AN ASSESSMENT OF SCOPE OPPORTUNITIES ASSOCIATED WITH EUROPEAN LOW-COST CARRIER USE OF NEXT GENERATION NARROW BODY AIRCRAFT ACROSS THE ATLANTIC

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Abstract

This research assesses the economies of scope opportunities that may arise through the use of next generation, long-range narrow body aircraft, namely the 737MAX-7, 737MAX-8, A321LR and A321XLR, by European Low-Cost Carriers (LCCs), who have hitherto been reluctant to consider transatlantic long-haul low-cost operations. A proof of concept approach was taken using actual 2021 aircraft schedules and 2018-2019 aircraft utilisation data and was compared with a selection of hypothesised schedules by European-based LCCs using new longer-range narrow body aircraft for long-haul transatlantic operations in addition to regular short-haul sectors with a particular focus on the winter season when average utilisation levels are generally lower than the busier European summer season. It was found that the superior capacity-range at maximum payload characteristics of the A321LR/XLR and 738MAX8 aircraft can potentially increase total aircraft utilisation rates during the quieter European winter season by adding a transatlantic sector to an aircraft's typical daily European operations to as many as 791 different route combinations to the Americas, some of which may be attractive for winter sun seekers and/or cost conscious independent travellers. It was noted that this type of interworked aircraft solution has its wider advantages and disadvantages e.g. it may only be attractive for existing short-haul LCCs with intentions for a one-class configuration on long-haul sectors, or multiple classes but with much lower levels of service differentiation. Individual constraints and considerations will be different for each carrier, therefore future research should centre on testing the concept within the networks and planning frameworks for individual case airlines.

Key words: Next generation narrow body aircraft; economies of scope; long-haul low-cost, interworked aircraft scheduling; low-cost carriers

1. Introduction

The aim of this research is to explore a new operational angle related to the *long-haul-low-cost* concept, namely how flying across the Atlantic may represent an economies of scope opportunity for Low Cost Carriers (LCCs) in light of the availability of new narrow body aircraft types such as the A321XLR. Airline CEOs have expressed skepticism about the business potential of Long-haul low-cost operations. O'Leary once stated: *"long haul is a different business. Short haul is commoditized. As long as it's safe and it's punctual, it works. The lowest cost will win. Whereas long-haul is a different model and I don't think long-haul, low-cost works"* (J. B. , 2016)*;* CEO of Wizz Air, Josef Varadi, is more open to the long-haul solution but does not seem to be interested in the Atlantic. When asked about the carrier's A321XLR plans in 2021 he replied: *"We'll go further east. We won't be going transatlantic* (J. P. , 2021).

Specifically, this study seeks to demonstrate that LCCs going transatlantic could be a good opportunity to achieve economies of scope in light of new narrow body aircraft types coming into the market. It should be noted that although an economic analysis can demonstrate the profitability of this model, many other internal aspects relevant to each carrier such as fleet composition, operative base locations, management willingness, and the existence of other goals can affect and influence its actual feasibility for any individual carrier.

Europe is one of the most served regions in the world in terms of LCC networks. Ryanair, easyJet, Vueling, Wizz Air and Volotea are amongst the most prevalent European based LCCs. In the past 30 years European LCCs have fought Full-Service Airlines (FSAs) and each other primarily on intra-European short-haul routes, pushing FSAs to focus more on medium to long-haul routes. It has been well documented that their no-frills approach, their efficiency seeking behaviour, their scale economies, and the proliferation of point-to-point networks has led them to be high-volume players in the intra-continental market. According to Akguc et al. 2018, the LCC share of international seat capacity in Europe between 2002 and 2017 rose from 10% to 42%.

Levels of competition between air carriers in Europe is intense and weaker players have a higher likelihood of failure. Since 2017, notable airline failures have included Air Berlin, Monarch, Primera Air, Germania, BMI,

Wow Air, Thomas Cook, Adria Airways, XL Airways and right at the beginning of the Covid-19 pandemic, FlyBE (Reuters, 2020). Players that can achieve a good level of efficiency are able to survive, particularly in light of the high seasonality of demand in Europe, which sees large peaks in summer periods, and much lower volumes during winter periods. This characteristic alone strongly challenges the liquidity of scheduled European carriers. This research focusses on the winter periods with respect to new long-range narrow body aircraft, where Europe based LCCs are more able to utilize spare capacity that would otherwise be engaged on intra-European routes during busier summer months to increase economies of scope targeting certain transatlantic destinations in the Americas on interworked aircraft schedule operations, leading to higher utilization.

Unlike the dedicated long-haul low-cost solutions of other carriers, most of which have failed, this approach is aimed at practical economies of scope or '*drop-in'* solutions, in which the goal is to maximize the utilisation of assets that are already owned or leased by an airline and which consequently do not require large-upfront investments in alternative aircraft, on-board configurations and product lines. JetBlue and Wizz Air are examples of carriers that have started to sample with using longer range narrow-body aircraft for longer haul operations, Wizz Air on Central Europe-Asia routes and JetBlue on north-Atlantic routes. Neither, however, have yet been able to consider aircraft interworkings during quieter winter months, or indeed base assumptions on using the latest long-range narrow body aircraft that will be available.
The rest of the paper is divided as follows: Section 2 details the proposed idea with links to the literature; Section 3 presents the methodology outline followed by results and findings, Section 4 summarises the benefits and drawbacks of such a solution plus a number of mitigating measures that can be taken to reduce the drawbacks and Section 5 draws overall conclusions.

2. The record so far

2.1 LCC experiments in long-haul markets

LCCs have expanded due to their efficiency-based approach, with a strong emphasis on standardization and simplification. "Frills" refer to all the non-essential services, such as complimentary food, in-flight entertainment systems, and business-class seating (Graeme Drummond, 2005). Unbundling these allowed

LCCs to strongly reduce many variable costs associated with daily operations. This model works well on short-haul markets given the vast majority of consumers want to reach their destinations quickly and economically and are often willing to give up in-flight food and entertainment in pursuit of lower prices (Picardo E., 2022). This helps to explain why the majority of LCCs focus almost exclusively on the short to medium haul routes.

Several LCCs have tried to break through into sustained long-haul operations with mixed fortunes over the past 15 years. In Asia-Pacific markets some carriers such as Scoot, JetStar and AirAsiaX have experienced some degree of success. On the other hand, European based carriers have had several failed experiments such as Norwegian and Wow Air. One differentiating factor between these Asian and European carriers is that Scoot, JetStar and AirAsiaX are not stand-alone companies, but subsidiaries of Singapore Airlines, Qantas and Air Asia respectively. Norwegian Air Shuttle decided to create a long-haul network, which started operations in 2013. They aggressively expanded in a short period of time, by opening a large number of bases in Europe and the US such as Rome, Paris Charles de Gaulle, Barcelona, Oslo, Copenhagen, London Gatwick, Fort Lauderdale (FLL), New York (JFK) and Los Angeles (LAX). Their ambition was to be a truly global LCC, with flights ranging from Asia to North America using new 787s. Research carried out by De Poret et al. (2015) suggested that even with new, more efficient 787 aircraft, it would still be difficult for carriers to make long-haul low cost operations viable across the Atlantic, with a focus on higher seating densities and cargo/ancillary revenues helping to partly mitigate these sensitivities.

In Europe, a few LCCs are working on launching long-haul routes at the time of writing. Among these Wizz Air launched new medium-haul routes to the UAE from Central Europe with over 15,000 seats for sale in May 2022 covering an average sector length of 4,000kms. It had as many as 280 Airbus A321neos on order as of May 2022. As part of this they selected 20 321XLR aircraft in 2020 (^ (EN) WIZZ, 2020) and stated that they are also looking to India as an interesting market for which they are considering commercial viability (P., 2021). “Norse Atlantic Airways”, a start-up based in Norway, ordered 15 787s (Bertoletti, 2021) and announced plans to operate transatlantic flights connecting London, Oslo, and Paris alongside Los Angeles, Miami, and New York City, as initial destinations in the wake of the demise of Norwegian’s long-haul operations. Another UK based start-up FlyPop aims to launch its first operations in summer 2022 to take

advantage of pent-up pandemic related demand between India and the UK, using leased A330s. In the CEO Nino Judge's words *"we went for the best value, slightly older A330s, where we could drive the price down. It has a high-density configuration, and that's when you truly get low-cost"* (Finlay, 2021). A further unproven carrier is Play Airlines, based in Reykjavik, that in a similar fashion to Wow Air, aims to connect the Americas with Europe through the Hub and Spoke and model, stopping over in Iceland using A321s (Sachindra, 2021). So far, they have only launched a limited number of flights to Europe. In the Americas, JetBlue, which is not a European carrier, opened a new route from New York to London Heathrow and Gatwick on a daily basis using A321neo LRs. Routes from Boston to LHR/LGW and New York to Amsterdam, Paris and Dublin are also planned according to CEO Geraghty (Slotnick, 2021). Interestingly Geraghty considers that the extended range A321XLR can open up central and eastern European destinations to the carrier too.

Due to the underperformance of European LCCs on long haul markets to date, this research focuses on European LCCs with well-established short-haul networks in order to access economies of scope possibilities.

2.2 The problem for European LCCs entering the transatlantic market

Ryanair's CEO O'Leary has been asked several times about the possibility of launching transatlantic routes and he always replied with skepticism about the long-haul low-cost formula. O'Leary always insisted on the fact that the only way to cover all costs and break-even in the long-haul market is with a double cabin configuration, in which the premium class travelers pay a premium to cover a greater percentage of total costs. This pricing formula is quite common, and in business vocabulary is named the *80:20 rule*, in which 20% of the customers provide 80% of the revenues and vice versa. The inefficiencies with operating long-haul relate to two main factors: -

- **Fleet changes** - To operate all year round in transatlantic markets wide-body aircraft are preferable: They are faster, more efficient, have a broader flight range and have more space for multiple configurations. Indeed, companies such as Jetstar, FlyPop and Scoot use wide body aircraft. This aspect itself is already a threat to one of the crucial points of the budget airlines' current business

model: fleet standardization. Having only one aircraft type allows for scale economies, larger bargaining power with aircraft manufacturers, common standards for training crew and maintenance personnel, smooth interchangeability of staff and standardization of processes and IT structures. The capital cost of a widebody aircraft is also up to three times higher that a narrow body such as the 737 or A320 (Boeing, 2022).

- **Flow and utilization efficiencies** - Beyond the fleet, there are utilisation efficiencies deployed on all routes. Ryanair, for example, can achieve a turnaround time of only 25 minutes in many of their airports, leading them to have as many flights as possible per day. With long haul operations it is harder to keep up this turnaround efficiency and standardization. Bigger airports are more congested and crews need to start undertaking costly stopovers at destinations.

2.3 Technical specifications of new narrow body aircraft

The Boeing 737 and the Airbus A320 are the two aircraft types that are extensively used by European LCCs. They fit well into this business model for their competitive prices, and their optimised seat capacity for intra-continental markets.

Airbus and Boeing started to consider redesigning their single-aisle bestsellers (the 737 and the A320) in the mid-2000s. They first improved the design of the wing by introducing winglets that reduce fuel consumption by approximately 3% on longer flights. To access greater efficiencies the next feature to be redesigned was the engines. Both CFM and Pratt & Whitney started to rethink their engines and the CFM LEAP1A/B and PW1000G were developed, employing new cutting-edge technologies that enable a 15% to 20% reduction in fuel burn, together with a noise reduction of about 50% compared to older models (CFM International, 2022).

