BRIEFING PAPER
OPERATIONAL IMPACT OF 3,500-FOOT RUNWAY LENGTH
SANTA MONICA AIRPORT

At the request of the City of Santa Monica, Coffman Associates has examined the capability of aircraft currently using the Santa Monica Airport to operate from a runway length reduced to 3,500 feet. **This analysis is strictly a calculation of the potential operational impacts based upon Santa Monica Airport operations and aircraft performance only. Coffman Associates offers no opinion or recommendations regarding runway length to the City of Santa Monica.**

Runway length requirements vary between aircraft types and are also affected by a variety of operating conditions and variables. The runway length required for any aircraft takeoff or landing (each is counted as an operation) considers the weight of the aircraft with fuel and other payload (passengers and cargo) on board, the airport's elevation, air temperature, atmospheric pressure, wind direction and velocity, available runway length and gradient (slope), runway surface condition (wet/dry), the aircraft's performance characteristics.

The airport elevation and gradient are set for a given runway. At Santa Monica Airport, the elevation is 177 feet above mean sea level (MSL), and the lone Runway 3-21 has a gradient of 1.2 percent with a grade change of 60 feet between the highest and lowest points on the runway.

For purposes of this analysis, aircraft performance characteristics were examined for two temperatures: the mean maximum temperature of the hottest month, commonly called the design temperature, of 75 degrees F; and the average temperature of the hottest month of 63 degrees F. Calm wind conditions were assumed, since aircraft would otherwise land and depart into wind, thereby decreasing the runway length required.

Wet pavement can affect the friction coefficient of the runway, particularly on landing. Aircraft performance charts increase landing length requirements for operating from a wet runway, so both wet and dry runways were analyzed for each aircraft.

With all these basic assumptions, the primary remaining variable is the weight of the aircraft. As weight is increased, the aircraft runway requirement becomes longer. For the purposes of determining the capability of each aircraft to operate from a given length, the individual aircraft performance charts were referenced to determine the aircraft's maximum operating weight to takeoff or land from that length of runway.

Since each aircraft has a basic operating empty weight (OEW), the weight to takeoff or land was translated to a percent useful load. Useful load is described as the weight of usable fuel plus passengers and cargo. A useful load of 100 percent means the aircraft can operate from the runway at its maximum weight. A useful load of 60 percent has been used in the past by FAA for runway length design and represents a reasonable operating weight for takeoff. Still, the aircraft may not be able to operate to its full range at that load. For landings, a 30 percent useful load is considered reasonable since most fuel has been burned off during flight. A useful load below 30 percent on takeoff, however, can be restrictive

after accounting for passenger and cargo loads plus required fuel reserves. This would limit the aircraft to a short flight to another nearby airport with a longer runway to load the necessary fuel for the remainder of the trip.

Utilizing FAA tables from FAA AC 150/5325-4B, it was determined that the full range of general aviation small aircraft (weighing 12,500 pounds or less) can operate from a runway length of 3,500 feet or less at 75 degrees F. Thus, the remaining analysis will focus upon the business jets and the few propeller aircraft over 12,500 pounds operating at the airport.

In 2016, Santa Monica Airport air traffic control tower counted a total of 88,210 operations. Airport records indicate 17,303 operations were by jets, with the remaining operations by helicopters and fixed wing propeller aircraft. Most of the propeller aircraft weigh 12,500 pounds or less. The Beech King-Air 300 and 350 turboprops, are exceptions which weigh over 12,500 pounds. The King-Air 300 made 258 takeoffs and landings at the airport in 2016, while the King-Air 350 made 870.

The runway length requirements for individual business jet models were analyzed using aircraft performance software produced by Ultra-Nav Aviation Inc. For takeoffs, the software accounts for the airfield conditions to determine the allowable takeoff weight of the aircraft for a given runway length. For landing, a landing weight is entered for each aircraft model to determine the runway length that will be required to safely land.

