

# The 737 MAX – Taking Flight

A PRODUCT ASSESSMENT



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**AVOLON** 

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### **Acknowledgement:**

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## Contents

The 737 Max - Taking Flight	2
Executive Summary	3
Key Findings	4
The Evolution of the 737 MAX	5
The 737 MAX Market and Competition	12
Risks and Mitigants	17
The 737 MAX Investor Proposition	20
Conclusions	22
<hr/>	
<b>Appendix A</b>	
Aircraft Cash Operating Cost	23
<hr/>	
<b>Appendix B</b>	
Airlines without MAX Commitments that have previously ordered 737NGs	24

## The 737 MAX – Taking Flight

Boeing unveiled the 737 MAX in August 2011 in response to Airbus' A320neo. The new family of MAX 7, MAX 8 and MAX 9 was designed to deliver maximum efficiency, reliability and comfort and leverages the strength of the existing 737NG with new technology CFM International LEAP-1B engines. The family has taken over 4,500 orders and commitments, of which the majority are for the 737 MAX 8 model. The MAX 7 and MAX 9 models have not shared the MAX 8's success, which has led to several tactical product line changes to re-position the new family, most recently introducing the MAX 10, which fills a crucial gap in the family and could be a game-changer.



Boeing unveiled the 737 Max in  
**August 2011**



The 737 Max family has  
**>4,500 orders**



## Executive Summary

This paper presents Avolon's assessment of the 737 MAX family and analyses the impact of the evolving changes to the family's composition on the narrowbody market. The key issues being debated by the industry are addressed: how will the MAX 10 improve the marketability of the MAX Family? Will it be a capable competitor for the A321neo? Has the airline industry's capacity up-gauging trend diluted the MAX 7's market and will recent changes to its design improve its prospects for investors and airlines? Is the MAX 9 now a marginalized product and will more customers migrate to the newly launched MAX 10? With only three customers, what is the outlook for the MAX 200? Will the LEAP engine, the chief source of efficiency, deliver on its promises?

At a broader level, the paper analyses the strategic moves that led to the launch of the MAX family and how Boeing responded to the strategic dilemma presented by Airbus. If Boeing had launched today's fully formed 737 MAX family in 2011 would their new-technology narrowbody market share split be closer to parity with Airbus? Why did Boeing launch the 737 MAX program without sufficient attention to the strengths of the A321neo? Why has Boeing's MAX strategy been more reactive compared to other programs? How has Airbus benefited from Boeing's iterative MAX family design?

Investors will be predominantly focused on the MAX 8, which remains the heart of the market. With the launch of the MAX 10, Boeing has the means to correct much of its market share imbalance with Airbus. With some limitations, the MAX 10 has the potential to replicate the MAX 8's market strength, resulting in two strong family members. Although later to market than the A321neo, the MAX 10 is a better competitor than the MAX 9, will protect Boeing from customer defections and addresses the growth needs of existing 737 operators. The MAX 9 is now wedged between other family members and has an uncertain future due to its marginalized role in the family. The MAX 200, a sub-variant of the MAX 8, has not proven to be the game-changer that Boeing expected and has gained very little traction with its target low cost and ULCC market. The MAX 7 has become a niche product for performance and range driven by a shift away from smaller variants of the narrowbody market, but if innovatively priced could do better than its current performance suggests.



## Key Findings



Boeing's MAX product strategy decisions have been reactive, resulting in lower market share and a plethora of variants which do not all reflect actual market demand.



The rush to get the **737 MAX** to market caused Boeing to neglect Airbus' key strength, the **A321**.



The recent launch of the **MAX 10** has strengthened the MAX family and has already doubled Boeing's market share in the large narrowbody segment. The aircraft is right-sized and will be a capable seat-cost machine for operators looking to grow beyond the **737-800** and **MAX 8**. Although the **A321neo** will remain the seat cost leader in high density configurations, the **MAX 10** is a much improved competitor compared to the **MAX 9**.



The **MAX 8** remains the heart of the MAX family and a key target for investors. The aircraft has maintained its Cash Operating Cost (COC) advantage over the **A320neo**, albeit only by a small margin.



A well understood, cost efficient and timely reconfiguration package to convert the **MAX 200** aircraft to the **MAX 8** model is required to increase investor appetite for the type in the event that sales pick up.



The **MAX 7** is a niche product when performance and range is required. The market shift away from smaller variants has been driven by several factors, including unit price and the focus of the LCCs on larger models. A change in pricing strategy could stimulate further demand.



The value proposition of the **MAX 9** has been severely impacted by the launch of the **MAX 10**. It is unclear what role remains for the aircraft but it is expected to have a very limited future.



**CFM** will deliver on its fuel burn commitment for the Leap engine, however it will be challenged to meet the cost performance of its predecessor, the CFM56. It is imperative that CFM puts commercial measures in place to allow the benefit of maintenance agreements to survive multiple operators and owners.

## The Evolution of the 737 MAX

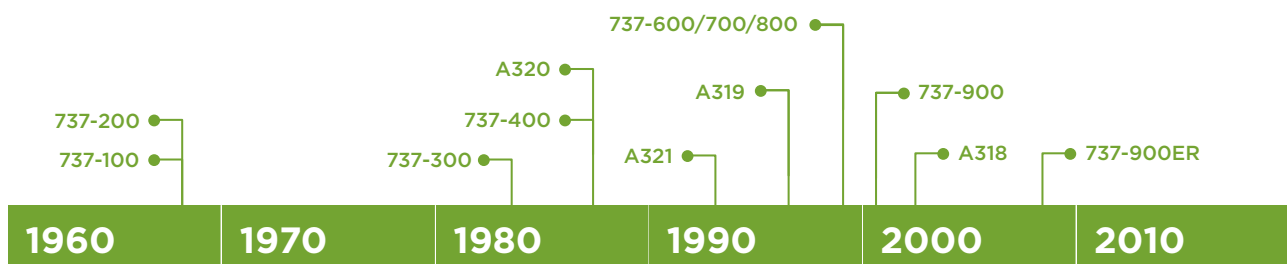
**The first MAX aircraft was delivered in May 2017, almost exactly 50 years after the first flight of the 737. The original 737-100 series model, with 85 seats in a 2-class configuration, was quickly followed by the -200, which went on to sell more than 1,100 units to well over 100 airlines.**

In 1981, the successor to the -200 was announced, a stretched and re-engined aircraft that encompassed a range of aerodynamic, structural and cabin features developed for the 757 and 767. The baseline 737-300 was offered alongside a stretched -400 and a -500 shrink and this 737 Classic family sold almost 2,000 aircraft to airlines and lessors, with the -300 variant accounting for over 50% at the then market sweet-spot of ~150 seats.

In 1984, Airbus entered the single aisle market with the launch of the A320, which began service in 1988, as depicted below in *Exhibit 1*. Within five years, despite Airbus' new entrant status, it had achieved significant competitive success against a 737 family that did not match its capabilities.

