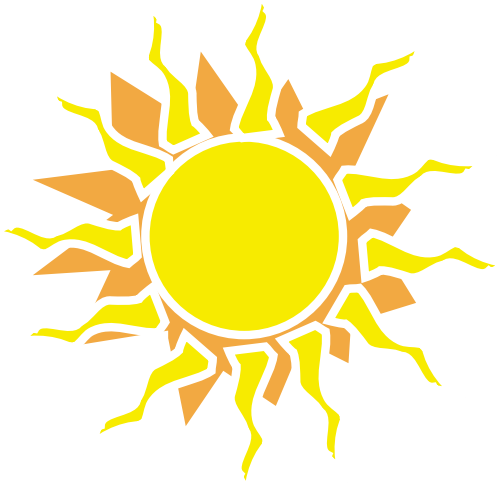
Take-off and landing performance can be critical in some aircraft selection exercises. The A320 family demonstrates strong operational capability.

A320 family: high performers in the heat



Selection of new aircraft depends on their potential revenues and operating costs. In many scenarios airlines find the higher operating efficiencies and lower cash operating costs not enough to justify the acquisition of new technology aircraft.

Exceptions to this are where the difference in operating performance between a new and old aircraft is large enough for an airline's operating economics to be transformed. A prime example is the selection of the A320 family by several airlines.

Mexicana, for example, discovered a considerable difference between the restricted take-off weights and payload of the 727-200 and A320. This has given the A320 a superior economic performance due to higher passenger payloads and revenues.

Only the earliest A320 models experience any (although quite small) take-off weight limitation and range reduction when operating in high ambient temperatures.

Operating restrictions

High ambient temperatures, airfield elevations and short runways can impose restricted take-off weights and subsequent payload limitations.

Air density is lowered by high ambient temperatures and airfield elevations. A lower air density will reduce the performance of the engines and lift generating power of the wings. This will mean the aircraft requires more runway length to achieve maximum take-off weight than at sea level. At some point the allowable take-off weight for a given runway length is less than maximum and then further reduces as air density decreases. Restrictions on take-off weight will eat into an aircraft's standard payload-range performance and limit its effective range circle with a standard payload from an airfield.

An airline has the option to accept reduced payloads for the same route distance or suffer a loss in range performance for standard payload. So, for example, where the highest specification 727-200 can carry a 150 passenger load up to about 2,100nm when it is not take-off weight restricted, it may only be able to carry 150 passengers up to 1,500nm when taking-off from Denver or Mexico City because of a restricted take-off weight. The actual maximum range with a standard 150 passenger payload will depend on the conditions of the day and the corresponding allowable take-off weight.

For routes that are longer than 1,500nm the passenger load for the 727-200 will be smaller. This will of course reduce revenue potential.

The traffic levels on the longer routes may mean an airline will use an aircraft capable of carrying 150 passengers the required distance. The operator might then use a larger aircraft such as a 757.

It is A320 family's ability to operate virtually unrestricted from many hot and high airfields that makes it attractive to airlines operating older equipment.

COMPARISON OF RESTRICTED TAKE-OFF WEIGHT AND RANGE CAPABILITIES

Aircraft type	Engine type	Standard MTOW (lb)	Temperature (degrees F)	Passenger payload	Range nm
A319-100	CFM56-5B6	149,900	90	124	2,750
A319-100	CFM56-5B6	149,900	100	124	2,750
A319-100	V.2524-A5	149,900	90	124	2,770
A319-100	V.2524-A5	149,900	100	124	2,770
A319-100	CFM56-5B6	162,000	90	124	3,160
A319-100	CFM56-5B6	162,000	100	124	3,160
A319-100	V.2524-A5	162,000	90	124	3,180
A319-100	V.2524-A5	162,000	100	124	3,180
A320-200	CFM56-5A1	162,000	90	150	2,660
A320-200	CFM56-5A1	162,000	100	150	2,450
A320-200	V.2500-A1	162,000	90	150	2,840
A320-200	V.2500-A1	162,000	100	150	2,710
A320-200	CFM56-5A3	166,400	90	150	2,800
A320-200	CFM56-5A3	166,400	100	150	2,800
A320-200	V.2527-A5	166,400	90	150	2,960
A320-200	V.2527-A5	166,400	100	150	2,960
A320-200	CFM56-5B4	169,800	90	150	2,930
A320-200	CFM56-5B4	169,800	100	150	2,930
A321-100	CFM56-5B2	187,400	90	185	2,380
A321-100	CFM56-5B2	187,400	100	185	2,380
A321-200	CFM56-5B3	196,200	90	185	2,380
A321-200	CFM56-5B3	196,200	100	185	2,380
A321-200	V.2533-A5	196,200	90	185	2,450
A321-200	V.2533-A5	196,200	100	185	2,450

Phoenix Sky Harbor with standard performance from the 11,000 foot runway.