Business jets that performed at least 50 operations at Santa Monica Airport in 2016 were analyzed, in addition to the King-Air 350 turboprop. It should be noted that the performance data for the following aircraft weighing over 12,500 pounds are not available in the software, but had at least 50 annual operations:

- Challenger 350 – 479 operations
- Embraer Legacy 500 – 64 operations
- Gulfstream 280 -95 operations
- Learjet 75 – 56 operations
- Beech King Air 300 - 258

Even with these exceptions, the analysis represents 16,331 of the 17,303 business jet operations (over 94 percent). A total of 31 business jet aircraft models were evaluated.

RUNWAY TAKEOFF LIMITATIONS

Table A presents the capability for these aircraft to depart from Santa Monica Airport on a 3,500-foot runway at 75 degrees and 63 degrees respectively. The takeoff weights to operate were determined, then translated to percent useful load. As indicated on the table, a 3,500-foot runway length would be outside their takeoff performance limits, particularly in wet runway conditions. Others could operate with minimal useful loads below the practical operating threshold of 30 percent useful load. At 75 degrees, nine of the 31 business jet aircraft would be limited from takeoff on a dry runway.

Table A
3,500 ft. Runway Takeoff Analysis
Santa Monica Airport
Airport Data

Elevation: 177 ft above mean sea level
Runway 21 Slope: -1.2%

Aircraft Designator	Aircraft Name	2016 Operations	75° F		63° F	
			Dry	Wet	Dry	Wet
BE40	**Beechjet 400A**	357				
C550	**Citation II (550)**	414				
C560	**Citation V (Model 560)**	695				
C56X	**Citation 560 XL**	2,027				
C750	**Citation X**	786				
C650	**Citation III**	154				
C501	**Citation I/SP**	71				
C510	**Citation Mustang**	297				
C680	**Citation Sovereign**	805				
C525	**Citation (525) CJ1**	683				
C25A	**Citation (525A) CJ2**	553				
C25B	**Citation CJ3**	603				
C25C	**Citation CJ4**	208				
CL30	**Challenger 300**	1,419				
CL60	**Challenger 601/604**	861				
EA50	**Eclipse 500**	90				
E50P	**Embraer Phenom 100**	1,149				
E55P	**Embraer Phenom 300**	1,125				
E135	**Embraer 135**	140				
F900	**Falcon 900EX**	308				
F2TH	**Falcon 2000**	749				
FA50	**Falcon 50 EX**	67				
GALX	**Gulfstream 200**	237				
G150	**Gulfstream 150**	195				
GLF4	**Gulfstream IV**	989				
H25B	**Hawker 800 (With T/R)**	491				
LJ31	**Lear 31A**	59				
LJ35	**Lear 35A**	76				
LJ45	**Lear 45**	256				
LJ60	**Lear 60**	174				
PRM1	**Premier 1A**	293				
	Totals Business Jet Operations	16,331				
B350	**King Air 350 (Turboprop)**	888				

Key

	Meets parameters for design load (60% useful load) parameters
	Limited to reduced loads (30% to 60% useful load)
	Below effective operational load limits

With a wet runway at 75 degrees, 15 more business jets for 21 of the 31 aircraft would be limited from takeoff. In fact, of the 10 aircraft that could operate under these conditions, all but two are in FAAs Approach Category B (approach speeds of less than 121 knots). The Lear 31 and 35 are the only two Approach Category C (approach speeds between 121 and 140 knots) aircraft that would be able to operate.

Table A also examines takeoff requirements at 63 degrees. Six of the nine aircraft still cannot operate from a 3,500-foot dry runway. The same ten aircraft that can takeoff from the wet runway at 75 degrees will also be able to at 63 degrees.

Table B
3,500 ft. Runway Landing Length Analysis
Santa Monica Airport
(30 Percent Minimum Useful Load)