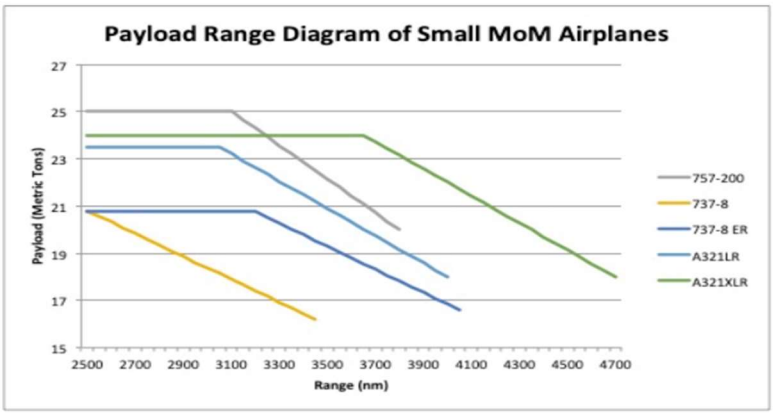
Importantly, both the A320neo and the 737MAX are ETOPS-180 rated, which means they have been certified to fly at a maximum of 180 minutes (of flight time) from the nearest suitable aerodrome. This rating is a safety measure and allows carriers to use the aircraft to fly across the Atlantic using standard routings (CFM International, 2022).

Airbus first flew its A320neo (New Engine Option) in 2014 and has received 7,986 orders as of May 2022. The neo is offered for all the three types in the A320 family (A319, A320 and A321). Due to its higher capacity characteristics, this research we will focus on the performance of the A321. The A321neo has a maximum seating capacity of 244 passengers thanks to the new Airbus Cabin Flex configuration, and a flight range at max payload of 6,460 km. Airbus then extended the range of this type by developing the A321LR, which can fly up to 7,400 km in a 2-class configuration of 206 passengers. Airbus went even further by launching the A321XLR, due to enter in service in 2023, which will be able to fly routes up to 8,700km long, something that was inconceivable for a twin-engine single aisle aircraft just a few years ago (Airbus, 2022). Airbus has a solid reputation in the European low-cost sector, as most carriers employ the A320 family. EasyJet, Wizz Air and Vueling are long term Airbus customers whereas other carriers, such as Jet2, are in the process of transitioning to Airbus (Reuters, 2021).

The first B737MAX first flew in 2016. Despite the two tragic incidents that shattered its early operational life and caused some cancellations in orders, the MAX has since regained full FAA and EASA certification and is starting to populate the skies again. Like Airbus, Boeing also offers four variants of the MAX: MAX7, MAX8, MAX9 and MAX10. The MAX10, which is due to be first delivered to airlines in 2023, will have a maximum range of 6,110km. Boeing is also working on the so called NMA (or B797), which is designed to fill an efficiency gap in the mid-size market but is not scheduled to enter service in the late 2020s (Boeing, 2022). Although Boeing has fewer customers in Europe compared to its Toulouse-based counterpart, it can count on Ryanair's loyalty. To date the most popular 737MAX version is the 737MAX8, with 189 seating capacity and a range of 7,500km.

Figure 1 and Table 1 demonstrate combined payload and maximum range capabilities for a number of middle-of-the-market (MoM) aircraft (Ackert, 2013). Though not in the market yet, the A321XLR has a clear

range and maximum payload advantage of the other aircraft types with only the older, more inefficiency B757-200 having a higher maximum payload offering but at a lower range of 3,100 nautical miles. Of the current production offering, the A321LR and 737MAX8(ER) have the highest range offering at maximum payload.



We stop the payload-range diagrams at the maximum fuel capacity of those aircraft

As well as basic aircraft payload and range capabilities:

Range	757-200	737-8	737-8 ER	A321LR	A321XLR
Max Payload	25	20.8	20.8	23.5	24
Range at Max Payload	3,100	2,500	3,200	3,050	3,650
Range at Max Fuel	3,800	3,450	4,050	4,000	4,700
Payload at Max Fuel	20	16.2	16.6	18	18

Figure 1: Payload range diagram of a selection of MoM aircraft

Surce: (epsilonaviation, 2019)

The maximum payload range capability is important as airlines will try to get their aircraft as full as possible. The effective range data for the aircraft types being used in this study shown in Table 2.

Table 2: Maximum payload range capabilities of the study's selected aircraft

Aircraft	**Nautical Miles**	**Kilometres**	**Max payload (tons)**
A321LR	3,050	5,649	23.5
B737MAX8	3,200	5,926	20.8
A321XLR	3,650	6,760	24

The aircraft considered for this study in Table 2 are limited to those that have been purchased (or ordered) by European LCCs, and that have scope to fly transatlantic routes.

3. Data outline and presentation of results

3.1. Data outline

As a proof of concept, this research relied on published data sources to demonstrate the feasibility of European LCCs operating interworked narrow body aircraft on short and long-haul routes during quieter winter seasons. Technical specifications of new aircraft were sourced directly and indirectly from Boeing and Airbus. Illustrative aircraft schedules data was obtained from Flightradar24 during the Winter 2021 period and transatlantic route combination distances were obtained from Great Circle Distance Mapper covering the main Western and Northern European nations and the US, Canada and the Caribbean. Data related to block hours and airline operating costs were obtained from the latest year of airline annual reports.

Economies of Scop*e* were defined in a standard way as efficiencies are generated by variety, not volume (Goldhar & Jelinek, 1983). The main focus for this study was finding way to better utilize aircraft on a wider variety of routes rather than increasing the number of aircraft and volume of total seat availability.

3.2. Seasonality of the European market

Demand seasonality is an issue which occurs in different industries, not just the airline industry and as a consequence corporations usually expand their operations in places where the effects of seasonality can be reversed or at least reduced. In this way they can balance demand and have more consistent cash flows throughout the year.

Figure 2 shows the number of passengers that flew in different months of the year in the three busiest markets in world - Asia-Pacific, Europe and North America up to September 2016. It is observable how the European market has been the most volatile of the three with the seasonal peak to trough differential of around 100 million passengers versus around 30 million in North America and only 10-15 million in Asia Pacific.

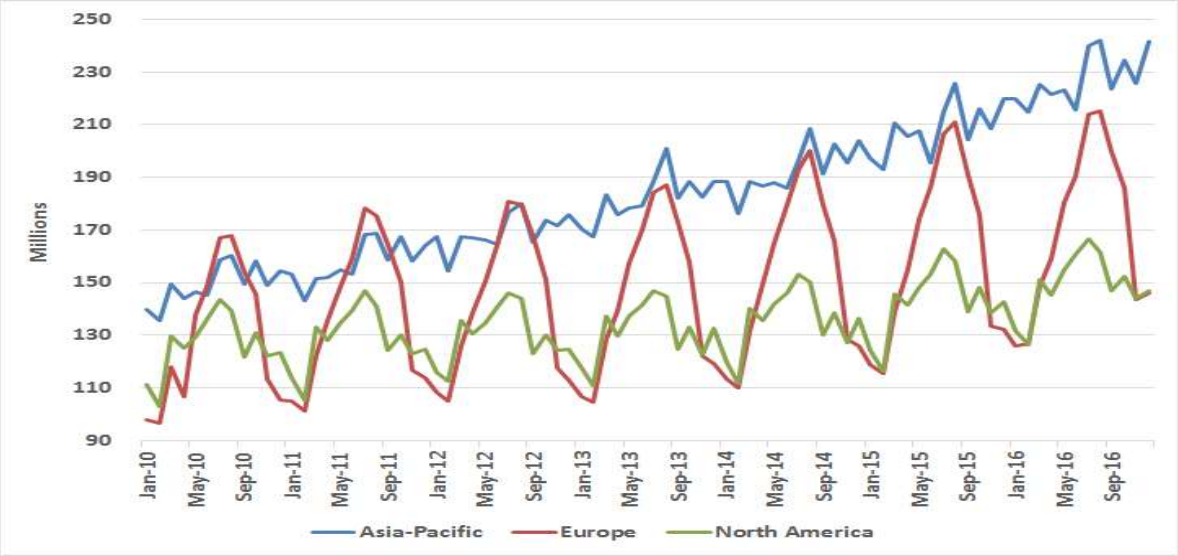


Figure 2: Passenger demand seasonality in three major markets through to September 2016

Source: (Lucas, 2018)

These seasonality differentials, particularly in Europe can lead to reductions in efficiency as determined by average annualized aircraft utilization statistics. The annual average block hours for WizzAir, Easyjet and Ryanair combined (in 2017 and 2018) was 10.94 hours per day. Adjusted for variation in monthly traffic levels, Figure 3 shows how average block hours vary from a peak in July and August to a low in January and February.

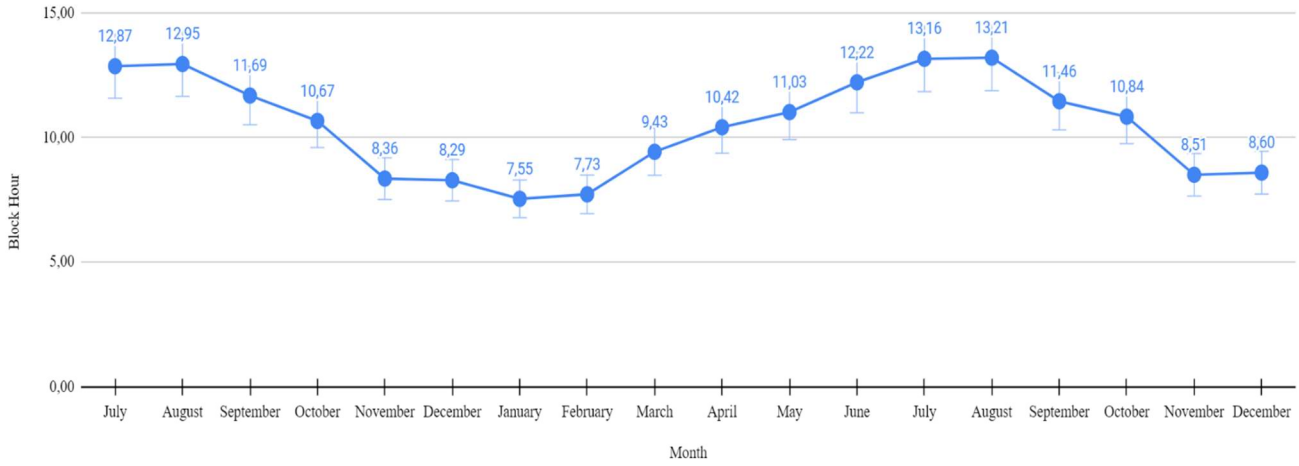


Figure 3: 2017 and 2018 monthly estimated variation in average block hours for U2, FR and W6

Sources: Annual reports (block hours), traffic data

It is clear from the graph that January and February utilizations are an estimated 40% lower than the summer peak. The variation also shows that the potential for increased utilization would take place between mid-October and mid-March every year (see section 3.5 for potentiality estimates in these months).

