The 737 MAX-8 entered service in May 2017 with a projected 14% lower fuel burn than its predecessor, the 737-800. Sander der Moor analyses he 737 MAX-8's performance, together with several variants of four other types, on routes of 227nm to 1,821nm.

737 MAX-8 fuel burn & operating performance

Following introduction of the A320neo variants almost three years ago, the 737 MAX-8's entry into service is now well under way, with first deliveries more than a year ago and the global fleet slowly growing. It is time to look at how the 737 MAX-8's fuel burn and operating performance compare to the A320neo's, and the other aircraft types these two models are replacing or competing with, including the A320ceo, 737-800 and the game-changing A220-300 (formerly Bombardier CS300).

Fuel burn & performance

This article features a comparative fuel burn and operating performance analysis on comparable aircraft with various airframe-engine combinations on five routes with tracked airway distances between 227 nautical miles (nm) and 1,821nm *(see tables, pages 26 & 30)*. With the 737 MAX-8 now firmly established in the narrowbody mix, and after the earlier arrival of the A320neo variants, this article follows on from examination of the A321neo's and A320neo's fuel burn and operating performance *(see A321neo fuel burn and operating performance, Aircraft, April/May 2018, page 14)*. This revealed that the A320neo and A321neo have a clear economic advantage over their predecessors. How does the 737 MAX family perform in comparison?

Aircraft types & variants

To allow for an open comparison between the 737 MAX-8 and 737-800 variants, the A320ceo and A320neo several types are included in the comparison. These are two A320ceo variants (-214, -232), two A320neo (-251, -271) variants, three versions of the 737-800, two engine-rating versions of the 737 MAX-8, and the A220-300.

All aircraft types have been examined with a typical two-class cabin layout, reflecting typical mainline configurations. With the exception of the A220-300, all 10 types have a standard six-abreast economy-class configuration. Premium cabins range in configuration by airline. Variations include four-abreast seating as opposed to the standard six-abreast premium seating with more seat pitch. Not selling the centre seats in a six-abreast premium cabin arrangement to provide four window and aisle seats per row provides more elbow room than economy-class seats.

Together with recent cabin redesigns driven by original equipment manufacturers (OEMs), some airlines have adopted new interior layout options that include repositioning the rear toilet(s), smaller and slimmer galleys, and extra seat capacity through use of slimmer seats. Others have simplified the product and cabin service itself, resulting in less space used for the galley(s), and freeing up space for more seats.

This makes it difficult to find a common cabin layout for a fair comparison. The most commonly observed cabin layouts and seat counts were used *(see table, page 24)*. The seat number used influences payloads carried and the number of available seat-miles (ASM) generated on each route.

Cabin configurations used in the comparison are: 145 seats for the A220-300; 153 for the two A320ceo variants; 161 for the two A320neo variants; and 158 for the two 737-800 variants and the two 737 MAX-8 variants.

Many factors play a role in across-the-board comparisons. Different aircraft weights than the ones used in the analysis (due to different aircraft configurations or different fuel policies and planning standards) will result in different operating weights. Performance deviations from book standard, different pilot techniques, and different operating environments will skew the numbers. More detailed analysis with more specific data is necessary if the information in this article generates interest.

737 MAX-8

The 737 MAX is the fourth generation of the 737, succeeding the 737 Next Generation (NG). The 737 MAX aircraft was certified by the US Federal Aviation Administration (FAA) on 8th March 2017. The first MAX-8 delivery was in May 2017. The 737 MAX-9 entered service in March 2018, and the MAX-7 is expected to enter service by January 2019. The MAX-200 is a high-density cabin version of the MAX-8, and will join the fleet in 2019. The last family member, the MAX-10, is scheduled to arrive at airports by 2020.

Compared to the 737NG, the 737 MAX models are equipped with more-efficient CFM LEAP-1B engines, and feature aerodynamic improvements and airframe modifications. These were expected to give the MAX family a fuel burn advantage of 14% over NG models. By now operators are actually reporting 15% better performance. Due to a variety of reasons, the MAX family is

The 737 MAX-8 has proved to have 14-16% lower fuel burn than its younger counterpart the 737-800, but about 1-2% higher than the A320neo.

substantially heavier than the NG family, with the MAX-8 reportedly weighing in at 6,500lbs more operating empty weight (OEW) than the 737-800 it replaces. The baseline aircraft family has a range of 3,300-3,850nm depending on type, load, configuration (auxiliary fuel tanks) and flight planning rules. The range of the MAX-8 variant will be 3,500nm.