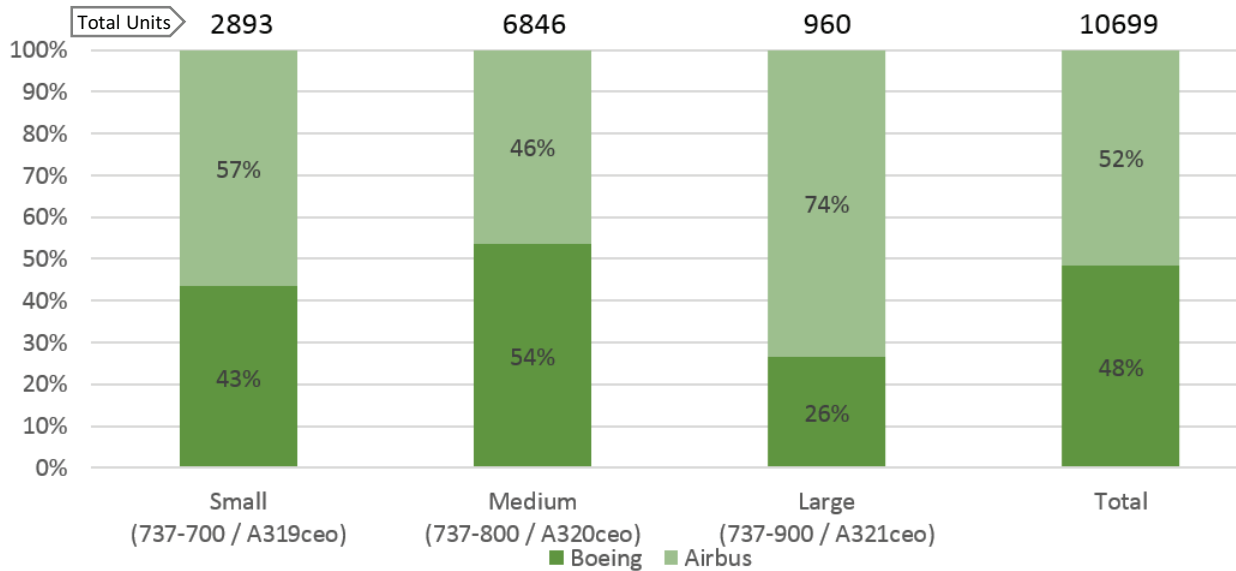
Consequently, in 1993, Boeing launched the 737 NG family, which evolved to broadly match the A320 family product range across four size segments. The design focus for the 737 NG was higher structural efficiency, greater range and performance, better fuel efficiency, lower maintenance cost and higher reliability and passenger comfort. Boeing's centerline aircraft, the -800, was significantly upgraded in terms of capacity, range and performance relative to the -400 and became a capable competitor to the A320, which was slightly smaller. Boeing has continued to develop the NG family with the addition of blended winglets, engine upgrades, aerodynamic improvements, the Boeing Sky Interior along with several navigation and avionics improvements.

**Exhibit 1: Airbus A320 Family and Boeing 737 Family Entry into Service Dates**



Whilst demand for the smallest gauge family members never took off, Boeing and Airbus achieved broad sales share parity overall and in two of the three remaining size segments over the period from the launch of the NG to the announcement of the NEO. However, at the largest end of the range, Boeing’s initial offering, the -900, failed to deliver on customers’ requirements. This forced a re-design and launch of the -900ER relatively late in the day, leaving Boeing with less than 30% of this market segment (Exhibit 2), as even the redefined variant fell short of the payload/range capabilities of the A321 and never appealed to the wider 737 operator base.

**Exhibit 2: Airbus A320ceo Family and Boeing 737 NG Family Order Book Market Share**  
Firm orders from the launch of the 737NG to the launch of the A320neo





Whilst each manufacturer had contemplated a new clean sheet design to replace their existing aircraft programs, until 2010, neither Boeing nor Airbus saw an opportunity or risk significant enough to justify launching either a derivative or an all new program. However, in December 2010, Airbus launched the A320neo, which promised to deliver 15% better fuel burn with two new engine options – the Pratt and Whitney (P&W) Geared Turbofan and the CFM LEAP-1A.

Airbus's decision to launch a re-engined A320 family (comprising of three aircraft, without the slow-selling A318), was enabled by the availability of a new geared turbofan engine developed by P&W, who were extremely motivated to re-enter the single aisle market and had been selling the merits of the engine very aggressively to Airbus. With little in the way of other engineering modifications required to the airframe, this would be a relatively low-cost family upgrade and Airbus also concluded that Boeing's strategic options in response would be constrained by several factors, including the configuration and design of the 737 itself and Boeing's engineering and financial resources, both under pressure as a result of the 787 program problems. A "simple" re-engineing of the A320neo would therefore present Boeing with an extremely challenging technical and commercial dilemma. In addition, a number of new competitors were beginning to challenge the mid-market single aisle space, including Bombardier with their new CSeries, also P&W GTF-powered, and Airbus saw the NEO as a way to limit the traction of these new programs at an early stage.

In February of 2011 Boeing's CEO, Jim McNerney, told analysts "We're going to do a new airplane" stating that they were not yet done evaluating the situation but that their current bias was to move to an all new aircraft at the end of the decade. By July of that year sentiment had swung, American Airlines placed the largest order in aviation history and Boeing had partly lost a key customer.

American's order for 460 narrowbody aircraft included 130 A320neo Family aircraft and 100 of Boeing's "expected new evolution of the 737 NG". Airbus had forced Boeing to re-engine their 737 NG family to prevent American's complete defection. On the 30th August 2011, one month after American's order, Boeing officially launched the 737 MAX program.

A new clean-sheet design aircraft from Boeing would have left too much time between the entry-into-service of the A320neo and Boeing's new offering, severely impacting their market share. If launched in 2012, a new program may not have entered into service until the end of the decade, leaving at least four years since the entry-into-service of the A320neo. More concerning to Boeing was their ability to match the A320neo production rate with an all-new program. Boeing would have to achieve rates in excess of 50 aircraft per month from a standstill position, a major challenge with significant risks.

The "do nothing" alternative was not an option. Bombardier, COMAC, Irkut and Embraer had all launched new programs competing on top of, or encroaching on the lower end of the 737 NG Family. Boeing had to act to protect their market position from these new entrants and Airbus.

