The A320neo entered service with a promise of 20% fuel efficiency savings. Nick Preston analyses the extent to which the aircraft has met this target across five typical intra-European routes, ranging from 227nm to 1,821nm in length.

A320neo fuel burn & operating performance

In January 2016 the A320neo (new engine option) became the first of a series of next generation, re-engined narrowbodies to enter commercial service. It will be followed into service by the A319neo and A321neo, as well as Boeing's new 737 MAX family.

Reducing fuel burn has been a major focus for next generation narrowbodies. Airbus claims the A320neo family will provide fuel burn per seat savings of up to 20% by 2020 when compared to similar-size, previous generation aircraft. It also claims the A320neo family will offer additional range, reduced engine noise and lower emissions.

The A320neo's fuel burn and operating performance are analysed here and compared to the A320ceo (current engine option) and 737-800 to determine if Airbus is on track to meet its targeted 20% improvement in fuel burn. The three aircraft types are compared across five typical short- and medium-haul intra-European routes that are between 227 nautical miles (nm) and 1,821nm.

Assumptions

Simulated flight plan data from Lufthansa Systems' Lido/Flight solution was used as the basis for this fuel burn and performance analysis. The results generated by these flight plans and subsequent independent calculations performed by *Aircraft Commerce*, should only be considered within the context of a series of assumptions.

Operational assumptions

The simulated flight plans assume that all the aircraft are operating under international flight rules, with reserve, diversion and contingency fuel requirements based on European Aviation Safety Agency (EASA) standards.

Route tracks, flight levels and cruise speeds are optimised to achieve minimum costs, while complying with airway rules and restrictions. The minimum cost track (MCT) takes account of fuel, navigation and operational time costs to provide an optimum routeing for each aircraft.

Weather assumptions include average temperatures for the month of June with 85% reliability winds.

The block fuel used for each sector is the sum of the trip and taxi fuel burn. It is assumed that each aircraft will taxi with both engines running. The block time is the sum of the trip and taxi times. Realistic taxi-in and taxi-out times are taken from averages for airports in the Lufthansa Systems' Lido/Flight database.

The cost of fuel is taken from Lufthansa Systems' Lido/Flight solution for Amsterdam Schiphol (AMS) airport for December 2016 and is assumed to be $1.23 per US Gallon (USG). From a fuel density perspective this analysis assumes that one USG is equal to 6.55lbs.

The flight plans were designed to show the maximum available payload that can be carried by each aircraft variant on each sector. The maximum payloads for each type were established using certain certified weight assumptions.

Aircraft weights and engines

There are multiple certified weight options available for all the aircraft in this analysis, and multiple engine options for the A320ceo and A320neo.

The combined aircraft weight and engine specifications chosen for this analysis are designed to reflect realistic in-service examples. Both engine families are represented for the A320ceo and A320neo.

This analysis can only offer a rough guide to comparative performance due to the number of potential alternative aircraft weight and engine specification combinations. Higher and lower weight specifications are available for the A320ceo and 737-800. The A320neo specifications used here assume the highest possible maximum take-off weight (MTOW) and maximum zero fuel weight (MZFW) combination currently available for that type. Higher or lower engine thrust ratings or build standards may be available for each variant. Any alterations to weight specifications or engine ratings will influence performance.

The dry operating weights (DOWs), or operating empty weights (OEWs) used in this analysis should only be treated as a rough guide. OEW will vary by individual aircraft; and can be influenced by factors including the cabin configuration, catering and cabin service items, engine variant and crew numbers and associated belongings. The OEWs used here should fall within a realistic in-service range.

It is possible that the OEWs for later-build A320neos will be lower than those used in this analysis. This is because the aircraft is still in the early stages of production and manufacturers typically find ways to reduce OEW as a programme matures. The A320ceos and neos in this analysis are equipped with Sharklets, and the 737-800 is equipped with Blended Winglets.

The first A320neo entered service with Lufthansa in January 2016. Airbus claims the aircraft will provide fuel burn per seat savings of up to 20%, by 2020, compared to similar-size, previous generation aircraft.

Aircraft capacity

The analysis takes raw flight plan data provided by Lufthansa Systems' Lido/Flight and extrapolates it further to provide a guide to each aircraft variant's potential fuel costs per available seat mile (ASM). The potential payload remaining for hold baggage and/or cargo is also identified.

To generate these figures *Aircraft Commerce* made its own independent assumptions regarding aircraft capacity.

Narrowbodies are usually configured in dual- or single-class arrangements. Full-service carriers often prefer a dual-class configuration consisting of a small first or business-class section at the front of the cabin, with the main economy section behind a curtain or divider. The typical economy layout in A320 and 737 family aircraft is based on six-abreast seating. Some full-service airlines configure their A320 or 737 family variants with four-abreast seating in the first- or business-class section. Others maintain the six-abreast layout throughout the cabin, but block the middle seat in the business class section to provide more space. Some full-service airlines might have separate sub-fleets of A320 or 737 family variants configured with different capacities depending on the routes and markets they serve.