Like its predecessor, the MAX series is offered in four lengths: three replacing the 737-700, -800 and -900. The MAX family also has a longer variant called the MAX-10. The four variants typically offer 138-230 seats in a cabin that includes a production-standard Boeing Sky Interior, with overhead bins and LED lighting based on the 787 family. Firm orders for the MAX family are in excess of 4,700 units.

This analysis looks at fuel burn performance of two sub-types of the 737 MAX-8, with different thrust ratings for the installed LEAP-1B engines: the MAX -8-27 has a 27,000lbs thrust rating, while the MAX 8-28 has a thrust rating of 28,000lbs. For both variants, maximum take-off weight (MTOW) is 181,200lbs, maximum landing weight (MLW) is 152,800lbs, and fuel capacity is the standard 6,820 US gallons (USG) *(see table, page 24)*. LEAP-1B engines have a bypass ratio (BPR) of 9.0:1, which is the lowest of the new generation engines analysed here. Cabins for the two MAX-8 variants are the same at 158 seats in a dual-class layout.

A320 neo

The two A320neos included in this analysis are the A320-251 and A320-271. They have an MTOW of 174,165lbs *(see table, page 24)*. To date 11 weight variation options have been certified, and the weight variant used in the analysis (WV055) has the highest MTOW of 174,165lbs, and the highest MLW of 148,591lbs. The A320neo's OEW is about 2,650lbs more than the A320ceo.

A320neo variants used in this analysis are equipped with two engine options: the A320-271 powered by the Pratt & Whitney PW1127G, rated at 27,075lbs thrust; and A320-251 powered by the CFM LEAP-1A26, rated at 26,596lbs thrust *(see table, page 24)*. The two engines have bypass ratios of 12.5:1 and 11.0:1. The PW1127G has an intake fan diameter of 81 inches, versus the LEAP-1A's fan diameter of 78 inches.

Both engines have wide fan diameters, and, therefore, a high propulsive efficiency, which is evident in the 11%-15% lower sector trip burns and 13%-17% more efficient burn per ASM compared to the A320ceo counterparts.

The PW1127G-powered A320-271 persistently has a lower fuel burn than the CFM LEAP-1A26-powered A320-251 on all five routes *(see table, page 24)*. This is unsurprising, given the higher bypass ratio of the PW1127G engine over the LEAP-1A engine.

The A320neo's fuel capacity, high gross weight (HGW) and fuel-efficient engines give its variants a range of about 3,200nm with a full payload of 161 passengers.

737-800

The 737-800 is a well-known workhorse in aviation. As the most popular of the four NG models, there are more than 4,800 737-800s in service around the world, making it the most widely-used narrowbody.

Three 158-seat 737-800 variants are included in this analysis, two with a medium MTOW of 155,500lbs (70.5 tonnes) and an MLW of 144,000lbs (65.3 tonnes); one equipped with winglets (737-800W) from Aviation Partners Boeing (APB) and one without those winglets, and powered by the CFM56-7B24 *(see table, page 24)*.

The heavier HGW variant has an MTOW of 174,200lbs (79.0 tonnes), an MLW of 146,300lbs (66.4 tonnes), is powered by CFM56-7B26 engines, and is also equipped with winglets. This is the 737-800W HGW *(see table, page 24)*.

All three variants have a standard fuel capacity of 6,875 USG. The engines have a bypass ratio of 5.1:1 (-7B26) and 5.3:1 (-7B24), which are the lowest of all engines for the 10 aircraft types analysed. Range for these aircraft is 1,850-2,500nm depending on type, configuration, load and planning rules.

APB winglets difference

While gathering flight plan data for this analysis, a clear opportunity arose to compare two identical aircraft in this set: two same-weight 737-800s, one of which is fitted with the APB winglets, on the five sectors as previously discussed. The resulting flight planning numbers show an expected in-flight burn difference of 4.00-4.17% (up to 1,000lbs) on the longest sectors, with even a 1.08% fuel burn reduction (60lbs) on the shortest, 250nm sector. These numbers are significant. Assuming a daily mix of these five routes in a day-to-day schedule, running an average of 10 flight hours