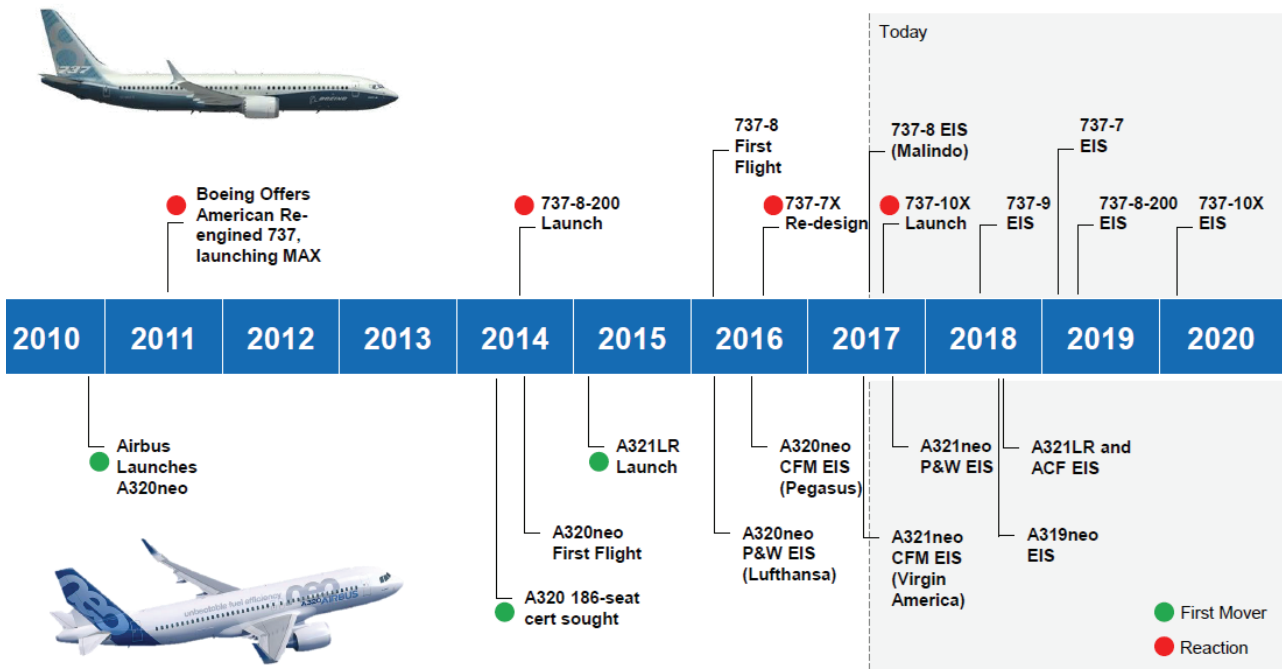


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Since engine efficiency and aircraft operating costs were key to countering Airbus’ A320neo, the challenge Boeing faced was to squeeze additional performance out of the existing platform. Throughout the development stage, the design underwent multiple changes: the engine diameter grew from 66 inches to 69.4 inches, a nose gear door bubble introduced to accommodate the modified gear was eliminated, the tail cone was re-shaped and advanced technology winglets were added. Boeing’s iterative design was an attempt to catch up with Airbus but this reactive approach, illustrated below in Exhibit 3, ultimately cost them market share, a situation they remain determined to remedy.

**Exhibit 3: 737 MAX and A320neo Program Timeline**

Boeing has struggled to match Airbus product strategy with their approach to MAX family development



The 737 MAX Family was originally launched with three members: the MAX 7, MAX 8 and MAX 9, each variant the same size as its NG predecessor. The main changes when comparing the 737 NG to the 737 MAX are shown below in Exhibit 4, the most significant being the new LEAP-1B engine, advanced technology winglets and aft body aerodynamic improvements. Since its original introduction, the MAX family has expanded: a higher capacity version of the MAX 8, the MAX 200 was launched in 2014; a stretched MAX 7 was announced in 2016, and a brand new model, the 737 MAX 10, was launched at the 2017 Paris Air Show.

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#### Exhibit 4: The 737 MAX Key Design Change

Source: Boeing



### **The 737 MAX 7**

The original MAX 7 had 400nm more range than its NG predecessor, allowing operators to serve new city pairs and to continue to use the aircraft's performance to add hot and high airport capability. By July 2016, approximately 1,200 737-700s were in active service, yet the MAX 7 had only secured 60 orders. With this limited sales traction, Boeing unveiled a re-design of the MAX 7 at the 2016 Farnborough Air Show. The changes from the original MAX 7 included a 76-inch stretch of the fuselage, use of the MAX 8's wing and landing gear, additional over wing exits and structural strengthening. The aircraft is now just under 13 feet shorter than the MAX 8, similar to the gap between the A319neo and A320neo. The Maximum-Take-off-Weight (MTOW) was increased to overcome the additional empty weight of the aircraft, allowing more range than the original MAX 7 and 800nm more range than the 737-700, almost two hours flying time. From a passenger perspective the aircraft can accommodate 12 more seats in a two class layout and up to 23 seats in a high density configuration.



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### **The 737 MAX 8**

The MAX 8 represents the largest opportunity for the 737 MAX family due to the popularity of the 737-800 and its size positioning at the heart of the market. The aircraft will fly over 500nm further than the -800 with a 7% lower cash operating cost. At the time of the MAX launch, Brent Crude prices were in excess of \$100/barrel meaning that an average operator would save over \$1.2 million per year per aircraft. Key customers were quick to order the MAX 8 and a year after the program was launched it had secured over 1,200 orders from 19 customers.

The 737-800 has a seat mile cash operating cost advantage over the heavier A320ceo as illustrated in Appendix A. The extra weight added to the MAX 8 along with its ground clearance restrictions helped Airbus to reduce this lead. For the low-cost carrier market, which is laser-focused on seat mile cost, Boeing wanted a solution to restore their original advantage, which led to the development of the MAX 200.

### **The 737 MAX 200**

In September 2014, Ryanair, became the launch customer for the MAX 200, a derivative of the MAX 8, with an order for 100 aircraft. Prior to this, Boeing, offering the MAX 8, had lost a series of key sales campaigns to Airbus. Boeing used the extra length of the MAX 8 airframe over the A320neo to enable the accommodation of up to 200 passengers by adding a mid-cabin exit door to the MAX 8 (*Exhibit 5*) along with local cabin modifications and a flight attendant station.

Avolon estimates that the aircraft will be approximately 600lb heavier with 300nm less range compared to the MAX 8. The additional seats on the aircraft will reduce galley space and overhead bin space on per passenger basis, and will also begin to encroach on the advantages of the larger MAX 9. Nevertheless, the capacity increase adds a significant incremental revenue opportunity over the MAX 8, with Ryanair expecting the higher seating capacity to add \$1 million per aircraft of annual revenue.

**Exhibit 5: Boeing 737 Max 200 New Exit Door Location**

Source: Boeing.com



***The 737 MAX 9***

The predecessor of the MAX 9, the 737-900ER, has not commanded the same success as Airbus' large narrowbody variant, but in the rush to get the 737 MAX to market Boeing neglected to consider and counter Airbus' key strength, the A321, instead opting to maintain the dimensions of the 737-900ER. Although the MAX 9 offers over 500nm more range as well as improved performance, the variant has not been a success. Prior to the 2017 Paris Air Show, Boeing had secured 231 announced orders compared to over 1,100 for the A321neo and the MAX 9 continued to suffer the same market pressure as the 737-900ER. As the market share gap with the NEO widened, this weakness in the portfolio urgently needed to be overcome.

***The 737 MAX 10***

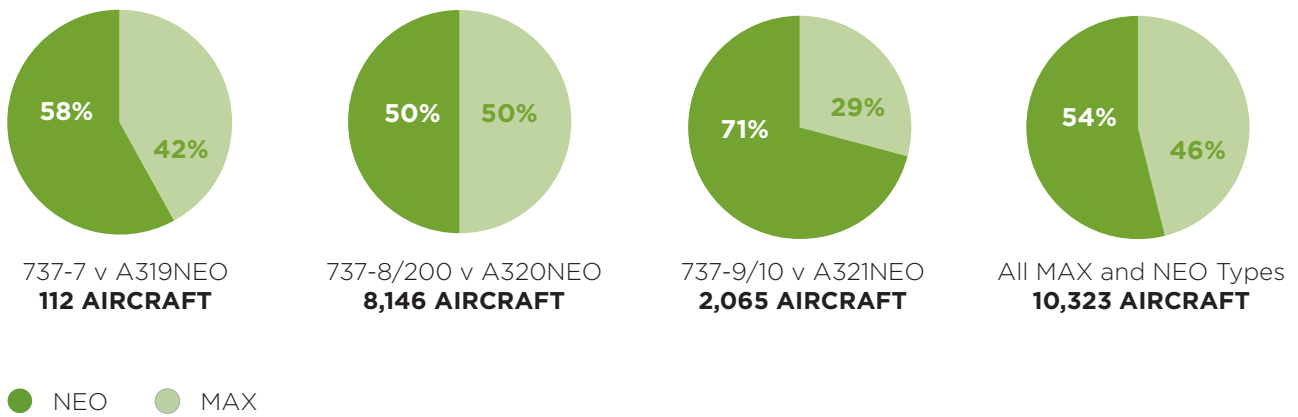
To address this market share gap, Boeing required a low-investment, low-risk development option to match the A321neo across the characteristics that airlines care about most: seat count and unit cost. The aircraft will have 300nm less range than the MAX 9, however range in excess of 3,000nm is only required for niche single-aisle markets. The MAX 10 was launched in Paris, securing orders and commitments for 361 aircraft over the Air Show week from a diverse mix of 16 customers including nine airlines.