Airport Data
Elevation: 177 ft above mean sea level
Runway 21 Slope: -1.2%

			Operational Parameters					
Aircraft		2016	CFR Part 25		CFR Part 135		CFR Part 91K	
Designator	Aircraft Name	Operations	Dry	Wet	Dry	Wet	Dry	Wet
BE40	**Beechjet 400A**	357						
C550	**Citation II (550)**	414						
C560	**Citation V (Model 560)**	695						
C56X	**Citation 560 XL**	2,027						
C750	**Citation X**	786						
C650	**Citation III**	154						
C501	**Citation I/SP**	71						
C510	**Citation Mustang**	297						
C680	**Citation Sovereign**	805						
C525	**Citation (525) CJ1**	683						
C25A	**Citation (525A) CJ2**	553						
C25B	**Citation CJ3**	603						
C25C	**Citation CJ4**	208						
CL30	**Challenger 300**	1,419						
CL60	**Challenger 601/604**	861						
EA50	**Eclipse 500**	90						
E50P	**Embraer Phenom 100**	1,149						
E55P	**Embraer Phenom 300**	1,125						
E135	**Embraer 135**	140						
F900	**Falcon 900EX**	308						
F2TH	**Falcon 2000**	749						
FA50	**Falcon 50 EX**	67						
GALX	**Gulfstream 200**	237						
G150	**Gulfstream 150**	195						
GLF4	**Gulfstream IV**	989						
H25B	**Hawker 800 (With T/R)**	491						
LJ31	**Lear 31A**	59						
LJ35	**Lear 35A**	76						
LJ45	**Lear 45**	256						
LJ60	**Lear 60**	174						
PRM1	**Premier 1A**	293						
	Total Business Jet Operations	16,331						
B350	**King Air 350 (Turboprop)**	888						

Notes/Key
Part 135 aircraft operations must be able to land within 60 percent of the available runway length (2,100 ft)
Part 91 Subpart k aircraft operations must be able to land within 85 percent of the available runway length (2,975 ft.)

Ability to operate at 63 but not 75 degrees F.
Cannot operate at 63 degrees F or above

RUNWAY LANDING LIMITATIONS

Table B presents the capability of each aircraft to operate from Santa Monica Airport with a 30 percent useful load under the two temperature conditions as well as from both a dry and wet runway. Aircraft operations are regulated by the United States Department of Transportation Code of Federal Regulations (CFR). These regulations are designed for the safe operation of aircraft, and can affect the runway length required for landing.

14 CFR Part 25 – *Airworthiness Standards: Transport Category Airplanes* includes regulations for safely landing jet aircraft. Part 25 includes aircraft owned and operated by private individuals and corporations for their own use. As can be seen from the tables, all but two aircraft, Citation X and Citation III, can land on a dry 3,500-foot runway at 75 degrees.

When the runway is wet, however, several more aircraft will be limited from landing under Part 25. As shown on **Table B**, all but two Citation aircraft models would not be able to land at 75 degrees as well as the Beechjet 400, Challenger 300 and 601/604, Gulfstream 200 and 150, Lear 31,35, and 60 and Premier 1A. The Eclipse 500 and Gulfstream IV would be capable to operate at 63 degrees but not 75 degrees.

When an aircraft operates "for hire" the rules and regulations of 14 CFR Part 135 – *Operating Requirements Commuter and On-Demand Operations* apply. At Santa Monica Airport, this includes air charters (air taxis) which operate on an on-demand basis carrying passengers or cargo. CFR Part 135 requires that the aircraft must be capable of landing within 60 percent of the available runway length. Thus, an aircraft would need to be able to land within 2,100 feet on a 3,500-foot runway.

The Part 135 landing requirements restrict all but a two of the business jet from landing on a 3,500-foot runway. The Citation I and II can operate from a 3,500-foot dry runway at both 75 degrees. None of the business jets would be capable of landing under Part 135 on a wet runway at 63 degrees.

Fractional ownership of aircraft is another form of aircraft ownership and a use that has become popular over the past twenty years. Under fractional ownership, a customer can purchase a pro-rated "share" of an aircraft rather than the entire plane. Like a resort time-share, the customer then pays a monthly maintenance fee and an occupied hourly fee. The aircraft is maintained and operated on-demand by a fractional operator business. Two of the fractional operators most frequently using Santa Monica Airport are NetJets and Flight Options.