AIRCRAFT SPECIFICATIONS & WEIGHTS

Aircraft type	A220-300	A320-214	A320-232	A320-251	A320-271	737-800	737-800W	737-800W HGW	737-MAX8 LEAP-27	737-MAX8 LEAP-28
Engine	PW1521G	CFM56-5B4/P	IAE V2527-A5	CFM LEAP-1A26	PW1127G	CFM56-7B24	CFM56-7B24	CFM56-7B26	CFM LEAP-1B27	CFM LEAP-1B28
Engine bypass ratio	12.1	5.7	4.8	11.0	12.5	5.3	5.3	5.1	9.0	9.0
MTXW - lbs	150,000	170,638	170,638	175,045	175,045	156,000	156,000	174,900	181,700	181,700
MTOW - lbs	149,000	169,756	169,756	174,163	174,163	155,500	155,500	174,200	181,200	181,200
MLW - lbs	129,500	145,505	145,505	148,590	148,590	144,000	144,000	146,300	152,800	152,800
MZFW - lbs	123,000	137,789	137,789	141,756	141,756	136,000	136,000	138,300	145,400	145,400
OEW/DOW - lbs	86,180	96,200	95,951	97,922	97,550	95,000	95,000	95,000	99,360	99,360
Max payload - lbs	38,656	42,496	42,496	42,145	42,145	45,900	45,900	45,900	45,532	45,532
Fuel capacity - USG	5,790	6,365	6,365	6,313	6,313	6,875	6,875	6,875	6,820	6,820
Dual-class seat	145	153	153	161	161	158	158	158	158	158
Passenger payload - lbs	33,495	35,343	35,343	37,191	37,919	36,498	36,498	36,498	36,498	36,498
Remaining cargo payload - lbs	3,325	6,246	6,495	6,643	7,015	4,502	4,502	6,802	9,542	9,542
Range with full passenger payload - nm	2,350	2,800	2,900	3,150	3,200	1,800	1,900	2,500	3,400	3,400
MTOW/seat - lbs	1,028	1,110	1,110	1,082	1,082	984	984	1,103	1,147	1,147
OEW/DOW/seat - lbs	594	629	627	608	606	601	601	601	601	629

(FH) per day, the average fuel burn difference can rise to 2,000lbs or an additional cost of $650 at current fuel prices. That equates to $237,000 per year for the life of the aircraft. This should be considered by every airline operating older-generation aircraft without winglets, that can be modified and have a remaining life to make it financially worthwhile.

A320 ceo

The two A320ceo versions analysed have an MTOW of 169,756lbs (77 tonnes), an MLW of 145,505lbs (66 tonnes) and a fuel capacity of 6,303 USG *(see table, page this page)*. These weight variants are one of 20 different available weight specifications. The lowest MTOW for the A320ceo is 145,505lbs (66 tonnes), and the highest certified MTOW is 171,961lbs (78 tonnes).

The variants analysed are the A320-232 powered by International Aero Engines V2527-A5, rated at 24,800lbs; and the A320-214 powered by CFM International CFM56-5B4/P, rated at 27,000lbs.

The V2725-A5 has a bypass ratio of 4.8:1, while the CFM56-5B4/P has a bypass ratio of 5.7:1. The fuel capacity of 6,303 USG gives the A320-200ceo a range of 2,800-2,900nm with a full payload of 153 passengers.

A220-300

The new A220-300 is the smallest aircraft type examined here, and is also relatively new in the narrowbody market. The type, the largest of the two A220 variants, entered service with launch customer Air Baltic less than two years ago. Depending on cabin configuration, it typically seats 130-160 passengers at full load.

Airlines operating the aircraft in a dual-class layout are Swiss, Korean Air and Air Baltic. Their cabin configurations vary from 127 to 145 seats, while using a single seat type for both cabins. Korean Air's cabin comprises five premium economy rows at 36-inch pitch, and 20½ rows of 31-inch pitch economy seats together with ample space for galleys and toilets.

In contrast, Swiss operates a business class with six rows spaced at 34 inches, with 12 seats closed off, leaving only 18 saleable. It also has 23 rows of 31-inch economy-class seats. The aircraft operates an 18/115 (133) configuration. Air Baltic has configured its aircraft with 145 seats.

For this article, the dual-class seat count is set at 145 because it is expected that future operators may choose to go for a lower seat pitch than the 31 inches of the two mentioned examples, together with smaller premium cabins.