Most low-cost carriers (LCCs) configure their A320 and 737 family aircraft in high-density, single-class, all-economy arrangements. They generally configure the whole fleet with the same capacity, unless they are transferring between old and new interior arrangements.

The average capacities of the in-service A320ceo, 737-800 and A320neo fleets are 165, 171 and 179 seats. The A320neo's higher capacity is because a new interior allows it to be configured with more seats. This interior configuration can be used for the A320ceo, but few aircraft have been fitted.

The A320neo's higher capacity should be treated with some caution due to the small sample size, but the averages indicate a trend for 737-800s to be configured with slightly more seats than A320ceos.

This analysis considers the potential performance of the A320neo, A320ceo and 737-800 when configured with typical full-service and LCC seat capacities. The same weight specifications are used for both cabin configurations analysed, including the same OEW for each aircraft variant. In reality, the OEW would differ between full-service and LCC configurations, but in the case of these narrowbody types the potential variation is not significant enough to have a detrimental impact on the performance comparison.

It should be noted that for reasons of commercial sensitivity it was not possible to identify the precise cabin configurations or capacities that account for the OEWs used in the simulated flight plans. Although the OEWs used in this analysis should fall within a realistic operational range, the actual capacities used might result in different OEWs that could have an impact on performance figures. The resulting available seat-miles (ASMs) generated, and consequently fuel burn and cost per ASM calculations, should only be considered within this context.

It is difficult to determine a typical dual-class capacity for A320 and 737 family aircraft due to the variation among operators. It was decided in this analysis to use realistic in-service examples from European full-service carriers. The A320ceo variants therefore have an assumed capacity of 168 seats based on Lufthansa's layout, while the 737-800 has an assumed capacity of 176 seats based on KLM's cabin arrangement. The difference between the assumed A320ceo and 737-800 capacities roughly follows the average fleet capacity trend. The A320neos have an assumed dual-class capacity of 180 seats, based on Lufthansa's cabin design.

Typical LCC capacities are easier to identify. Some of the most common arrangements have seen A320ceos and 737-800s configured with 180 and 189 seats. There are still relatively few A320neos in operation, but early indications suggest the most popular LCC configuration is an all-economy 186-seat arrangement.

An increase in the certified exit limit and the introduction of Airbus's new, more efficient rear galley and lavatory design, known as Space-Flex, means that A320ceos and neos can be configured with more than 180 seats. easyJet has confirmed its intention to retrofit its existing A320ceo fleet with the same 186-seat configuration that it plans to use on the A320neos it has on order.

Relatively few A320ceos are configured with the new Space-Flex layouts. Those that are will perform better against the 737-800 and A320neo in terms of costs per ASM, as a result of generating more ASMs due to their additional seats. It was decided to use the

AIRCRAFT SPECIFICATIONS & WEIGHTS USED IN FUEL BURN SIMULATIONS

Aircraft	A320-271neo	A320-251neo	A320-214	A320-232	737-800
Engine	PW1127G	CFM LEAP-1A26	CFM56-5B4/P	V2527-A5	CFM56-7B26
MTXW-lbs	175,047	175,047	170,638	170,638	173,000
MTOW-lbs	174,165	174,165	169,756	169,756	172,500
MLW-lbs	148,592	148,592	145,505	145,505	144,000
MZFW-lbs	141,757	141,757	137,789	137,789	136,000
OEW-lbs	95,901	95,901	93,256	93,256	93,796
Max payload-lbs	45,856	45,856	44,533	44,533	42,204
Fuel capacity-USG	6,303	6,303	6,506	6,506	6,875
Fuselage length	123 ft 3-inches	123 ft3-inches	123 ft3-inches	123 ft3-inches	124 ft 9-inches
Cabin width	12ft 10-inches	12ft 10-inches	12ft 10-inches	12ft 10-inches	12ft 4-inches
Dual-class seating	180	180	168	168	176
Single-class seating	186	186	180	180	189

Note: Fuel capacity figures are converted from lbs using 1 USG = 6.55lbs.

lower assumed capacities for the A320ceo variants in this analysis, because they are more representative of the majority of the current in-service fleet.

Baggage and cargo

The analysis also attempts to demonstrate the payload remaining for hold luggage and/or cargo once the weight of the passengers and their hand luggage has been accounted for. This is calculated by removing the assumed weight of passengers and their hand luggage from the maximum available payload. The resulting available payload does not account for the weight of any lower deck unit load devices (ULDs). The tare weights of these ULDs would have to be subtracted to determine the net payload remaining for luggage and cargo. This will only apply to the A320ceo and A320neo, since these aircraft can hold up to seven LD3-45 ULDs in their lower holds. In contrast the 737-800 can only be bulk loaded.

In this analysis it is assumed that the average weight of a passenger, including hand luggage, is 194lbs, and that the average hold bag weighs 37lbs. This can be used to identify how many hold bags an aircraft could accommodate as well as its passenger and hand luggage payload.

Aircraft

The exact specifications used for each aircraft in this analysis are summarised here *(see table, this page)*. Each aircraft variant is analysed in typical dual-class, full-service and single-class LCC configurations.

