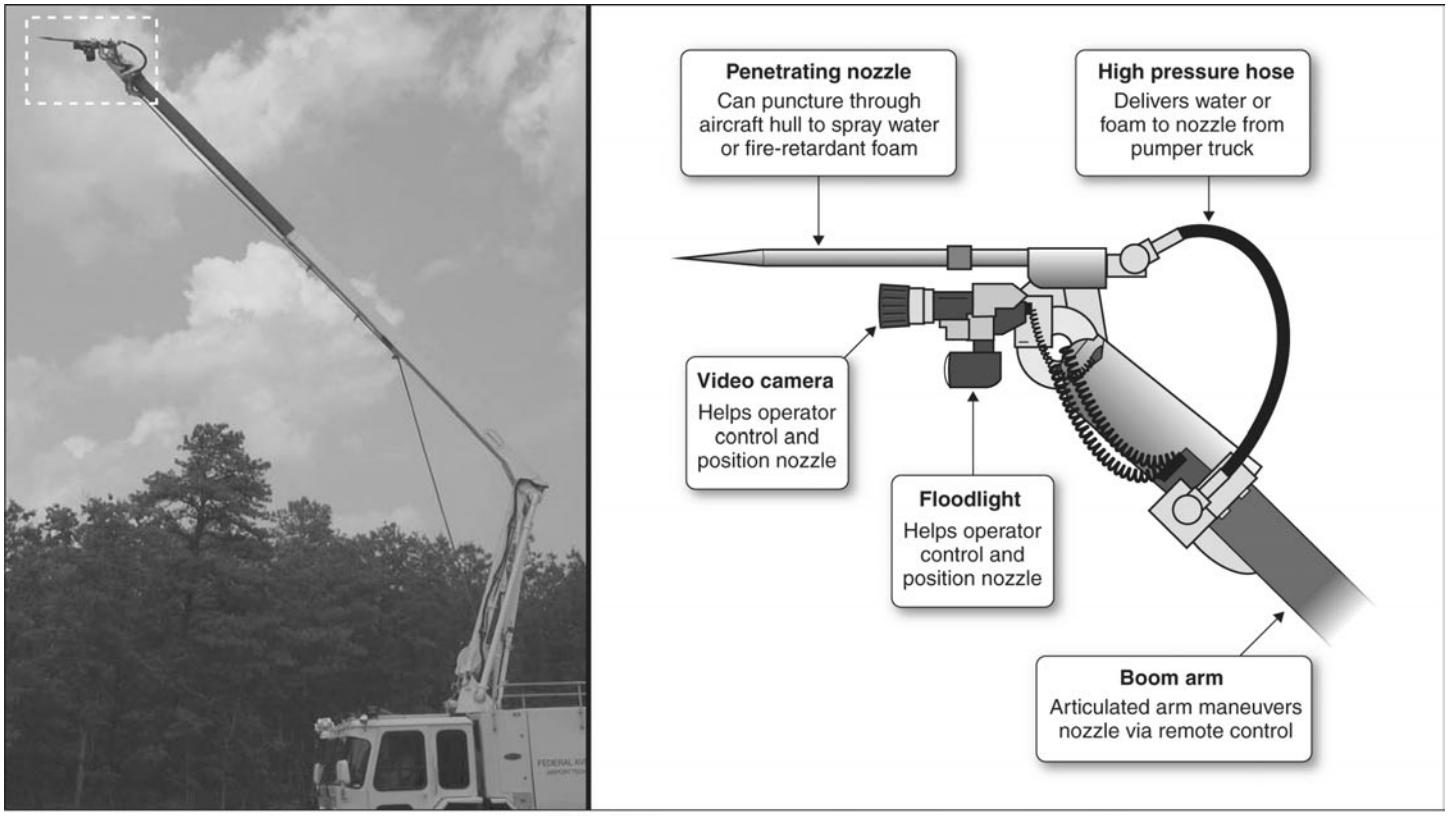
- The A380 can hold almost 82,000 gallons of fuel, compared to about 57,300 gallons carried by the Boeing 747-400. While an A380 or a 747-400 may not be fueled to maximum capacity, the proportional increase in fuel that could be on the A380 compared to that of a 747-400 means that fire fighters will need additional water and extinguishing agent to contain and extinguish a fire. Although the A380 will have Glare material, designed to increase the amount of time it takes before a fire can enter the cabin, it will not be installed on the underside of the aircraft where a fire caused by leaking fuel is most likely to occur, according to a FAA official. Thus, assuring that airports have sufficient extinguishing agent is important.

- Airports may not have the necessary equipment to access the upper deck of the A380 for fire fighting or evacuation purposes. Most fire and rescue officials at the airports we visited indicated that they do not have the equipment to access the upper deck of the A380 for fire fighting or evacuation purposes. Although the height to the upper deck door of the A380 is essentially the same as that of the 747, according to a FAA official, the need to invest in such equipment now becomes more critical for the A380 because more passengers are seated on the upper deck of the A380.

- The A380 was designed with 16 evacuation slides and the longest slide, on the upper deck, will extend out about 50 feet from the aircraft. This increased number of slides could improve passenger evacuation, but according to some fire and rescue officials we interviewed, the number and position of the A380's slides could also impede the fire and rescue vehicles' access to the aircraft and making it more difficult to suppress the fire.

  Several airport fire and rescue officials with whom we spoke were confident they could respond to an A380 incident with their current resources. However, most stated that they were evaluating personnel, equipment, and training needs to ensure that the airport was adequately prepared for the A380. Fire and rescue officials from several airports stated that the introduction of A380-sized aircraft will only increase their needs for additional personnel and equipment. For example, officials from some airports told us that they are planning to add a vehicle with a penetrating nozzle with a higher reach that can inject fire extinguishing agent into the upper deck of the A380. Figure 5 shows a fire fighting vehicle with a penetrating nozzle fully extended and elevated to its maximum height of 50 feet.

Figure 5: Fire Fighting Vehicle with Penetrating Nozzle



Source: FAA and GAO.

To help address these safety concerns, FAA has begun evaluating the need to update its airport fire and rescue safety guidance for new large aircraft, such as the A380. Officials from FAA's Technical Center said that the guidance needs to be updated to reflect the A380's vertical height, high numbers of passengers, second passenger deck, and increased fuel loads.[27] FAA is also researching the need to increase the amount of water and extinguishing agent needed to respond to an A380 incident. In addition, FAA is studying the quantity of fire-suppressing agents needed to combat fires on new large aircraft and double-deck aircraft—taking into account

[27]FAA performs firefighting research at the FAA William J. Hughes Technical Center (Technical Center) to improve the effectiveness or better use current firefighting equipment to provide an increase in passenger survivability under the extreme conditions of a post-crash fire.

the vertical dimension of the A380. However, FAA officials noted that most of the airports expecting to receive A380 flights currently exceed the vehicle and extinguishing agent requirements applicable to the aircraft and therefore would likely already meet new standards. FAA researchers are also helping to develop a penetrating nozzle on a 65-foot boom that would provide greater extension and a higher reach to inject fire extinguishing agent into the upper deck of the A380.

A380's Impact on Capacity at U.S. Airports Is Uncertain

The impact of the A380 on the capacity of U.S. airports is uncertain and would depend on multiple factors. Airport capacity is generally measured by the maximum number of takeoffs and landings that can occur within a given period of time. The A380 could increase passenger capacity at airports because it can carry more passengers than current aircraft and fewer flights could be used to accommodate air traffic growth. However, potential operating restrictions and the increased flight separation requirements could adversely impact capacity by limiting the number of flights that airports can handle. Further, the effects of gate restrictions, such as the number of gates available for A380 use and restricted use of gates adjacent to the A380, and terminal congestion from the increased number of passengers will need to be evaluated and could cause delays to the A380 and other aircraft. The extent of disruptions and delays caused by possible operating restrictions, increased separation requirements, and gate restrictions would depend on the time of day, the number of A380 operations, and the volume of overall traffic. Many airport officials stated that as long as the number of A380 operations per day remains low, the impact of the A380 on airport capacity—even with operating restrictions, increased separation requirements, and gate restrictions—should not be significant; however, as the number of A380 operations increases, the potential for an adverse impact also grows.

A380 Designed to Provide Some Capacity Benefits

The A380 was created, in part, to help alleviate airport capacity constraints caused by the continued growth in passenger and cargo air traffic. Air traffic in the U.S. increased by 35 percent from 1991 to 2001. Despite the low passenger travel following the events of September 11, 2001, FAA forecasts this growth to continue—estimating that air traffic will triple over the next 20 years. The current and projected growth in air traffic will also include new classes of aircraft, such as the A380. This greater diversity of aircraft—in terms of size, speed, and operating requirements—will add to the demands placed on the national airspace system and airports.

Historically, airlines have addressed increased passenger demand by simply adding more flights and airports by expanding infrastructure. However, these are not viable options when airport runway infrastructure cannot be expanded and the volume of landings and departures at an airport exceeds the limits to operate efficiently. For example, in August 2006, FAA proposed a rule to limit the number of flights at New York's LaGuardia Airport to reduce the level of congestion and delays. To offset the limit on flights, the rule encourages the use of larger aircraft at the airport to accommodate increased passenger demand. By using larger aircraft, the airport could accommodate more passengers with fewer or with the existing number of daily flights. Similarly, London's Heathrow airport plans to increase its passenger capacity without increasing the number of daily flights by expecting as many as one of every 10 flights to be an A380 by 2020.

According to Airbus, the A380 will help alleviate capacity constraints by accommodating more passengers and freight on each flight than any other aircraft in use today. Airbus officials estimate that the A380 can carry at least 35 percent more passengers and the A380 freighter will carry 50 percent more cargo volume per flight than other aircraft currently in use. In addition, the A380 can fly up to 8,000 nautical miles non-stop, enabling airlines to carry more passengers for greater distances than the current largest aircraft. Thus, the A380 could transport more people or freight greater distances with the same number—and possibly fewer—aircraft than are used currently. At congested airports, when A380 aircraft are used, airlines could meet anticipated growth in air travel without having to schedule additional flights.