The aircraft is exclusively powered by the PW1500G engine, a variant of the new-generation, ultra-high bypass geared turbofan PW1000G engine family produced by Pratt & Whitney (PW). Two thrust ratings are available, 21,970 lbs take-off/20,760lbs maximum continuous as delivered by the PW1521G, and 24,400/23,050lbs respectively from the PW1524G. These engines have a bypass ratio of 12.0:1 *(see table, this page)*.

Another important feature of this clean sheet design aircraft is the all-new maintenance programme which should give it a maintenance cost advantage over older aircraft types. Range for the baseline aircraft is around 2,350nm with a full passenger load.

How we compared

This group of 10 aircraft was compared on the basis of absolute fuel burn and fuel burn per ASM on five routes covering 250-2,000nm. These routes have been used in previous analyses *(see A321neo fuel burn & operating performance, Aircraft Commerce, April/May 2018, page 14)*.

The chosen routes are typical daily fare for this group of aircraft and are five European sectors that aircraft of this size may typically operate. Amsterdam was the origin for all flights, with the following destinations: London Heathrow (LHR), United Kingdom; Dublin (DUB), Ireland; Rome Fiumicino (FCO), Italy; Faro (FAO), Portugal; and Tenerife (TFS) in the Spanish Canary Islands. These routes have tracked airway distances of 227nm up to 1,821nm *(see table, page 26)*, which, combined with route-specific wind components, turn into equivalent still-air distance (ESAD) of 250-2,008nm.

Using this fundamental metric of passenger-carrying capacity provides a good indication of operational efficiency.

ASMs are calculated by multiplying the number of available seats with the

ROUTE CHARACTERISTICS

Route	AMS-LHR	AMS-DUB	AMS-FCO	AMS-FAO	AMS-TFS
Flight time - mins	41-44	72-75	109-111	172-175	274-276
Taxi out time - mins	15	15	15	15	15
Taxi in time - mins	15	15	15	15	15
Block time - mins	71-74	97-100	144-146	199-202	299-301
Tracked distance - nm	227	435	732	1,131	1,821
Wind component - kts	-33 to -31	-43 to -39	-14 to -14	-37 to -35	-41 to -39
ESAD - nm	250-252	484-488	756-757	1,232-1,240	1,998-2,008
Alternate airport & distance - nm	LGW/150	BFS/101	CIA/43	LIS/160	LPA/85

actual flown distance, the ESAD. It is important to understand that ASMs are calculated on actual available seats. If some passenger seats are unavailable for sale due to regulatory, performance or technical reasons (even seats dedicated for crew rest), such seats must not be included in the ASM metrics of affected flights. This was the case on a few flights on the longest sector of this analysis.

Performance of the aircraft was examined using OEW and zero fuel weight (ZFW) on the basis of operating a typical two-class, full-service operation.

The aircraft were planned to operate with a full payload of passengers, with an allowance of 231lbs per passenger and associated baggage. This resulted in relatively high passenger-related payloads for each type *(see table, this page)*. These are higher than most scheduled airline operations are likely to experience (cargo excluded).

Fuel and operational performance numbers for the 10 aircraft variants were generated by Lufthansa Systems, using its Lido/Flight flightplanning system. All 50 flight plans were produced based on the same assumptions and inputs (baseline: EASA IFR with alternate, 5% contingency fuel, fixed-Mach cruise, fixed routes, 0% performance degradation, 85% average winds for June, all-engine taxi, and normal standard operating procedures).

Lido/Flight optimises climb, cruise and descent segments of a flight, based on performance specifications of the particular airframe-engine combinations as received from the OEMs. It also uses specific operating philosophies (flight level caps, performance degradation factors, amended performance buffers in planning, padding) as requested by customers. If not creating an optimised route itself, once a route has been decided, Lido/Flight will plan an optimal vertical profile based on parameters applicable to the aircraft and its operator, achieving lowest overall total cost for the planned flight by balancing fuel, time-related, and airspace access costs.

The flight level (FL) on the shortest route, AMS-LHR, was capped at FL260 to allow for a minimum level cruise segment. This reflects normal airline practice, whereas on other city-pairs Lido/Flight was free to select optimum flight levels for the cruise segments.

Climb and descent profiles differed per aircraft type, with the A220-300 being the slowest in climb and the two A320neos the fastest. Cruise speeds for all aircraft types and variants on all routes were set at a representative fixed-Mach number of Mach 0.78. More operators are moving away from fixed-Mach cruise modes, such as a specific Mach number or long-range cruise (LRC) in favour of cost index (CI) flying. This is a more cost-conscious and economic way of managing operational costs. Since CI flying relies heavily on operators' internal cost structures and fuel prices, however, no two operators plan and operate flights using the same CI. This means that a flight-for-flight comparison would not be possible. For this reason, a fixed-Mach speed was selected that would satisfy all 10 aircraft variants.