The A320neo is analysed with both engine family options. In this case one variant is equipped with Pratt and Whitney PW1127G engines, and the other with CFM LEAP-1A26 powerplants. These are the A320-271neo and A320-251neo *(see table, this page)*.

It is assumed that both variants would have a dual-class, full-service capacity of 180 seats and an LCC capacity of 186.

Both A320neo variants are assumed to have an MTOW of 174,165lbs, an OEW of 95,901lbs and a maximum structural payload of 45,856lbs. In reality the OEW would vary between engine type and cabin configuration, but the examples used here should be within a realistic range *(see table, this page)*.

The A320ceo is also analysed with both available engine families. One variant is powered by CFM56-5B4/P engines, while the other is equipped with IAE V2527-A5 powerplants. These are the A320-214 and the A320-232 *(see table, this page)*.

The assumed capacity is 168 seats in a dual-class, full-service arrangement and 180 seats in a single-class LCC configuration. The two A320ceo variants have an MTOW of 170,638lbs, an OEW of 93,256lbs, and a maximum structural payload of 44,533lbs.

There is only one engine family option for the 737-800. In this case it is assumed that the aircraft is equipped with the CFM56-7B26 variant *(see table, this page)*. The assumed capacity for the 737-800 is 176 seats in a typical full-service layout, and 189 in an LCC configuration.

In this analysis the 737-800 has an MTOW of 172,500lbs, an OEW of 93,796lbs and a maximum structural payload of 42,204lbs.

The A320ceo and A320neo have the same fuselage dimensions with a length of 123 feet and three inches (123ft 3-inches) and a cabin width of 12ft 10-inches. The difference in assumed capacities between the two generations in this analysis is purely due to advancements in exit limits and interior configurations. It has already been noted that these changes can also be applied to A320ceos.

The cabin of the A320ceo and A320neo is about six inches wider than the 737-800. Although this allows wider seats, it does not permit the Airbus aircraft to accommodate extra seats abreast. The 737-800 is about one and a half feet longer than the A320ceo and A320neo. This, along with basic cabin design, may explain why the average capacity of 737-800s has typically been higher than that of the A320ceo.

Routes

Five short- to medium-haul intra-European routes were chosen for the analysis. All five sectors depart from AMS and the destination airports are London Heathrow (LHR), Dublin (DUB), Rome Fiumicino (FCO), Faro (FAO) in Portugal, and Tenerife (TFS) in the Canary Islands.

These airport-pairs were chosen since they reflect the broad range of route types and sector lengths that A320 and 737 family aircraft are expected to serve, from short-haul, business-focused markets to longer-distance, leisure-orientated flights.

The sector length for each airport-pair is stated in terms of the tracked distance and equivalent still air distance (ESAD).

The tracked distance is determined by airway rules and restrictions. It can vary slightly by aircraft type, depending on individual climb, cruise and descent profiles. The ESAD is based on the tracked distance, but also takes into account the influence of en-route winds, which can lengthen or shorten the effective distance flown. If an aircraft experiences a tailwind the ESAD will be shorter than the tracked distance, but if it experiences a headwind the ESAD will be longer. The ESAD considers an aircraft's airspeed rather than its ground speed throughout a flight. The ASM figures generated in this analysis are based on the ESAD rather than the tracked distance for each sector.

BLOCK FUEL BURN PERFORMANCE OF A320NEO, A320CEO & 737-800

City-pair	Aircraft variant	Engine variant	PLNTOW (lbs)	PLNLW (lbs)	PLNZFW (lbs)	Available payload (lbs)	ESAD (nm)	Block time (hr:min)	Block fuel (USG)
AMS-LHR	A320-271neo	PW1127G	149,273	145,518	141,757	45,856	245	01:16	645
	A320-251neo	CFM LEAP-1A26	149,523	145,680	141,757	45,856	245	01:16	658
	A320-214	CFM56-5B4/P	146,867	142,497	137,789	44,533	245	01:17	738
	737-800	CFM56-7B26	145,428	140,977	136,000	42,204	246	01:19	751
	A320-232	V2527-A5	146,498	142,244	137,789	44,533	246	01:18	807
AMS-DUB	A320-271neo	PW1127G	151,844	145,960	141,757	45,856	472	01:36	949
	A320-251neo	CFM LEAP-1A26	152,094	146,128	141,757	45,856	472	01:36	962
	A320-214	CFM56-5B4/P	149,778	142,849	137,789	44,533	472	01:37	1,109
	737-800	CFM56-7B26	148,389	141,313	136,000	42,204	473	01:39	1,131
	A320-232	V2527-A5	149,501	142,750	137,789	44,533	473	01:38	1,143
AMS-FCO	A320-271neo	PW1127G	153,799	145,178	141,757	45,856	728	02:20	1,387
	A320-251neo	CFM LEAP-1A26	154,014	145,314	141,757	45,586	728	02:20	1,400
	A320-214	CFM56-5B4/P	151,982	141,907	137,789	44,533	728	02:21	1,609
	737-800	CFM56-7B26	150,547	140,357	136,000	42,204	728	02:22	1,627
	A320-232	V2527-A5	151,622	141,822	137,789	44,533	728	02:22	1,653
AMS-FAO	A320-271neo	PW1127G	160,352	147,143	141,757	45,856	1,186	03:13	2,072
	A320-251neo	CFM LEAP-1A26	160,644	147,298	141,757	45,856	1,186	03:14	2,093
	A320-232	V2527-A5	159,163	144,055	137,789	44,533	1,186	03:15	2,428
	A320-214	CFM56-5B4/P	159,765	144,201	137,789	44,533	1,186	03:14	2,431
	737-800	CFM56-7B26	158,338	142,632	136,000	42,204	1,186	03:15	2,453
AMS-TFS	A320-271neo	PW1127G	167,511	146,455	141,757	45,856	1,932	04:50	3,265
	A320-251neo	CFM LEAP-1A26	167,857	146,619	141,757	45,856	1,932	04:50	3,293
	A320-232	V2527-A5	167,430	143,308	137,789	44,533	1,932	04:50	3,795
	A320-214	CFM56-5B4/P	168,292	143,433	137,789	44,533	1,933	04:50	3,846
	737-800	CFM56-7B26	166,881	141,897	136,000	42,204	1,933	04:51	3,865