The aircraft has a comparable seat count to the A321neo and transcontinental range. It will complete the MAX family with equally spaced seating capacities between the MAX 7, MAX 8 and MAX 10. Its flexibility in seating capacity and range capability avoids the mistakes of the original 737-900 design, which delivered only 52 units. Design changes for the MAX 10 include a fuselage stretch of 66 inches compared to the MAX 9 and semi-levered main landing gear to enhance low-speed performance.

## The 737 MAX Market and Competition

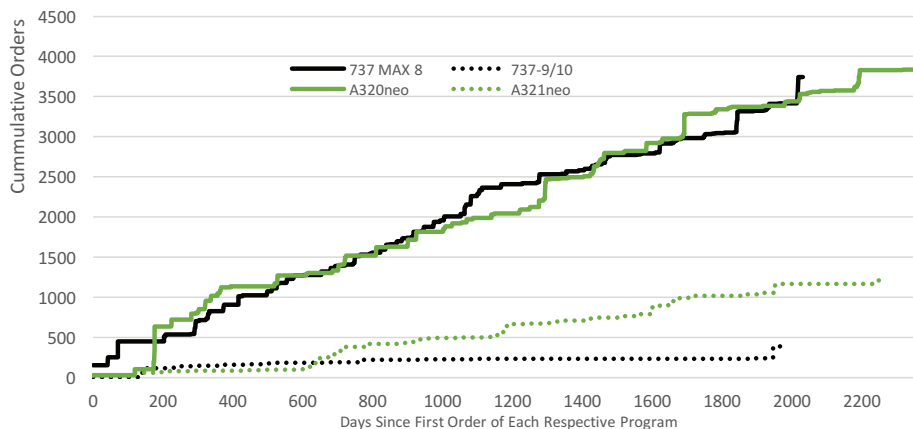
Both manufacturers have been successful in selling their re-engined narrowbody families. Together, enough NEO and MAX aircraft have been sold to replace 80% of today’s in service CEO and NG fleets. By the time of Boeing’s first firm MAX order in December 2011 Airbus had already received over 1,100 orders for its newly re-engined A320neo. Nevertheless, the total order book for the 737 MAX now stands at approximately 4,500 aircraft, 19% less than the A320neo, with an overall family market share split of 54/46 in favour of Airbus. The current market shares for each model (post-Paris Air Show) is shown below in Exhibit 6.

**Exhibit 6: NEO v MAX Market Share by Type**  
In Service, On Order and LOIs included



Analysis of the cumulative orders booked from the date of the first order for each type confirms Airbus to be the market leader, however, by subtype, the A320neo and 737 MAX 8 are tracking a very similar path, whilst the A321neo has pulled significantly ahead of the 737 MAX 9 (Exhibit 7), a gap that the 737 MAX 10 is designed to rectify.

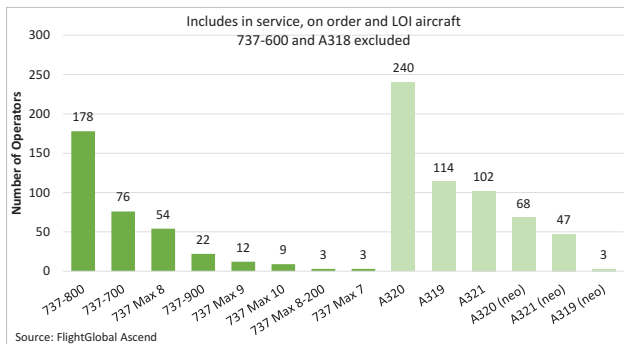
**Exhibit 7: NEO v MAX Orders**  
Baselined from date of the first order for each respective program  
A319neo and 737 MAX 7 not included



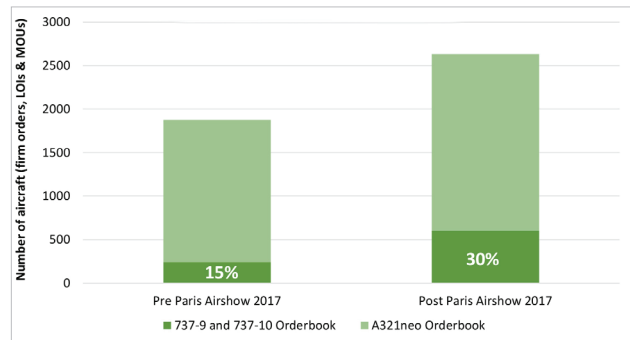
A key metric supporting aircraft residual values and investor appetite – is market liquidity. Airbus has positioned its A320ceo family well. The A319ceo, A320ceo and A321ceo have all exceeded over 100 operators (in service, on order and letters of intent) whereas Boeing has only achieved this with the 737-800 (*Exhibit 8*). The re-engined versions have not yet had the benefit of secondary market transactions to increase their operator base but it is apparent that the A320neo, A321neo and 737 MAX 8 have a clear lead over all other MAX or NEO types. The MAX 9, MAX 200, A319neo and MAX 7 all have a lot of ground to make up on their siblings and it might be already too late for these models to gain the momentum they need to be considered widely investable assets.

Entering the 2017 Paris Air Show, Boeing had a 15%<sup>1</sup> share of the total A321neo and 737 MAX 9 order book. By the close, with the MAX 10 included, this had grown to 30% (*Exhibit 9*). It is too early to know how the operator base will develop for the MAX 10 but it has already surpassed three of the re-engined models and is tracking closely behind the MAX 9 which, along with the MAX 8, is expected to experience further order conversions to the MAX 10. If the MAX 10 sales momentum continues it will result in two strong family members and a product line that is better able to compete with the A320neo.

**Exhibit 8: Airline Operators of A320 & 737 family members**  
Includes in service, on order and LOI aircraft  
737-600 and A318 excluded



**Exhibit 9: MAX 10 Paris Air Show impact on large segment market share**



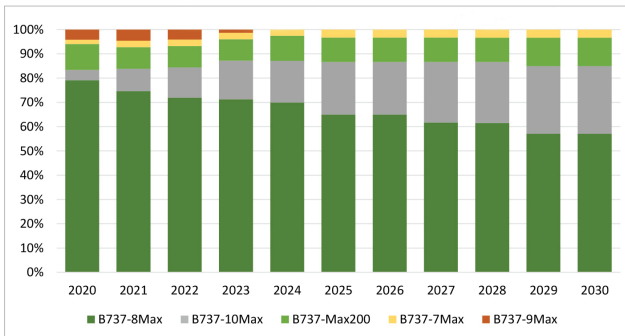
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1. Including firm orders, MOUs and LOIs

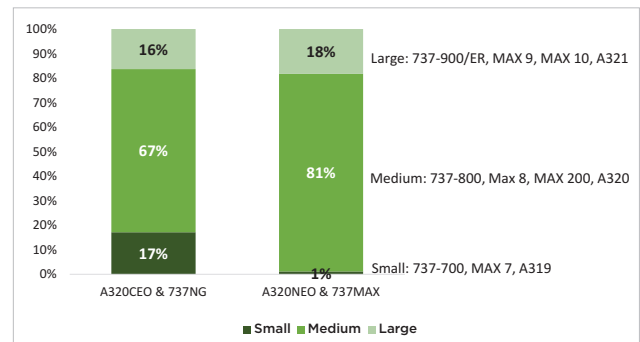
Avolon’s World Fleet Forecast (*Exhibit 10*) projects that the MAX 10 will account for approximately 20% of all 737 MAX family deliveries, which would equate to around 2,000 aircraft. This compares to the A321neo, which is forecast to account for 40% of the A320neo family, with over 4,000 deliveries.

