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Airport-operations Simulation Aids Evaluation of Strategies to Prevent Runway Incursions at LAX

Tests conducted in a U.S. National Aeronautics and Space Administration simulator showed that a taxiway extension and revised traffic-management procedures might help to reduce runway incursions at Los Angeles (California, U.S.) International Airport.

FSF Editorial Staff

Pilots and air traffic controllers based at Los Angeles (California, U.S.) International Airport (LAX) participated in an interactive study conducted in 2001 in a U.S. National Aeronautics and Space Administration (NASA) airport-operations simulator that evaluated several methods to reduce runway incursions at the airport. During simulations replicating peak operations at LAX, some methods were found to be unsafe or problematic; others showed promise of reducing the relatively high rate of runway incursions at the airport.

The study was conducted at NASA's FutureFlight Central (FFC), an airport-operations simulation facility that began operations in December 1999. FFC is located at the NASA Ames Research Center in Moffett Field, California.

NASA said that the LAX study at FFC was the "first attempt ever to model a major hub airport with controllers and pilots interacting in real time."[1] The study focused on the parallel runways located on the south side of the airport, where the majority of runway incursions at LAX have occurred.

In 1998 through 2000, LAX ranked fourth among U.S. airports in operations (i.e., takeoffs and landings) but had the largest number of runway incursions, according to U.S. Federal Aviation Administration (FAA) data.[2, 3]

The data show that LAX recorded 2,336,563 operations and 30 runway incursions during the period.

The highest number of operations (2,670,303) was recorded at the William B. Hartsfield Atlanta (Georgia) International Airport (ATL), which had 11 runway incursions during the period. The second-highest number of operations (2,703,603) was recorded at Chicago (Illinois) O'Hare International Airport (ORD), which had 14 runway incursions during the period. The third-highest number of operations (2,662,815) was recorded at Dallas–Fort Worth (Texas) International Airport (DFW), which had 15 runway incursions during the period.

The rates of runway incursions per 100,000 operations at these airports during the period were 0.41 at ATL, 0.52 at ORD, 0.56 at DFW and 1.28 at LAX.

The geometry of an airport — that is, how the runways and taxiways are configured — has a substantial effect on an airport's exposure to runway incursions, said David Kurner, regional runway safety program manager for FAA's Western-Pacific Region.[4]

"At LAX, because of the parallel runways in the southern complex, where aircraft come off the outboard runway

[Runway 25L] and cross the inboard runway [Runway 25R] is a problem area," Kurner said. "That is the area of most concern to us right now."

The southern-complex runways are the longest runways at LAX (see Figure 1). Runway 25L is 11,096 feet (3,384 meters) long and is used primarily for landings. Runway 25R, which is 12,091 feet (3,688 meters) long, is used primarily for departures.

Of the 30 runway incursions at LAX in 1998 through 2000, five were classified by FAA as Category A runway incursions, and seven were classified by FAA as Category B runway incursions. "Category A and [Category] B represent major runway incursions where there was a high risk of a collision," FAA said.[5]

The FAA runway-incursion-severity categories are defined as follows:

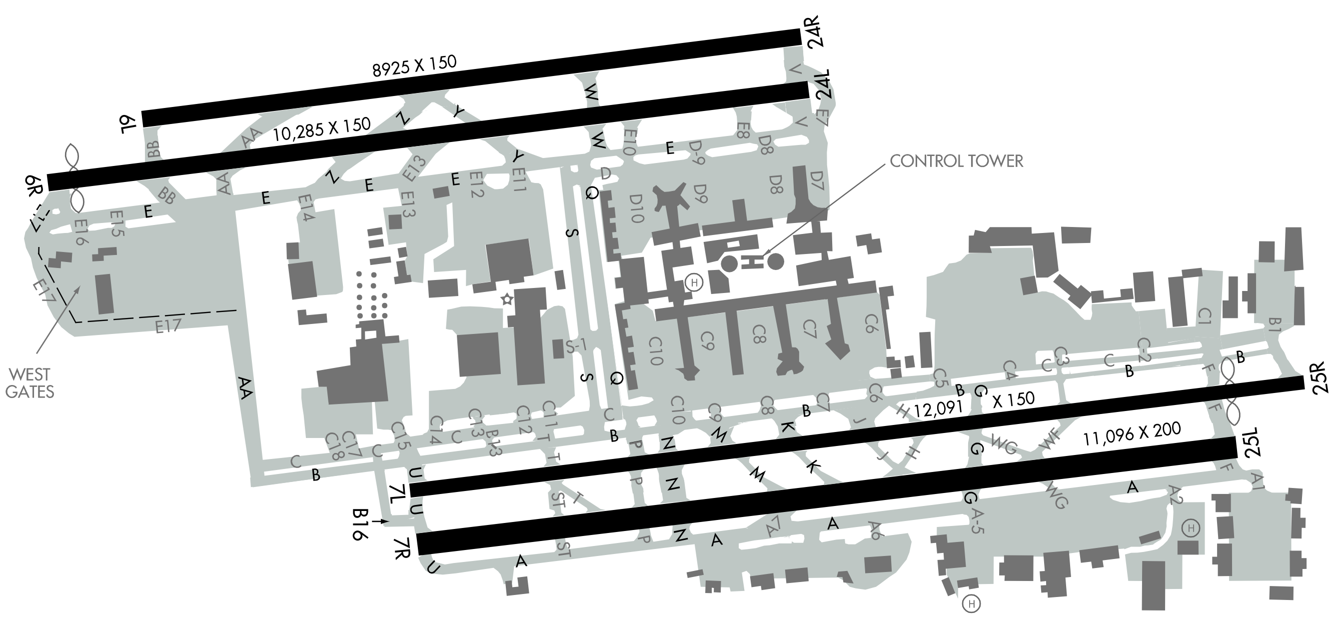
- Category A runway incursions occur when required air traffic control "separation [between two or more aircraft, or between an aircraft and obstacles (e.g., vehicles, equipment or personnel) on the runway] decreases and participants take extreme action to narrowly avoid a collision."
- Category B runway incursions occur when "separation decreases and there is significant potential for a collision."
- Category C runway incursions occur when "separation decreases but there is ample time and distance to avoid a potential collision."
- Category D runway incursions involve "little or no chance of collision but meet the [FAA] definition of a runway incursion (i.e., any occurrence on an airport runway involving an aircraft, vehicle, person or object on the ground that creates a collision hazard or results in a loss of required separation with an aircraft taking off, intending to take off, landing or intending to land)."

Of the 12 Category A and Category B runway incursions at LAX in 1998 through 2000, eight involved airplanes that landed on Runway 25L and — either because of controller error or pilot error — taxied onto Runway 25R or penetrated the runway safety area while another airplane was being operated on Runway 25R. (FAA defines runway safety area as "a defined surface surrounding the runway prepared [for] or suitable for reducing the risk of damage to airplanes in the event of an undershoot, overshoot or excursion from the runway.")[6]

FAA reports on the Category A runway incursions at LAX included the following information:[7]

- In day visual meteorological conditions (VMC) on Dec. 8, 1998, the crew of a Boeing 757 landing on Runway 25L was told by the controller to exit the runway on Taxiway N and to hold short of Runway 25R. The crew