3.3 Costs that can be amortized

The main cost that LCCs must amortize as much as possible is the aircraft's capital cost. This is also one of the various reasons why successful LCCs decide to use the B737s and A320s' family. These types have a list price that ranges between US$ 95 to 120 million compared to the wider bodies that range from US$ 200 to 400 million. In 2019 Ryanair stated: "*As of March 31, 2019, Ryanair had €9.0bn of property, plant and equipment long-lived assets, virtually all of which consisted of aircraft*" (Ryanair, 2019). Considering that the carrier's total assets in that year were €14.8bn, it is possible to say that nearly 60% of the whole company's assets relate to its aircraft. This is the reason why efficiency-seeking is extremely important in this market, and why having for instance, only two thirds of the fleet operating during the winter represents a significant underutilization of assets.

Beyond aircraft, there are two other important cost categories for LCCs: Airports and ground handlings, and crew costs. We can observe in Table 4 that for EasyJet in 2019, airports and handlings accounted for more than 40% and crews for more than 12% of the total headline costs, excluding fuel.

HEADLINE COSTS EXCLUDING FUEL

Headline cost per seat excluding fuel decreased by 0.4% to £43.26 (2018: £43.43) and decreased by 0.8% at constant currency.

	2019				2018	
	Amounts without adoption of new IFRSs £ million	Impact of new IFRSs £ million	As reported £ million	Cost per seat £ million	As reported £ million	Cost per seat £ million
Operating costs/(income)						
Airports and ground handling	1,848	(3)	1,845	17.57	1,649	17.32
Crew	859	–	859	8.18	754	7.92
Navigation	409	–	409	3.89	400	4.20
Maintenance	387	(85)	302	2.88	313	3.28
Selling and marketing	157	–	157	1.50	143	1.50
Other costs	480	(24)	456	4.36	507	5.32
Other Income	(29)	–	(29)	(0.27)	(13)	(0.13)
	4,111	(112)	3,999	38.11	3,753	39.41
Ownership costs						
Aircraft dry leasing	187	(182)	5	0.05	152	1.59
Depreciation	240	244	484	4.61	199	2.09
Amortisation	15	–	15	0.14	15	0.15
Net finance charges	15	24	39	0.35	17	0.19
	457	86	543	5.15	383	4.02
Total headline costs excluding fuel	4,568	(26)	4,542	43.26	4,136	43.43

Headline airports and ground handling cost per seat increased by 1.5%, and by 1.1% at constant currency. Airport charges were

Table 3: EasyJet headline costs 2019, Source: (EasyJet, 2019)

In the past some companies have been able to minimise crew costs with freelance contracts, however, lately trade unions and European laws made these practices very hard to implement, granting a continuation of fixed salary contracts with bonuses per flight and daily allowances (Pilotjobsnetwork, 2022).

Whilst aircraft ownership costs would not change if aircraft were employed on winter transatlantic routes, crew and airport related costs would experience an increase for additional operations but spread over a greater level of output due leading to scale and scope economies.

Although LCCs can save on some variable costs and take advantage of down periods to conduct heavy maintenance, which is due on average every two years anyway depending on aircraft type and age, if there was an economics of scope opportunity leading to increased coverage and utilization, this might outweigh the advantages of reducing the number of aircraft operating during the winter.

3.4. How interworked winter schedules could work

As previously stated, the purpose is to explore the economies of scope achievable during the quieter winter months in Europe. This idea stems from the general principles that a) for an airline a parked aircraft is a cost, whereas an airplane that is in the air can be generating revenue and b) there is a lower incidence of seasonality on transatlantic routes versus intra-European routes during autumn and winter months.

Thus, the same aircraft that are used in summer, and parked during winter, can be used during the low demand periods for a combination of short and long-haul sectors. As described earlier, this new approach can be adopted only with the A321LRs, 737MAX8s, and for certain routes by the A321XLRs.

An aircraft, besides daily maintenance, does not need to stop to actually "rest"; daily maintenance is around 1.5 hours, meaning 22.5 hours are available to operate inclusive of turnaround times between sectors. This leads to three possible options in going transatlantic with these aircraft:

1. Set up one transatlantic destination per day, and operate just one return sector
2. Set up a transatlantic destination plus one European short haul route
3. Set up one transatlantic destination plus two short-haul rotations within the 22.5 hours

These last two solutions represent the same concept as Wizz Air with its new UAE destination. Table 4 and 5 show two examples of how Wizz Air have scheduled aircraft using both options:

Table 4: One longer-haul plus one short haul rotation from Sofia, Bulgaria.

Flight Number	**Origin**	**Departure time at origin**	**Departure time at destination**	**Destination**	**Arrival time at origin**	**Arrival time at destination**	**Travel time in hours**
W64427	Sofia (SOF)	06.20	06.20	Tel Aviv (TLV)	08.50	08.50	2.30
W64428	Tel Aviv (TLV)	09.40	09.40	Sofia (SOF)	12.25	12.25	2.45
W64431	Sofia (SOF)	13.45	14.45	Abu Dhabi (AUH)	18.40	19.40	4.55
W64432	Abu Dhabi (AUH)	20.25	19.25	Sofia (SOF)	02.00	1:00	5.35
Total 24-hour utilization (block hours)							15.45

Schedules correct as of October 2021 Source:Flightradar24

Table 5 One longer-haul plus two short haul rotations from Catania, Italy.

Flight Number	Origin	Departure time at origin	Departure time at destination	Destination	Arrival time at origin	Arrival time at destination	Travel time in hours
W65576	Catania (CTA)	06.10	06.10	Milan (MXP)	08.05	08.05	1.55
W65575	Milan (MXP)	08.40	08.40	Catania (CTA)	10.25	10.25	1.45
W68183	Catania (CTA)	11.10	11.10	Bologna (BLQ)	13.05	13.05	1.55
W68184	Bologna (BLQ)	13.30	13.30	Catania (CTA)	15.00	15.00	1.30
W68197	Catania (CTA)	15.35	17.35	Dubai (DXB)	20.45	22.45	5.10
W68198	Dubai (DXB)	23.30	21.30	Catania (CTA)	05.25	03.25	5.55
Total 24-hour utilization (flight hours)							18.10

Schedules correct as of October 2021 Source: (Flighradar24, 2021)

It is observable how the second option tends to be tighter, with shorter turnarounds, and the last flight lands at 03.25am, which would not be particularly popular with passengers. Moreover, in this mode there is a risk of cumulating delays during the daily operation which, indeed, happened on the first day Wizz Air implemented this schedule (16/10/2021), with the last flight landing in Catania at 04.58 am instead of 03.25 (Flighradar24, 2021).

Before going further, it is important to consider crew operation limits. For simplicity it is considered that a crew can fly a maximum of four sectors or two rotations if flights are no longer than about 2.5 hours. Alternatively, they can fly two sectors that are no longer than about 6 hours each (with a short turnaround). A further alternative, though mostly outside the scope of permitted Flight Duty Periods (FDPs) is that crews fly two shorter sectors plus one longer haul rotation for about 12:30 hours of total duty time if they start in the morning, or 10:30 hours if they start in the evening (EASA, 2017).

In the Wizz Air Catania example, however, we can observe that a crew managed the first four short flights of the day and then switched to a fresh crew that flew to Dubai and back again. This method also prevents the need for costly crew stopovers. For transatlantic flights, due to longer flight times and larger time zone differentials it would seem that a suitable option from a crew perspective would be to use the same crew for two short sectors in Europe followed by the outward long-haul sector and a stopover with a separate crew for the return transatlantic flight followed by a short-haul rotation on a separate aircraft. This can be illustrated with the below example in Table 6.

Table 6: Interworking aircraft and crew: one short and one long haul rotation

Origin	**Departure time at origin**	**Departure time at destination**	**Destination**	**Arrival time at origin**	**Arrival time at destination**	**Travel time in hours**
London (STN)	11.10	12.10	Nuremberg (NUE)	12.50	13.50	1.40
Nuremberg (NUE)	14.20	13.20	London (STN)	16.00	15.00	1.40
London (STN)	16.15	11.15	Boston (BOS)	23.15	18.15	7.00
Boston (BOS)	19.30	00.30	London (STN)	02.00	07.00*	6.30
Total 24-hour utilization (flight hours)						16:50

*Once landed in STN, the plane will have 4 hours 30 minutes for daily maintenance and to board passengers for the first flight of the day.

In this schedule two crews are involved: one operating the first two flights to Nuremberg and then flying on the outbound sector to Boston followed by a stopover. A second would fly the Boston to STN sector and then would operate on two short-haul flights with a separate aircraft (since the one in Table 6 would go into maintenance to end the duty).

With a schedule like this, crew efficiency, with respect to the Atlantic configuration, is high. Passengers depart and arrive during appreciable hours, the short-haul sectors are shorter and not amongst the densest routes, and morning landings in London are convenient for regular maintenance.

Though with little margin for error and sacrificing elements of crew efficiency, it would be possible to add an extra short-haul rotation to an suitable aircraft's schedule similar to the Wizz Air Autumn 2021 schedule from Catania. To do two very short-haul destinations such as Luxembourg and Eindhoven would be combined with the shortest long-haul sector possible as show in Table 7.

Table 7: Interworking aircraft (not crew): two short haul rotations followed by a long-haul rotation

Origin	**Departure time at origin**	**Departure time at destination**	**Destination**	**Arrival time at origin**	**Arrival time at destination**	**Travel time in hours**
London (STN)	08.30	07.30	Luxembourg (LUX)	09.45	08.45	1.15
Luxembourg (LUX)	09.20	10.20	London (STN)	10.40	11.40	1.20
London (STN)	12.10	11.10	Eindhoven (EIN)	13.15	12.15	1.05
Eindhoven (EIN)	12.40	13.40	London (STN)	13.45	14.45	1.05
London (STN)	15.45	10.45	Boston (BOS)	22.45	17.45	7.00
Boston (BOS)	19.00	00.00	London (STN)	01.30	06.30*	6.30
Total 24-hour utilization (flight hours)						18:15

*Once landed in STN, the plane will then have 2 hours for the daily maintenance and to board the passengers for the first flight of the day.

With this configuration, six daily flights are operable with a long-haul route included, keeping travel times from a passenger perspective workable, with limited time for maintenance in the morning, and workable turnarounds. With this schedule reduced crew efficiency would be a likely outcome as the crew operating

the first four sectors would not be able to complete the outward long-haul route anymore and would have to finish their flight duty periods there and then or with one further short-haul rotation on a separate aircraft. Two further crews would still be needed to fulfill the long-haul outward and return schedule, though they could still be used for a shorter sector on a separate aircraft at either end of the route. Clearly, the number of realistic combinations of destinations using an interworked six flight in a day solution would be limited to domestic or very short intra-continental flights. Although maximizing aircraft utilization, this would need to be balanced against the risk of cumulating delays and deteriorations in the customer experience due to the lack of buffer time and redundancy in the schedule.

Assumptions for common thresholds in a four-sector interworked solution like that shown in Table 6 is a maximum of 8/8.15 hours for the long-haul part and no more than 1.5 hours for the short haul sector, leaving enough time for longer turnarounds and maintenance activity. As traveling westward across the Atlantic takes a little longer than coming back because of Jet Stream wind patterns the maximum sector length of 8/8.15 hours should be considered as an average across the outward and return legs.

3.5. Analysis of possible routes

Some range calculations were undertaken to identify potential routes that do not exceed the maximum payload ranges as outlined in Table 2. Table 8 details an extract from the full chart of considered routes, which can be found in Appendix A.