Last, to create the same atmosphere for all aircraft types, statistical average winds and temperatures were used.

For the comparison, European Aviation Safety Agency (EASA) standards and rules, have been applied conservatively, with an alternate destination airport (under certain conditions, EASA allows for planning without an alternate as well).

Contingency fuel was set at 5% of trip fuel (with a minimum amount to be able to hold for five minutes over the destination), taking the conservative approach as opposed to the more economic 3%+ en-route alternate (ERA) option where a suitable ERA is planned for. Final reserve fuel was the normal amount required to hold for 30 minutes at 1,500 feet above ground level (AGL) over the alternate airport at planned gross weight.

Operationally, it was assumed that, again conservatively, all engines would be used for both taxi-out and taxi-in. Taxi times from departure point and at the five destinations were taken from the Lido database, adding 500-1,200lbs of fuel per trip in auxiliary power unit (APU) burn and taxi fuel burns, depending on aircraft type, season and city-pair operated.

Routes

The main operational factors and characteristics of the five routes are summarised *(see table, this page)*: flight times, taxi times, resulting block times, and information on used distances, wind components and alternate airports.

Aircraft performance

The flight plans generated for the 10 aircraft variants on the five routes are for maximum passenger payloads. All seats are filled where possible and capped by payload where necessary. The resulting performance metrics (flight times, block times, fuel burn, ASMs) for each aircraft on each of the five routes have been summarised *(see table, this page)*. Various per-ASM metrics were calculated and form part of the same results.

The ESADs for each aircraft variant on each of the five routes are listed (*see table, this page)*. While the tracked distance is the same for each variant on the same route, there is a small difference in the ESAD between aircraft variants, because flight profiles differ in horizontal and vertical speeds between aircraft types so that the different wind components at different altitudes have different overall effects over the length of the route. The ESAD on AMS-LHR, for example, varies from 250nm to 252nm. This is not a dramatic difference by itself, but over longer distances this effect becomes noticeable. The ESAD spread on AMS-TFS is 1,998nm to 2,008nm *(see table, this page)*.

Relative fuel burn

Fuel burns are listed in absolute terms in USG, and in burn per ASM. Because aircraft have been analysed with full passenger payloads, the more important comparison is relative difference in burn per ASM between the most fuel-efficient type and the nine other aircraft.

Relative fuel cost

Crude oil prices are creeping to $100 per barrel, with just over $90 per barrel equal to Jet A-1 prices of 215 US cents per USG in mid-September 2018. This not only puts pressure on airlines in controlling operating costs, but exacerbates relative cost differences between aircraft types as well. The lowest fuel cost per ASM performance seen in our comparison is the 161-seat A320-271neo on the (longest) AMS-TFS sector at 2.19 cents per ASM. The spread on all five routes is 2.19-3.31 cents *(see table, page 30)*. The highest fuel cost per ASM is with the 153-seat A320-214 at 4.59 cents per ASM, and a spread of 3.80-4.59 cents per ASM across the five routes *(see table, page 30)*.

Longer airport-pairs produce lower fuel burn and cost per ASM than shorter routes, because average fuel burn per flight hour decreases with longer route length, and the number of ASMs increases fast with longer mission length.

Relative operational cost

The three major operational cost items for a flight are fuel burn, overflight costs ('airspace access costs'), and the time-dependent costs related to the aircraft, crew and maintenance. These costs form a significant burden on the operation, almost doubling the per ASM cost compared to fuel cost alone.

The lowest total cost per ASM performance seen in our comparison is again the 161-seat A320-271neo on the (longest) AMS-TFS sector at 4.25 cents per ASM, and a spread of 4.25-5.85 cents per ASM for the five routes. The highest total cost per ASM is 8.23 cents, and a spread of 7.28-8.23 cents per ASM belongs again to the 153-seat A320-214.

In this, the cost variables of time-dependent costs and overflight costs do not differ much by aircraft type in the same weight category. Overflight costs are usually based on certified MTOW (cost/tonne), and time-dependent costs are not so different as well with similar cockpit and cabin crew complements, and the same maintenance costs related to operating the aircraft.