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.

The shortest sector is AMS-LHR, on which all of the aircraft operate a tracked distance of 227nm. All five variants experience a headwind, with an average wind component of 25 knots (kts). The ESAD ranges from 245nm for the two A320neo variants and the CFM-powered A320ceo, to 246nm for the 737-800 and IAE-powered A320ceo. The total taxi time is 35 minutes, allowing 15 minutes for taxi-out and 20 minutes for taxi-in. The alternate airport is London Gatwick (LGW).

The tracked distance on AMS-DUB is 437nm for all five aircraft. Each aircraft experiences an average headwind component of 29kts on this sector. The ESAD ranges from 472nm for the two A320neo variants and the CFM-powered A320ceo, to 473nm for the 737-800 and IAE-powered A320ceo. The total taxi time is 25 minutes, with 15 minutes allowed for taxi-out and 10 minutes for taxi-in. The alternate airport is Belfast International (BFS).

On AMS-FCO each aircraft operates a tracked distance of 732nm. All five aircraft experience a 2kts tailwind component and an ESAD of 728nm. The total taxi time is 35 minutes, with 15 minutes allowed for taxi-out and 20 for taxi-in. The alternate airport is Rome Ciampino (CIA).

On AMS-FAO each aircraft operates a tracked distance of 1,131nm. All five variants experience a headwind with an average wind component of 19kts. This results in an ESAD of 1,186nm for all five aircraft. The total taxi time is 27 minutes accounting for 15 minutes' taxi-out at AMS and 12 minutes' taxi-in at FAO. The alternate airport is Lisbon (LIS).

The longest sector in this analysis is AMS-TFS. The tracked distance on this airport-pair is 1,821nm for all five aircraft. A headwind component of 25kts was experienced by each variant. This results in ESADs of 1,932nm for the two A320neo variants and the IAE-powered A320ceo, and 1,933nm for the 737-800 and CFM-powered A320ceo. The total taxi time is 25 minutes, assuming a taxi-out time of 15 minutes at AMS and a taxi-in time of 10 minutes at TFS.

Performance

The following analysis is split into three sections. The first summarises the block fuel and block time performance figures taken directly from the simulated flight plans. The following two sections apply independent *Aircraft Commerce* capacity assumptions to the raw flight plan data to examine the potential fuel costs per ASM in typical full-service and LCC configurations. It should be noted that different capacity assumptions will influence the cost per ASM result.

Block fuel and block times

The two A320neo variants burn the least block fuel across each of the five routes *(see table, this page)*. The IAE-powered A320ceo burns the most block fuel on the three shortest sectors, but its comparative efficiency improves as route length increases and it begins to burn less fuel than the CFM-equipped A320ceo and 737-800. The 737-800 burns the most block fuel on the longest sectors from AMS-FAO and AMS-TFS.

The PW-powered A320neo burns marginally less block fuel than the variant with CFM LEAP engines on all five sectors. It uses 2% less block fuel on AMS-LHR, and 1% less on the other four routes.