Table 8: Transatlantic route range possibilities using new narrow body aircraft

Distance (in km)		Canada					USA								
City of Departure / Arrival	Bermuda	Quebec	Montreal	Ottawa	Toronto	Hamilton	Boston	New York	Philadelphia	Baltimora	Washington	Pittsburg	Columbus	Cleveland	Detroit
Rome	6730	6380	6610	6760	7110	7180	6620	6900	7040	7200	7240	7360	7600	7420	7430
Florence / Pisa	6500	6110	6340	6490	6840	7000	6360	6650	6790	6930	6980	7090	7330	7130	7170
Bologna	6540	6120	6350	6500	6850	6900	6370	6670	6810	6950	7000	7100	7340	7160	7170
Venice	6590	6130	6360	6500	6860	6920	6390	6680	6820	6980	7020	7110	7350	7170	7190
Milan	6310	5880	6150	6260	6600	6700	6210	6410	6560	6720	6740	6880	7120	6910	7010
Turin	6230	5830	6080	6190	6550	6640	6090	6360	6490	6680	6680	6820	7060	6870	6900
Nice	6250	5910	6130	6280	6620	6700	6130	6430	6560	6720	6760	6870	7120	6940	6960
Marseille	6100	5790	6010	6170	6510	6580	6000	6290	6420	6600	6670	6750	7000	6790	6840
Lyon	6020	5640	5870	6010	6330	6430	5880	6170	6290	6470	6480	6620	6850	6670	6700
Paris	5780	5300	5540	5680	6010	6090	5560	5850	5980	6140	6170	6280	6510	6330	6350
Touluse	5790	5500	5730	5890	6240	6290	5710	6020	6140	6280	6340	6460	6710	6530	6560
Bordeaux	5600	5290	5520	5670	6020	6080	5500	5810	5940	6080	6130	6250	6500	6320	6360
Alicante	5760	5690	5910	6060	6400	6470	5840	6130	6260	6410	6440	6600	6860	6690	6740
Malaga	5470	5500	5700	5870	6200	6270	5620	5910	6020	6160	6220	6390	6640	6480	6540
Barcelona	5900	5680	5890	6060	6390	6470	5870	6150	6290	6460	6460	6630	6880	6710	6750
Madrid	5470	5340	5570	5720	6010	6110	5510	5790	5930	6060	6120	6260	6500	6350	6410
Valencia	5740	5570	5840	6000	6330	6420	5790	6050	6200	6380	6370	6540	6800	6620	6700
Siviglia	5330	5350	5550	5720	6010	6120	5470	5750	5880	6030	6040	6240	6500	6330	6400
Lisbon	5020	5030	5220	5390	5740	5800	5150	5430	5550	5720	5720	5920	6170	6000	6090
Porto	5020	4920	5140	5290	5650	5700	5070	5360	5490	5630	5680	5840	6100	5920	5970
Dublin	5150	4550	4770	4900	5260	5340	4830	5130	5260	5430	5450	5530	5760	5560	5590
Cork	4990	4450	4680	4830	5180	5240	4720	5000	5150	5310	5350	5440	5670	5490	5500
Belfast	5160	4500	4730	4870	5220	5310	4800	5080	5230	5410	5430	5500	5750	5530	5540
Manchester	5410	4790	5020	5160	5500	5580	5090	5360	5500	5680	5690	5790	6020	5830	5850
Birmingham	5450	4860	5100	5230	5580	5640	5150	5450	5580	5740	5780	5860	6080	5900	5900
Liverpool	5370	4760	5000	5120	5460	5530	5050	5340	5470	5640	5660	5750	5970	5800	5800
Glasgow	5280	4570	4800	4930	5280	5370	4900	5180	5310	5480	5490	5570	5810	5570	5610
Edinburgh	5340	4630	4850	4980	5340	5430	4950	5230	5360	5540	5550	5630	5870	5650	5660
London	5560	5020	5240	5390	5730	5800	5350	5580	5690	5880	5880	5980	6240	6060	6080
Amsterdam	5900	5270	5500	5650	5980	6060	5580	5870	5990	6160	6170	6270	6510	6320	6310
Eindhoven	5950	5350	5580	5720	6070	6140	5650	5940	6070	6220	6270	6350	6580	6400	6390
Bruxelles	5900	5350	5580	5720	6050	6110	5640	5920	6060	6200	6230	6340	6540	6390	6400
Luxembourg	6020	5500	5740	5870	6210	6280	5780	6070	6210	6350	6380	6490	6720	6520	6550
Oslo	6140	5260	5680	5600	5930	6010	5630	5910	6010	6210	6210	6250	6460	6290	6240
Dusseldorf	6160	5450	5670	5890	6170	6240	5730	6040	6170	6330	6370	6450	6680	6490	6480
Hamburg	6220	5530	5760	5890	6230	6310	5850	6120	6270	6430	6480	6520	6750	6570	6550
Cologne	6070	5430	5720	5860	6200	6270	5790	6070	6210	6360	6400	6480	6710	6520	6530
Frankfurt	6200	5640	5870	6010	6350	6420	5940	6200	6350	6500	6510	6630	6850	6660	6670
Stuttgart	6270	5740	5970	6110	6460	6530	6020	6300	6450	6610	6650	6730	6960	6780	6780
Berlin	6480	5800	6010	6160	6480	6560	6120	6410	6550	6680	6740	6800	7010	6820	6820
Munich	6470	5920	6150	6290	6640	6710	6210	6490	6630	6790	6800	6910	7150	6950	6960
Geneva	6100	5680	5910	6050	6410	6480	5920	6210	6360	6510	6550	6660	6900	6720	6730
Zurich	6250	5790	6000	6150	6490	6560	6040	6320	6470	6620	6670	6750	7000	6810	6820
Copenaghen	6350	5580	5800	5930	6260	6330	5920	6210	6330	6480	6510	6570	6770	6570	6580
Malmo	6390	5630	5850	5970	6300	6370	5970	6250	6370	6520	6570	6620	6810	6650	6630
Stockholm	6570	5650	5870	5990	6310	6410	6010	6310	6430	6610	6620	6640	6860	6650	6620
Wien	6810	6230	6470	6610	6950	7010	6530	6820	6960	7020	7150	7230	7430	7260	7270

Aircraft Type	Range at Max Payload (km)	Routes Idintified
A321LR	X<5600	143
737Max8	5600<X<5900	266
A321XLR	5900<X<6500	613
	6500<X<6750	791

*All the route distances are rounded to the second decimal. Source: Great Circle Distance Mapper

The color-coded legend depicts route combinations that are and are not possible with the selected aircraft. Green coded routes are achievable with the A321LR, yellow coded routes with the B737MAX8 and light blue by the A321XLR. Orange coded combinations are also possible with the A321XLR but, given they are over 8.15 hours fight time, it would not be feasible to interwork them with a short-haul sector on the operating day.

In the conservative scenario a 250km margin for error was applied for the A321s, and a 100km margin for the 737 MAX, to reflect situations where actual meteorological conditions and indirect routings can lead to distance underestimations. Results are shown as an extract in Table 9 with the full details provided in Appendix A.

Table 9: Transatlantic route range possibilities using new narrow body aircraft (conservative scenario)

Distance (in km)		Canada					USA								
City of Departure / Arrival	Bermuda	Quebec	Montreal	Ottawa	Toronto	Hamilton	Boston	New York	Philadelphia	Baltimora	Washington	Pittsburg	Columbus	Cleveland	Detroit
Rome	6730	6380	6610	6760	7110	7180	6620	6900	7040	7200	7240	7360	7600	7420	7430
Florence / Pisa	6500	6110	6340	6490	6840	7000	6360	6650	6790	6930	6980	7090	7330	7130	7170
Bologna	6540	6120	6350	6500	6850	6900	6370	6670	6810	6950	7000	7100	7340	7160	7170
Venice	6590	6130	6360	6500	6860	6920	6390	6680	6820	6980	7020	7110	7350	7170	7190
Milan	6310	5880	6150	6260	6600	6700	6210	6410	6560	6720	6740	6880	7120	6910	7010
Turin	6230	5830	6080	6190	6550	6640	6090	6360	6490	6680	6680	6820	7060	6870	6900
Nice	6250	5910	6130	6280	6620	6700	6130	6430	6560	6720	6760	6870	7120	6940	6960
Marseille	6100	5790	6010	6170	6510	6580	6000	6290	6420	6600	6670	6750	7000	6790	6840
Lyon	6020	5640	5870	6010	6330	6430	5880	6170	6290	6470	6480	6620	6850	6670	6700
Paris	5780	5300	5540	5680	6010	6090	5560	5850	5980	6140	6170	6280	6510	6330	6350
Toulouse	5790	5500	5730	5890	6240	6290	5710	6020	6140	6280	6340	6460	6710	6530	6560
Bordeaux	5600	5290	5520	5670	6020	6080	5500	5810	5940	6080	6130	6250	6500	6320	6360
Alicante	5760	5690	5910	6060	6400	6470	5840	6130	6260	6410	6440	6600	6860	6690	6740
Malaga	5470	5500	5700	5870	6200	6270	5620	5910	6020	6160	6220	6390	6640	6480	6540
Barcelona	5900	5680	5890	6060	6390	6470	5870	6150	6290	6460	6460	6630	6880	6710	6750
Madrid	5470	5340	5570	5720	6010	6110	5510	5790	5930	6060	6120	6260	6500	6350	6410
Valencia	5740	5570	5840	6000	6330	6420	5790	6050	6200	6380	6370	6540	6800	6620	6700
Siviglia	5330	5330	5550	5720	6010	6120	5470	5750	5880	6030	6040	6240	6500	6330	6400
Lisbon	5020	5030	5220	5390	5740	5800	5150	5430	5550	5720	5720	5920	6170	6000	6090
Porto	5020	4920	5140	5290	5650	5700	5070	5360	5490	5630	5680	5840	6100	5920	5970
Dublin	5150	4550	4770	4900	5260	5340	4830	5130	5260	5430	5450	5530	5760	5560	5590
Cork	4990	4450	4680	4830	5180	5240	4720	5000	5150	5310	5350	5440	5670	5490	5500
Belfast	5160	4500	4730	4870	5220	5310	4800	5080	5230	5410	5430	5500	5750	5530	5540
Manchester	5410	4790	5020	5160	5500	5580	5090	5360	5500	5680	5690	5790	6020	5830	5850
Birmingham	5450	4860	5100	5230	5580	5640	5150	5450	5580	5740	5780	5860	6080	5900	5900
Liverpool	5370	4760	5000	5120	5460	5530	5050	5340	5470	5640	5660	5750	5970	5800	5800
Glasgow	5280	4570	4800	4930	5280	5370	4900	5180	5310	5480	5490	5570	5810	5570	5610
Edinburgh	5340	4630	4850	4980	5340	5430	4950	5230	5360	5540	5550	5630	5870	5650	5660
London	5560	5020	5240	5390	5730	5800	5350	5580	5690	5880	5880	5980	6240	6060	6080
Amsterdam	5900	5270	5500	5650	5980	6060	5580	5870	5990	6160	6170	6270	6510	6320	6310
Eindhoven	5950	5350	5580	5720	6070	6140	5650	5940	6070	6220	6270	6350	6580	6400	6390
Bruxelles	5900	5350	5580	5720	6050	6110	5640	5920	6060	6200	6230	6340	6540	6390	6400
Luxembourg	6030	5500	5740	5870	6210	6280	5780	6070	6210	6350	6380	6490	6720	6520	6550
Oslo	6140	5260	5680	5600	5930	6010	5630	5910	6010	6210	6210	6250	6460	6290	6240
Dusseldorf	6160	5450	5670	5890	6170	6240	5730	6040	6170	6330	6370	6450	6680	6490	6480
Hamburg	6220	5530	5760	5890	6230	6310	5850	6120	6270	6430	6480	6520	6750	6570	6550
Cologne	6070	5490	5720	5860	6200	6270	5790	6070	6210	6360	6400	6490	6710	6520	6530
Frankfurt	6200	5640	5870	6010	6350	6420	5940	6200	6350	6500	6510	6630	6850	6660	6670
Stuttgart	6270	5740	5970	6110	6460	6530	6020	6300	6450	6610	6650	6730	6960	6780	6780
Berlin	6480	5800	6010	6160	6480	6560	6120	6410	6550	6680	6740	6800	7010	6820	6820
Munich	6470	5920	6150	6290	6640	6710	6210	6480	6630	6790	6800	6910	7150	6950	6960
Geneva	6100	5680	5910	6050	6410	6480	5920	6210	6360	6510	6550	6660	6900	6720	6730
Zurich	6250	5790	6000	6150	6490	6560	6040	6320	6470	6620	6670	6750	7000	6810	6820
Copenaghen	6350	5580	5800	5930	6260	6330	5920	6210	6330	6480	6510	6570	6770	6570	6580
Malmo	6390	5630	5850	5970	6300	6370	5970	6250	6370	6520	6570	6620	6810	6650	6630
Stockholm	6570	5650	5870	5990	6310	6410	6010	6310	6430	6610	6620	6640	6860	6650	6620
Wien	6810	6230	6470	6610	6950	7010	6530	6820	6960	7020	7150	7230	7430	7260	7270