737 MAX-8 versus MAX-8

The two variants of the 737 MAX-8 examined here are identical aircraft, with the exception of the engines. The LEAP-1B27 and LEAP-1B28 (maximum continuous thrust of 27,270lbs and 28,690lbs respectively) show almost equal operating performance and fuel burn results, as may be expected. The 420lbs difference in rated maximum continuous thrust does show in slightly higher trip fuel burns, which run from 0.08% on the longest, 2,000nm sector to 0.38% on the shortest, 250nm sector. In absolute terms, the delta varies from 3lbs to 18lbs of fuel on the examined flights, with the lowest delta on the second, 500nm route.

737 MAX-8 versus A320neo

Probably the biggest question is how do the two upgraded narrowbody mainstays, the 737 MAX-8 or A320neo, compare? The answer, based on data produced by Lufthansa System's Lido/Flight, is that the two A320neo variants win this comparison, both in absolute fuel burn (block fuel) and burn per ASM; as well as total flight costs per ASM. This is while the A320neo carries more passengers (161 for the A320neo versus 158 for the 737 MAX-8), and it also achieves this with shorter block times.

The A320-251 (the LEAP-powered neo) burns 1.65% more on the 250nm short sector to 0.65% more on the 2,000nm long sector than its stablemate the A320-271 (the PW-powered neo). On the shortest sector (AMS-LHR), the 737 MAX-8 has a slightly lower block fuel (10USG), but a higher burn per ASM in the case of the LEAP-1B27-powered A320neo. The LEAP-1B28-powered variant of the 737 MAX-8 loses on all fronts to both A320neo variants, both in absolute and relative fuel burn comparisons by 1.6-2.4% and 3.4-4.3%.

737 MAX-8 versus 737-800

Of relevance to 737-800 operators is how the 737 MAX variants compare to NG generation counterparts. When launched, Boeing aimed for the MAX to have a 14% reduction in fuel burn compared to the NG. By now, operational experience has shown that the 737 MAX-8 has 15% better fuel economy than the 737-800.

Lido flight plans support this observation, with differences on the first four routes ranging from 14.89% to 15.96% (108USG to 365USG of fuel) when comparing the 27,000lbs engine version of the MAX-8 with the lighter version of the 737-800W. These numbers drop slightly to 14.82-15.55% for the 28,000lbs version of the MAX-8. The comparison cannot be completed for the fifth, longest sector, since the lower-weight 737-800W has a payload issue with a resulting drop in seat count, invalidating the like-for-like comparison.

When comparing the 737 MAX-8 27,000lbs engine versions to the HGW version of the 737-800W, similar fuel burn differences are shown. Predicted fuel burn improvement ranges from 15.00% to 15.96% (108USG to 592USG) on the five routes. Again the 28,000lbs variant of the MAX-8 is slightly less efficient.

737 MAX-8 versus A320ceo

When launched, Boeing aimed for the 737 MAX-8 to feature a 16% lower fuel burn than the then rival A320 product, the A320ceo. This number was later revised down to coincide with 'meeting or exceeding the A320neo performance'.

The Lido flight plans show that the resulting numbers range from 15.19% to 18.58% (102USG to 748USG) when comparing the 27,000lbs version of the MAX-8 with the A320-214 (the CFM56-powered variant).

The picture is better in the case of the more efficient IAE V2527-powered A320-232, where it burns 10.71% to 11.44% (74USG to 394USG) more than the MAX-8, but the A320-232 easily outperforms the 737-800s in this respect. As with the 737-800 comparisons, these numbers drop by a tenth of a percent for the 28,000lbs version of the 737 MAX-8.

MAX-8 versus A220-300

Even though the A220-300 and the MAX-8 are two different aircraft designed for different markets, one cannot help but to draw a comparison between the two aircraft types, if only from an airline boardroom perspective when comparing aircraft to satisfy a 130-145 seat market.

On a fuel cost per seat basis, the numbers show that the A220-300 is about 2.2-2.5% more efficient than the two MAX-8 variants on the shortest sector, AMS-LHR. On all other sectors the MAX-8 variants perform better on a per-seat cost basis, up to 4.58% on the longest sector (AMS-TFS).

On a total cost (fuel+ATC+time) per seat basis the A220-300 stays ahead of the two MAX-8 variants on the first three sectors, by up to 2.96%. The A220-300 then gives way to the MAX-8s on the last two, longer routes where the best MAX-8 scores a 1.17% better cost performance.