In addition to alleviating capacity constraints, Airbus and airport officials told us that the potentially greater number of passengers on each A380 compared to currently used aircraft could translate into economic benefits for the airports and local communities that would receive them. Specifically, airport expansion to accommodate anticipated growth in air travel, including the larger volume of passengers that the A380 could bring to an airport, could contribute to an area's economic growth.[28] According to Airbus and some airport officials, if airports received more passengers,

[28]Simply providing more seats on an aircraft does not necessarily equate to more passengers being carried. However, if more passengers travel on the routes that A380s will be used than can be accommodated with current capacity, or if the introduction of the A380 leads to lower airfares, then airports receiving A380 service might also see an increase in the number of passengers.

airports will benefit from greater parking revenues, passenger facility charges, retail and restaurant sales, and other services. In addition, if A380 service increases the number of passengers flowing in and out of the airport, that increase could translate into more job opportunities at the airport and in the community. Studies have indicated that economic benefits can accrue to local economies as a result of activity at airports through expansion projects, directly and indirectly, in terms of additional jobs or increased salaries and wages. Therefore, the economic impact of A380 service on local communities near airports could be substantial, but it is not certain because the degree to which passenger volume would increase is uncertain. Furthermore, any economic benefits realized by airports and local communities as a result of airport improvements to enhance capacity, including accommodating A380 service, may represent transfers of economic activity from one airport or community to another.[29]

Airports' Planned Operating Restrictions, Increased Flight Separation Requirements, and Gate Limitations Could Offset Some Capacity Benefits

Airports' planned operating restrictions and separation requirements resulting from A380 ground and flight operations, as well as the reduction in gate utilization and flexibility could offset some of the capacity gains anticipated as a result of the aircraft at U.S. airports.[30] Potential operating restrictions and the increased separation requirements imposed to ensure the safety of the A380 and other aircraft at airports and during flight could result in a reduction in the number of flights that airports can accommodate. Furthermore, gate availability, restricted use of gates adjacent to A380 gates, and potential congestion issues could reduce gate utilization and flexibility at some airports—which could also lead to fewer flights at an airport. According to most of the airport officials and experts we interviewed, the extent to which operating restrictions, increased separation requirements, and gate utilization would impact capacity would depend on the volume of A380 traffic, the time of day, and the volume of overall air traffic.

[29]Economic transfers can represent real benefits for airports making the improvements, but from a national perspective they may not represent net benefits because some economic activity may be simply transferred from other airports.

[30]Any restrictions and requirements that limit potential capacity gains will also limit the economic benefits to the airports and local communities.

Operating Restrictions on the A380 at U.S. Airports Could Adversely Impact Capacity

Most U.S. airports we visited that expect to receive the A380 are not designed for aircraft of this size and, therefore may need to implement operating restrictions to safely accommodate the A380. These restrictions can come in many forms—from restricting the A380 to certain runways and taxiways to stopping the movement of other aircraft when the A380 is in close proximity. In addition some airports have designated specific routes for the A380 to use when landing and taxiing. These specific routes are needed because the wingspan of the A380 prevents the aircraft from passing various objects on the airfield, such as buildings, without violating the spacing requirements established by FAA. Therefore, airports expecting large aircraft service like the A380 will have to evaluate taxi routes to ensure required distances from other objects are maintained—which is a normal procedure for airports that receive larger aircraft.

The effect of these operating restrictions have not been determined, but a potential impact is that airports may not be able to handle as many landings and departures in a given time period. For example, at one airport, airport officials said landings and departures could not be performed on one runway while an A380 is taxiing to or from the runway for about two miles on the adjacent taxiway. According to the air traffic controllers, this would disallow use of that runway for about three minutes. Even delays of a few minutes at an airport could increase the operating costs of air carriers. For example, FAA officials from FAA's Technical Center estimated that one minute of delay would cost an air carrier at San Francisco airport about $57, or about $3,400 per hour. Similarly, the A380 may need to follow a designated route to and from the runway—and not necessarily the most efficient route—potentially delaying other aircraft that may need to wait for the A380 to complete its maneuvers. As a result, fewer aircraft could be able to access runways to land and depart in a given period. Most experts and air traffic controllers said the cumulative effect of these restrictions could reduce the number of flights at a busy airport because delays exacerbate airport congestion and make the job of managing air traffic more difficult. In the long-term, airports could work with airlines to schedule A380 aircraft during off-peak times to lessen this effect. However, airlines may be reluctant to schedule these flights during off-peak hours because it might be contrary to their international flight time slots to which A380s will likely be largely used. Regardless, even if schedules were adjusted to account for the operating restrictions, the additional time associated with the restrictions could result in the airport being unable to accommodate as many flights as it could if not for the A380 operating at the airport.

According to many airport officials and aviation experts with whom we spoke, the extent of disruptions and delays caused by the operating restrictions would depend on the time of day, the number of A380 operations, and the volume of overall traffic. Many airport officials and experts we interviewed stated that as long as the number of A380 flights per day remains low, the impact of the operating restrictions should not be significant; however, as the number of A380 flights increases, the potential impact would also grow.

Separation Requirements for A380 Could Adversely Impact Airspace and Airport Capacity

The increased separation requirements for the A380 could adversely impact airspace and airport capacity. Under ICAO's current guidance, separation distances are based on the size of the aircraft following an A380, with lighter aircraft requiring a greater separation. To illustrate the increased separation requirements for the A380 on approach for landing, there must be a 6 nautical-mile separation between a heavy category aircraft, such as a 747-400, trailing an A380. In comparison, a heavy aircraft trailing another heavy aircraft needs to be separated by 4 nautical miles. The cumulative effect of this extra separation could adversely impact airspace capacity by reducing the number of flights that could be accommodated in the airspace during a given time frame, according to most of the experts we interviewed. In addition, the additional separation between the A380 and other aircraft during takeoff and landing can reduce the number of arrivals and departures at an airport, which could also negatively impact airport capacity. Airbus officials, however, noted that such reductions in the number of arrivals and departures will be countered by the potential increase in the number of passengers per A380 flight—that is, the number of airplane operations may decrease, but the number of passengers arriving and departing from the airport may increase.

Most of the experts we interviewed generally agreed that the increased flight separations required for the A380 could have a significant impact on airport capacity, but noted the magnitude of the impact would depend on timing of flights and volume of A380 traffic. Most airport officials at the airports we visited indicated that they expected few A380 flights and therefore, did not anticipate that the additional separation or ground traffic issues would have a significant impact. FAA's analysis of capacity at a few airports expecting to receive the A380 supports these views.[31] For

[31]This analysis was conducted at FAA's Technical Center, which performs capacity studies for airports. These studies consider a variety of factors, such as the actual traffic at the airport, airlines' projections of future flights, and airport improvements such as new runways.

example, using ICAO's current separation standards—which increase separation by the size of the aircraft following an A380—FAA projected that A380 operations at the San Francisco airport in 2015 would add no increase in delays given the few A380s expected. However, given the larger number of expected A380s at New York's JFK airport, A380 operations would increase the total annual delay about 2 percent in 2015 over the expected total annual delay without A380 service. In addition, FAA projected that as the number of A380 flights increase by 2025, an increase of about 1 percent in the total annual delay can be expected at San Francisco airport and almost 2 percent at New York's JFK airport over the expected hours of total annual delay without A380 service. The projected cost to airlines in 2025 for A380-related delays at San Francisco airport would be $11.6 million and $59.2 million at JFK airport.[32] According to Airbus officials, however, the analysis does not reflect potential cost savings to airlines due to the reduction in the number of arrivals and departures and as previously noted the potential increase in the number of passengers per A380 flight. Without an integrated analysis that includes passenger throughput, we are unable to determine the net effect.

A380 Could also Create Gate and Terminal Disruptions

The size of the A380 may also impact gate utilization in several ways. First, the A380 will need to use gates with at least two passenger loading bridges. The A380—similar to the 747-400—will be limited to using specific gates because not all gates have two bridges. Similarly, many terminal areas at U.S. airports where traffic bottlenecks and congestion are common will not have the necessary clearances for an A380 to operate on taxilanes between or beside other aircraft (see fig. 6). Thus, the A380 will be limited to certain gates. Second, the size of the A380 could restrict the size of the aircraft at the adjacent gate, or close the gate entirely. Third, loading and unloading passengers and baggage on an A380 could take longer because of the increased number of passengers on the aircraft. As a result, the A380 could tie up a gate longer than other aircraft, reducing the number of aircraft that could be served by the gate in a given period. According to most of the experts with whom we spoke said these gate

[32]The studies evaluated the potential impact of new large aircraft at San Francisco and New York JFK airports in 2006, 2015, and 2025 with and without the introduction of the A380, and projected that A380 traffic would increase delays by 2025. The assumptions used in the capacity studies included the anticipation that necessary infrastructure improvements would be in place by 2006, air traffic demand including fleet mix are established before and after the introduction of the A380, and operational procedure restrictions needed were identified. In addition, the anticipated A380 flights used for the two airports were nine daily flights in 2015 and 16 in 2025 for San Francisco; and 14 daily flights in 2015 and 52 in 2025 for JFK.

issues can reduce flexibility in airport operations and lead to delays. However, Airbus officials noted that the interior cabin design of the A380 and the use of two bridges should allow turnaround times of about 90 minutes—which is similar to the turnaround time of the 747-400.

Figure 6: The Taxilane Object Free Area Requirement for the A380

Source: GAO representation of FAA information.

The increased passenger load carried by an A380 could strain current airport terminal facilities and operations, such as check-in, baggage claim, and customs and immigration services. For example, most experts we interviewed said that a surge in passengers created by an A380 going through airport check-in procedures could not only delay the A380 passengers but also passengers of other flights. In addition, the amount of baggage from an A380 flight to load or unload could lead to delays for passengers and other aircraft waiting at the gate. One expert noted that the delays caused by the new security procedures introduced in the summer of 2006—which resulted in an increase in checked baggage for a period of time—illustrates how surges in the amount of baggage loaded and unloaded can lead to delays and congestion. However, airport officials generally had no concerns with the A380's impact on airport terminal facilities and operations. Additionally, a few experts told us that the A380's incremental increase in passengers and baggage over that of a 747-400 would have little impact on terminal operations, especially at airports that will only receive a few A380 flights per day.

As mentioned earlier, the next generation air transportation system is being designed to accommodate as much as 3 times the current air traffic, including the introduction of new large aircraft such as the A380. The planning underway involves so-called "curb-to-curb" initiatives that are

designed, in part, to address the potential capacity and gate disruption issues discussed above. Since the planning and implementation phases of the next generation system remain in the early stages, however, it is currently unclear the extent to which the initiatives will effectively mitigate those potential issues.