Source: Great Circle Distance Mapper

Aircraft Type	Range at Max Payload (km)	Routes Idintified
A321LR	X<5350	73
737Max8	5350<X<5800	219
A321XLR	5800<X<6500	613

Although in the conservative scenario the number of possible transatlantic routes decreased from 791 to 613, estimated flight times for all 613 routes in the conservative scenario are less than 8:15 hours fight time, meaning that an interworked short-haul sector could be bolted on to an aircraft's daily schedule in all 613 cases.

From the analysis the impact of the new A321XLR is quite clear with an additional 394 transatlantic route combinations coming within range in the conservative scenario. Such routes, of course, are purely theoretical, given the many other planning considerations surrounding route development including critically pinpointing what levels of demand could be with new direct capacity. In the case of Quebec City, for example, the chances of attracting a good volume of demand would naturally be stronger from France, which shares some cultural aspects. Another possibility could be on winter sun routes that have not yet been tapped into, such as Dublin to points in the Caribbean such as Antigua, Puerto Rico, Dominican Republic, or Barbados.

Another potential barrier relates to the location of current bases and aircraft. Wizz Air, for example, has most of its bases in East Europe, and unsurprisingly they focus more on eastbound rather than westbound for long-haul. Over the longer-term new bases can open, either on a permanent or a seasonal winter basis, which would conform to this study's underpinning goal. Fleet composition is another clear barrier. A321LRs have not become very popular among European budget airlines, partly due to seating capacity reductions of about 40 seats compared to the standard A321neo. Thus, the main focus for higher density, longer-range aircraft fall on the 737MAX and A321XLR. Carriers would need a critical mass of these aircraft, however, to start making interworked transatlantic routes in winter feasible. Ryanair, for example, aims to have 212 737MAX8 in their fleet by 2025 (O'Leary, 2021), which is more than enough to focus on the Atlantic. Conversely, Wizz Air has only 20 A321XLRs on order that will be part of 376 units fleet by 2026, meaning that the chances of being able to maximize scale efficiencies during winter months will be only limited to 20 aircraft. If Wizz Air were to increase their focus on narrow body long-haul then it may be possible to purchase more A321XLRs rather than standard A321neos since the price would not be substantially different (CUMMINS, 2020).

3.6 Increased block hour opportunity

In Figure 3 we saw that the annual average block hours in the European low-cost market is almost 11 block hours per day, with downturns in winter to 7/8 per day, whilst in the summer the peak it reaches 13 hours per day. To understand how much the implementation of transatlantic flights would be able to counteract the seasonality of the demand, WizzAir and Ryanair were selected as major European LCCs for a block hour analysis since their situation in terms of fleet composition and bases makes transatlantic operations possible.

3.6.1 Ryanair

Ryanair has more than 200 737MAX8 on order, and it is well established in all locations in western Europe from which it could fly across the Atlantic. From the preceding analysis, at least 219 routes using the B737MAX are feasible from Europe, and Ryanair already has an active presence in these European destinations. Hypothetically, with enough demand Ryanair could use all its 200 MAXs to run daily transatlantic operations, whilst using mainly their 737-800ERs for Europe only operations.

If 180 of the 219 route combinations were to be initiated with biweekly operations between October and March, average flight hours on such routes would be 15 for a roundtrip. Thus, every month there would be an increase of 23.38 flight hours. As the MAXs join the fleet, the denominator for the block hours increases as well: Ryanair foresees a fleet of 600 aircraft in total with the arrival of the MAXs, which brings 23.38 hours of flight time to add 1.29 block hours in each month that they would operate transatlantic flights. Ryanair has an annual average of 9.23 block hours, and between November and February it ranges from 6.64 to 7.35. Assuming 1.29 block hours are added in each of these months, the increase would be at least 17.6% monthly, and 7.8% annually, taking the average from 9.23 to 9.94 block hours.

Since FR have a sufficient number of MAXs at their disposal. If they chose to employ each MAX on the Atlantic everyday during the winter, the amount of block hours they could add would be as much as 5.05, exceeding even the summer levels. Obviously, there is no chance that each of these routes have enough demand to require daily operations, but at the same time this prospect gives an indication that Ryanair could easily seize this potential market within the scope of its future fleet.

Figure 4 shows the baseline block hour distribution in blue, the levels that could be reached with the implementation of 180 transatlantic routes in red, and the levels it could reach employing all ordered MAXs on daily basis on all 219 routes during the winter in yellow.

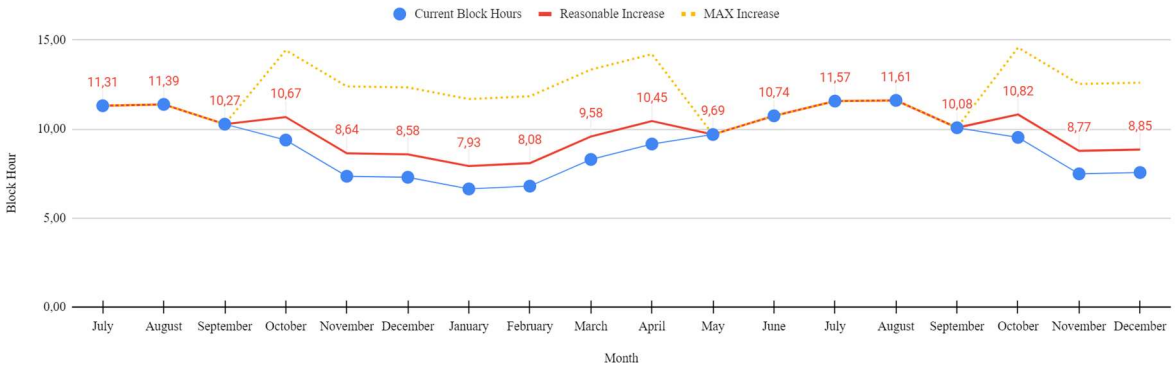


Figure 4: Average block hours for Ryanair in base case (blue), twice weekly winter transatlantic services on 180 route combinations (red) and daily winter services on all 219 route combinations using all ordered MAX aircraft (yellow)

3.6.2 Wizz Air

Wizz Air is in a totally different situation; in terms of transatlantic operations it would be distinct from Ryanair. While Ryanair could fly on only 219 routes with the MAX, Wizz Air has an immense potential of 613 routes with the A321XLR, but at the same time Ryanair is well located in western Europe and it could operate these new routes with its existing bases, whilst Wizz Air is mostly rooted in Eastern Europe and not too many transatlantic routes are available from there. Plus, at the time of writing Ryanair has 200 MAXs on order while Wizz Air only has 47 XLRs. This means that Ryanair has less fleet potential, but all the capacity to expand into this market, whereas Wizz Air has more fleet potential, but less geographical advantage and fleet capacity to exploit it. This comparison is summarized in Table 10.

Table 10: WizzAir and Ryanair interworked long-haul potentiality

	Ryanair	**Wizz Air**
LR narrow body Fleet Capacity	200	47
Potential Routes	219	629
Geographical position for transatlantic	Good	Weak
Annual block hour difference estimate	0.71 (9.23 – 9.94)	1.01 (12.85 – 13.59)

For WizzAir it is hypothesized, for the purposes of this proof of concept, that it will have established several bases in western Europe. WizzAir has already demonstrated an interest in this market with a bid to buy EasyJet in 2021, which was refused by the latter. Given the main constraint for WizzAir would be its A321XLR fleet size we use fleet as the main driver restricting potential volumes of transatlantic operations.

If it is assumed that 30 out of the 47 ordered XLRs, are used for transatlantic flights during winter period, the number of routes that could be served is large (629). To reach each of those with a single flight per week a dedicated fleet of 90 XLRs would be needed. Since it is unrealistic to imagine such a hypothesis, it is assumed that 30 XLRs could be employed daily for a long-haul rotation, regardless of the route served.

Considering, as before, an average of 15 hours per roundtrip flight, the number of additional flight hours per month would be 13.64, which divided into a future fleet of 450 aircraft results in an estimated annual average of 1.01 additional block hours. Wizz Air has average block hours of 12.58, with winter downturns reducing to virtually 10 block hours, so an increase of 1.01 would mean an increase of 10% during winter months, and an increase of 4.5% on the annual average.

Displaying the maximum increase in capacity in the same way as with Ryanair and assuming full usage of the XLRs fleet on a daily basis during the winter season, the amount of additional block hours would become 1.58, or a 15% increase in winter months and 7% overall.

Figure 5 shows the baseline block hours of WizzAir in blue, the reasonable increase scenario of 30 XLRs operating daily long-haul operations in pink and the whole XLRs fleet on a daily basis scenario in green.

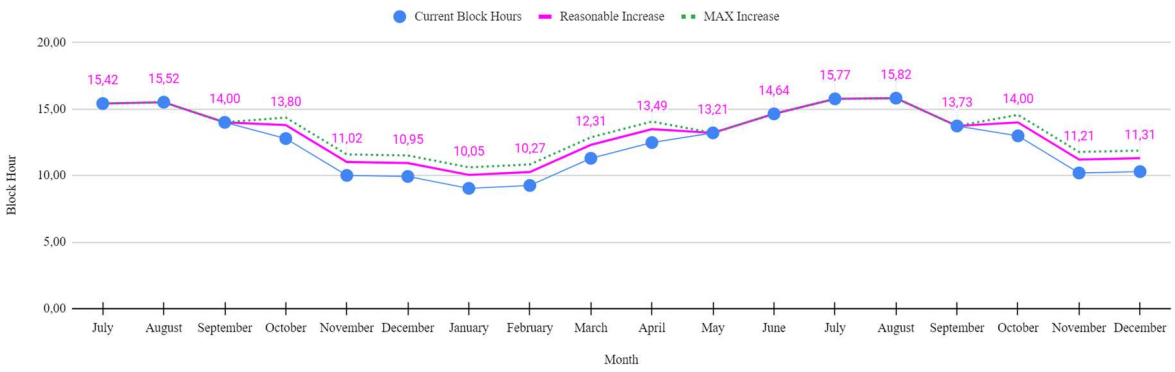


Figure 5: Average block hours for WizzAir in base case (blue), 30 XLRs on a daily long haul transatlantic service in winter (pink) and using all 47 ordered XLRs daily in the winter months (green)

Despite the wider number of long-haul route combinations available with the A321XLR, Ryanair clearly has the greater scope economies opportunity due to the flexibility it would have with a larger long range narrow body aircraft order.