In terms of differences in absolute

FUEL BURN PERFORMANCE IN FULL-SERVICE CONFIGURATION

City-pair	Aircraft variant	Engine variant	Available payload lbs	Pax capacity	Hold bags per pax	Cargo (lbs) 1 hold bag per pax	ASMs	Fuel burn USG per ASM	Fuel cost per ASM (cents)
AMS-LHR	A320-271neo	PW1127G	45,856	180	1.6	4,276	44,100	0.0146	1.80
	A320-251neo	CFM LEAP-1A26	45,856	180	1.6	4,276	44,100	0.0149	1.84
	737-800	CFM56-7B26	42,204	176	1.2	1,548	43,296	0.0173	2.13
	A320-214	CFM56-5B4/P	44,533	168	1.9	5,725	41,160	0.0179	2.21
	A320-232	V2527-A5	44,533	168	1.9	5,725	41,328	0.0195	2.40
AMS-DUB	A320-271neo	PW1127G	45,856	180	1.6	4,276	84,960	0.0112	1.37
	A320-251neo	CFM LEAP-1A26	45,856	180	1.6	4,276	84,960	0.0113	1.39
	737-800	CFM56-7B26	42,204	176	1.2	1,548	83,248	0.0136	1.67
	A320-214	CFM56-5B4/P	44,533	168	1.9	5,725	79,296	0.0140	1.72
	A320-232	V2527-A5	44,533	168	1.9	5,725	79,464	0.0144	1.77
AMS-FCO	A320-271neo	PW1127G	45,856	180	1.6	4,276	131,040	0.0106	1.30
	A320-251neo	CFM LEAP-1A26	45,856	180	1.6	4,276	131,040	0.0107	1.31
	737-800	CFM56-7B26	42,204	176	1.2	1,548	128,128	0.0127	1.56
	A320-214	CFM56-5B4/P	44,533	168	1.9	5,725	122,304	0.0132	1.62
	A320-232	V2527-A5	44,533	168	1.9	5,725	122,304	0.0135	1.66
AMS-FAO	A320-271neo	PW1127G	45,856	180	1.6	4,276	213,480	0.0097	1.19
	A320-251neo	CFM LEAP-1A26	45,856	180	1.6	4,276	213,480	0.0098	1.21
	737-800	CFM56-7B26	42,204	176	1.2	1,548	208,736	0.0118	1.45
	A320-232	V2527-A5	44,533	168	1.9	5,725	199,248	0.0122	1.50
	A320-214	CFM56-5B4/P	44,533	168	1.9	5,725	199,248	0.0122	1.50
AMS-TFS	A320-271neo	PW1127G	45,856	180	1.6	4,276	347,760	0.0094	1.15
	A320-251neo	CFM LEAP-1A26	45,856	180	1.6	4,276	347,760	0.0095	1.16
	737-800	CFM56-7B26	42,204	176	1.2	1,548	340,208	0.0114	1.40
	A320-232	V2527-A5	44,533	168	1.9	5,725	324,576	0.0117	1.44
	A320-214	CFM56-5B4/P	44,533	168	1.9	5,725	324,744	0.0118	1.46

Notes:
1). Hold bags per pax limit assumes all remaining payload used for hold bags once pax/hand luggage are accounted for.
2). Cargo payload based on remaining payload after pax, hand luggage and hold luggage accounted for. Assumes one hold bag per pax.

block fuel between types, the PW-powered A320neo burns less fuel than any other variant analysed. It burns 13-15% less block fuel than the CFM56-powered A320ceo, 14-16% less than the 737-800, and 14-20% less than the IAE-powered A320ceo *(see table, page 21)*.

The CFM LEAP-powered A320neo burns 11-14% less block than the CFM56-equipped A320ceo, 12-15% less than the 737-800, and 13-18% less than the IAE-powered A320ceo. Overall, the A320neo has up to 20% lower trip fuel burn than the A320ceo *(see table, page 21)*.

The two A320neo variants have a modest increase in the scale of their block fuel burn advantage over the CFM-powered A320ceo, as sector length increases. The opposite trend occurs when the A320neos are compared to the IAE-equipped A320ceo with the fuel burn advantage decreasing as route length increases.

The CFM56-powered A320ceo burns 1-2% less block fuel than the 737-800 on the four shortest sectors. The two aircraft burn about the same quantity of fuel on AMS-TFS. The CFM56-equipped A320ceo also burns 3-8% less block fuel than the IAE-powered A320ceo on the three shortest routes. The two A320ceos burn similar fuel quantities on AMS-FAO, but the aircraft with IAE engines has a 1% fuel burn advantage on AMS-TFS. The 737-800 burns 2-7% less block fuel than the IAE-equipped A320ceo on the three shortest sectors, but 1-2% more on the two longest routes.

The PW-powered A320neo has the lowest fuel trip costs across the five airport pairs. These trip costs range from $793 on AMS-LHR to $4,017 on AMS-TFS. Across the five sectors the PW-equipped A320neo's fuel trip costs are $17-34 less than those of the CFM-powered A320neo. The A320neo with PW engines demonstrates fuel trip cost savings of $131-738, $115-714 and $199-651 when compared to the 737-800, CFM56-powered A320ceo and IAE-equipped A320ceo respectively.

The CFM LEAP-powered A320neo has fuel trip costs ranging from $809 on AMS-LHR to $4,051 on AMS-TFS. Its fuel trip costs are $114-703 less than those of the 737-800, $99-680 less than those of the CFM56-Powered A320ceo, and $183-617 less than those of the IAE-equipped A320ceo.

The A320ceo with IAE engines has the highest fuel trip costs on the shortest sectors of AMS-LHR, AMS-DUB and AMS-FCO. The 737-800 has the highest fuel trip costs on the two longest routes, AMS-FAO and AMS-TFS.

The two A320neos offer the shortest or joint shortest block times across all five sectors. The 737-800 has the longest or joint-longest block times.

Both A320neo variants demonstrate block times ranging from one hour and 16 minutes on AMS-LHR, to four hours and 50 minutes on AMS-TFS. They have the same block times on each sector except AMS-FAO where the PW-Powered variant has a one-minute advantage.