Foreign Airports Have Taken Different Approaches to Prepare for the A380

Selected foreign airports we visited have taken different approaches to prepare for the introduction of the A380. These differences reflect the age and the expected level of A380 traffic at the airports—and, in some cases, the anticipated economic benefits of the A380 flights. The different approaches include adopting alternative airport design standards to accommodate new large aircraft, making significant investment in existing infrastructure, and designing airports that allow for new large aircraft. By implementing these approaches, officials from the foreign airports we visited do not anticipate that the introduction of the A380 will result in delays or disruptions at their airports, despite higher levels of expected A380 traffic compared to most U.S. airports because these airports will not have to impose operating restrictions on the A380 to the extent of U.S. airports.

Adopting Alternative Standards to Accommodate New Large Aircraft

The A380 Airport Compatibility Group (AACG), which includes four European aviation authorities, agreed to adopt adaptations of the ICAO standards for A380 operations at existing airports that do not currently meet the requirements.[33] For example, ICAO standards require runway width to be no less than 60 meters (about 200 feet) and taxiway width 25 meters (about 82 feet), but the AACG decided widths of 45 meters (about 150 feet) for runways and 23 meters (about 75 feet) for taxiways would be adequate to safely operate the aircraft. Officials of European civil aviation authorities said the AACG decision was based on runway-to-taxiway centerline deviation studies that have found that large aircraft do not deviate significantly from the centerline. In addition, the AACG decision was influenced by the anticipation that the A380 would be certified by the

[33]The A380 Airport Compatibility Group (AACG) is an informal group, consisting of a number of European aviation authorities (France, Germany, the United Kingdom, and the Netherlands), airport and industry representatives. It was formed to agree to and promote a common position among the group members regarding the application of ICAO requirements, with respect to the A380 for infrastructure and operations at existing major European airports that currently do not meet the requirements. Australia has also adopted the AACG standards.

European Aviation Safety Agency (EASA) to operate on 45-meter runways—which occurred in December 2006.[34] In contrast, the FAA type certificate does not include approval to operate on 150-foot-wide runways and evaluations of these operations have not been completed. According to FAA, the decision about runway width is an operational concern, rather than a certification issue. FAA is currently evaluating the use of narrower runways (less than 200 feet).[35] FAA expects to complete its evaluations and issue a decision in summer 2007.

Making Significant Investment in Infrastructure Changes

Like most U.S. airports, the older foreign airports we visited were not designed to accommodate aircraft as large as the A380. However, unlike the U.S. airports, these foreign airports made significant investments in infrastructure changes and improvements in anticipation of future growth and the need to modernize, which included accommodating new large aircraft such as the A380.[36] For example:

- Airport officials at London Heathrow airport indicated about $885 million would be related to accommodating the A380. Heathrow's investments related to the A380 included widening and strengthening its two runway's shoulders and upgrading runway lighting, demolition and redevelopment of a portion of an existing terminal to add four A380 gates and allow more space for the aircraft, and development of a new terminal to provide five A380 gates by 2008 and 14 by 2011.

- At the Paris Charles de Gaulle airport, about $132 million is being spent to prepare for the A380. The investment includes widening and strengthening two runways at the airport and building a new satellite terminal complex specifically to accommodate the A380. Initially, nine gates with upper deck

[34]EASA, the European regulatory counterpart to FAA, develops common safety and environmental standards for European Member States in civil aviation. It monitors the implementation of standards in the Member States and provides the necessary technical expertise, training and research.

[35]If Airbus successfully completes its flight demonstration, the A380 will receive FAA Flight Standards approval to operate on 150-foot-wide runways (45 meters). If Airbus does not successfully demonstrate the A380's capability, FAA will require that airports expecting to receive the A380 meet the Design Group VI standard of 200-foot-wide runways and 100-foot-wide taxiways. If an airport does not meet the taxiway standard, airport officials can apply for Modifications to Standards through FAA. For FAA to approve a modification, the airport must demonstrate that they can provide an acceptable level of safety to the standard on a case-by-case basis.

[36]See appendix II for summaries of the foreign airports' A380 plans and operations.

access and two remote parking positions are available, but airport officials expect the number of A380 gates to increase to about 30 by 2018.

- At the Beijing Capital airport, A380-related improvements have been included in the $3 billion renovation projects—particularly to prepare for the 2008 Olympic Games—that include building a new terminal to handle the anticipated increase in future demand, a new 3,800-meter-long, 60-meter-wide runway to accommodate the A380, new facilities and cargo areas, and additional landing areas.

- At the Amsterdam Schiphol airport, a new 60-meter-wide, 3,800-meter-long runway and associated taxiways were built that meet international standards, and the terminal was expanded at a cost of over $440 million and $213 million, respectively, to expand capacity and maintain its competitive position as an international hub. The new, longer runway and terminal expansion projects were initiated to enhance overall capacity of the airport and to accommodate new large aircraft, such as the A380. The terminal will have four gates ready for the A380 in 2007.

In contrast, all the 18 U.S. airports expecting to receive the A380 plan to invest about $927 million in total on A380 infrastructure changes—which is only slightly more than the investments being made at Heathrow. The most a single U.S. airport is investing in infrastructure changes to accommodate the A380 is $151 million. The level of planned investments reflects the expected level of A380 traffic. Specifically, the foreign airports we visited are expecting more A380 traffic, in part, because they will serve as hub airports for international travel or serve as hubs for airlines that have purchased the A380. For example, JFK expects about 16 A380 arrivals and departures per day in 2015—possibly the most daily A380 flights at any U.S. airport. However, Heathrow airport officials expect that by 2020, one of every 10 aircraft arriving and departing will be an A380, or about 130 arrivals and departures per day. Similarly, officials at the Paris Charles de Gaulle airport estimate that at least 10 percent of all passengers arriving at the airport will be aboard an A380 by 2020.

In addition to the level of investment, U.S. and foreign airports differ in the type of investments. Foreign airports, in particular European airports, are investing more in terminal and gate improvements to accommodate the A380 than U.S. airports. For example, London Heathrow, Paris Charles de Gaulle, and Amsterdam Schiphol airports have undertaken major terminal and gate improvement projects to accommodate the A380. In contrast, the

majority of investments reported by U.S. airports (83 percent) were for runway and taxiway projects to accommodate the A380.[37] This difference likely reflects that all Asian airports meet ICAO standards, including runway and taxiway width, for new large aircraft, such as the A380, and that the AACG determined that European airports could use more narrow runway and taxiway widths for the A380, which negated the need to widen the runways or taxiways.

Designing Airports That Allow for New Large Aircraft

Seven of the eight Asian and Canadian airports we visited were designed for future expansion or were built to allow new large aircraft, such as the A380.[38] Five airports—Singapore Changi, Hong Kong, Tokyo Narita, Montréal Trudeau, and Toronto Pearson—were not designed specifically for the A380, but rather were built to accommodate the arrival of new large aircraft in the future and either complied with or needed only minimal modifications to comply with international standards applicable to new large aircraft. For example, at the Singapore Changi and Toronto Pearson airports, the runways were wide enough to accommodate the A380, but the shoulders needed to be modified to comply with ICAO requirements. Taken as a whole, these airports will not have to impose operating restrictions on the A380 except for a few instances, but not to the extent as U.S. airports.

Two Asian airports in Bangkok, Thailand and Guangzhou, China, were built in compliance with the international standards for new large aircraft.[39] According to airport officials, these two airports were built because of the economic activity they were expected to generate for their region and their countries. Moreover, these officials stated that to remain

[37]For more information on the costs of infrastructure changes at U.S. airports to accommodate the A380, see GAO, *Commercial Aviation: Costs and Major Factors Influencing Infrastructure Changes at U.S. Airports to Accommodate the New A380 Aircraft*, GAO-06-571 (Washington, D.C.: May 19, 2006).

[38]The seven airports include Guangzhou Baiyun, Singapore Changi, Hong Kong, Tokyo Narita, Bangkok Suvarnabhumi, Toronto Pearson, and Montréal Trudeau. The remaining airport, Beijing Capital, was not built to accommodate the future arrival of new large aircraft and required significant improvements to the airfield to comply with the required standards, such as reconstructing one of its runways to accommodate the A380.

[39]The Bangkok Suvarnabhumi airport is the only airport that fully complies with the required international standards for new large aircraft. The Guangzhou Baiyun airport is fully compliant with the requirements for one side of the airfield that will be used for A380 operations, while the other noncompliant side will not be used for the A380.

competitive, the airports had to be able to receive new large aircraft, and in particular the A380 because it represents the next generation of aircraft. Because these two Asian airports in Bangkok and Guangzhou were built to comply with international standards for new large aircraft, they will not need to restrict A380 operations or the movement of other aircraft as they move around the airfields to and from terminals. Figure 7 shows a picture of the Baiyun International Airport in Guangzhou, China.

Figure 7: Baiyun International Airport, Guangzhou, China

Source: Baiyun Airport Authority.

In comparison, most of the 18 U.S. airports expecting to receive the A380 and the three European airports we visited were not built to comply with international standards for new large aircraft, such as the A380. As a result, officials from the U.S. airports told us that they anticipated imposing operating restrictions on the A380 or aircraft operating in proximity to the A380 to ensure safety. As discussed previously, European airports have adopted alternative standards and only one of these airports we visited plans to impose some operating restrictions.

Concluding Observations

Many large airports in the U.S. and around the world are facing capacity constraints as passenger and cargo traffic continues to grow. The A380 was designed, in part, to help alleviate these capacity constraints. However, the impact of its arrival on airport capacity in the United States is uncertain. The exact impact will likely vary by geographic regions of the U.S. and will depend on a range of factors, including the volume of A380 traffic, timing of these aircrafts' operations, and the operating restrictions imposed on the aircraft and those aircraft operating around it. Although many U.S. airports are facing capacity constraints, the decisions by airport officials to make the necessary infrastructure changes to accommodate the aircraft were not solely driven by potential capacity gains. Rather, officials at some airports told us that they want to receive the A380 to help their airport's competitive position. They are expecting that the economic benefits from having A380 service at their airport will outweigh the costs associated with the infrastructure changes needed to accommodate the aircraft.