4. Benefits and drawbacks of European LCCs operating long-haul winter flights across the Atlantic

4.1 Exploitation of time zone differences

In the busy European summer, an LCC aircraft's block hours can reach up to 18 hours per day, with the first flight taking off at 6am and the last one landing around midnight. Night periods are often used for daily maintenance that can take around an hour and a half, but it they are also very useful for schedule "*fire-breaks*" so that can any accumulated delays on the previous day can be reset for the following day.

It would be possible to utilize modern A320 and B737 aircraft for yet more hours but given Europe is broken down into only three different GMTs and flights usually last for no more than 3-4 hours it is difficult to exploit nights for additional sectors where demand would naturally be low due to the disturbed sleep patterns and poor onward connections that early morning flights would involve.

Operating on longer Atlantic sectors mean time zone differences are big enough to make a difference in demand patters and airline scheduling. For European airlines there are two advantages in going westward for time zone exploitation: first arrivals into the American would be at an earlier, more reasonable time often in daylight hours and secondly daily maintenance routines could be kept in the early morning. To illustrate the point, a flight departing from Europe in the afternoon would arrive on east coast USA by the early evening, giving passengers time to reach their final resting point by night time. After a turnaround, the evening return flight would also be convenient, helping passengers to sleep during the flight, and brings them to their destination in the morning where they can proceed with their day with good onward connections. The aircraft would also be back at base for daily morning maintenance.

4.2 Point to Point model

The point-to-point model has two main advantages, one from the company point of view and from the passenger perspective:

- **Company perspective:** Complexity of hub operations and offering online or interline connections is avoided and turnaround times can be reduced. More secondary or second tier markets can be served directly, stimulating additional demand.
- **Passenger perspective:** The point-to-point system reduces total travel time for passenger since no stops are needed and the vast majority of consumers want to reach their destinations quickly and economically (Picardo E., 2022).

With the proposed interworked model in this study it could be possible for European LCCs to start increasing their offering of what could be described as a low-cost version of hub connections either through self-connections, where no published connection is available and the financial risk of missed connections lies with the passenger or as an ancillary product, which LCCs could sell for more than it might cost to take on some connection liability. European LCCs would effectively have the choice to stay true to the simplicity of their point-to-point model or to introduce some complexity if the financial gain outweighs the cost of doing so.

4.3 Winter holidays

Winter Sun belongs to the travel industry terminology and indicates those destinations that are targeted by travelers because they are hot in winter. Airlines are well familiar with this concept, and many try to exploit it as much as possible, for example British Airways offers winter flights to Dubai, Barbados, and Mauritius (British Airways, 2022); American Airlines offers winter flights to the Caribbean, Mexico, Florida (American Airlines, 2022); but also, within Europe, LCCs can focus on the Canaries, Morocco, Red Sea Resorts and even Middle East destinations such as Jordan and Israel during the winter.

Despite the availability of some warm European destinations over the winter, demand is not strong enough to utilize European LCC fleets enough. Going transatlantic could allow some LCCs to target routes that reach longer haul winter spots, such as: Bermuda, Antigua, the Virgin Islands, Puerto Rico, Guadeloupe, St. Lucia, Martinique, Dominican Republic and Barbados (See Appendix 1 for details on options).

For some destination airports winter sun demand can outweigh total demand in some hub airports during the winter months. In a typical week of November all the Canary Island airports, for example, combined see

more departures (3,145 in total) than London Heathrow (2,692), Paris Charles De Gaulle (2,371) or even JFK (2,898) (FlightRadar24, 2021).

4.4 Crew stopovers

On long-haul sectors there is a need for crew stopovers due to flight duty hour regulations. While many other costs can be somehow incorporated into existing departments and operations, this one cannot be amortized. Once the decision is taken to implement Atlantic routes, the aim would be to try to reduce these extra costs to a minimum through, for example, signing bilateral agreements between airlines hotels (or a chain) and trying to arrange scheduled in order to reduce crew time spent away. EASA regulations stipulate that the minimum rest a crew must have between two transatlantic flights is 14 hours (Easa, 2021). For the reasons outlined in section 4.1 arrivals into the American would typically happen in the evening meaning crews would be able to rest at least 24 hours. In addition not all the destinations will have enough demand to schedule one flight per day, therefore either the crew would need to stop for more days or triangulations with multiple origins could be arranged. The concept of triangulation would be to arrange flights to make a crew that arrived at the destination (point B) from an origin A in Europe on a certain date, fly back to an third point C in Europe and then move from point C back to A with a domestic or regional flight. The same will happen for crews that arrived at destination (point B) from point C. Another cost reduction measure related to crew stopovers could be to have dedicated crews for short haul and long haul so that the long haul crew as a percentage of the total would be quite small given the majority of European LCC traffic would continue to be short-haul and it could reduce the number of crew that would need to be partake in stopovers and number of crew members need to undertaken additional training would be lower (see section 4.5).

4.5 Crew training

Crews, both pilots and flight attendants, are required to pass periodic examinations to test their ability to manage different critical situations that may occur. These examinations, that comprise both simulator details and recurrent online courses, are scheduled and executed in compliance with the relative regulations that do not particularly differ in terms of jurisdiction as they are based on ICAO's directives, but do differ in terms

of type of flight. A long-haul flight has some different aspects compared to the short haul ones, and some specific training should be provided in order to enable the crews to operate these flights (e.g. an ETOPS course). Also, this kind of cost does not represent a totally new expense but would belong to training activities and centres that already exist in the daily operations of airlines, and consequently the related costs would be incorporated and amortized within existing departments.

4.6 The need for flexible use of cabins

As mentioned in section 2.2, Michael O'Leary stated on numerous occasions that for LCCs entering long-haul markets the aircraft need to be configured with a double cabin. In other words, premium class passengers, subsidising cheaper economy class fares.

European business class travel has changed in recent years and this may be the solution to the cabin issue. Many airlines no longer have a dedicated business class cabin on short haul markets. Instead, a full economy class cabin is utilized with a movable curtain to act as a divide between business and economy class. As seen in Table 11 the seat pitch and seat width are standardised throughout the cabin across the main European full-service airlines. The exception to this is the bulkhead and emergency exit seats, which may offer more legroom. Additionally, some airlines may differentiate in the quality of the seat it has in the business class section. In the flex cabin configuration, airlines can sell business class tickets and only use the window and aisle seats, leaving the middle seat free, thus giving the illusion of a bigger seat.

Table 11: European legacy carriers narrow body aircraft business class details

Airline	Rows	Middle Seat	Pitch	Width	Comments
AF	Adjustable	Free	29-32**	18	
AY	Adjustable	Free	31	18	
BA	Adjustable	Free	30	17	
IB	Adjustable	Free	30-31**	17	** Dependant on a/c and curtain divider
KL	Adjustable***	Free	33	17	*** Not all a/c have movable curtain divider
LH	Adjustable	Free	30	18	
LX	Adjustable	Free*	31-34**	18	* A220 Seat Configuration is 2 / 3

Source: Compiled using airline websites and seatguru.com, (2022).

The benefit of such a system is that the revenue management team can adjust their inventory according to demand. Initially, the flight can go on sale with the first four rows as the premium seats and the remainder as economy seats. The economy passengers paying to pre-assign seats would see availability from row 13 and above. Rows 5 – 12 will be blocked and passengers unable to buy them. Should the airline see demand for the premium product is high, then it could add a further four rows to the premium class inventory. If demand for premium seats is not high, then the airline can release rows 9 – 12 into the economy inventory, safeguarding rows 5 – 8 for future allocation to either cabin. This affords flexibility to the airline and it does not require additional time to transition from short-haul operations to long-haul.

5. Conclusions

Although long-haul low-cost operations are no longer a new concept, this study proposes a scheduling concept that can allow LCCs to take advantage of new longer range narrow body aircraft coming into the market and in doing so provide a greater level of sustained competition for full-service airlines wishing to either downgauge their own aircraft within a dedicated long-haul network or maintain existing widebody long-haul aircraft.

Despite various specific models being considered, to our knowledge none of them consider the exact same terms that are explored in this study – namely the economies of scope opportunity for European budget airlines if they interwork transatlantic rotations into short-haul schedules as an answer to the lower demand experienced in Europe during the winter months.

The paper describes this type of solution can become feasible thanks to the arrival of the 737MAX, and the upcoming A321XLR. Describing the features of the two aircrafts we reported their range capacity with operations at maximum payload with the A321XLR displaying superior characteristics in this regard.

To demonstrate the proposal, a sample of interworked aircraft schedules were provided, and some comparisons with similar, already-existing operations in the market. We reported some of the potential transatlantic routes using both a base and conservative range scenario. Even in the conservative range scenario it would be possible for the A321XLR to serve over 600 transatlantic route combinations with the B737MAX8 able to serve over 200 of them.

The estimated impact of these operations on aircraft block hour utilization was also examined using the cases of WizzAir and Ryanair as two of the largest European LCCs in the market in 2022. It is clear that the additional coverage allowed through introducing long-haul rotations and interworked solutions in winter months could increase average annual block hours by between 7% and 8%. Interestingly, though WizzAir has opted for the superior long-range narrow body options, their smaller A321XLR order in comparison to Ryanair's 737MAX order, means more scope opportunities would exist for Ryanair in addition to its current advantage in terms of its number of western European bases.

The wider pros and cons of implementing this proposal were also discussed and included the exploitation of time zones, the opportunity for flexible use of the LCC point-to-point model, exploiting price elastic demand for longer haul winter sun destinations, the need for crew stopovers, additional crew training and a requirement for flexible cabins on aircraft that would be interworked respectively. The points act as an introduction only and would need further consideration in future research.

In conclusion, although this research is limited to a proof of concept analysis, it has been possible to understand that European LCCs going transatlantic can be positive. First it could help carriers to counteract the low season, leading to higher annual aircraft utilization and second, many destination options are available, most not currently served by competitors and more so with the introduction of the new A321XLR. Each individual carrier would have their own bespoke considerations to make on the feasibility of this mode and future research could explore further testing of the proof of concept on specific case carriers to detect opportunities and barriers.