Comparing the mix of the smaller variants of the current 737 NG and A320ceo family fleets with their re-engined successors, it is apparent that demand has shifted – the smaller variants of both families have all but disappeared from the order books. Whilst the 737-700 and A319ceo hold a combined 17% of the current fleet, the MAX 7 and A319neo account for a mere 1% of family orders (*Exhibit 11*).

**Exhibit 10:**  
**Forecast 737 MAX Family Production Share**  
Source: Avolon World Fleet Forecast 2017-2036



**Exhibit 11: A320 and 737 family share mix by size**



Whilst the 737-700 and A319ceo hold a combined 17% of the current fleet, the MAX 7 and A319neo account for a mere 1% of family orders (*Exhibit 11*).

As detailed on page 15, this shift in demand has been driven by several factors - the rise of internet and mobile bookings with increasing load factors focusing LCCs on larger aircraft; the average size of narrowbody aircraft today is significantly larger compared to when the 737NG was launched; the A320neo and MAX 8 offer enhanced take-off performance limiting the number of markets where performance aircraft like the MAX 7 and A319neo are needed.



## Drivers of the Up-Gauging Trend

The LCC Revolution	Turnaround Time Improvements																																																																		
<ul style="list-style-type: none"> <li>We have experienced a structural change in fares and non-fuel related costs. Since 2000, in the US domestic market alone, airfares (including fee revenue) net of taxes and adjusted for inflation have fallen 22%. With this the ability of the LCCs to fill seats is impressive</li> <li>The ease at which travelers can now purchase airline tickets has been a shot in the arm for airlines.</li> <li>Larger aircraft carry an additional trip cost however the trip fuel cost difference between a 737-700 and 737-800 on an average sector is approximately \$250, a small amount considering the larger aircraft typically carries 30 to 35 more passengers.</li> </ul>	<ul style="list-style-type: none"> <li>Less passengers on the aircraft means less boarding and deplaning time resulting in higher utilization and in some cases an additional revenue flight per day.</li> <li>Reducing turn-time by 10 minutes with an average trip length of 500 nautical miles can improve airplane utilization by 8 percent<sup>2</sup>.</li> <li>With efficiencies in passenger boarding and aircraft handling airlines are getting close to maximum turnaround efficiency even from the larger models.</li> </ul>																																																																		
Airframer Profit Margins	Ancillary Revenue																																																																		
<ul style="list-style-type: none"> <li>The incremental cost to manufacture a larger variant within the same family is far outweighed by the incremental revenue potential the airframer can achieve.</li> <li>This is evident across several programs. Even if the market demanded smaller aircraft the airframers' ability to upsell the larger variants knows no bounds.</li> <li>The following chart shows how the fortunes of the smaller variants of the 737, 787, 767, 777, A320 and A330 programs have fared since 2000.</li> </ul>	<ul style="list-style-type: none"> <li>Although driven by the LCC revolution the power of ancillary revenue is immense and it has driven up load factors.</li> <li>A recent study by IdeaWorks<sup>3</sup> shows that in 2015 airlines such as Spirit, Jet2 and Qantas earned over \$40 per passenger in ancillary revenue. The average operating cost<sup>4</sup> per passenger on board a 737-800, flying an 800nm sector, is approximately \$51.</li> <li>Due to the unbundling of fares there are incremental revenue benefits to having more passengers on board the aircraft. This is driving airlines to larger variants.</li> </ul>																																																																		
<div style="text-align: center;"> <h3>Number of Annual Aircraft Deliveries</h3> <table border="1" style="margin: 10px auto; border-collapse: collapse;"> <caption>Number of Annual Aircraft Deliveries (2000-2016)</caption> <thead> <tr> <th>Year</th> <th>Smaller Family Members</th> <th>Larger Family Members</th> </tr> </thead> <tbody> <tr><td>2000</td><td>375</td><td>282</td></tr> <tr><td>2001</td><td>417</td><td>271</td></tr> <tr><td>2002</td><td>333</td><td>245</td></tr> <tr><td>2003</td><td>278</td><td>207</td></tr> <tr><td>2004</td><td>263</td><td>308</td></tr> <tr><td>2005</td><td>308</td><td>322</td></tr> <tr><td>2006</td><td>441</td><td>284</td></tr> <tr><td>2007</td><td>558</td><td>229</td></tr> <tr><td>2008</td><td>577</td><td>219</td></tr> <tr><td>2009</td><td>726</td><td>151</td></tr> <tr><td>2010</td><td>795</td><td>168</td></tr> <tr><td>2011</td><td>808</td><td>161</td></tr> <tr><td>2012</td><td>963</td><td>190</td></tr> <tr><td>2013</td><td>1034</td><td>200</td></tr> <tr><td>2014</td><td>1100</td><td>157</td></tr> <tr><td>2015</td><td>1180</td><td>83</td></tr> <tr><td>2016</td><td>1199</td><td>83</td></tr> </tbody> </table> </div>	Year	Smaller Family Members	Larger Family Members	2000	375	282	2001	417	271	2002	333	245	2003	278	207	2004	263	308	2005	308	322	2006	441	284	2007	558	229	2008	577	219	2009	726	151	2010	795	168	2011	808	161	2012	963	190	2013	1034	200	2014	1100	157	2015	1180	83	2016	1199	83	<div style="text-align: center;"> <h3>Ancillary Revenue Per Passenger</h3> <table border="1" style="margin: 10px auto; border-collapse: collapse;"> <caption>Ancillary Revenue Per Passenger</caption> <thead> <tr> <th>Airline</th> <th>Ancillary Revenue Per Passenger</th> </tr> </thead> <tbody> <tr><td>Spirit</td><td>\$51.80</td></tr> <tr><td>Jet2.com</td><td>\$50.84</td></tr> <tr><td>Allegiant</td><td>\$49.94</td></tr> <tr><td>United</td><td>\$44.16</td></tr> <tr><td>Qantas</td><td>\$42.70</td></tr> </tbody> </table> </div>	Airline	Ancillary Revenue Per Passenger	Spirit	\$51.80	Jet2.com	\$50.84	Allegiant	\$49.94	United	\$44.16	Qantas	\$42.70
Year	Smaller Family Members	Larger Family Members																																																																	
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2011	808	161																																																																	
2012	963	190																																																																	
2013	1034	200																																																																	
2014	1100	157																																																																	
2015	1180	83																																																																	
2016	1199	83																																																																	
Airline	Ancillary Revenue Per Passenger																																																																		
Spirit	\$51.80																																																																		
Jet2.com	\$50.84																																																																		
Allegiant	\$49.94																																																																		
United	\$44.16																																																																		
Qantas	\$42.70																																																																		

2. [http://www.boeing.com/commercial/aeromagazine/articles/qtr\\_4\\_08/pdfs/AERO\\_Q408\\_article03.pdf](http://www.boeing.com/commercial/aeromagazine/articles/qtr_4_08/pdfs/AERO_Q408_article03.pdf)

3. <http://www.ideaworkscompany.com/wp-content/uploads/2016/07/2015-Top-10-Airline-Ancillary-Revenue-Rankings-Final.pdf>

4. Direct Operating Cost (included lease / capital cost) assuming a jet fuel price of \$2.00 /USG. 175 pax 737-800, 10 year old aircraft, lease rate of \$200,000 / month, assuming industry average taxi times.