While the impact of operating restrictions on airport capacity is not clear, FAA and industry experts generally agreed that the A380 will add another element of complexity to airport operations and airspace management. This could limit A380 operations to designated gates, taxiways, or runways at many airports. This will reduce air traffic controllers' flexibility in making routing decisions for the A380 and other aircraft. Further exacerbating this situation is the current and projected growth in air traffic as well as the rollout of new classes of aircraft that could have their own operating and infrastructure requirements. Optimizing the use of airspace and airport facilities to the growth in air traffic and new classes of aircraft, including the A380, will be challenging.

To address some of these challenges, airports expecting to receive the A380 are making infrastructure changes to accommodate it that involve retrofitting or expanding existing infrastructure, such as runways and taxiways. As we have previously reported, the airports estimated that these changes will be costly and were driven by the introduction of the A380, but they will also benefit current aircraft and other new large aircraft that may be introduced in the future. If recent history is a guide, the evolution of aircraft will not stop with the A380 as evident with Boeing's decision to go forward with its own new large aircraft, the 747-8. Thus, to help mitigate future difficulties, federal policymakers, airport officials, and other stakeholders are considering the introduction of the A380 and other new classes of aircraft as they move forward with airport development throughout the nation as well as the development of the next generation air transportation system.

Agency Comments and Our Evaluation

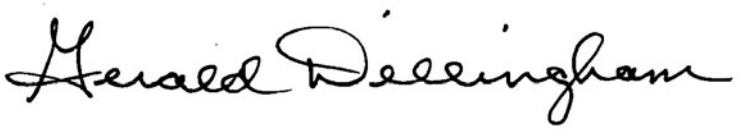
We provided a draft of this report to the Department of Transportation for review and comment. FAA officials generally agreed with the report's findings. FAA officials also provided technical clarifications via e-mail, which were incorporated as appropriate.

In addition, we provided a draft of this report to Airbus North America Holdings, Inc. (Airbus) for review and comment. Airbus provided written comments, which are reprinted in appendix III. In its letter, Airbus states that we correctly identified potential safety and capacity issues associated with the introduction of the A380. However, regarding our discussion on capacity issues, Airbus expresses concern that we overemphasized the operational constraints imposed on or by the A380. We interviewed a range of aviation experts and examined a variety of studies and analyses to understand any potential impact, both positive and negative, the A380 could have on capacity. Although the report does describe the potential operational constraints associated with the introduction of the A380, we believe the report provides a balanced discussion regarding the potential benefits that new large aircraft, such as the A380, could provide to help alleviate capacity constrained U.S. airports as well as the potential capacity reduction due to operating restrictions, increased separation, and gate utilization issues associated with A380 operations. Airbus also suggests that our capacity discussion should include information on passenger throughput, noting that we use one definition of capacity—that is, the maximum number of aircraft takeoffs and landings (aircraft movements) that can occur during a given period. We acknowledge that we defined capacity by aircraft movements and agree that passenger throughput is another measure of capacity. We chose to use aircraft movements as the definition of capacity for this report because FAA uses the maximum number of aircraft movements to express airport capacity. The report includes information on the potential impact of the A380 on passenger throughput—specifically, that the A380 could accommodate more passengers and freight on each flight than any other aircraft in use today. However, we added additional information on the A380's potential impact on passenger throughput on the basis of Airbus' comments. Airbus also provided technical comments, which were incorporated, as appropriate.

As agreed with your office, unless you publicly announce the contents of this report earlier, we plan no further distribution until 10 days from the report date. At that time, we will send copies to appropriate congressional committees, the Secretary of Transportation, and representatives of Airbus. We will also make copies available at no charge on the GAO Web site at http://www.gao.gov.

If you have any questions about this report, please contact me at (202) 512-2834 or by e-mail at dillinghamg@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. Individuals making key contributions to this report were Nikki Clowers, Assistant Director; Vashun Cole; and Frank Taliaferro.

Sincerely yours,



Gerald L. Dillingham, Ph.D.
Director, Physical Infrastructure Issues

Appendix I: Objectives, Scope, and Methodology

We were asked to review and identify the impact of the Airbus A380 on U.S. airports. In May 2006, we issued a report that estimated the costs of infrastructure changes that U.S. airports plan to make to accommodate the A380.[1] This report discusses (1) the safety issues associated with the introduction of the A380, and how U.S. airports are addressing them, (2) the potential impact of A380 operations on the capacity of U.S. airports, and (3) how selected foreign airports are addressing these safety and capacity issues.

To address these issues, we reviewed published studies on operational issues related to the A380 and on aircraft fire and rescue equipment and tactics, A380 emergency evacuations, pavement strength issues for the A380's weight, and other safety-related issues. We also reviewed FAA's design standards and attended FAA briefings on its type validation and type certification processes. For our May 2006 report, we analyzed the A380-related requests for Modifications to Standards made by the U.S. airports we visited and summarized FAA decisions regarding the infrastructure and operational impacts to the airports. We also discussed—with FAA and airport officials—the effect that Modifications to Standards would have on airports' infrastructure. For this report, we discussed with FAA officials the safety considerations of Modification to Standards, but did not analyze the extent that Modifications to Standards are used at all U.S. airports. We also examined FAA William J. Hughes Technical Center's (Technical Center) analysis of the impact of new large aircraft operations at Memphis International, New York John F. Kennedy International, and San Francisco International Airports. We analyzed the Technical Center's methodology in preparing these analyses and the results of these analyses and met with FAA officials to discuss the analyses. We determined that the Technical Center's analyses were sufficiently reliable for our purposes. We also examined the International Civil Aviation Organization's (ICAO) guidance and standards for airport design and aircraft separation.

We interviewed officials from FAA and representatives from ICAO, Airbus, and aviation trade association to discuss safety and capacity issues associated with the arrival of the A380. In addition, we conducted semi-structured interviews with 17 aviation experts to obtain their views on the

[1]GAO, *Commercial Aviation: Costs and Major Factors Influencing Infrastructure Changes at U.S. Airports to Accommodate the New A380 Aircraft*, GAO-06-571 (Washington, D.C.: May 19, 2006).

impact of the A380 on airport operations and capacity and potential safety issues. We contracted with the National Academy of Sciences (NAS) to identify individuals who are experts in the fields of safety, capacity, infrastructure, and certification. We developed an interview guide that asked for the expert's views on a series of questions on safety and capacity issues related to the introduction of the A380 and pre-tested this guide with two experts to ensure that the questions sufficiently addressed the issues and were not biased, misleading, or confusing. We incorporated feedback from our pretests into the interview guide, and then used the guide for our interviews. After conducting the interviews, we analyzed the experts' responses to our questions to identify major themes. The aviation experts we interviewed were not selected randomly and their views and opinions cannot be generalized to the larger population of experts and aviation officials. See table 2 for the aviation experts we interviewed.

Table 2: Aviation Experts Interviewed by GAO

Expert	Title and affiliated organization
Kristin Allen	Facilities, Operations and Maintenance Manager, San Francisco International Airport
Randy Babbitt	Chairman and CEO, Eclat Consulting
Kevin Bleach	Manager of Aviation Technical Services, Port Authority New York and New Jersey
Tony Broderick	Consultant, Airbus North America Holdings, Inc.
Dan Cohen-Nir	Programs Director, Airbus North America Holdings, Inc.
Frank Frisbie	Vice President, Apptis
George Greene	Chief Scientific and Technical Advisor for Wake Turbulence, NASA
John Hansman	Professor, MIT
John Hayhurst	Vice President (retired), Boeing Air Traffic Management
Steve Lang	Manager of Planning, Control, and Integration, Air Traffic Services, FAA
Dick McAdoo	Atlantic Southeast Airlines (retired)
Tom McSweeny	Director, International Safety and Regulatory Affairs, Boeing Commercial Airplanes
Amedeo Odoni	Professor, MIT
Clint Oster	Professor, Indiana University
Marc Schoen	Manager, Airport Technology, Boeing Commercial Airplanes
John Sullivan	Professor, Purdue University
Ray Valeika	Senior Vice President, Delta Airlines (retired)

Source: GAO.

We conducted site visits to the 18 U.S. airports that are making infrastructure improvements to accommodate the A380. (Table 3 shows the U.S. airports that we visited.) We conducted these site visits from September 2005 to February 2006. During these site visits, we interviewed airport officials, including airport management, air traffic controllers, and fire and rescue personnel, and toured the airport facilities to identify safety and capacity challenges associated with the arrival of the A380 at their airport and efforts they were undertaking to mitigate these challenges. To ensure the accuracy of information summarized in the report, we verified the information we collected with officials from the 18 airports in the fall of 2006.

Table 3: United States Airports Visited by GAO

Airport name	Location
Ted Stevens Anchorage International Airport	Anchorage, Alaska
Fort Worth Alliance Airport	Fort Worth, Texas
Hartsfield-Jackson Atlanta International Airport	Atlanta, Georgia
Chicago O'Hare International Airport	Chicago, Illinois
Dallas-Fort Worth International Airport	Fort Worth, Texas
Denver International Airport	Denver, Colorado
Indianapolis International Airport	Indianapolis, Indiana
Los Angeles International Airport	Los Angeles, California
Louisville International Airport	Louisville, Kentucky
Memphis International Airport	Memphis, Tennessee
Miami International Airport	Miami, Florida
New York John F. Kennedy International Airport	New York, New York
Ontario International Airport	Ontario, California
Orlando International Airport	Orlando, Florida
Philadelphia International Airport	Philadelphia, Pennsylvania
San Francisco International Airport	San Francisco, California
Tampa International Airport	Tampa, Florida
Washington Dulles International Airport	Dulles, Virginia

Source: GAO.

We also conducted site visits to 11 Asian, Canadian, and European airports that will be receiving the A380. (Table 4 shows the foreign airports we visited.) We conducted these site visits from February 2006 to November 2006. We selected these high-capacity airports based on the expected level of A380 operations or the presence of airlines that have ordered the A380 aircraft and intend on using these airports as a hub for their operations.

During these site visits, we interviewed airport officials, including airport management, air traffic controllers, and fire and rescue personnel, and toured the airport facilities to identify the safety and capacity challenges associated with the arrival of the A380 and the efforts being undertaken to mitigate these challenges. We summarized the information obtained for this report and sought verification from the 11 airports in the winter of 2006.