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Appendix A: Transatlantic route range possibilities with new narrow body aircraft

Distance (in km)			Canada					USA						
	City of Departure / Arrival	Bermuda	Quebec	Montreal	Ottawa	Toronto	Hamilton	Boston	New York	Philadelphia	Baltimora	Washington	Pittsburg	Columbus
Italy	Rome	6730	6380	6610	6760	7110	7180	6620	6900	7040	7200	7240	7360	7600
	Florence / Pisa	6500	6110	6340	6490	6840	7000	6360	6650	6790	6930	6980	7090	7330
	Bologna	6540	6120	6350	6500	6850	6900	6370	6670	6810	6950	7000	7100	7340
	Venice	6590	6130	6360	6500	6860	6920	6390	6680	6820	6980	7020	7110	7350
	Milan	6310	5880	6150	6260	6600	6700	6210	6410	6560	6720	6740	6880	7120
	Turin	6230	5830	6080	6190	6550	6640	6090	6360	6490	6680	6680	6820	7060
France	Nice	6250	5910	6130	6280	6620	6700	6130	6430	6560	6720	6760	6870	7120
	Marseille	6100	5790	6010	6170	6510	6580	6000	6290	6420	6600	6670	6750	7000
	Lyon	6020	5640	5870	6010	6330	6430	5880	6170	6290	6470	6480	6620	6850
	Paris	5780	5300	5540	5680	6010	6090	5560	5850	5980	6140	6170	6280	6510
	Touluse	5790	5500	5730	5890	6240	6290	5710	6020	6140	6280	6340	6460	6710
	Bordeaux	5600	5290	5520	5670	6020	6080	5500	5810	5940	6080	6130	6250	6500
Spain	Alicante	5760	5690	5910	6060	6400	6470	5840	6130	6260	6410	6440	6600	6860
	Malaga	5470	5500	5700	5870	6200	6270	5620	5910	6020	6160	6220	6390	6640
	Barcelona	5900	5680	5890	6060	6390	6470	5870	6150	6290	6460	6460	6630	6880
	Madrid	5470	5340	5570	5720	6010	6110	5510	5790	5930	6060	6120	6260	6500
	Valencia	5740	5570	5840	6000	6330	6420	5790	6050	6200	6380	6370	6540	6800
	Siviglia	5330	5350	5550	5720	6010	6120	5470	5750	5880	6030	6040	6240	6500
Portugal	Lisbon	5020	5030	5220	5390	5740	5800	5150	5430	5550	5720	5720	5920	6170
	Porto	5020	4920	5140	5290	5650	5700	5070	5360	5490	5630	5680	5840	6100
Ireland	Dublin	5150	4550	4770	4900	5260	5340	4830	5130	5260	5430	5450	5530	5760
	Cork	4990	4450	4680	4830	5180	5240	4720	5000	5150	5310	5350	5440	5670
UK	Belfast	5160	4500	4730	4870	5220	5310	4800	5080	5230	5410	5430	5500	5750
	Manchester	5410	4790	5020	5160	5500	5580	5090	5360	5500	5680	5690	5790	6020
	Birmingham	5450	4860	5100	5230	5580	5640	5150	5450	5580	5740	5780	5860	6080
	Liverpool	5370	4760	5000	5120	5460	5530	5050	5340	5470	5640	5660	5750	5970
	Glasgow	5280	4570	4800	4930	5280	5370	4900	5180	5310	5480	5490	5570	5810
	Edinburgh	5340	4630	4850	4980	5340	5430	4950	5230	5360	5540	5550	5630	5870
	London	5560	5020	5240	5390	5730	5800	5350	5580	5690	5880	5880	5980	6240
Netherland	Amsterdam	5900	5270	5500	5650	5980	6060	5580	5870	5990	6160	6170	6270	6510
	Eindhoven	5950	5350	5580	5720	6070	6140	5650	5940	6070	6220	6270	6350	6580
Belgium	Bruxelles	5900	5350	5580	5720	6050	6110	5640	5920	6060	6200	6230	6340	6540
Luxembourg	Luxembourg	6030	5500	5740	5870	6210	6280	5780	6070	6210	6350	6380	6490	6720
Norway	Oslo	6140	5260	5680	5600	5930	6010	5630	5910	6010	6210	6210	6250	6460
Germany	Dusseldorf	6160	5450	5670	5890	6170	6240	5730	6040	6170	6330	6370	6450	6680
	Hamburg	6220	5530	5760	5890	6230	6310	5850	6120	6270	6430	6480	6520	6750
	Cologne	6070	5490	5720	5860	6200	6270	5790	6070	6210	6360	6400	6490	6710
	Frankfurt	6200	5640	5870	6010	6350	6420	5940	6200	6350	6500	6510	6630	6850
	Stuttgart	6270	5740	5970	6110	6460	6530	6020	6300	6450	6610	6650	6730	6960
	Berlin	6480	5800	6010	6160	6480	6560	6120	6410	6550	6680	6740	6800	7010
	Munich	6470	5920	6150	6290	6640	6710	6210	6480	6630	6790	6800	6910	7150
Switzerland	Geneva	6100	5680	5910	6050	6410	6480	5920	6210	6360	6510	6550	6660	6900
	Zurich	6250	5790	6000	6150	6490	6560	6040	6320	6470	6620	6670	6750	7000
Denmark	Copenaghen	6350	5580	5800	5930	6260	6330	5920	6210	6330	6480	6510	6570	6770
Sweden	Malmo	6390	5630	5850	5970	6300	6370	5970	6250	6370	6520	6570	6620	6810
	Stockholm	6570	5650	5870	5990	6310	6410	6010	6310	6430	6610	6620	6640	6860
Austria	Wien	6810	6230	6470	6610	6950	7010	6530	6820	6960	7020	7150	7230	7430

Distance (in km)		USA				Caribbeans									
	City of Departure / Arrival	Cleveland	Detroit	Milwaukee	Chicago	Antigua	US Virgin Island	saint kitties	Porto Rico	Guadalupe	Dominique	Martinique	Barbados	Saint Vincent	Grenada
Italy	Rome	7420	7430	7710	7780	7490	7680	7550	7750	7540	7580	7590	7570	7710	7840
	Florence / Pisa	7130	7170	7440	7510	7300	7490	7360	7550	7360	7390	7420	7410	7540	7670
	Bologna	7160	7170	7440	7500	7380	7550	7430	7620	7420	7470	7490	7490	7620	7740
	Venice	7170	7190	7440	7500	7450	7630	7500	7700	7530	7540	7570	7580	7700	7840
	Milan	6910	7010	7230	7290	7180	7370	7230	7430	7230	7270	7290	7300	7410	7570
	Turin	6870	6900	7170	7230	7080	7280	7150	7330	7140	7170	7200	7210	7330	7470
France	Nice	6940	6960	7240	7310	7050	7240	7290	7350	7080	7140	7170	7160	7290	7400
	Marseille	6790	6840	7130	7180	6880	7090	6940	7190	6940	6970	6950	6990	7130	7270
	Lyon	6670	6700	6970	7030	6880	7070	6940	7140	6950	6973	7010	7020	7140	7280
	Paris	6330	6350	6600	6680	6720	6910	6770	6980	6800	6850	6880	6900	7000	7160
	Touluse	6530	6560	6860	6910	6580	6760	6630	6840	6630	6660	6690	6690	6810	6940
	Bordeaux	6320	6360	6640	6710	6430	6610	6480	6680	6460	6510	6550	6560	6680	6800
Spain	Alicante	6690	6740	7060	7110	6370	6580	6430	6670	6390	6430	6450	6420	6560	6680
	Malaga	6480	6540	6870	6900	6000	6230	6070	6320	6030	6070	6090	6060	6190	6310
	Barcelona	6710	6750	7020	7110	6610	6830	6700	6920	6670	6700	6720	6710	6840	6970
	Madrid	6350	6410	6520	6770	6120	6330	6170	6440	6190	6220	6250	6230	6340	6480
	Valencia	6620	6700	7010	7050	6390	6600	6460	6710	6430	6450	6480	6460	6600	6730
	Siviglia	6330	6400	6520	6760	5880	6110	5950	6200	5940	5950	5970	5950	6080	6220
Portugal	Lisbon	6000	6090	6410	6450	5630	5850	5690	5940	5680	5710	5720	5710	5840	5980
	Porto	5920	5970	6300	6340	5720	5920	5780	6000	5770	5800	5830	5830	5950	6080
Ireland	Dublin	5560	5590	5840	5910	6240	6380	6280	6430	6320	6370	6420	6470	6550	6700
	Cork	5490	5500	5760	5840	6050	6190	6090	6230	6120	6170	6220	6260	6360	6510
UK	Belfast	5530	5540	5800	5850	6290	6420	6340	6440	6380	6420	6470	6520	6630	6770
	Manchester	5830	5850	6080	6150	6500	6600	6540	6690	6580	6610	6670	6710	6820	6970
	Birmingham	5900	5900	6150	6230	6510	6650	6570	6700	6580	6620	6670	6710	6820	6970
	Liverpool	5800	5800	6040	6140	6450	6650	6500	6650	6530	6590	6630	6680	6770	6910
	Glasgow	5570	5610	5850	5940	6450	6570	6490	6610	6520	6570	6630	6680	6780	6930
	Edinburgh	5650	5660	5900	5990	6510	6650	6560	6680	6590	6640	6690	6740	6850	6990
	London	6060	6080	6330	6420	6600	6750	6630	6820	6660	6690	6770	6770	6890	7030
Netherland	Amsterdam	6320	6310	6550	6640	6950	7110	6990	7160	7010	7060	7100	7140	7260	7400
	Eindhoven	6400	6390	6630	6700	6970	7120	7020	7180	7030	7080	7120	7160	7270	7390
Belgium	Bruxelles	6390	6400	6610	6730	6880	7050	6940	7120	6960	7000	7040	7070	7180	7320
Luxembourg	Luxembourg	6520	6550	6790	6890	7000	7170	7050	7210	7080	7110	7150	7170	7280	7420
Norway	Oslo	6290	6240	6430	6550	7410	7520	7450	7520	7460	7510	7570	7630	7760	7900
Germany	Dusseldorf	6490	6480	6730	6800	7060	7060	7110	7250	7140	7170	7210	7240	7350	7480
	Hamburg	6570	6550	6780	6850	7240	7460	7350	7500	7380	7420	7470	7500	7610	7750
	Cologne	6520	6530	6770	6850	7070	7240	7120	7270	7150	7200	7230	7260	7360	7510
	Frankfurt	6660	6670	6920	7000	7190	7350	7240	7430	7260	7300	7340	7360	7470	7610
	Stuttgart	6780	6780	7030	7110	7220	7390	7260	7480	7280	7320	7350	7380	7490	7640
	Berlin	6820	6820	7030	7130	7530	7680	7580	7750	7610	7640	7690	7720	7820	7970
	Munich	6950	6960	7220	7280	7400	7560	7440	7620	7470	7500	7540	7560	7660	7800
Switzerland	Geneva	6720	6730	7010	7060	6970	7150	7030	7200	7030	7070	7100	7110	7230	7370
	Zurich	6810	6820	7080	7150	7160	7340	7210	7380	7230	7260	7300	7310	7430	7570
Denmark	Copenaghen	6570	6580	6780	6880	7470	7620	7520	7660	7560	7570	7660	7680	7790	7940
Sweden	Malmo	6650	6630	6820	6910	7510	7650	7550	7700	7570	7650	7700	7750	7830	7970
	Stockholm	6650	6620	6810	6880	7810	7940	7860	7950	7900	7950	7990	8060	8150	8310
Austria	Wien	7260	7270	7490	7580	7760	7930	7800	8000	7840	7870	7900	7910	8010	8160

Aircraft Type	Range at Max Payload (km)	Routes Idintified
A321LR	X<5600	143
737Max8	5600<X<5900	266
A321XLR	5900<X<6500	613
	6500<X<6750	791