Aircraft Performance	Replacement Market Dynamics
<ul style="list-style-type: none"> <li>The smaller variants of aircraft families typically enjoy longer range and better low-speed performance compared to their larger siblings due to the fact that the families typically share the same wing and engine hardware, but smaller aircraft carry lighter payloads.</li> <li>This holds true for the 737 MAX and A320neo programs, however the A320neo and 737 MAX 8 offer enhanced take-off performance due to aerodynamic, engine and control law improvements resulting in up to several tons more take-off weight compared to their predecessors on occasions when those predecessors would have been otherwise limited.</li> </ul>	<ul style="list-style-type: none"> <li>The average seat size of the narrowbody aircraft fleet at the time of the launch of the 737 NG was considerably different to when the 737 MAX was launched.</li> <li>Airlines considering the 737 NG at that time were operating narrowbody aircraft such as the 737 Classics and MD80s with an average seat count of 109 seats compared to an average seat count of 149 at the time of launch of the 737 MAX.</li> <li>It was natural for the airlines operating 737 Classics to grow smoothly into the 737-700 rather than taking a bigger jump toward larger variants, such as the 737-800.</li> </ul>



It was natural for the airlines operating 737 Classics to grow smoothly into the 737-700 rather than taking a bigger jump toward larger variants, such as the 737-800.

## Risks and Mitigants

**Investing in aircraft requires an in-depth appreciation for the competitive, technical and commercial risks specific to the aircraft model being considered. The 737 MAX faces emerging competitors who are encroaching on their market. Its unit cost leadership in the market place has been challenged and has obliged CFM to push the boundaries of their engine design. For lessors, a host of new entrants with MAX orders could impact the ability to place aircraft and their profitability.**

### ***Aircraft Competition***

New and established manufacturers have emerged trying to compete in the lucrative narrowbody market. Irkut and COMAC are making a direct play against Airbus and Boeing whilst Bombardier and Embraer are aiming, at least in part, to take a share of the A319 and 737-700 replacement market. It is difficult for new entrants to gain market traction as airlines are concerned that they will not produce reliable aircraft or have the network to support them. However, while there are many factors working against these new entrants, they also have strengths. Government support for both COMAC and Irkut will seed their home market, enabling them to build a customer base and to lower production unit costs. A large installed fleet with global customers enables Bombardier and Embraer to make credible sales pitches to smaller customers with growth ambitions that may not be deemed important by the Big Two. The new entrants have normalized Airbus' and Boeing's engine advantage; COMAC selected the LEAP engine to power the C919 and Irkut, Bombardier and Embraer selected Pratt and Whitney to power their offerings.

It will take time, perhaps decades, for the new entrants to materially change the market, but the duopoly is being challenged.

### ***Engine Maintenance Cost***

The predecessor of the LEAP, the CFM56 is a well understood and widely accepted engine - its reliability and time-on-wing characteristics are second to none, a reputation earned over two decades. Investors must also be mindful that the LEAP engine will be challenged to match the CFM56 right out of the box. The engine will continue to be developed and improved as CFM learns more about its operational characteristics.

All indications are that CFM and Boeing are achieving their fuel burn targets for the LEAP-1B. Fuel efficiency is key for airlines regardless of fuel price, however in today's lower oil price environment other cost elements are moving higher on the list of airlines' concerns. To achieve its fuel burn performance, CFM had to raise temperatures and pressures on the LEAP which could impact the engine's time on-wing. Once off-wing and in the overhaul facility, cost is predominantly driven by the hot section of the engine. To achieve better fuel burn performance, the LEAP engine has an additional stage of high pressure (HP) turbine. For a narrowbody aircraft engine, a set of HP turbine blades and associated parts can cost well in excess of \$1m. CFM has committed to keep LEAP maintenance costs at CFM56 levels, which will oblige them to continue to innovate and offer competitive aftermarket packages.

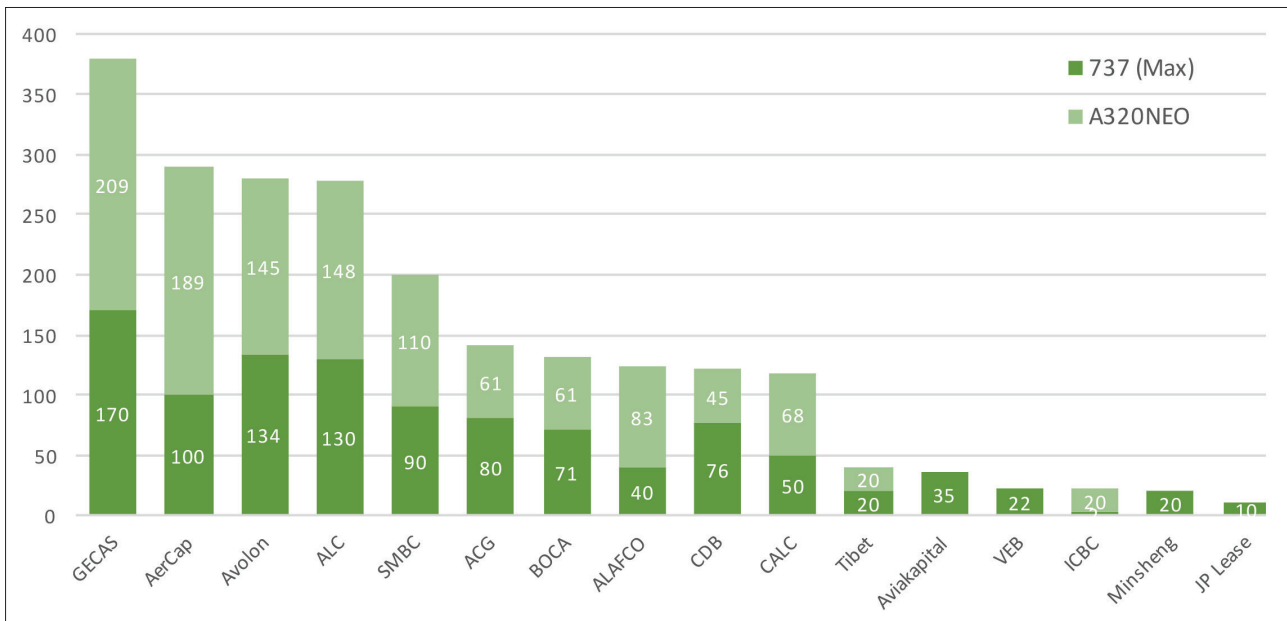
Commercial guarantees and commitments will provide comfort to airlines, but do not deliver equivalent benefit to lessors and investors, who require whole-life coverage. Leased aircraft transition from operator to operator and can be sold multiple times over the course of their life. If the right commercial packages are not in place for investors, demand for leased aircraft will reduce, lease rates will follow, and a valuable distribution channel for the manufacturers and source of financing for the airlines will be constrained. CFM and Boeing will be focused on, and must ensure, a comprehensive solution for investors.

With the potential for higher maintenance costs, lessors may also be under-reserved when airlines make maintenance claims. This could strain relationships, creating risk for lessors when negotiating extensions and additional business with the airline.

**Leasing Competition**

A key issue being debated by the industry is the level of orders being placed by leasing companies, which hold 21% of the entire NEO and MAX order book. Four lessors, Avolon, GECAS, AerCap and ALC, each have over 250 aircraft on order, including letters of intent (LOIs), and memorandums of understanding (MOUs), and account for 50% of the entire leasing order book. New entrants are also emerging, with CDB and CALC in particular having significant orders, as shown in *Exhibit 12*.