The two A320neo variants show block time savings of 1-3 minutes over the 737-800 across the five sectors.

On each of the AMS-LHR, AMS-DUB, AMS-FCO and AMS-FAO sectors the PW-powered A320neo demonstrates one- and two-minute block time advantages over the CFM56 and IAE-Powered A320ceos respectively. The A320ceos match the block time performance of the PW-powered A320neo on AMS-TFS.

The CFM LEAP-powered A320neo demonstrates a one-minute block time advantage over the CFM56-powered A320ceo on the three shortest sectors.

FUEL BURN PERFORMANCE IN LCC CONFIGURATION

City-pair	Aircraft variant	Engine variant	Available payload lbs	Pax capacity	Hold bags per pax	Cargo (lbs) 1 hold bag per pax	ASMs	Fuel burn USG per ASM	Fuel cost per ASM (cents)
AMS-LHR	A320-271neo	PW1127G	45,856	186	1.4	2,890	45,570	0.0141	1.74
	A320-251neo	CFM LEAP-1A26	45,856	186	1.4	2,890	45,570	0.0144	1.78
	737-800	CFM56-7B26	42,204	189	0.8	N/A	46,494	0.0161	1.99
	A320-214	CFM56-5B4/P	44,533	180	1.4	2,953	44,100	0.0167	2.06
	A320-232	V2527-A5	44,533	180	1.4	2,953	44,280	0.0182	2.24
AMS-DUB	A320-271neo	PW1127G	45,856	186	1.4	2,890	87,792	0.0108	1.33
	A320-251neo	CFM LEAP-1A26	45,856	186	1.4	2,890	87,792	0.0110	1.35
	737-800	CFM56-7B26	42,204	189	0.8	N/A	89,397	0.0127	1.56
	A320-214	CFM56-5B4/P	44,533	180	1.4	2,953	84,960	0.0130	1.61
	A320-232	V2527-A5	44,533	180	1.4	2,953	85,140	0.0134	1.65
AMS-FCO	A320-271neo	PW1127G	45,856	186	1.4	2,890	135,408	0.0102	1.26
	A320-251neo	CFM LEAP-1A26	45,856	186	1.4	2,890	135,408	0.0103	1.27
	737-800	CFM56-7B26	42,204	189	0.8	N/A	137,592	0.0118	1.45
	A320-214	CFM56-5B4/P	44,533	180	1.4	2,953	131,040	0.0123	1.51
	A320-232	V2527-A5	44,533	180	1.4	2,953	131,040	0.0126	1.55
AMS-FAO	A320-271neo	PW1127G	45,856	186	1.4	2,890	220,596	0.0094	1.16
	A320-251neo	CFM LEAP-1A26	45,856	186	1.4	2,890	220,596	0.0095	1.17
	737-800	CFM56-7B26	42,204	189	0.8	N/A	225,154	0.0109	1.35
	A320-232	V2527-A5	44,533	180	1.4	2,953	213,480	0.0114	1.40
	A320-214	CFM56-5B4/P	44,533	180	1.4	2,953	213,480	0.0114	1.40
AMS-TFS	A320-271neo	PW1127G	45,856	186	1.4	2,890	359,352	0.0091	1.12
	A320-251neo	CFM LEAP-1A26	45,856	186	1.4	2,890	359,352	0.0092	1.13
	737-800	CFM56-7B26	42,204	189	0.8	N/A	365,337	0.0106	1.30
	A320-232	V2527-A5	44,533	180	1.4	2,953	347,760	0.0109	1.34
	A320-214	CFM56-5B4/P	44,533	180	1.4	2,953	347,940	0.0111	1.36

Notes:
1). Hold bags per pax limit assumes all remaining payload used for hold bags once pax/hand luggage are accounted for.
2). Cargo payload based on remaining payload after pax, hand luggage and hold luggage accounted for. Assumes one hold bag per pax where possible.
3). 737-800 would only be able to accommodate 0.8 hold bags per pax in this configuration with no payload remaining for cargo.

The two variants have the same block time on AMS-FAO and AMS-TFS. The A320neo with CFM LEAP engines has a two-minute block time advantage over the IAE-equipped A320ceo on the three shortest sectors and a one-minute advantage on AMS-FAO. The IAE-powered A320ceo matches the block time performance of the CFM-equipped A320neo on the longest sector between AMS-TFS.

According to the flight plans generated for this analysis, the five aircraft variants have very similar climb, cruise and descent speeds, although the A320ceos and A320neos have a 20kts cruise advantage over the 737-800. This partly explains why the 737-800 has the slowest block times.

The A320neos have a slightly superior climb performance to the A320ceos, so they reach the top of climb faster. This contributes to their shorter block times on some sectors.

None of the five aircraft variants suffers from payload-range restrictions on the sectors covered by this analysis. This means they all operate each route with the maximum payload permissible by the chosen weight specifications. The two A320neos have a maximum payload of 45,856lbs giving them a payload advantage of 1,323lbs over the A320ceos and 3,652lbs over the 737-800.