Distance (in km)			Canada					USA						
	City of Departure / Arrival	Bermuda	Quebec	Montreal	Ottawa	Toronto	Hamilton	Boston	New York	Philadelphia	Baltimora	Washington	Pittsburg	Columbus
Italy	Rome	6730	6380	6610	6760	7110	7180	6620	6900	7040	7200	7240	7360	7600
	Florence / Pisa	6500	6110	6340	6490	6840	7000	6360	6650	6790	6930	6980	7090	7330
	Bologna	6540	6120	6350	6500	6850	6900	6370	6670	6810	6950	7000	7100	7340
	Venice	6590	6130	6360	6500	6860	6920	6390	6680	6820	6980	7020	7110	7350
	Milan	6310	5880	6150	6260	6600	6700	6210	6410	6560	6720	6740	6880	7120
	Turin	6230	5830	6080	6190	6550	6640	6090	6360	6490	6680	6680	6820	7060
France	Nice	6250	5910	6130	6280	6620	6700	6130	6430	6560	6720	6760	6870	7120
	Marseille	6100	5790	6010	6170	6510	6580	6000	6290	6420	6600	6670	6750	7000
	Lyon	6020	5640	5870	6010	6330	6430	5880	6170	6290	6470	6480	6620	6850
	Paris	5780	5300	5540	5680	6010	6090	5560	5850	5980	6140	6170	6280	6510
	Touluse	5790	5500	5730	5890	6240	6290	5710	6020	6140	6280	6340	6460	6710
	Bordeaux	5600	5290	5520	5670	6020	6080	5500	5810	5940	6080	6130	6250	6500
Spain	Alicante	5760	5690	5910	6060	6400	6470	5840	6130	6260	6410	6440	6600	6860
	Malaga	5470	5500	5700	5870	6200	6270	5620	5910	6020	6160	6220	6390	6640
	Barcelona	5900	5680	5890	6060	6390	6470	5870	6150	6290	6460	6460	6630	6880
	Madrid	5470	5340	5570	5720	6010	6110	5510	5790	5930	6060	6120	6260	6500
	Valencia	5740	5570	5840	6000	6330	6420	5790	6050	6200	6380	6370	6540	6800
	Siviglia	5330	5350	5550	5720	6010	6120	5470	5750	5880	6030	6040	6240	6500
Portugal	Lisbon	5020	5030	5220	5390	5740	5800	5150	5430	5550	5720	5720	5920	6170
	Porto	5020	4920	5140	5290	5650	5700	5070	5360	5490	5630	5680	5840	6100
Ireland	Dublin	5150	4550	4770	4900	5260	5340	4830	5130	5260	5430	5450	5530	5760
	Cork	4990	4450	4680	4830	5180	5240	4720	5000	5150	5310	5350	5440	5670
UK	Belfast	5160	4500	4730	4870	5220	5310	4800	5080	5230	5410	5430	5500	5750
	Manchester	5410	4790	5020	5160	5500	5580	5090	5360	5500	5680	5690	5790	6020
	Birmingham	5450	4860	5100	5230	5580	5640	5150	5450	5580	5740	5780	5860	6080
	Liverpool	5370	4760	5000	5120	5460	5530	5050	5340	5470	5640	5660	5750	5970
	Glasgow	5280	4570	4800	4930	5280	5370	4900	5180	5310	5480	5490	5570	5810
	Edinburgh	5340	4630	4850	4980	5340	5430	4950	5230	5360	5540	5550	5630	5870
	London	5560	5020	5240	5390	5730	5800	5350	5580	5690	5880	5880	5980	6240
Netherland	Amsterdam	5900	5270	5500	5650	5980	6060	5580	5870	5990	6160	6170	6270	6510
	Eindhoven	5950	5350	5580	5720	6070	6140	5650	5940	6070	6220	6270	6350	6580
Belgium	Bruxelles	5900	5350	5580	5720	6050	6110	5640	5920	6060	6200	6230	6340	6540
Luxembourg	Luxembourg	6030	5500	5740	5870	6210	6280	5780	6070	6210	6350	6380	6490	6720
Norway	Oslo	6140	5260	5680	5600	5930	6010	5630	5910	6010	6210	6210	6250	6460
Germany	Dusseldorf	6160	5450	5670	5890	6170	6240	5730	6040	6170	6330	6370	6450	6680
	Hamburg	6220	5530	5760	5890	6230	6310	5850	6120	6270	6430	6480	6520	6750
	Cologne	6070	5490	5720	5860	6200	6270	5790	6070	6210	6360	6400	6490	6710
	Frankfurt	6200	5640	5870	6010	6350	6420	5940	6200	6350	6500	6510	6630	6850
	Stuttgart	6270	5740	5970	6110	6460	6530	6020	6300	6450	6610	6650	6730	6960
	Berlin	6480	5800	6010	6160	6480	6560	6120	6410	6550	6680	6740	6800	7010
	Munich	6470	5920	6150	6290	6640	6710	6210	6480	6630	6790	6800	6910	7150
Switzerland	Geneva	6100	5680	5910	6050	6410	6480	5920	6210	6360	6510	6550	6660	6900
	Zurich	6250	5790	6000	6150	6490	6560	6040	6320	6470	6620	6670	6750	7000
Denmark	Copenaghen	6350	5580	5800	5930	6260	6330	5920	6210	6330	6480	6510	6570	6770
Sweden	Malmo	6390	5630	5850	5970	6300	6370	5970	6250	6370	6520	6570	6620	6810
	Stockholm	6570	5650	5870	5990	6310	6410	6010	6310	6430	6610	6620	6640	6860
Austria	Wien	6810	6230	6470	6610	6950	7010	6530	6820	6960	7020	7150	7230	7430

Distance (in km)		USA				Caribbeans									
	City of Departure / Arrival	Cleveland	Detroit	Milwaukee	Chicago	Antigua	US Virgin Island	Saint Kitties	Porto Rico	Guadalupe	Dominique	Martinique	Barbados	Saint Vincent	Grenada
Italy	Rome	7420	7430	7710	7780	7490	7680	7550	7750	7540	7580	7590	7570	7710	7840
	Florence / Pisa	7130	7170	7440	7510	7300	7490	7360	7550	7360	7390	7420	7410	7540	7670
	Bologna	7160	7170	7440	7500	7380	7550	7430	7620	7420	7470	7490	7490	7620	7740
	Venice	7170	7190	7440	7500	7450	7630	7500	7700	7530	7540	7570	7580	7700	7840
	Milan	6910	7010	7230	7290	7180	7370	7230	7430	7230	7270	7290	7300	7410	7570
	Turin	6870	6900	7170	7230	7080	7280	7150	7330	7140	7170	7200	7210	7330	7470
France	Nice	6940	6960	7240	7310	7050	7240	7290	7350	7080	7140	7170	7160	7290	7400
	Marseille	6790	6840	7130	7180	6880	7090	6940	7190	6940	6970	6950	6990	7130	7270
	Lyon	6670	6700	6970	7030	6880	7070	6940	7140	6950	6973	7010	7020	7140	7280
	Paris	6330	6350	6600	6680	6720	6910	6770	6980	6800	6850	6880	6900	7000	7160
	Touluse	6530	6560	6860	6910	6580	6760	6630	6840	6630	6660	6690	6690	6810	6940
	Bordeaux	6320	6360	6640	6710	6430	6610	6480	6680	6460	6510	6550	6560	6680	6800
Spain	Alicante	6690	6740	7060	7110	6370	6580	6430	6670	6390	6430	6450	6420	6560	6680
	Malaga	6480	6540	6870	6900	6000	6230	6070	6320	6030	6070	6090	6060	6190	6310
	Barcelona	6710	6750	7020	7110	6610	6830	6700	6920	6670	6700	6720	6710	6840	6970
	Madrid	6350	6410	6520	6770	6120	6330	6170	6440	6190	6220	6250	6230	6340	6480
	Valencia	6620	6700	7010	7050	6390	6600	6460	6710	6430	6450	6480	6460	6600	6730
	Siviglia	6330	6400	6520	6760	5880	6110	5950	6200	5940	5950	5970	5950	6080	6220
Portugal	Lisbon	6000	6090	6410	6450	5630	5850	5690	5940	5680	5710	5720	5710	5840	5980
	Porto	5920	5970	6300	6340	5720	5920	5780	6000	5770	5800	5830	5830	5950	6080
Ireland	Dublin	5560	5590	5840	5910	6240	6380	6280	6430	6320	6370	6420	6470	6550	6700
	Cork	5490	5500	5760	5840	6050	6190	6090	6230	6120	6170	6220	6260	6360	6510
UK	Belfast	5530	5540	5800	5850	6290	6420	6340	6440	6380	6420	6470	6520	6630	6770
	Manchester	5830	5850	6080	6150	6500	6600	6540	6690	6580	6610	6670	6710	6820	6970
	Birmingham	5900	5900	6150	6230	6510	6650	6570	6700	6580	6620	6670	6710	6820	6970
	Liverpool	5800	5800	6040	6140	6450	6650	6500	6650	6530	6590	6630	6680	6770	6910
	Glasgow	5570	5610	5850	5940	6450	6570	6490	6610	6520	6570	6630	6680	6780	6930
	Edinburgh	5650	5660	5900	5990	6510	6650	6560	6680	6590	6640	6690	6740	6850	6990
	London	6060	6080	6330	6420	6600	6750	6630	6820	6660	6690	6770	6770	6890	7030
Netherland	Amsterdam	6320	6310	6550	6640	6950	7110	6990	7160	7010	7060	7100	7140	7260	7400
	Eindhoven	6400	6390	6630	6700	6970	7120	7020	7180	7030	7080	7120	7160	7270	7390
Belgium	Bruxelles	6390	6400	6610	6730	6880	7050	6940	7120	6960	7000	7040	7070	7180	7320
Luxembourg	Luxembourg	6520	6550	6790	6890	7000	7170	7050	7210	7080	7110	7150	7170	7280	7420
Norway	Oslo	6290	6240	6430	6550	7410	7520	7450	7520	7460	7510	7570	7630	7760	7900
Germany	Dusseldorf	6490	6480	6730	6800	7060	7060	7110	7250	7140	7170	7210	7240	7350	7480
	Hamburg	6570	6550	6780	6850	7240	7460	7350	7500	7380	7420	7470	7500	7610	7750
	Cologne	6520	6530	6770	6850	7070	7240	7120	7270	7150	7200	7230	7260	7360	7510
	Frankfurt	6660	6670	6920	7000	7190	7350	7240	7430	7260	7300	7340	7360	7470	7610
	Stuttgart	6780	6780	7030	7110	7220	7390	7260	7480	7280	7320	7350	7380	7490	7640
	Berlin	6820	6820	7030	7130	7530	7680	7580	7750	7610	7640	7690	7720	7820	7970
	Munich	6950	6960	7220	7280	7400	7560	7440	7620	7470	7500	7540	7560	7660	7800
Switzerland	Geneva	6720	6730	7010	7060	6970	7150	7030	7200	7030	7070	7100	7110	7230	7370
	Zurich	6810	6820	7080	7150	7160	7340	7210	7380	7230	7260	7300	7310	7430	7570
Denmark	Copenaghen	6570	6580	6780	6880	7470	7620	7520	7660	7560	7570	7660	7680	7790	7940
Sweden	Malmo	6650	6630	6820	6910	7510	7650	7550	7700	7570	7650	7700	7750	7830	7970
	Stockholm	6650	6620	6810	6880	7810	7940	7860	7950	7900	7950	7990	8060	8150	8310
Austria	Wien	7260	7270	7490	7580	7760	7930	7800	8000	7840	7870	7900	7910	8010	8160

Aircraft Type	Range at Max Payload (km)	Routes Idintified
A321LR	X<5350	73
737Max8	5350<X<5800	219
A321XLR	5800<X<6500	613