Los Angeles (California, U.S.) International Airport



Source: U.S. Federal Aviation Administration

Figure 1

told the controller, "I think we just missed it. We'll hurry up." The controller observed the airplane moving past Taxiway M and told the crew, "November is the first 90-degree [turn] and hold short of Runway 25R." The crew said, "Roger, we'll get off at November." The crew exited Runway 25L on Taxiway N, taxied onto Runway 25R and then began to taxi westbound. At the time, a McDonnell Douglas MD-80 was departing from Runway 25R. The controller canceled the MD-80 crew's takeoff clearance. The MD-80 crew, however, had observed the B-757 and already had rejected the takeoff at about 120 knots, which was slower than the selected V_1 speed.[8] The MD-80 captain told investigators that "if he had accelerated another 10 knots to V_R [rotation] speed, he would not have been able to stop or climb over the B-757." FAA attributed the runway incursion to pilot deviation, which is defined as an action of a pilot that violates any U.S. Federal Aviation Regulation (e.g., failure to obey an ATC instruction).[9]

- In night instrument meteorological conditions (IMC) on Jan. 2, 1999, the crew of a B-737 (airplane no. 1) landed on Runway 25L and exited on Taxiway K. The crew acknowledged and read back the controller's instruction to hold short of Runway 25R. The controller then cleared another B-737 (airplane no. 2) to take off on Runway 25R. The controller observed airplane no. 1 moving faster than normal and told the crew to hold short for traffic departing on Runway 25R; the crew of airplane no. 1 read back the instruction. The controller then told the crew of airplane no. 2 to discontinue the takeoff because of traffic on the runway; the crew of airplane no. 2 did not acknowledge the instruction. Airplane no. 2 lifted off Runway 25R near Taxiway G. The crew of airplane no. 1 told investigators that they stopped as soon as they heard the controller cancel airplane no. 2's takeoff clearance and that they used reverse thrust to move the airplane backward. FAA attributed the runway incursion to pilot deviation.

- In night IMC on Jan. 3, 1999, a controller, who was working all tower positions, told the crew of a B-757 (airplane no. 1) to taxi into position and hold on Runway 24L. The controller then cleared the crew of another B-757 (airplane no. 2) to land on Runway 24L. The report said that the controller did not tell the crew of airplane no. 2 that airplane no. 1 was holding in position for departure on Runway 24L. A few moments later, the crew of airplane no. 2 told the controller that they were conducting a go-around because there was an airplane on the runway. The crew of airplane no. 2 said that they flew over airplane no. 1 at 150 feet to 200 feet (46 meters to 61 meters). FAA attributed the runway incursion to operational error, which is defined as a controller action that results in less-than-required separation between two or more aircraft, or between an aircraft and obstacles (e.g., vehicles, equipment or personnel) on the runway, or an aircraft landing or departing on a closed runway.[10]

- In day IMC on Nov. 23, 1999, the crew of a B-757 was cleared by one controller to take off on Runway 25R about the same time the crew of an MD-88 was cleared by another controller (LC1) to land on Runway 25L and told to turn right on Taxiway N, hold short of Runway 25R and remain on LC1's frequency. A portion of the MD-88 crew's readback was unintelligible, but LC1 believed that the crew had read back the hold-short instruction. The report said that about 26 seconds later, LC1 again told the MD-88 crew to hold short of Runway 25R. The MD-88 crew did not reply and taxied the airplane across Runway 25R. The B-757 crew said that they flew about 100 feet (31 meters) over the MD-88. FAA attributed the runway incursion to pilot deviation.

- In night IMC on March 5, 2000, the crew of a Douglas DC-9 was told to hold short of Runway 24L at Taxiway Z, but the crew taxied the airplane onto Runway 24L. The crew of a B-737, which had been cleared for takeoff on Runway 24L, lifted off 100 feet to 499 feet (152 meters) before Taxiway Z. FAA attributed the runway incursion to pilot deviation.

FAA reports on the Category B runway incursions at LAX included the following information:[11]

- In day VMC on Sept. 16, 1998, the crew of an MD-80 landing on Runway 25L correctly read back a controller's instruction to hold short of Runway 25R on Taxiway M. At the time, a B-737 was lifting off of Runway 25R and the crew of an Embraer EMB-120 had been cleared for takeoff on Runway 25R. The controller then observed that the MD-80's nosegear was across the runway edge line. The controller canceled the EMB-120 crew's takeoff clearance; the EMB-120 crew, however, had not begun the takeoff. The report said that the B-737 "climbed over" the MD-80. FAA attributed the runway incursion to pilot deviation.