Full-service configuration

The full-service configurations used here are based on realistic dual-class arrangements currently in service with European airlines. The assumed capacities are 180 seats for the A320neos, 176 for the 737-800 and 168 for the A320ceos.

When these assumptions are applied to the raw Lufthansa Systems' Lido/Flight data it is possible to generate speculative ASMs and potential fuel costs per ASM.

In the full-service layout the two A320neos demonstrate the lowest fuel burn and costs per ASM across the five sectors, with the PW-powered example offering slightly lower costs than the CFM LEAP-equipped variant *(see table, page 22)*. The superiority of the A320neos is not surprising given that they have the lowest block fuel burn and generate the most ASMs.

The PW-powered A320neo's fuel costs per ASM range from 1.15 cents on AMS-TFS to 1.80 cents on AMS-LHR. Its fuel costs per ASM are 0.01-0.04 cents lower than those of the CFM LEAP-powered A320neo. This is equivalent to 2% lower fuel costs per ASM on AMS-LHR, and 1% less on the other four sectors. The PW-powered A320neo's fuel costs per ASM are 0.24-0.34 cents lower than those of the 737-800, 0.30-0.41 cents lower than those of the CFM56-powered A320ceo and 0.28-0.60 lower than those of the IAE-powered A320ceo *(see table, page 22)*. These differences are equal to 16-18%, 19-21% and 20-25% lower fuel costs per ASM.

The CFM LEAP-powered A320neo's fuel costs per ASM are 1.16-1.84 cents. Its fuel costs per ASM are 14-17% less than those of the 737-800, 17-20% less than those of the CFM56-powered A320ceo and 19-24% less than those of the IAE-powered A320ceo.

There is evidence that the fuel cost per ASM advantage of the A320neos increases over the CFM56-powered A320ceo as sector length increases. Their fuel cost advantage over the IAE-equipped A320ceo decreases with increasing route length.

The 737-800 has lower fuel costs per ASM than the two A320ceo variants on each route, even though it has higher block fuel burn than the CFM56-

equipped aircraft on all five sectors and higher block fuel usage than the IAE-powered variant on AMS-FAO and AMS-TFS. The 737-800's fuel costs per ASM are 3-4% lower than those of the CFM56-equipped A320ceo and 3-11% less than those of the IAE-equipped variant. The 737-800's higher block fuel burn is offset by its extra capacity and ability to generate more ASMs.

The CFM56-powered A320ceo demonstrates a fuel cost per ASM advantage of 3-8% over the IAE-equipped variant on the shortest three sectors. The two A320ceos have the same fuel costs per ASM on AMS-FAO, but the IAE-powered aircraft has a 1% advantage on AMS-TFS.

All the aircraft are capable of operating with a full passenger and hand luggage payload across all five sectors. The A320ceos would offer the most remaining payload for hold luggage or cargo in this full-service configuration, despite offering nearly 1,300lbs less in gross payload than the A320neos. This is because the A320ceos are configured with fewer seats and less of their available payloads are used up for passengers and hand luggage.

On each of the five routes the A320ceos have 11,941lbs of payload available for hold bags and/or cargo. This compares to 10,936lbs for the A320neos, and 8,060lbs for the 737-800. If all of these remaining payloads were dedicated to hold luggage, the A320ceos, A320neos and 737-800 could accommodate up to 322, 295 and 217 bags respectively. This roughly equates to an allowance of 1.9, 1.6 and 1.2 hold bags per passenger for the A320ceos, A320neos and 737-800.

Alternatively, if it is assumed that each passenger will check in one hold bag, all the aircraft could operate across all five sectors with a full passenger, hand and hold baggage payload and still have payload remaining for cargo. In this scenario the A320ceo and A320neo would offer 5,725lbs and 4,276lbs of cargo payload respectively across each of the five sectors. The 737-800 would offer the lowest cargo payload of 1,548lbs.

LCC configuration

The LCC configurations used here are based on high-density, single-class examples representative of the current in-service fleet. The assumed capacities are 189 seats for the 737-800, 186 for the A320neos and 180 for the A320ceos.

Each aircraft demonstrates lower fuel costs per ASM in the LCC configuration, because they are operating with higher seat numbers that generate more ASMs than the lower-capacity, full-service configurations. The same block fuel costs are subsequently spread over a larger number of ASMs.

The comparative fuel cost per ASM performance follows a similar pattern to that seen in the full-service configuration. The two A320neos again offer the lowest fuel costs per ASM across all five sectors with the PW-powered variant demonstrating marginally lower costs than the CFM LEAP-equipped aircraft *(see table, page 24)*.

The PW-equipped A320neo's fuel costs per ASM range from 1.12 cents on AMS-TFS to 1.74 cents on AMS-LHR. Its fuel costs per ASM are 0.01-0.04 cents lower than those of the CFM LEAP-equipped A320neo *(see table, page 24)*. This equates to 2% lower fuel costs on AMS-LHR and 1% lower costs on the other four sectors.

The PW-powered A320neo's fuel costs per ASM are 0.18-0.25 cents lower than those of the 737-800, 0.24-0.32 cents lower than those of the CFM-equipped A320ceo and 0.22-0.50 cents lower than those of the A320ceo with IAE engines *(see table, page 24)*. This is equivalent to 12-15%, 16-18% and 17-22% lower fuel costs per ASM respectively.