14 CFR 91 Subpart K – *Fractional Ownership Operations* regulates the fractional owners and operators. When the fractional aircraft is operated under the control of the individual fractional owner, Part 91K requires aircraft to be able to land within 85 percent of the available runway. This would mean landing within 2,975 feet on a 4,000-foot runway. If the aircraft is under the control of the fractional operator, then the 60 percent rule of Part 135 applies unless that operator uses a Destination Airport Analysis Program (DAAP). DAAP is recognition that the operator has the systems and the processes in place to assess airports and conditions that are suitable for increased landing regulatory landing distance. There are 22 conditions governing the use of DAAP that must be in place prior to departure to the destination airport.

A total of 15 of the 31 business jets analyzed could land on a 3,500-foot dry runway under Part 91K at 75 degrees and at 63 degrees. Only three business jets could land under Part 91K on the same runway wet at 75 degrees, and four jets on a wet runway at 63 degrees.

SUMMARY AND CONCLUSIONS

This analysis has evaluated the aircraft that operate at Santa Monica Airport for their capability to operate from a 3,500-foot runway. Utilizing FAA performance charts for small aircraft (weighing 12,500 pounds or less) it was determined that this category of aircraft would be able to continue to operate at the airport on a regular basis. A total of 31 business jets that frequent the airport and performed over 94 percent of the business jet operations at the airport in 2016 were evaluated separately using individual aircraft performance tables and graphs. A turboprop (Beech King-Air 350) weighing over 12,500 pounds that performed at least 870 operations in 2016 was also evaluated.

The analysis concluded that most of the business jets would be able to continue to operate at least under 14 CFR Part 25 which govern general aviation aircraft operations not "for hire". The exceptions were the Citation III, Embraer 135, Gulfstream 200 and 150, Hawker 800 and Lear 45 that would not be able to depart from a 3,500-foot runway under any of the conditions analyzed. The Citation X could not land on the same length of runway under any of the examined conditions.

Table C
Percent Jet Fleet Mix Remaining Operable
3,500 ft. Runway Length Analysis
Santa Monica Airport

	Runway Length (ft)	
	75° F	**63° F**
Takeoff		
60% Useful Load		
Dry Runway	55.6%	57.7%
Wet Runway	23.8%	36.2%
30% Useful Load		
Dry Runway	79.8%	91.0%
Wet Runway	36.7%	36.7%
Landing (30% Useful Load)		
Part 25		
Dry Runway	94.2%	94.2%
Wet Runway	27.9%	34.6%
Part 91k		
Dry Runway	45.7%	45.7%
Wet Runway	8.2%	9.4%
Part 135		
Dry Runway	3.0%	3.0%
Wet Runway	0.0%	0.0%

A wet runway and the increased length landing requirements for aircraft operating under Parts 135 or 91 subpart K further restrict the jet capabilities on the shorter runway lengths. None of the business jets could operate under Part 135 in wet conditions. Only the Citation I and II could operate on a dry 3,500-foot runway in dry conditions. Under Part 91k 15 aircraft could operate from the dry runway, but just five from a wet runway, and one of those at less than 75 degrees.

Table C provides a summary of the percent of 2016 operational jet fleet mix that could operate from a 3,500-foot runway length. At a minimum operating level of 30 percent useful load on takeoff, 79.8 percent of departures could be accommodated at the design temperature of 75 degrees. The percentage for a dry runway change increases to 91.0 percent at the average temperature of 63 degrees. On a wet runway, 3,500 feet can accommodate 36.7 percent of the jet departures at both 75 and 63 degrees

The ability to carry higher loads will be a factor in supporting regular operations. At 60-percent useful

load, 55.6 percent of the jet departures could be accommodated on a dry 3,500-foot runway at 75 degrees. This declines to 23.8 percent on a wet runway at the same temperature. At the average temperature of 63 degrees, the percentages are 57.7 percent for a dry runway and 36.2 percent when wet.