**Exhibit 12: Lessor NEO v MAX Current Order Books**  
Includes LOIs and MOUs (as at 30th June 2017)



All data is from FlightGlobal Ascend except for Avolon which is company data

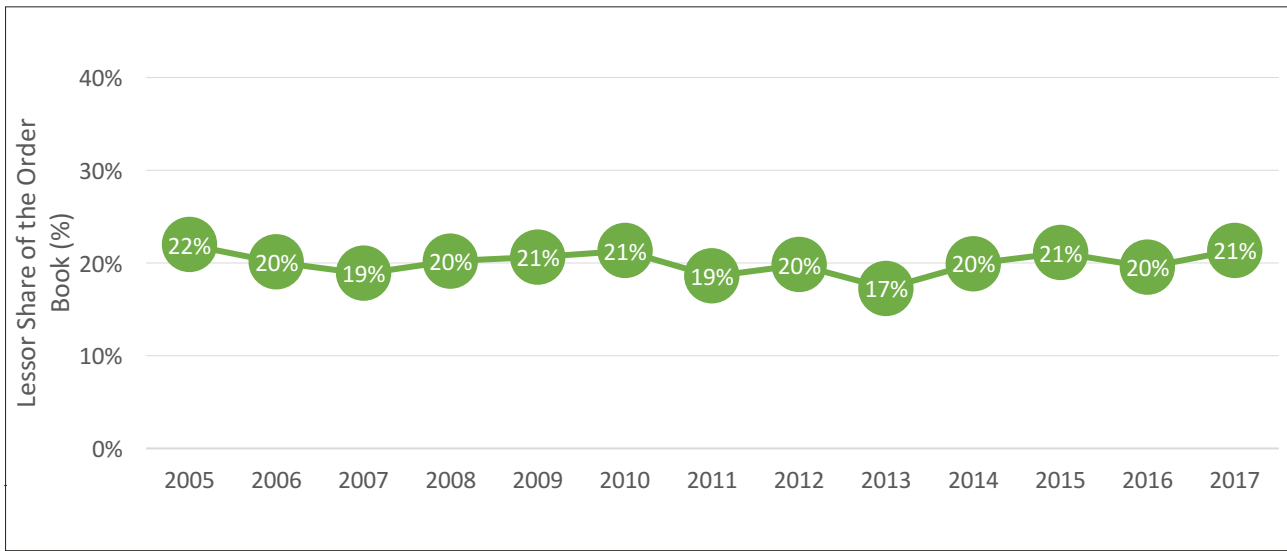
However, even with the increased number of aircraft on order, the ratio of lessor orders to the overall narrowbody order book has remained stable. Since 2005 lessor orders have averaged 20% of the total order book (*Exhibit 13*) demonstrating that as the market grows lessors continue to take a consistent share.



However, even with the increased number of aircraft on order, the ratio of lessor orders to the overall narrowbody order book has remained stable.

**Exhibit 13: Lessor Narrowbody Orders as a Percentage of the Entire Order Book**

Includes LOIs and MOUs  
737 NG/MAX and A320 CEO/NEO Families Only

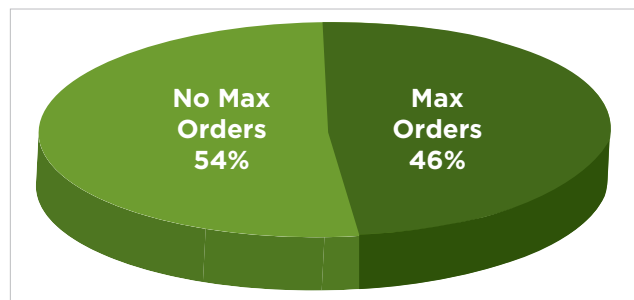


Despite the scale of the lessor backlog, demand for lessors' MAX order books is expected to be robust; 65% of all airlines currently operating 737NGs have no commitments, either directly or through the lessor channel, for MAX or NEO – well over 100 in total. Over time, the majority of these airlines will want to re-fleet with new generation aircraft and, given the long-dated nature of the OEM backlogs, will look to the lessor channel to satisfy their requirements.

Even amongst the airlines that have historically been direct customers of Boeing for 737NGs, over half have not placed orders for MAX aircraft (Exhibit 14). The ten largest of these, which include Delta, Shenzhen Airlines, Qantas, ANA and Japan Airlines, together operate 800 NGs and a further 37 airline customers have NG fleets totalling 400 aircraft. The full list of uncommitted direct NG customers is in Appendix B.

**Exhibit 14: Over half of Boeing's direct 737 customer airlines have not placed MAX orders**

Source: FlightGlobal Ascend



## The 737 MAX Investor Proposition

With common family design principles, it's logical for Boeing to offer a wide choice to airlines, however the family should reflect actual market demand and too much choice can be a negative factor in the minds of investors. Although lessors finance over 40% of the world's commercial aircraft deliveries, they do not support all models and family members equally, with asset liquidity being a key determinant of investment appetite. Airlines should therefore expect to look further afield to finance some of the more marginalized MAX family members. As summarized below, in Exhibit 15, the investment strength of the MAX 8 is not yet evident in the other MAX variants.

**Exhibit 15: Summary of Investor Proposition**

Variant	Investor Proposition	Key Investment Considerations
737 MAX 7	Caution	Small operator base. Highest unit cost member of the MAX family. Performance advantage weakened by more capable MAX 8. Pricing incentives may stimulate demand
737 MAX 8	Invest	Large operator base. Large incumbent 737-800 fleet. Heart of the narrowbody market.
737 MAX 200	Watch	Small operator base. Unit cost leader in the medium narrowbody market. Unproved reconfiguration. Lack of orders from its target market. Expect a small operator base
737 MAX 9	Caution	Small operator base. Marginalized by the launch of the MAX 10. Limited role in the family.
737 MAX 10	Watch	Successful launch. Good growth vehicle for large 737-800 and MAX 8 fleets. Engine maintenance cost and performance concerns.

### **The 737 MAX 7: Serves a Niche**

The additional seats in the stretched MAX 7 have increased its operating cost-per-seat advantage over the A319neo (Appendix A), however, this segment of the market will not be where the "NEO v MAX" battle is won or lost. The MAX 7 will retain some 737-700 customers with an offering that competes on trip and seat cost, airfield and range capabilities. However, the improved airfield and range performance of the MAX 8 reduces the number of markets in which, on the other hand, a high performance aircraft like the MAX 7 is required. While Bombardier and Embraer will take a share of the small narrowbody market segments, the MAX 7 offers full commonality with larger family members and will serve as a sub-fleet for airlines.

With a common wing and landing gear to the MAX 8, production of the MAX 7 will be simplified, enabling marginal cost pricing to aggressively defend Boeing customers from defecting and stimulate sales in a way not achieved with the 737-700. Based on Avolon's proprietary Aircraft Economics Model, in order to equalize the seat cost difference between it and the MAX 8, and so reduce the operating cost risk for operators, Boeing would need to price the aircraft at least \$10m dollars below the MAX 8, which is in line with appraisers' views of the difference between similarly sized narrowbody aircraft in today's market.