- In day VMC on Oct. 18, 1999, the crew of an EMB-120 taxiing eastbound on Taxiway B was cleared for takeoff on Runway 25R. The report said that "a few transmissions later," the controller cleared the crew of a B-737 holding on Taxiway M to cross Runway 25R. The EMB-120 crew heard the controller clear the B-737 to cross the runway and rejected the takeoff when they observed the B-737 crossing the runway. The report said that the controller was not aware of the traffic conflict until after he asked the EMB-120 crew why they had rejected their takeoff. FAA attributed the runway incursion to operational error.

- In night IMC on Dec. 2, 1999, the crew of a B-757 that had landed on Runway 25L and exited on Taxiway N was told to hold short of Runway 25R. The crew of a B-747 was cleared to take off on Runway 25R. About 40 seconds later, the B-757 crew told the controller, "We are just past the hold bars, holding short." The report said that the hold bars are not visible from the tower after sunset. "The controller checked the ground radar, analyzed the position and speed of the departing B-747 and decided not to abort its takeoff," the report said. The B-747 departed without incident. FAA attributed the runway incursion to pilot deviation.

- In day VMC on April 2, 2000, a B-767 crew failed to follow a controller's instructions after landing on Runway 25L and crossed the Runway 25R hold bars at Taxiway M as an EMB-120 was climbing out on takeoff from Runway 25R, the report said. FAA attributed the runway incursion to pilot deviation.

- In day VMC on July 21, 2000, the crew of an EMB-120 was told to taxi into position and hold on Runway 24L. Another airplane was crossing Runway 24L at Taxiway Y. The controller observed the EMB-120 begin to roll and told the crew that they had been cleared to hold for takeoff. The EMB-120 crew rejected the takeoff and exited the runway at Taxiway W. FAA attributed the runway incursion to pilot deviation.

- In night VMC on Nov. 16, 2000, the crew of an MD-80 (airplane no. 1) landing on Runway 24R was cleared to cross Runway 24L. The crew of another MD-80 (airplane no. 2) was cleared for takeoff on Runway 24L. The controller observed airplane no. 1 quickly approaching Runway 24L on Taxiway Z and canceled airplane no. 2's takeoff clearance, the report said. Airplane no. 2 had rolled about 800 feet (244 meters) when the takeoff clearance was canceled. FAA attributed the runway incursion to operational error.

- In day VMC on Dec. 8, 2000, the crew of a B-737 entered Runway 25R without authorization and created a conflict with another B-737 departing on Runway 25R, the report said. The closest proximity of the airplanes was 1,000 feet (305 meters). FAA attributed the runway incursion to pilot deviation.

Preliminary data indicate that eight runway incursions occurred at LAX in 2001.[12] One was classified by FAA as a Category B runway incursion. The FAA preliminary report on the incident said that it occurred in night IMC on Feb. 23, 2001, and involved an Airbus A319 that landed on Runway 25L and exited on Taxiway K. The A319 crew was told to hold short of Runway 25R. The crew read back the instruction "but crossed the hold bars and conflicted with [another] B-737 on departure [from] Runway 25R," the report said. "Also, a B-737 on … final [approach] for Runway 25R was sent around to avoid loss of separation." FAA attributed the runway incursion to pilot deviation.[13]

Despite efforts to reduce runway incursions at LAX, the problem has persisted, said Thomas Winfrey, public relations representative for Los Angeles World Airports (LAWA), which owns and operates LAX and three other airports in California: Ontario International Airport, Palmdale Regional Airport and Van Nuys Airport.[14]

"We have spent money in many ways," Winfrey said. "[We have installed] signage on the airfield — upright stop signs to warn pilots where they are, flashing red lights to help gain pilots' attention, wider paint striping on hold lines on taxiways and extensive training programs with people who move planes around the field. [Nevertheless,] runway incursions are a continuing problem for us."