A320 test

The A320 suffers few payload restrictions because of its combination of aerodynamics, thrust to weight ratio and high operating performance. Where the A320, MD-80 and 727-200 have similar range capabilities for the same passenger load when operating from sea-level airfields in standard conditions, the A320 loses less range capability in high temperatures.

An airline will consider new types, such as the A320, to provide it with improved operating performance. A credible test is to analyse the restrictions on an aircraft's performance from an airfield at high elevation with short runways and high ambient temperatures for many days each year. Examples include Phoenix Sky Harbor (PHX), Mexico City and Denver International; the last two are at particularly high elevations. Although Phoenix is only 1,133 feet above sea level and has a 11,000 foot runway it experiences extremely high ambient temperatures for many days during the year. Ambient temperatures are often 90°F (about 32°C) and higher. PHX's adjusted International Standard Atmosphere (ISA) standard temperature is 12.734 degrees centigrade.

Aircraft often begin to experience deterioration in operating performance when temperatures start to exceed 85°F, and many suffer severe restrictions when temperatures reach 90°F to 95°F. The acid test for the A320 family aircraft with respect to high ambient temperatures is to analyse the restrictions in take-off weight and range reductions with standard passenger payload in conditions of 90°F to 100°F.

The restricted take-off weights and range capabilities of A320 family variants are summarised in the table *(this page)*. Conditions used are an ambient temperature of ISA plus 20°C or 25°C on PHX's 11,000 foot runway.

A320 family

Besides operating conditions, the configuration of each variant will have an impact on performance. First, there are the three basic A319, A320 and A321 versions of the aircraft. Second, each model has several gross weight options and each of these has several engine choices with different thrust ratings. Each engine will experience different levels of thrust degradation as temperature rises and so a different level of weight restriction.

High performers

The table clearly shows that all variants in the A320 family experience virtually no performance limitations when ambient temperature rises from 90°F to 100°F. The results also illustrate that there is little or no difference in operating performance between the same model and variant of aircraft powered by two different engines. What should be appreciated is that the payloads used take passenger weight at 200lb, whereas a weight of up to 210lb is used in some circumstances. The range of the aircraft would be less than that shown in the table by a few hundred nautical miles.

The only two variants to suffer a noticeable drop in performance with increased temperature are A320-200 variants powered by the CFM56-5A1 and V.2500-A1. Only the loss of 210nm range capability in the case of the CFM56-powered aircraft and 130nm for the V.2500-powered aircraft is experienced when the temperature increases from 90°F to 100°F.

The range of all three main types is never less than 2,380nm. An airline operating these types from an airfield with an elevation of only a few thousand feet above sea level is hardly affected by high temperatures. It also shows the range advantage the A319 and A320 have over their older generation counterparts. This is because types like the 737-200 and 727-200 have shorter ranges in standard conditions and these are reduced in high ambient temperatures. The MD-80 has shorter range performance than the A320 family, but the MD-80's take-off weight is only restricted by a few thousand pounds at the same high temperatures.

The implications are that the A320 family aircraft will rarely be taken out of consideration in aircraft selection and fleet planning exercises since they can always be relied on to operate a near full passenger payload and so maintain their highest revenue generating potential on a larger number of routes. The unrestricted and superior range advantage of the aircraft over older types also means an airline can be more flexible about the size of aircraft operated on its route network.

Illustrations of how the A320 family is affected by high airport elevations would be to analyse it at airfields such a Katmandu, Mexico City, Denver, and Addis Abbaba. Each of these also experiences different ambient temperatures which vary throughout the year. Denver has cold weather during the winter, but has further performance-limiting high temperatures during the summer. The affects of short runways could be made by analysing the aircraft family at an airport such as Memphis. AC