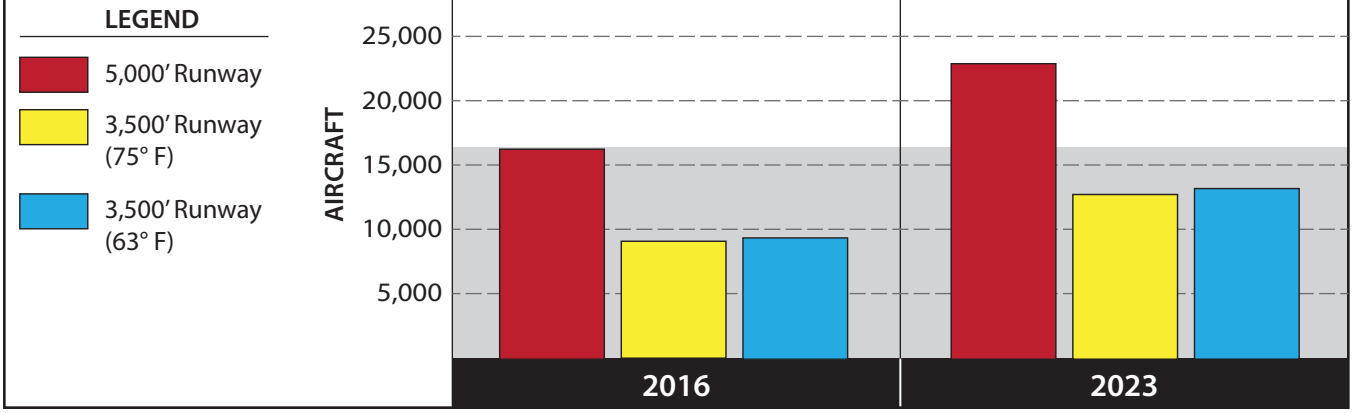
For landing, the percentages that can be accommodated drop from 94.2 percent under Part 25 and dry to 27.9 percent on a wet runway at 75 degrees. The percentages only change slightly at 63 degrees. Part 135 would be extremely limited at 3,500 feet with on 3.0 percent of the operational fleet mix on a dry runway and zero percent on a wet runway.

In summary, the largest impact of a runway length reduced to 3,500 feet or less would be to effectively to shut down business jet charter operators who fly others as part of their business. Most of the business jets operated privately for personal and corporate use would be able to still operate at reduced runway lengths on a dry runway. Many however, could elect not to continue to operate at Santa Monica Airport, due to limited loading or individual insurance requirements for a longer runway length.

Exhibits A and **B** graphically compares existing and future jet operations related to the current runway length and a 3,500-foot runway, based upon annual growth rates of five and 10 percent. Under general design conditions, there is potential for a 44 percent reduction in jet operations based upon the current operational fleet mix.

FIVE PERCENT ANNUAL GROWTH RATE - 60 PERCENT USEFUL LOAD

Runway Length	2016	2023
5,000 ft.	16,331	22,979
3,500 ft. (75° F)	9,072	12,765
3,500 ft. (63° F)	9,429	13,268



TEN PERCENT ANNUAL GROWTH RATE - 60 PERCENT USEFUL LOAD

Runway Length	2016	2023
5,000 ft.	16,331	31,824
3,500 ft. (75° F)	9,072	17,679
3,500 ft. (63° F)	9,429	18,374