New engines, old airframes

One aspect of the comparison involves the new engines which enable significant increases in operational efficiency. The airframes themselves have hardly changed; the MAX is basically the fuselage with the same wing as the NG family, but with a blended winglet added. There is not much improvement in aerodynamic efficiency from the airframe other than reducing parasitic and induced drag, and keeping the airflow laminar for

BLOCK FUEL BURN PERFORMANCE OF A220-300, A320CEO, A320NEO, 737-800 & 737 MAX-8 WITH FULL PAX PAYLOAD

City-pair	Aircraft variant	Engine variant	Seats	Payload carried lbs	ESAD nm	ASMs	Block time min	Block fuel USG	Fuel /ASM
AMS-LHR	A220-300	PW1521G	145	33,495	252	36,540	74	654	0.01789
	A320-214	CFM56-5B4/P	153	35,343	251	38,403	72	830	0.02162
	A320-232	IAE V2527-A5	153	35,343	250	38,250	73	802	0.02096
	A320-251neo	CFM LEAP 1A26	161	37,192	251	40,412	71	738	0.01827
	A320-271neo	PW1127G	161	37,192	251	40,412	72	727	0.01798
	737-800	CFM56-7B24	158	36,499	252	39,816	74	846	0.02124
	737-800W	CFM56-7B24	158	36,499	252	39,817	74	836	0.02100
	737-800W HGW	CFM56-7B26	158	36,499	252	39,816	74	836	0.02101
	737-MAX8-27	CFM LEAP-1B27	158	36,499	252	39,816	74	728	0.01828
	737-MAX8-28	CFM LEAP-1B28	158	36,499	252	39,816	74	731	0.01835
AMS-DUB									
	A220-300	PW1521G	145	33,495	487	70,615	100	952	0.01348
	A320-214	CFM56-5B4/P	153	35,343	488	74,664	99	1,200	0.01607
	A320-232	IAEV2527-A5	153	35,343	484	74,052	99	1,130	0.01526
	A320-251neo	CFM LEAP 1A26	161	37,192	485	78,085	97	1,011	0.01295
	A320-271neo	PW1127G	161	37,192	485	78,085	97	1,000	0.01281
	737-800	CFM56-7B24	158	36,499	486	76,788	99	1,224	0.01594
	737-800W	CFM56-7B24	158	36,499	486	76,788	99	1,189	0.01548
	737-800 HGW	CFM56-7B26	158	36,499	486	76,788	99	1,189	0.01547
	737-MAX8-27	CFM LEAP-1B27	158	36,499	486	76,788	99	1,024	0.01333
	737-MAX8-28	CFM LEAP-1B28	158	36,499	486	76,788	99	1,024	0.01334
AMS-FCO									
	A220-300	PW1521G	145	33,495	757	109,765	146	1,371	0.01249
	A320-214	CFM56-5B4/P	153	35,343	757	115,821	145	1,733	0.01496
	A320-232	IAE V2527-A5	153	35,343	757	115,821	145	1,620	0.01399
	A320-251neo	CFM LEAP 1A26	161	37,192	756	121,719	144	1,448	0.01190
	A320-271neo	PW1127G	161	37,192	756	121,719	144	1,436	0.01179
	737-800	CFM56-7B24	158	36,499	757	119,609	146	1,758	0.01470
	737-800W	CFM56-7B24	158	36,499	757	119,609	146	1,702	0.01423
	737-800W HGW	CFM56-7B26	158	36,499	757	119,609	146	1,706	0.01426
	737-MAX8-27	CFM LEAP-1B27	158	36,499	757	119,609	145	1,469	0.01228
	737-MAX8-28	CFM LEAP-1B28	158	36,499	757	119,609	146	1,471	0.01230
AMS-FAO									
	A220-300	PW1521G	145	33,495	1,240	179,800	202	2,083	0.01159
	A320-214	CFM56-5B4/P	153	35,343	1,238	189,414	200	2,635	0.01391
	A320-232	IAE V2527-A5	153	35,343	1,239	189,567	201	2,428	0.01281
	A320-251neo	CFM LEAP 1A26	161	37,192	1,232	198,357	199	2,151	0.01084
	A320-271neo	PW1127G	161	37,192	1,232	198,357	199	2,135	0.01076
	737-800	CFM56-7B24	158	36,499	1,239	195,767	201	2,660	0.01359
	737-800W	CFM56-7B24	158	36,499	1,239	19,767	201	2,549	0.01302
	737-800W HGW	CFM56-7B26	158	36,499	1,239	195,767	201	2,552	0.01304
	737-MAX8-27	CFM LEAP-1B27	158	36,499	1,239	195,767	201	2,187	0.01117
	737-MAX8-28	CFM LEAP-1B28	158	36,499	1,239	195,767	201	2,189	0.01118
AMS-TFS									
	A220-300	PW1521G	145	33,495	2,000	290,000	301	3,266	0.01126
	A320-214	CFM56-5B4/P	153	35,343	2,008	307,224	299	4,139	0.01347
	A320-232	IAE V2527-A5	153	35,343	2,008	307,224	300	3,785	0.01232
	A320-251neo	CFM LEAP 1A26	161	37,192	1,998	321,687	299	3,338	0.01038
	A320-271neo	PW1127G	161	37,192	1,998	321,687	299	3,316	0.01031
	737-800	CFM56-7B24	127	29,436	2,008	255,877	300	3,989	0.01559
	737-800W	CFM56-7B24	132	30,579	1,999	264,621	301	3,830	0.01447
	737-800W HGW	CFM56-7B26	158	36,499	2,008	317,273	301	3,983	0.01255
	737-MAX8-27	CFM LEAP-1B27	158	36,499	1,999	315,851	300	3,391	0.01074
	737-MAX8-28	CFM LEAP-1B28	158	36,499	1,999	315,851	300	3,394	0.01075