Table 4: Asian, Canadian, and European Airports Visited by GAO

Airport name	Location
Asian airports	
Suvarnabhumi Airport	Bangkok, Thailand
Capital Airport	Beijing, China
Baiyun Airport	Guangzhou, China
Hong Kong Airport	Hong Kong, China
Narita Airport	Tokyo, Japan
Changi Airport	Singapore
Canadian airports	
Montréal-Pierre Elliott Trudeau International Airport	Montréal, Québec
Toronto Pearson International Airport	Toronto, Ontario
European airports	
Amsterdam Schiphol Airport	Amsterdam, Netherlands
London Heathrow Airport	Middlesex, United Kingdom
Paris Charles de Gaulle Airport	Paris, France

Source: GAO.

We performed our work from May 2005 to March 2007 in accordance with generally accepted government auditing standards.

Appendix II: Foreign Airport Summaries

To determine how foreign airports were addressing the potential safety and capacity issues associated with the introduction of the A380, we visited 11 foreign airports. The following are summaries of the information airports' provided on operations and their A380 plans.

Asian Airports

Bangkok Suvarnabhumi International Airport, currently the operating hub for Thai Airways, opened in 2006 and was built as an ICAO Code F airport that could handle 45 million passengers and three million tons of cargo per year at a cost of about $3.9 billion.[1] The airport is one of the largest in Asia, with a terminal slightly larger than that of Hong Kong airport. The final phase of construction, expected to begin in about 2015, will add a fourth runway and another terminal to increase the capacity to 100 million passengers per year. A maintenance facility has also been built at the airport that can house up to three A380s in one hangar at the same time. Officials of the Thai Department of Civil Aviation do not expect that the A380 would cause delays at their airport. A380 flight operations will begin with Qantas and United Arab Emirates airlines service in early 2008. Thai Airways ordered six A380 aircraft and will begin service in 2009 or 2010 after it takes its first delivery from Airbus. Table 5 provides A380-related issues at Suvarnabhumi airport.

Table 5 Bangkok Suvarnabhumi International Airport

Airport facilities	
Expected start of A380 service (month/year):	Early 2008.
Number of A380 landings and departures each day (initial year and 5th year of service):	Initially: Anticipates 12 per day.
5th year: 12 per day (possibly more).	
Carriers expected to bring A380 to airport (year of arrival):	Singapore Airlines, Air France, and Qantas (2008), Emirates and Lufthansa (2008 or 2009), and Thai Airways (2009 or 2010).
Expected level of A380 passenger and cargo operations:	Passenger: Not available.
Cargo: Not available.	
Airfield design standards (runway and taxiway width and separations):	Airfield is ICAO Code F compliant.

[1]ICAO Code F is the international acceptable standards for aircraft with wingspans over 214 feet such as the Airbus A380 and the proposed Boeing 747-8.

Airport facilities	
Airport baggage claim, terminal seating, and customs and immigration spatial concerns:	None. Passenger waiting rooms could become crowded and baggage facilities in the new airport were built to receive new large aircraft such as the A380.
Terminal gates A380-ready:	Five A380 gates with one upper and two lower boarding bridges.
Deviations from ICAO Code F standards:	None.
Operating restrictions used for the A380:	None.
Possible impact of A380 operations on ground operations (special designated routing issues):	None.
Potential effect of ground operational restrictions on capacity (airport assessment):	None.
Current Aircraft Rescue and Fire Fighting (ARFF) capability (in terms of equipment, personnel, and training):	Meets ICAO ARFF requirements for A380-sized aircraft.

Source: GAO analysis of information obtained from Suvarnabhumi airport officials.

Beijing Capital International Airport has been upgraded with several renovations since it opened in 1958, and in 2005 it handled about 41 million passengers and about 782,000 tons of cargo. Airport officials said that in anticipation of the increasing aviation demands due to the economic development of the Beijing area as well as the 2008 Beijing Olympic Games, Beijing Capital airport officials have begun a $3 billion airport expansion plan to double the existing capacity. When completed, the airport will be able to handle 60 million passengers, 1.8 million tons of cargo, and about 500,000 flights per year. A380-related improvements have been incorporated in the renovation projects, which include building a new terminal to handle the anticipated increase in future demand, a new 3,800-meter-long, 60-meter-wide runway to accommodate the A380, new facilities and cargo areas, and additional landing areas. In addition, major terminal and gate improvement projects have been undertaken to accommodate the A380. China Southern Airlines is the only Chinese A380 customer. However, in addition to China Southern Airlines, Air France, and Lufthansa Airlines have expressed their intent to operate the A380 at the Beijing airport. Table 6 provides A380-related issues at Beijing airport.

Table 6: Beijing Capital International Airport

Airport facilities	
Expected start of A380 service (month/year):	Uncertain.
Number of A380 landings and departures each day (initial year and 5th year of service):	Initially: Not available. 5th year: Not available.
Carriers expected to bring A380 to airport (year of arrival):	China Southern Airlines, Air France, and Lufthansa Airlines.
Expected level of A380 passenger and cargo operations:	Passenger: Not available. Cargo: Not available.
Airfield design standards (runway and taxiway width and separations):	Improvements are being made to some areas of the airfield to comply with ICAO Code F standards; however, no plans to restructure the entire airport to meet Code F requirements.
Airport baggage claim, terminal seating, and customs and immigration spatial concerns:	None. Passenger waiting rooms and baggage facilities expanded to enhance new large aircraft operations.
Terminal gates A380-ready:	Once modifications are completed in the existing terminal areas, both existing terminals and a new terminal can have a total of 12 A380 gates if necessary.
Deviations from ICAO Code F standards:	None.

Airport facilities	
Operating restrictions used for the A380:	None.
Possible impact of A380 operations on ground operations (special designated routing issues):	None.
Potential effect of ground operational restrictions on capacity (airport assessment):	ICAO separations standards for the A380 due to wake turbulence could slow landing and departures and reduce the number of flights allowed to land and depart during peak hours.
Current Aircraft Rescue and Fire Fighting (ARFF) capability (in terms of equipment, personnel, and training):	Plans to upgrade capability to meet ICAO ARFF requirements for A380-sized aircraft.

Source: GAO analysis of information obtained from Beijing airport officials.

Guangzhou Baiyun International Airport, currently the operating hub for China Southern airlines, opened in 2004. It cost roughly $2.39 billion, is one of the three large hub airports on the Chinese mainland, and is the busiest airport in south China. In 2005, the airport handled 23.5 million passengers and 750,000 tons of cargo. The airport was the first in China designed and built with the hub concept and a capacity to accommodate a projected annual growth of 27 million passengers and 1.4 million tons of cargo through 2010. China Southern Airlines is the only Chinese A380 customer and has already considered replacing an existing nonstop route from Guangzhou to Los Angeles using an A380. The airport has one runway and will have one gate ready for the A380 in 2008 and plans to add additional A380 gates as needed in future planned concourses. Airport officials said A380-related improvements exist in a $2.22 billion expansion plan that includes the construction of an additional runway, terminal, and cargo facilities. The facilities will be increased as the expansion plans are completed with a capacity to accommodate 80 million passengers and 2.5 million tons of cargo annually. Table 7 provides A380-related issues at Baiyun airport.

Table 7: Guangzhou Baiyun International Airport

Airport facilities	
Expected start of A380 service (month/year):	Fall 2008.
Number of A380 landings and departures each day (initial year and 5th year of service):	Initially: Not available. 5th year: Not available.
Carriers expected to bring A380 to airport (year of arrival):	China Southern Airlines (2008).
Expected level of A380 passenger and cargo operations:	Passenger: Not available. Cargo: Not available.
Airfield design standards (runway and taxiway width and separations):	The airfield is partially ICAO Code F compliant.
Airport baggage claim, terminal seating, and customs and immigration spatial concerns:	None. Passenger waiting rooms and baggage facilities were designed to accommodate A380 passenger loads.
Terminal gates A380-ready:	One A380-capable gate that will be available and equipped with two passenger boarding bridges, another gate will be used to handle an A380 flight, and plan to add two A380 gates equipped with three passenger boarding bridges.
Deviations from ICAO Code F standards:	None.

Airport facilities	
Operating restrictions used for the A380:	The West Runway was built to ICAO Code E standards and will not be used for A380 operations.
Possible impact of A380 operations on ground operations (special designated routing issues):	None.
Potential effect of ground operational restrictions on capacity (airport assessment):	None.
Current Aircraft Rescue and Fire Fighting (ARFF) capability (in terms of equipment, personnel, and training):	Meets ICAO ARFF requirements for A380-sized aircraft.

Source: GAO analysis of information obtained from Baiyun airport officials.

Hong Kong International Airport is the busiest airport for freight (by weight) in the world, handling about 3.6 million tons of freight in 2006. The airport also handled about 44.5 million passengers in 2006. The airport was built on a landfill in the Hong Kong bay and began operations in 1998. The airport has additional expansion plans to increase passenger capacity to 80 million per year by 2025. However, in order to achieve that capacity the airport authority is planning to conduct engineering and environmental feasibility studies on the construction of a third runway for the airport. The airport authority had spent approximately $15 million in airport enhancement works for the operation of A380 passenger flights and was certified as an ICAO Code F airport in July 2006. The airport is an operating hub for DHL freight, and FedEx and UPS also operate at the airport. No airline based in Hong Kong has purchased the A380, but airport officials expect to accommodate foreign carriers' A380 flights. The airport serves about 80 foreign airlines and about 70 percent of the flights to Hong Kong are wide-body jets. Singapore Airlines will likely be the first to bring an A380 into Hong Kong. Table 8 provides A380-related issues at Hong Kong airport.

Table 8: Hong Kong International Airport

Airport facilities	
Expected start of A380 service (month/year):	Early to mid 2008.
Number of A380 landings and departures each day (initial year and 5th year of service):	Initially: Anticipates four flights per day. 5th year: 10 flights per day (possibly more).
Carriers expected to bring A380 to airport (year of arrival):	Singapore Airlines, Lufthansa, Qantas Airlines, United Arab Emirates, Virgin Atlantic and Air France.
Expected level of A380 passenger and cargo operations:	Passenger: Not available. Cargo: Not available.
Airfield design standards (runway and taxiway width and separations):	Airfield is generally ICAO Code F compliant.
Airport baggage claim, terminal seating, and customs and immigration spatial concerns:	None. Passenger waiting rooms and baggage facilities can accommodate the A380 and other new large aircraft.
Terminal gates A380-ready:	Two A380 gates (each with one upper and one lower deck bridge) with the ability to expand up to a total of five A380 gates.
Deviations from ICAO Code F standards:	No deviations from ICAO Code F standards for the operation of A380.