FAA's Kurner said, "To date, LAX has done more in the way of runway safety devices than I've seen in most other places. … They have done virtually everything we know of to increase the visibility of holding positions, [and the FAA has helped to increase] the education and awareness of vehicle drivers, pilots, mechanics who position aircraft and controllers."

In March 1999, airport-operations managers, airport control tower managers, FAA representatives, airline representatives, pilots, controllers and others met to discuss the runway-incursion problem at LAX. A steering committee was created, and six different methods to reduce runway incursions were developed by the committee. In August 2000, LAWA, FAA and United Airlines contracted with NASA to conduct at FFC a study of the six methods.

The study was conducted in two phases. The first phase, conducted in February 2001, comprised baseline simulations to determine whether the airport-simulation model developed by NASA had adequate fidelity (realism) to replicate operations at LAX. The simulation model was based on peak operations recorded at the airport in June 2000.

The NASA report on Phase I of the study said, "The Phase I approach was to present a realistic environment for the controllers, such that they operate in the FFC tower the way they would in the LAX tower. … Two groups of four LAX controllers worked each of the four tower positions [north local control, north ground control, south local control and south ground control] over a two-day period, for a total of four simulation days."[15]

The controllers worked in a full-scale control tower simulator with a 360-degree visual display of airport operations. Six controllers from Los Angeles Tower and a representative of the National Air Traffic Controllers Association participated in the tests, said Boris Rabin, FFC simulations manager.[16] During the simulations, the controllers interacted with 16 pilots.

"We have a group of pilots who work under contract here," Rabin said. "Some are retired commercial pilots." Two United

The U.S. National Aeronautics and Space Administration (NASA) FutureFlight Central airport-operations simulator has 12 controller workstations and a 360-degree display of the airport environment. (NASA photo)

Airlines pilots, who operated frequently at LAX, also participated in the tests. Each pilot received 54 hours of instruction before the simulations were conducted. The pilots operated multiple aircraft at computer workstations. Rabin said that each workstation had a plan-view display of the airport and a communications frequency-control panel.

During each one-hour simulation, the controllers and pilots handled an average of 170 programmed aircraft movements.

The Phase I report said that when the baseline simulations were completed, a formal survey of the participating controllers showed that they rated their simulated workload "about the same as [at] LAX" and that they perceived the airport model as providing a realistic replication of operations at LAX.

"LAX officials, FAA air traffic controllers and FAA observers judged that the FFC simulation was sufficiently representative of LAX operations that FFC could be used to study the impact of the [methods] proposed in Phase II on operations at LAX," the report said.

The Phase II simulations were conducted in April 2001. Rabin said that a different group of controllers from LAX, and one controller who had retired from the control tower at San Francisco (California) International Airport (SFO), participated in the simulations. The retired SFO controller managed traffic on a north-complex runway when the study required two local controllers for the south-complex runways.

The NASA report on Phase II of the study said that of the six methods studied, the following four methods were found to show little potential or no potential for reducing runway incursions, and/or potential for creating traffic-management problems:[17]

- Use the inboard runways (i.e., Runway 25R and Runway 24L) primarily for arrivals and the outboard runways (Runway 25L and Runway 24R) primarily for departures: This method reduced the frequency at which airplanes crossed runways but resulted in congestion of airplanes on some taxiways. The taxiway congestion resulted in landing aircraft occupying runways longer. The report said that this method was "regarded as having about the same potential for runway incursions as the current mode of operations."

- Use one local controller for Runway 25L and one local controller for Runway 25R: This method "created workload and coordination problems between the local controllers and was regarded as unsafe," the report said.