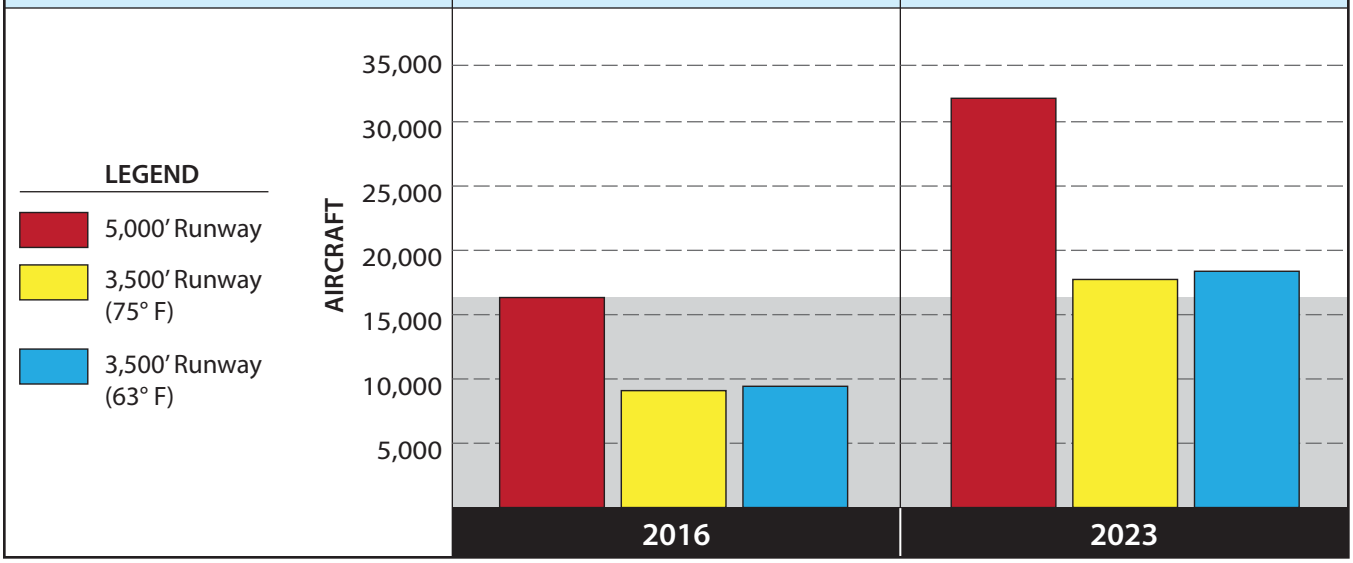
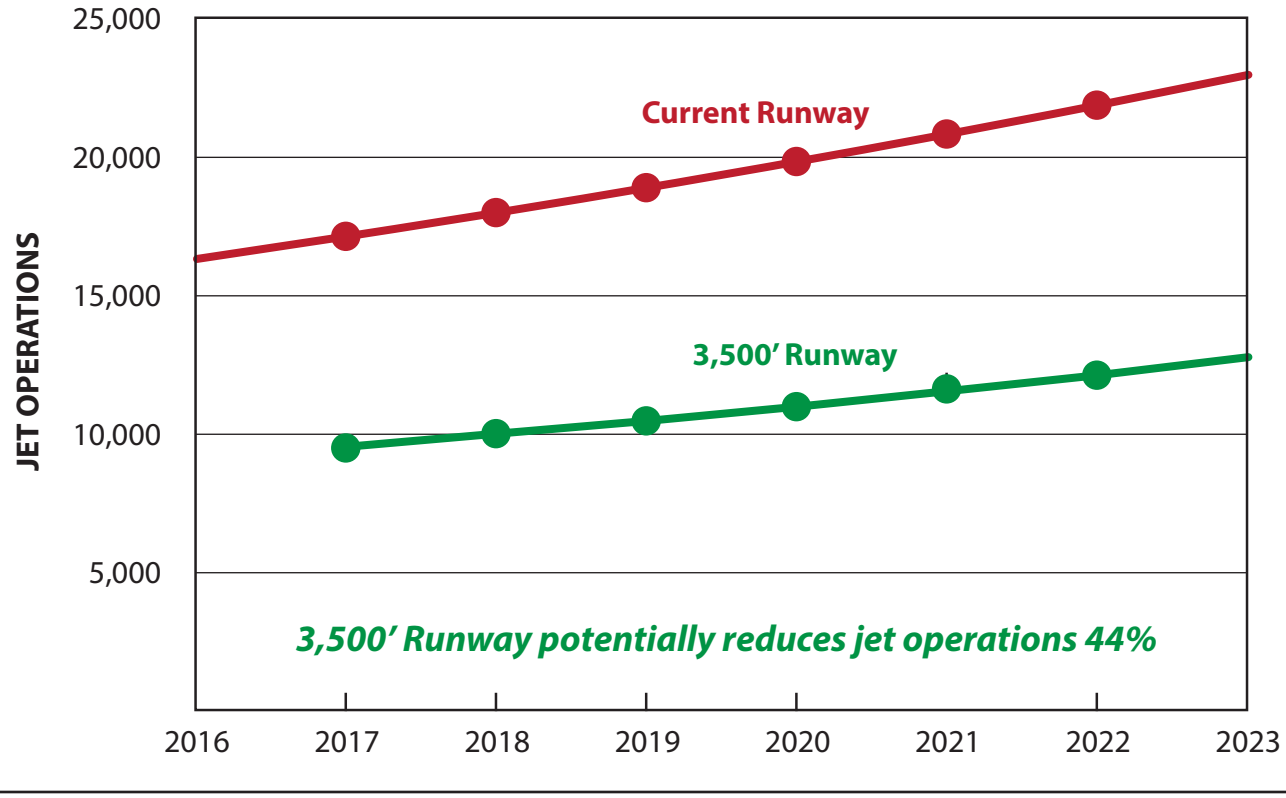