Airport facilities	
Operating restrictions used for the A380:	Stop-hold positions have been placed further back from runway centerline.
Possible impact of A380 operations on ground operations (special designated routing issues):	No significant delay on operations on the taxiways and apron is expected.
Potential effect of ground operational restrictions on capacity (airport assessment):	ICAO separation from the A380 due to wake turbulence would reduce the arrival and departure rates.
Current Aircraft Rescue and Fire Fighting (ARFF) capability (in terms of equipment, personnel, and training):	Meets ICAO ARFF requirements for A380-sized aircraft.

Source: GAO analysis of information obtained from Hong Kong airport officials.

Singapore Changi International Airport has undergone several expansions since the airport opened in 1981. In 2006, the airport handled over 35 million passengers and almost two million tons of cargo. Changi airport is the operating hub for Singapore Airlines, which is the launch customer for the Airbus A380. Singapore Airlines will begin receiving its A380 deliveries in the fall of 2007 and plans to begin flight operations in January 2008 with flights to London Heathrow and San Francisco airports. Lufthansa, Qantas, Korean Air, and Virgin Atlantic airlines could begin flights to Singapore by 2010. The airport authority has spent about $43 million on improvements such as widening runway shoulders, and runway-taxiway and taxiway-taxiway intersections, installing upper deck loading bridges, and expanding the seating areas to handle A380 passenger loads. The airport has two parallel runways and will have 11 gates ready for the A380 in 2007—a total of 19 gates will be available in 2008. Changi airport will also have a maintenance facility with hangars that can fully enclose two A380 aircraft and a third A380 compatible hangar under construction. In 2008, a new terminal (Terminal 3) will open for operations and will enable the airport to accommodate 64 million passengers per year and add 8 more gates for the A380. Table 9 provides A380-related issues at Changi airport.

Table 9: Singapore Changi International Airport

Airport facilities	
Expected start of A380 service (month/year):	Uncertain.
Number of A380 landings and departures each day (initial year and 5th year of service):	Initially: Uncertain. 5th year: Uncertain.
Carriers expected to bring A380 to airport (year of arrival):	Singapore Airlines (2007), Emirates and Qantas Airlines.
Expected level of A380 passenger and cargo operations:	Passenger: Not available. Cargo: Not available.
Airfield design standards (runway and taxiway width and separations):	Airfield is ICAO Code F compliant.
Airport baggage claim, terminal seating, and customs and immigration spatial concerns:	None. Passenger waiting rooms and baggage facilities expanded in Terminals 1 and 2, and Terminal 3 will open in 2008 based on new large aircraft operations.
Terminal gates A380-ready:	All 19 gates that are A380-ready will have one upper and two lower bridges.
Deviations from ICAO Code F standards:	None.
Operating restrictions used for the A380:	None.

Airport facilities	
Possible impact of A380 operations on ground operations (special designated routing issues):	None.
Potential effect of ground operational restrictions on capacity (airport assessment):	ICAO separation standards from the A380 due to wake turbulence could slow landing and departures and reduce the number of flights allowed to land and depart during peak hours.
Current Aircraft Rescue and Fire Fighting (ARFF) capability (in terms of equipment, personnel, and training):	Meets ICAO ARFF requirements for A380-sized aircraft.

Source: GAO analysis of information obtained from Changi airport officials.

Tokyo Narita International Airport, which opened in 1978, handles the majority of international passenger traffic in Japan and in 2005 handled over 31 million passengers and more than 2.3 million tons of cargo. In terms of the number of international passengers, it is ranked eighth in the world and second highest in the world in terms of the volume of international cargo. To date, six airlines—Lufthansa, Air France, Qantas, Virgin Atlantic, Singapore Airlines, and Korean Airlines—have announced plans to operate A380s at the airport. No Japanese air carrier has any immediate plans to purchase the A380. The airport has one runway and will have ten gates ready for the A380. Airport officials said existing facilities are used to accommodating very large passenger loads arriving at the same time on a daily basis. In fact, large aircraft, such as the 747-200, 747-400, and 777-200, currently make up about 75 percent of the traffic at Narita airport. The officials said the nominal increase in passenger loads on A380 flights will not have a significant impact on the efficiency of the airport's internal operations. Table 10 provides A380-related issues at Narita airport.

Table 10: Tokyo Narita International Airport

Airport facilities	
Expected start of A380 service (month/year):	First half 2008.
Number of A380 landings and departures each day (initial year and 5th year of service):	Initially: Not available. 5th year: Not available.
Carriers expected to bring A380 to airport (year of arrival):	Singapore Airlines, Korean Airlines, Lufthansa, Air France, Virgin Atlantic Airways and Qantas Airways.
Expected level of A380 passenger and cargo operations:	Passenger: Not available. Cargo: Not available.
Airfield design standards (runway and taxiway width and separations):	Airfield is ICAO Code F compliant.
Airport baggage claim, terminal seating, and customs and immigration spatial concerns:	Minimal. Plan to use adjacent seating areas near A380 gates to handle the increase in passenger loads for the A380 flights, and baggage claim facilities will be reviewed for possible expansion.
Terminal gates A380-ready:	Ten gates will be capable of accommodating the A380 initially with one upper deck and one lower deck boarding bridges.
Deviations from ICAO Code F standards:	None.

Airport facilities	
Operating restrictions used for the A380:	Runway B will be used for A380 operations. Taxiway separation issues exist and will require restrictions to prohibit two A380 operating on the parallel taxiways.
Possible impact of A380 operations on ground operations (special designated routing issues):	None.
Potential effect of ground operational restrictions on capacity (airport assessment):	None.
Current Aircraft Rescue and Fire Fighting (ARFF) capability (in terms of equipment, personnel, and training):	The airport has the resources to meet ICAO ARFF requirements for A380-sized aircraft.

Source: GAO analysis of information obtained from Narita airport officials.

Canadian Airports

Montréal Trudeau International Airport, first opened in 1941, is the third busiest airport in Canada in terms of passenger traffic (after Toronto Pearson and Vancouver airports) and served about 11 million passengers in 2005. The airport is undergoing a major $716 million expansion and modernization plan designed to double terminal capacity to handle 25 million passengers per year and enhance the level of passenger service. The first A380 arrival is expected during the summer of 2009 with an Air France flight on its daily Paris to Montréal route. Montréal Trudeau, which serves as the main operating hub for Air France, is expected to be the only airport in Canada with a daily A380 flight. Airport officials said that no major investments were needed because runway width and clearances between runways and taxiways comply with ICAO Code F requirements. The airport has three runways and one gate that will be available to accommodate the A380 in 2007. The runways are 62 meters wide, but vary in length and have non-paved, grass shoulders. Airport officials stated that two of the runways do not meet the necessary length requirement for A380 departures, but could be occasionally used for landings. Table 11 provides A380-related issues at Trudeau airport.

Table 11: Montréal Trudeau International Airport

Airport facilities	
Expected start of A380 service (month/year):	Summer 2009.
Number of A380 landings and departures each day (initial year and 5th year of service):	Initially: Two daily (summer only). 5th year: Not available.
Carriers expected to bring A380 to airport (year of arrival):	Air France.
Expected level of A380 passenger and cargo operations:	Passenger: Not available. Cargo: Not available.
Airfield design standards (runway and taxiway width and separations):	Airfield is ICAO Code F compliant.
Airport baggage claim, terminal seating, and customs and immigration spatial concerns:	None. Plan to use the seating area of the adjacent gate to the A380 gate to handle the increase in passenger load for A380 flights.
Terminal gates A380-ready:	One gate is available that can accommodate the A380 and will use one upper and one main deck boarding bridge.
Deviations from ICAO Code F standards:	Non-paved runway and taxiway shoulders and taxiway widths of 23 meters compliant with ICAO Code E standards.

Airport facilities	
Operating restrictions used for the A380:	Runway 10/28 must be inoperable until the A380 taxis from Runway 6L/24R to terminal area. Runways 6R/24L and 10/28 could be used for A380 landings but not for departures unless weight restrictions were imposed.
Possible impact of A380 operations on ground operations (special designated routing issues):	None.
Potential effect of ground operational restrictions on capacity (airport assessment):	None. Will schedule A380 flights during non-peak hours.
Current Aircraft Rescue and Fire Fighting (ARFF) capability (in terms of equipment, personnel, and training):	Due to limited expected traffic, the airport does not meet ICAO ARFF requirements for A380-sized aircraft.

Source: GAO analysis of information obtained from Trudeau airport officials.

Toronto Pearson International Airport, first opened in 1939, is Canada's busiest airport and handled almost 30 million passengers, 410,000 tons of cargo, and about 410,000 flights in 2005. Four carriers operate at Pearson that has purchased the A380, but none have indicated intent to operate their A380s at the airport. The airport is nearing completion of a $3.7 billion Airport Development Program to address improvements in groundside, terminal and airside infrastructure. Airport officials said the investments in airport infrastructure were meant to replace and expand their capacity to receive more passengers and freight and were not directed exclusively to accommodating the A380 because they did not expect many A380s at the airport. However, about $37.3 million of the improvement costs can be attributed directly to accommodating the A380 and future new large aircraft for airfield and terminal modifications. The airport currently has two runways and will have four gates ready for the A380 in 2007. The runways are 60 meters wide, but have non-paved, grass shoulders that may have to be paved to protect against jet blast. Airport officials stated they took A380 needs into account when designing the new Terminal 1, which opened in April 2004. Table 12 provides A380-related issues at Pearson airport.

Table 12: Toronto Pearson International Airport

Airport facilities	
Expected start of A380 service (month/year):	Unknown.
Number of A380 landings and departures each day (initial year and 5th year of service):	Initially: Not available. 5th year: Not available.
Carriers expected to bring A380 to airport (year of arrival):	None.
Expected level of A380 passenger and cargo operations:	Passenger: Not available. Cargo: Not available.
Airfield design standards (runway and taxiway width and separations):	Airfield is ICAO Code F compliant.
Airport baggage claim, terminal seating, and customs and immigration spatial concerns:	None.
Terminal gates A380-ready:	Four A380 gates are available with one upper and one lower deck boarding bridge.
Deviations from ICAO Code F standards:	None.
Operating restrictions used for the A380:	None anticipated, but will use procedural restrictions for the A380 when it is on the runways or taxiways if needed.