- Require all airplanes landing on Runway 25L to turn left off the runway and to use Taxiway A, Taxiway U and an extended Taxiway B16 to taxi to their gates: The extension of Taxiway B16 — which moved the portion of the taxiway oriented north-south out of the Runway 25R runway safety area — was found to have beneficial results. Nevertheless, ground-traffic movement changes that accompanied this method (primarily, requiring all airplanes taxiing from the north complex to the south complex to use Taxiway Q, and requiring all airplanes taxiing from the south complex to the north complex to use Taxiway AA) created congestion on Taxiway E that was sufficient to prevent airplanes from exiting Runway 24L. The report said that this method was rejected because it increased the potential for runway incursions on the north-complex runways.

- Change traffic-management procedures as in the previous method, but allow controllers to instruct the crews of airplanes landing on Runway 25L to turn right off the runway and to cross Runway 25R; this procedure was authorized only when the controllers determined that the airplanes would not have to hold short on Runway 25R: The report said that this method "showed some positive potential" but was not considered as beneficial as two other methods.

The report said that the following methods were judged by the study participants to offer the greatest safety (i.e., the lowest risk of runway incursion) and the greatest efficiency in traffic management.

- Require all airplanes landing on Runway 25L to turn left off the runway and to use Taxiway A, Taxiway U and an extended Taxiway B16 to taxi to their gates. This method also allowed controllers more flexibility in assigning taxi routes by making Taxiway AA available for airplanes taxiing northbound or southbound, using Taxiway S for airplanes taxiing southbound and using Taxiway Q for airplanes taxiing northbound. The report said that the participating controllers ranked this method highest among the six methods in reducing the potential for runway incursions and in affording traffic-management efficiency.

- Use the procedures employed in the previous method, and use two local controllers for the south-complex runways — one local controller for Runway 25L and one local controller for Runway 25R. The participating controllers said that this method afforded the same traffic-management efficiency as current operations at LAX and showed potential for reducing runway incursions.

Both methods involve extension of Taxiway B16. FAA's Kurner said that a short extension and a long extension of the taxiway are being considered.[18] The short extension would result in Taxiway B16 intersecting with Taxiway B 1,000 feet (305 meters) farther west. The long extension would result in Taxiway B16 intersecting with Taxiway AA.

"A plan to extend B16 is on the books now," Kurner said. "The north portion of B16 currently is in a runway safety area, which has to be kept clear when aircraft are operating on the runway. The B16 extension will take [taxiing] aircraft out of harm's way. It appears to be a pretty good option. The idea is to move [taxiing aircraft] out of the high-exposure zone and keep capacity at the current levels."

Winfrey said that the LAWA board in January 2001 voted to hire a consultant to analyze the costs, environmental effects and construction logistics of extending Taxiway B16.[19]

"We are going to have the consultant develop a detailed plan for building the new taxiway," he said.♦

Notes

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4. Kurner, David. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. Feb. 5, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

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6. FAA. *Change 1 to Airport Design*. Advisory Circular 150/5300-13. June 5. 1991.

7. FAA Office of Runway Safety. February 2002.

8. U.S. Federal Aviation Regulations (FARs) Part 1 defines V_1 as "the maximum speed in the takeoff at which the pilot must take the first action (e.g., apply brakes, reduce thrust, deploy speed brakes) to stop the airplane within the accelerate-stop distance. V_1 also means the minimum

speed in the takeoff, following a failure of the critical engine at V_{EF}, at which the pilot can continue the takeoff and achieve the required height above the takeoff surface within the takeoff distance." Part 1 defines V_{EF} as "the speed at which the critical engine is assumed to fail during takeoff."

9. FAA. *FAA Runway Safety Report: Runway Incursion Severity Trends at Towered Airports in the United States, 1997–2000*.
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17. NASA FFC. *Los Angeles International Airport Runway Incursion Studies: Phase II Alternatives Simulation*.
18. Kurner.
19. Winfrey.

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