The CFM LEAP-powered A320neo's fuel costs per ASM are 1.13-1.78 cents. Over the five sectors its fuel costs per ASM are 0.17-0.21 cents less than those

Based on the assumptions used in this analysis, the A32oneos burn up to 14-25% less fuel per seat than previous generation aircraft in a typical service configuration. In a LCC configuration, they burn 11-22% less fuel per seat.

of the 737-800, 0.23-0.28 cents less than those of the CFM-equipped A320ceo, and 0.22-0.46 cents less than those of the A320ceo with IAE engines. This equates to respective fuel cost savings of 11-13%, 14-17% and 16-21%.

There is a general trend for the two A320neos' fuel cost per ASM advantage over the CFM-powered A320ceo to increase with sector length. Their fuel cost advantage over the IAE-equipped A320ceo decreases with increasing route length.

The fuel cost per ASM savings offered by the A320neos are less in the LCC configuration than in the full-service layout. In the full-service layout the A320neos had a 12-seat capacity advantage over the A320ceos and a four-seat advantage over the 737-800. In the LCC layout the A320neo's capacity advantage over the A320ceo is reduced to six seats, and it has three fewer seats than the 737-800. This results in the A320neos generating a smaller ASM advantage over the A320ceos and fewer ASMs than the 737-800 in the LCC configuration. The superior block fuel burn performance of the A320neos means that they maintain a double-digit fuel cost per ASM advantage over the 737-800, despite generating fewer ASMs.

The 737-800 again demonstrates lower fuel costs per ASM than the two A320ceos on each sector, partly due to its assumed capacity advantage, which in this case is nine seats. The 737-800's fuel costs per ASM are 3-4% lower than those of the CFM-powered A320ceo, and 3-11% less than those of the A320ceo with IAE engines.

The comparable fuel cost per ASM performance of the two A320ceos is exactly the same as in the full-service configuration.

In the LCC layout all the aircraft can operate with a full passenger and hand luggage payload on every sector. The A320neos offer the most additional payload for hold luggage and/or cargo.

On each sector the two A320neos have 9,772lbs of payload remaining for hold luggage or cargo. The A320ceos and 737-800 have 9,613lbs and 5,538lbs of payload available. If all of the remaining payload is dedicated to hold luggage the A320neos, A320ceos and 737-800 could accommodate up to 264, 259 and 149 hold bags respectively. This roughly equates to an allowance of 1.4 bags per passenger for the A320neos and A320ceos, and 0.8 bags per passenger for the 737-800. A 737-800 with the weight specifications used in this analysis and configured with 189 seats, would not be able to accommodate a hold bag for each passenger when operating with a 100% load factor. Only 79% of passengers would be able to take a hold bag. This is unlikely to be a major concern for LCCs, since their policy of charging additional fees for hold bags results in fewer passengers checking bags in on their flights. It is also unlikely that all 189 passengers will need an individual bag, as families or couples often share hold bags between them. It is therefore unlikely that more than 149 checked bags will be required on most LCC 737-800 services.

Unlike the 737-800, the A320neos and A320ceos can accommodate one hold bag per passenger and still have 2,900lbs of payload remaining for cargo.

Summary

The two A320neo variants offer lower block fuel burn and lower fuel costs per ASM than the older generation types they are designed to replace. In some scenarios the A320neos do not quite match the marketed 20% improvement in fuel efficiency, but in others they exceed this target.

The PW-powered A320neo uses slightly less fuel than the CFM LEAP-equipped variant, so it has marginally lower fuel costs per ASM. The PW-powered A320neo's block fuel burn was 1-2%, 14-16% and 13-20% lower than that of the CFM LEAP-powered A320neo, 737-800 and two A320ceo variants.

In full-service configuration, the PW-powered A320neo's fuel costs per ASM were 1-2%, 16-18% and 19-25% less than those of the CFM LEAP-powered A320neo, 737-800 and two A320ceos. In the LCC configuration the A320neo with PW engines demonstrated fuel cost per ASM savings of 1-2%, 12-15% and 16-22% compared to the CFM-powered A320neo, 737-800 and two A320ceos.

The differences in performance between the PW- and CFM LEAP-equipped A320neos should be treated with some caution, since this analysis does not vary OEWs to account for differences in engine weight.

The two A320neos offered block time savings over the 737-800 on all sectors. They also matched or outperformed the block times offered by the two A320ceos.

In the LCC configuration the two A320neos offer the most remaining payload for hold luggage and cargo. In the full service configuration they offer the second highest payload for luggage and cargo after the A320ceos.

In the assumptions section of the analysis it was identified that A320ceos can be configured with similar seat capacities to A320neos. If the A320ceos were configured with the same number of seats as their successors, the difference in fuel costs per ASM between the two generations would be smaller, because the A320ceos would have generated more ASMs. In this scenario the difference in fuel costs per ASM would have matched the difference in block fuel burn between the neo and ceo variants. The A320neos would therefore still have had a 13-20% advantage. AC