Airport facilities	
Possible impact of A380 operations on ground operations (special designated routing issues):	None.
Potential effect of ground operational restrictions on capacity (airport assessment):	ICAO separation standards could slow landings and departures and reduce the total number of flights during peak hours. Airport officials noted that they would not allow A380 flights to adversely impact capacity.
Current Aircraft Rescue and Fire Fighting (ARFF) capability (in terms of equipment, personnel, and training):	The airport has the resources to meet ICAO ARFF requirements for A380-sized aircraft.

Source: GAO analysis of information obtained from Pearson airport officials.

European Airports

Amsterdam Schiphol Airport is one of four major European hubs for passenger and freight air traffic. It is the third busiest European airport for cargo traffic with over 1.4 million tons transported and fourth in passenger traffic with over 44 million passengers in 2005—much of which is due to the trans-shipment of cargo and connecting passenger traffic. The airport will not be a hub for A380 traffic but will accommodate significant A380 passenger transfers to other planes bound to other destinations. A380 flight operations could begin in February 2008 with flights from Malaysian Airlines. Schiphol began planning for airport improvements related to new large aircraft in 1996. The new Code F runway and associated taxiways cost over $440 million and the expansion of the terminal cost over $213 million. The airport has one runway that is compliant with ICAO Code F but will also use the other four 45-meter runways and associated 23-meter taxiways in accord with a European agreement that Code E infrastructure could be used for the A380. Airport officials said A380s will be operated on the runways and taxiways not designed to Code F standards under waivers approved by the Netherlands Civil Aviation Authority. The airport will also have two gates ready for the A380 in 2007 and another two after 2008. Schiphol officials indicated that they would not need many additional A380 gates in the future when A380 flights increase because large aircraft gate occupancy and turnaround time present no issues. Table 13 provides A380-related issues at Schiphol airport.

Table 13: Amsterdam Schiphol International Airport

Airport facilities	
Expected start of A380 service (month/year):	Summer schedule 2008.
Number of A380 landings and departures each day (initial year and 5th year of service):	Initially: Anticipates four per day. 5th year: Anticipates 10 per day.
Carriers expected to bring A380 to airport (year of arrival):	Malaysian Airlines (2008).
Expected level of A380 passenger and cargo operations:	Passenger: 2008 (two daily landings and departures) and 2015 (8-10 daily landings and departures). Cargo: Not available.
Airfield design standards (runway and taxiway width and separations):	Airfield is ICAO Code E compliant.
Airport baggage claim, terminal seating, and customs and immigration spatial concerns:	None. No concerns with seating and customs, but baggage systems were expanded.
Terminal gates A380-ready:	Two gates will be ready for the A380 in 2007 with two boarding bridges.

Airport facilities	
Deviations from ICAO Code F standards:	Noncompliant runways and taxiways will be operated under waivers.
Operating restrictions used for the A380:	Use of one taxiway bridge may be limited.
Possible impact of A380 operations on ground operations (special designated routing issues):	All standard taxi routes are compliant with A380 operations.
Potential effect of ground operational restrictions on capacity (airport assessment):	ICAO separation standards could slow landings and departures and reduce the total number of flights during peak hours.
Current Aircraft Rescue and Fire Fighting (ARFF) capability (in terms of equipment, personnel, and training):	Capability meets ICAO ARFF requirements for A380-sized aircraft.

Source: GAO analysis of information obtained from Schiphol airport officials.

London Heathrow International Airport is the world's busiest airport in terms of international flights. The airport is an important hub with the largest number of passengers of any European airport in 2005—almost 68 million—and handled about 1.4 million tons of cargo. The airport has reached its capacity for flights but would like to increase passenger capacity to 90 million by 2020 and 95 million by 2030. The first A380 flight will likely be Singapore Airlines in early 2008. Airport officials said they made significant investments of about $885 million in airport improvements to expand their capacity to receive more passengers. Most of the spending was used to build new terminals and gates to accommodate the A380, but also included widening and strengthening its two runway's shoulders and upgrading runway lighting, and improvements to existing terminals to provide A380 gates. The airport will use two 50-meter-wide, parallel runways that are not Code F compliant for width and will use a waiver approved by the United Kingdom Civil Aviation Authority. The airport will have 12 gates ready for the A380 by 2008, but Heathrow officials anticipate that they will need about 35 A380 gates by 2015. In addition, they eventually expect that one of every ten aircraft arriving and departing (130 arrivals and departures) will be an A380 by 2020. Table 14 provides A380-related issues at Heathrow airport.

Table 14: London Heathrow International Airport

Airport facilities	
Expected start of A380 service (month/year):	February 2008
Number of A380 landings and departures each day (initial year and 5th year of service):	Initially: Anticipates 16 per day. 5th year: Anticipates 30 per day.
Carriers expected to bring A380 to airport (year of arrival):	Singapore Airlines (2008), Emirates (2008), Qantas Airlines (2008), United Arab Emirates (2008), Malaysia Airlines(2009) Thai Airways.
Expected level of A380 passenger and cargo operations:	Passenger: Not available. Cargo: Not available.
Airfield design standards (runway and taxiway width and separations):	Airfield is ICAO Code E compliant.
Airport baggage claim, terminal seating, and customs and immigration spatial concerns:	None. Terminal seating was expanded, and new baggage systems were installed to accommodate new large aircraft operations.
Terminal gates A380-ready:	12 A380 gates will be available in 2008 with one lower and one upper boarding bridges.

Airport facilities	
Deviations from ICAO Code F standards:	Runway width and taxiway-to-object free zone separations are noncompliant.
Operating restrictions used for the A380:	A380 routes defined and runway holds reconfigured to provide ICAO Code F compliant routes.
Possible impact of A380 operations on ground operations (special designated routing issues):	No additional impact anticipated above what could be expected from existing B747 traffic.
Potential effect of ground operational restrictions on capacity (airport assessment):	ICAO separation standards could slow landings and departures and reduce the total number of flights during peak hours.
Current Aircraft Rescue and Fire Fighting (ARFF) capability (in terms of equipment, personnel, and training):	Meets ICAO ARFF requirements for A380-sized aircraft.

Source: GAO analysis of information obtained from Heathrow airport officials.

Paris Charles de Gaulle International Airport handled about 53.7 million passengers and over two million tons of cargo in 2005. The initial A380 flights from France to North America will be to the New York JFK and Montréal Trudeau airports beginning in 2009. United Arab Emirates, Singapore, and China Southern airlines could begin flights to Paris in 2008 and 2009, and will be an A380 operating hub for KLM-Air France. Over $132 million has been invested for infrastructure upgrades to accommodate the A380, such as widening taxiway bridges to allow A380 access to all terminals. The investment also included widening and strengthening two runways at the airport and building a new satellite terminal complex specifically for A380s. The airport has four runways that will be used for A380 operations. Two of the runways are 60 meters wide and comply with ICAO Code F width, but their 2,700-meter-lengths will likely be too short for departures. The two 4,200-meter-long, 45-meter-wide runways can be used for departures and landings but will have to be operated under waivers approved by the French Civil Aviation Authority. Nine gates will be ready for the A380 in 2008 and will be increased up to 30 by 2018. Airport officials estimated that at least 10 percent of all passengers arriving at the airport will be aboard an A380 by 2020. Table 15 provides A380-related issues at Charles de Gaulle airport.

Table 15: Paris Charles de Gaulle International Airport

Airport facilities	
Expected start of A380 service (month/year):	Summer 2008
Number of A380 landings and departures each day (initial year and 5th year of service):	Initially: Anticipates eight per day. 5th year: Not available.
Carriers expected to bring A380 to airport (year of arrival):	Emirates (2008), Singapore Airlines (2009), China Southern (2009), Air France (2009), Korean Air (2010), Thai Airways (2010), Malaysian Airlines (after 2010).
Expected level of A380 passenger and cargo operations:	Passenger: Not available. Cargo: Not available.
Airfield design standards (runway and taxiway width and separations):	Airfield is ICAO Code E compliant.
Airport baggage claim, terminal seating, and customs and immigration spatial concerns:	None. Passenger waiting rooms and baggage facilities will be crowded, but sufficient.

Airport facilities:	
Terminal gates A380-ready:	Nine gates will be ready for the A380 in 2008 with most having two boarding bridges, but some will have three boarding bridges.
Deviations from ICAO Code F standards:	Runway and taxiway width, obstacle free zones and stop-hold positions on taxiways leading to runways are less than ICAO standards.
Operating restrictions used for the A380:	The A380 will be restricted to using two taxiing routes from each terminal to each runway.
Possible impact of A380 operations on ground operations (special designated routing issues):	None.
Potential effect of ground operational restrictions on capacity (airport assessment):	ICAO separation standards could slow landings and departures and reduce the total number of flights during peak hours.
Current Aircraft Rescue and Fire Fighting (ARFF) capability (in terms of equipment, personnel, and training):	Meets ICAO ARFF requirements for A380-sized aircraft.

Source: GAO analysis of information obtained from Charles de Gaulle airport officials.

Appendix III: Comments by Airbus

AIRBUS

Dan Cohen-Nir
Programs Director
Safety and Technical Affairs

VIA EMAIL

April 11, 2007

Dr. Gerald Dillingham
Director of Civil Aviation Issues
Government Accountability Office
441 G Street, N.W., Room 2T23B
Washington, DC 20548

Dear Dr. Dillingham:

Airbus truly appreciates the opportunity offered by the Government Accountability Office to review, and submit comments on, the Draft Report titled "Potential Safety and Capacity Issues Associated with the Introduction of the New A380 Aircraft."

Airbus further commends the GAO for its continued effort in providing a comprehensive assessment of the opportunities and challenges that the U.S. airport system will have, or face, with the introduction of the A380.

As mentioned in the GAO report, The Boeing Company has launched an aircraft to compete with the A380 – the airplane design group VI Boeing 747-8, which has dimensions and characteristics that should require the same assessment as the A380: runway and taxiway widths; airfield horizontal separations; gate availability and compatibility; increased number of passengers over the current larger aircraft; aircraft rescue and fire fighting categorization and requirements; wake vortex characterization and classification. Consequently, most of the operational and safety-related items discussed in the report are relevant for the 747-8 as well, in particular at U.S. airports that will have 747-8 flights before A380s.

From the inception of the A380, Airbus designers understood the many challenges they would face designing the largest commercial aircraft ever, under great scrutiny of the regulatory authorities in particular and of the aviation industry in general.