Exhibit A
JET OPERATIONS GROWTH RATE COMPARISON 2016-2023

FIVE PERCENT ANNUAL GROWTH RATE



TEN PERCENT ANNUAL GROWTH RATE

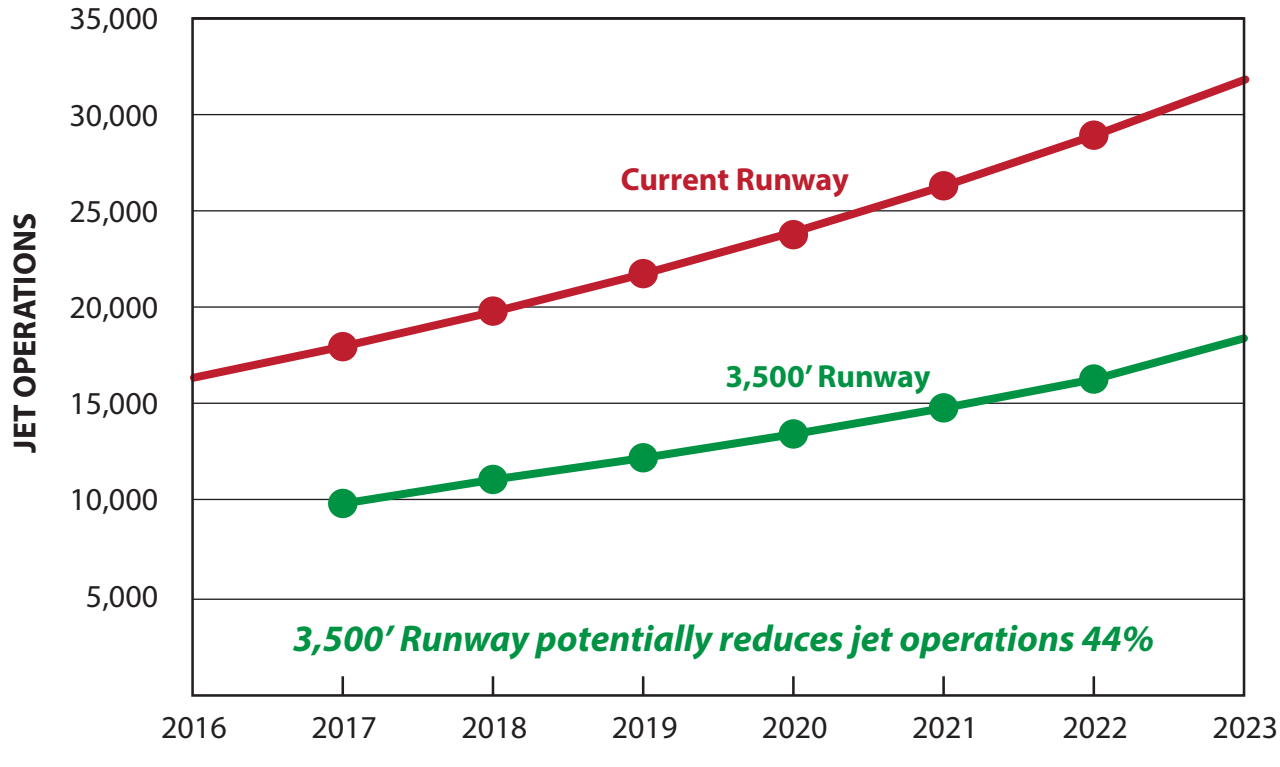


Exhibit B
ANNUAL JET OPERATIONS GROWTH RATE COMPARISON