Source: Lufthansa Systems' Lido/Flight

Notes:
1). Lufthansa Systems provided block fuel figures in lbs. These have been converted to USG using 1 USG = 6.55lbs.

longer. The A320 presents a similar story with its younger design.

Changes in aircraft fuel efficiency are largely delivered by the engines. Both the Pratt & Whitney PW1000G family and CFM-International LEAP family are much more efficient and less noisy, and produce lower emissions.

There are two key questions. How do the two new engine families stack up against each other, and how do the LEAP-powered A320neo and 737 MAX compare?

The comparison fleet includes one aircraft type that is fitted with both engine family models, the A320neo. The A320-251 variant is fitted with the CFM LEAP-1A26 engine, and the A320-271 variant is equipped with the PW1100G engine. The different engine core architectures clearly do not point to a winning combination. The comparative test results show that, like-for-like, the PW1127G outperforms the LEAP-1A26 by between 0.65% (long sector, 2,000nm) and 1.65% (short sector, 250nm).

LEAP-1A versus LEAP-1B

This raises the question of how LEAP-powered aircraft compare. The A320neo's LEAP-1A has a bypass ratio of 11.0:1, whereas the 737 MAX-8's LEAP-1B has a bypass ratio of 9.0:1. On paper the -1B would have the higher fuel burn performance due to its lower bypass ratio.

It turns out that the planned take-off weights of the MAX and neo in the flightplans were near to each other, with the MAX being slightly heavier (1,300lbs on the shortest, 250nm sector to 1,700lbs on the longest, 2,000nm sector). All planned take-off weights were equalised for the five sectors, and the revised fuel burns (normalisation factor) were analysed.

It appears that the A320neo-LEAP combination outperforms the 737 MAX-LEAP combination on the medium and longer sectors by 0.5%-1.0% lower fuel burn, whereas the roles reverse on the shorter sectors. The -1B27 on the 737 MAX-8 has a higher thrust rating than the -1A26 engine that powers the A320neo, which may explain the slightly higher sector burns. The LEAP-1A would also be the more efficient engine, which is where airframe aerodynamics come into play. More analysis is clearly required.

Summary

Comparative analysis has shown that the 737 MAX-8 is 1-3% less efficient per ASM than its competitor, the A320neo. This may not be surprising, given the A320neo's higher bypass ratio engines and its three-seat higher capacity. A lot depends on aircraft configuration, both physically (engine rating, weights) and in the cabin (layout, seat count), and on how aircraft are operated in airline-specific environments. The market will choose a certain aircraft type for its operations based on many other factors than simply fuel burn or operational cost. Fleet commonality (airframe, engines), OEM support, operating philosophy, aircraft availability, financial considerations, modification or design plans all drive an aircraft selection.

In the end, in this market for aircraft with 145-200+ seats, both brands field impressive aircraft that get the job done in an efficient and safe manner. Ongoing research and development will no doubt deliver performance improvement packages that will be available both as forward fit and retrofit. AC