The A380 has undergone an unprecedented two-year-long and five-continent-wide testing program from the arid Middle Eastern deserts to the frigid Canadian Northern Territories – while crossing the poles several times. At the time this letter is written, the 5-strong family of flight test aircraft has logged more than 3,339 flying hours and 2,307 take-offs since April 27, 2005. And most importantly, FAA and EASA have certified the A380 type design on December 12, 2006.

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The A380 is meeting, or exceeding, its commitments. It is a testament not only to Airbus designers but also to Airbus aerospace partners around the globe, including the American aerospace industry.

The reaction of airport authorities, airlines, regulators, and political leaders from the U.S. and international cities that have witnessed the A380 at their airports has been extremely positive and has validated the notion that the A380 represents the most socially responsible solution to the increase in air travel.

Specific Comments

Safety

Above all, the A380 is the first fly-by-wire new larger aircraft and uses the latest technology to enhance flight safety. The A380 flight control system largely benefits from the in-service experience accumulated on the A320 and A340 fly-by-wire aircraft, together with the introduction of new technologies that improve safety and reliability both in the air and on the ground.

Airbus commends the GAO report for acknowledging some specific safety enhancements introduced on the A380 such as the External & TAxiing Camera System (ETACS) and exterior/interior material used to reduce flammability.

With respect to the cabin rescue, regardless of the airport equipment available, the A380 provides a further line of defense against pre- or post-crash fire with its next generation cabin evacuation slides. Unlike current larger aircraft, the slides are equipped with two re-entry lines, which provide direct access for fire fighters or emergency responders into both main deck and upper deck.

As already mentioned, the FAA has certified the A380 type design, which means that the aircraft complies with applicable certification requirements.

The GAO report states that the wake of the A380 creates safety issues. However, those potential issues have been identified and already addressed. The wake vortex separation standards that ICAO has developed and promulgated in November 2006 are providing the same level – or an increased level – of safety, compared to separation standards for other large aircraft flying today.

The A380 is the first (and, so far, the only) commercial aircraft that has undergone a comprehensive wake vortex characterization program before its entry into service. As indicated in the GAO report, current separation guidance could be more conservative than the final standards and later reduced on the basis of tests, analyses and operational experience with the aircraft. There is precedent for such a reduction on the Boeing 747 in the years after entry into service.

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The impact of wake vortices generated by commercial aircraft is an industry issue that goes well beyond the A380 and consequently the scope of the report. It is worthwhile mentioning nevertheless that the need for wake vortex characterization of all future commercial aircraft (747-8; 787; A350 XWB) and the possible reclassification of existing aircraft in new wake vortex categories may be two of the most wide-ranging outcomes of the A380 wake vortex assessment campaign.

Airport Compatibility

The A380 is the first new large aircraft that has been designed to be compatible with existing airports, as the result of a 16-year long dialogue with regulators, customer airlines, airport operators, pilot and trade associations and ground handlers. Such airport compatibility, in fact, was a design criterion for the aircraft from the very beginning.

The long-standing partnerships have brought to fruition EASA approval of A380 operations on existing airports with 150-ft wide runways and 75-ft wide taxiways. A similar process with FAA is well underway for a successful conclusion during the summer of 2007, which should allow in-service A380 operations on 150-ft runways in the United States.

At the time of this letter, the A380 has visited more than 45 airports worldwide, including six in North America, covering most early A380 destination airports. The A380 has shown exemplary airport compatibility (producing less noise and emissions and requiring less runway for take-off and landings than the 747-400; creating no infrastructural damage or deterioration; fitting into terminal gates using available ground support equipment).

In two independently-run airport compatibility check and airline route proving campaigns, Airbus in cooperation with two customer airlines has brought the A380 most recently to the United States, testing and validating the aircraft compatibility with the U.S. airspace and airport systems.

Under the most realistic operational conditions, two A380 aircraft have been operated into four major U.S. gateways: New York Kennedy International Airport (JFK), Chicago O'Hare International Airport (ORD), Washington Dulles International Airport (IAD) and Los Angeles International Airport (LAX). With FAA's permission for those visits, the A380 mostly operated to and from existing 150-ft wide runways and 75-ft wide taxiways. In the case of ORD, IAD and LAX, and to a lesser extent JFK, the aircraft was being operated using the same infrastructure and existing ground support equipment as a 747-400 would have.

By all accounts, the A380 visits were extremely successful, with operations proceeding smoothly and uneventfully.

These visits have demonstrated clearly that the aircraft is capable of being operated safely, efficiently and without any significant adverse impact on U.S. airports.

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Gate availability and productivity

The discussion about the effect of the A380 introduction on gate efficiency has to be enunciated in broader terms than just the geometrical and numerical effects of a wider wingspan and of an increased number of passengers.

Several U.S. and international airports serve current larger aircraft flights that accommodate more than 450 passengers and operate contact gates with dual loading bridges. In addition, the physical characteristics of existing large aircraft (Boeing 747-400 and 777-300ER, Airbus A340-600) and Boeing's new larger aircraft already create or will create gate-availability challenges at U.S. airports, none of which is unique to the A380.

While some airports may be confronted with the downsizing of adjacent gates and increased passenger processing times, most airports have already prepared an appropriate number of A380 contact gates and have worked with customer airlines to optimize passenger flow processes.

As noted in the GAO report, the A380 new cabin architecture (wider front and aft stairs; main deck front doors' location which reduces bottlenecks in the cabin) and optimized servicing concept (upper deck catering) will offer the opportunity for airlines to service the aircraft with a 90-minute turn-around time and, therefore, significantly improve gate productivity. Stated in another way, while carrying 35% more passengers, the A380 turn around time is 13% or 12 minutes shorter than the 747-400's.

Airbus turn-around time assumptions have been validated recently. During a demonstration in Frankfurt, Germany in March 2007, one customer airline serviced an A380 flight arriving from Asia and then heading to the United States (approximately 500 passengers, baggage and cargo on both arriving and departing flights) with a turn-around time of 95 minutes, which included the mandatory cabin security inspection.

Capacity discussion

The GAO report uses one definition for airport capacity: that is, the maximum number of aircraft take-offs and landings (movements) that can occur within a given period of time. However, any discussion of airport capacity must include an analysis of the passenger throughput, not merely airport number of movements. Indeed, airlines are ultimately in the business of moving people and goods between airports. All experts agree that international air travel is expected to grow in such way that the number of international passengers will triple over the next 20-25 years. This growth would take place with or without the A380 and will require that U.S. airports invest to handle the increase in passengers and cargo. The introduction of the A380 will help reduce or indeed offset the increased number of aircraft operations required to carry the 200 percent increase in passengers from one airport destination to another.

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With regard to capacity, the GAO identifies operating restrictions on the ground as potentially impacting capacity. As aforementioned, the A380 operational restrictions on the ground that may impact airport capacities are minimized by the design and performance of the aircraft.

As to capacity issues related to wake turbulence, the GAO report referenced an FAA study on the potential delays, induced by the currently-imposed A380 wake vortex longitudinal separation increases, at U.S. airports by 2015 and 2025 and provided quantitative data for SFO and JFK airports.

The assumptions of the study were not fully available to Airbus at the time of this letter. Nevertheless, it is Airbus' understanding that both airports have considered the amount of delays exclusively attributed to the A380 acceptable and manageable. These two airports[1/2] enthusiastically embrace the entry into service of the A380. Once again, the potential delays induced by the current wake vortex separations have to be balanced by the fact that the A380 helps reduce or offset the increased number of aircraft operations.

Finally, as the GAO and Airbus have stated, current wake vortex separations could be more conservative than the final standards and later reduced on the basis of tests, analyses and operational experience with the aircraft. It could dramatically reduce or even eliminate the amount of delays potentially experienced at SFO and JFK.

Foreign Airports

Airbus broadly concurs with the GAO findings. The foreign airports, which have been visited, have been indeed more proactive on average in terms of long-term capital investments required to accommodate the A380. It is mostly explained by a more intense competitive environment as well as by a different approach to cope with a larger number of A380 flights in the early years of operations. Thus, there is no doubt that foreign airports will benefit from the A380, rather than being impacted by it.

Concluding Statement

International air travel is expected to experience a two- to three-fold increase worldwide in the early part of the 21st Century. In developed nations like the United States, building additional airports, or even individual runways and terminals, is often not a practical solution. With those sorts of infrastructure limitations, the primary ways to increase passenger throughput are by increased efficiencies of movement (in the air and on the ground) or through increased passenger and cargo-carrying capabilities of the aircraft themselves.

[1] "The arrival of the A380 is as important to JFK International Airport as the Boeing 747 was when it was introduced." Bill DeCota, Aviation Director, Port Authority of New York and New Jersey.
[2] "We planned for the future by designing the new International Terminal to accommodate the New Large Aircraft, such as the A380." John L. Martin, Director, San Francisco International Airport.

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The A380, with its step increase in passenger (and cargo) capacity, was designed to be just such a safe, efficient, environmentally-friendly solution to that problem.

The GAO correctly identified "potential" safety and capacity issues surrounding the introduction of the A380 into service. The report is largely a very positive analysis of how and why the A380 does NOT introduce any significant safety or capacity issues. No airliner has been designed with more regard for safety than the A380 and it has benefited from the tremendous strides made in aviation safety over the past several decades - from advanced flight control systems, to modern materials with flame-retardant properties, to state-of-the-art emergency evacuation slides, and many, many more.

On the capacity side, there seems to have been an overemphasis on the operational constraints imposed on or by the A380. Although there is tacit acknowledgement in the report of the passenger throughput increases the A380 brings with its higher seating capacity, there seems to have been much more exhaustive work done on the potential delays that could accrue from currently-imposed increases in separation. Furthermore, again, the airport operational constraints of large aircraft are not and will not in the future be unique to the A380.

These analyses are based on myriad assumptions that are affected by multiple variables that can only be approximated for the year 2025, for example, and overlook the benefits the A380 will bring to the capacity constraints being faced by the world's largest airports. And yet, the analyses have shown results that interested airport officials have deemed acceptable and manageable.

Airbus suggests that any capacity discussion must include an analysis of the capacity of the aircraft projected, as well as the reduction in aircraft movements made possible by the introduction of the A380 and other large aircraft.

Airbus appreciates the opportunity to provide views and to submit comments and, as in the past, is ready to assist you and the GAO at any opportunity in the important endeavor of this study.

Sincerely yours,

Dan Cohen-Nir
Programs Director
Airbus North America Holdings Inc.

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