Since its redesign, Boeing has secured one additional firm order for a single aircraft along with MOUs from Kunming Airlines for ten units and Air Lease Corporation for five. Whilst the -700 was the right-sized aircraft to enable fast turn times and replace 737 Classics, airlines are trading less time on the ground for the lower unit costs in the air of the larger types

### **The 737 MAX 8 - Heart of the Market**

The MAX 8 has incrementally grown its operating cost advantage over the 737-800 it replaces. Its 50% market share versus Airbus in the medium narrowbody market is a testament to the flexibility of the 737 platform and the ability of Boeing's engineers to squeeze efficiency out of their design. With average narrowbody seat counts trending towards 160, the MAX 8 is now the right-sized aircraft, with exceptional range and airfield capabilities, positioned at the heart of the narrowbody market.

Boeing argues that its customers have larger installed fleets than Airbus' which will lead to more follow-on orders. Airbus counters that their order book contains more faster-growing LCCs. Both arguments are valid. The ratio of narrowbody aircraft on order to in-service for Boeing's Top 10 MAX customers is half of Airbus' (0.6x vs 1.2x) whereas 66% of Airbus' orders are from LCCs vs 57% for Boeing.

The extra take-off weight added to the 737 MAX 10 will raise the prospect of a “flow-back” of these enhancements to the MAX 8. Generally this is good news for investors and airlines, however, if the upgrades are not applicable to pre-delivered MAX 8 aircraft, they could impact residual values.

### The 737 MAX 200 – Limited Traction

With only three firm customers secured in three years, the MAX 200 raises questions for investors.

Although the MAX 200 offers more seats, Boeing’s promise of the aircraft being a “game changer” for the LCCs has not come to fruition. Since its launch, several LCC sales campaigns have come and gone with the airlines ultimately choosing the MAX 8 or MAX 10. The MAX order book contains orders for yet to be announced family members which could ultimately end up being MAX 200 aircraft, however, the MAX 10 will decrease the likelihood of this occurring.

Although the market acceptance of a MAX 200 retrospectively, reconfigured as a MAX 8, is yet to be proven. Inexpensive and timely retrofit solutions will be important to ensure a healthy secondary market that spans both network and low-cost carrier business models.

### The 737 MAX 9 – At Risk

Even before the launch of the MAX 10, the market’s reception to the MAX 9 was lukewarm. United Airlines decision to convert orders for 100 MAX 9s to the MAX 10 demonstrates the aircraft’s vulnerability. It will no longer serve as the lowest unit cost family member and whilst airfield performance is expected to be superior to the MAX 10, it is inferior to the MAX 8. The A321ceo has attracted five times the number of operators as the 737-900ER. The A321neo is maintaining that advantage with five times the number of announced operators as the MAX 9. Appraisers assign a higher value to an A321ceo over a 737-900ER despite the 737-800 garnering a higher value than an A320ceo, based on the average of four appraisers.

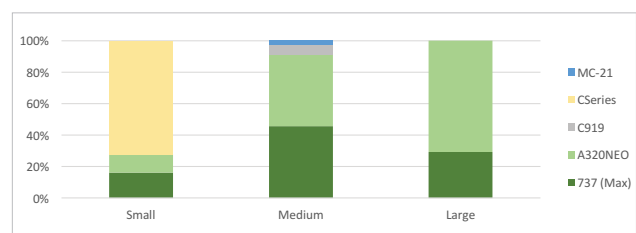
The MAX 9 incurs a significant operating cost per seat penalty when compared to the A321neo, particularly with Airbus’ 240 seat configuration. This difference, almost 7%, is untenable and ultimately led to the launch of the MAX 10. To avoid fragmenting the large narrowbody market, Boeing will have to consider the future of the MAX 9. While some operators may value the additional performance of the aircraft over the MAX 10, packages to improve hot and high airfield performance will better serve these customers rather than the potential for weak residual values driven by a more limited operator base and small installed fleet. The MAX 9 is unlikely to attract new customers or additional orders, with airlines opting for the MAX 10 instead.

### The 737 MAX 10 – Taking Off

In 2016, the A321 outsold every other commercial aircraft variant<sup>5</sup>. The MAX 10 will serve as a crucial gap closer to take market share back from the A321neo and is expected to be a compelling unit cost aircraft. Network carriers, such as United and Air Canada will be attracted to the MAX 10. Low-cost and hybrid carriers, such as Lion Air and Alaska will benefit from its lower unit costs. Charter carriers, such as TUI will find the MAX 10 an attractive 757 replacement for popular leisure markets.

#### Exhibit 16: New Technology Narrowbody Market Family Share

**Large:** 737-900/ER/9/10, A321ceo/neo, **Medium:** 737-800/8, A320ceo/neo, MC21, and C919 **Small:** 737-700, A319, CS300  
In Service, On Order and LOI/MOU aircraft quantities  
737-600, A318, CS100 Excluded Unannounced types assumed to be most popular family member i.e. 737-8, A320neo, CS300



Many incumbent 737-800 and future MAX 8 operators will likely embrace the MAX 10, in the way that A320 operators embraced the A321. Fifteen 737-800 operators fly over 800 A321s today, a strong indication of the lack of a suitable 737 family member to grow into, but no shortage of demand.

There are still limitations to what the MAX 10 can achieve, however. With the same engine thrust options as the MAX 9 (up to 28,000 lbf), but a fuselage stretched to fit two additional seat rows, the MAX 10 will have airfield performance limitations. With engine thrust options of up to 35,000 lbf, the A321neo will continue to win in markets where airfield performance and capacity is important. The A321LR’s 97t maximum take-off weight will also create a range advantage for a small number of operators and missions that Boeing will not be able to match. The MAX 9 has been unable to consistently compete against the A321neo, taking a meagre 15% market share in the large narrowbody segment. The MAX 10 has already increased that share to 30%.

5. Announced orders accounting for type swaps and cancellations.

## Conclusions



Boeing's MAX product strategy decisions have been reactive, resulting in lower market share and a plethora of variants which do not all reflect actual market demand.



In launching the **A320neo**, Airbus presented Boeing with both a technical and commercial dilemma. The MAX was Boeing's only option to compete against the A320neo in a timely manner. A clean-sheet design would have entered the market several years after the A320neo and Boeing's ability to match the A320neo production rate with that of a new program would have taken several years to achieve, at the cost of market and customer share.



In the rush to get the **737 MAX** to market, Boeing neglected to consider and counter Airbus' key strength, the **A321**.



MAX 10

The recent launch of the **MAX 10** has strengthened the MAX family and has already doubled Boeing's market share in the large narrowbody segment.



MAX 8

The **737 MAX 8** remains the heart of the MAX family and a key target for investors. The aircraft has maintained its Cash Operating Cost (COC) advantage over the A320neo on a per seat and trip basis, although only by a small margin.



MAX 7

The **MAX 7** is a niche product when performance and range is required. The market shift away from smaller variants has been driven by several factors, including unit price and the focus of the LCCs on larger models. A change in pricing strategy could stimulate further demand.



Boeing has secured only three customers in three years for the **737 MAX 200** rendering it questionable from an investor perspective. A proven, cost efficient and timely **MAX 8** reconfiguration package may assist residual values, however, airlines will have to carry approximately 600lb additional weight compared to a factory built MAX 8.



MAX 9

The **737 MAX 9** no longer serves as the lowest unit cost family member and is severely impacted by the launch of the MAX 10. With only slightly improved unit cost over the MAX 8 it is unclear what role remains for the aircraft which is expected to have a very limited future.



The **737 MAX 10** will complete the MAX family and will be a much improved competitor compared to the MAX 9. It will be a capable seat cost machine for operators looking to grow beyond the 737-800 and 737 MAX 8, however, it will have some airfield performance limitations. The A321neo will remain the high density seat cost leader in this market.



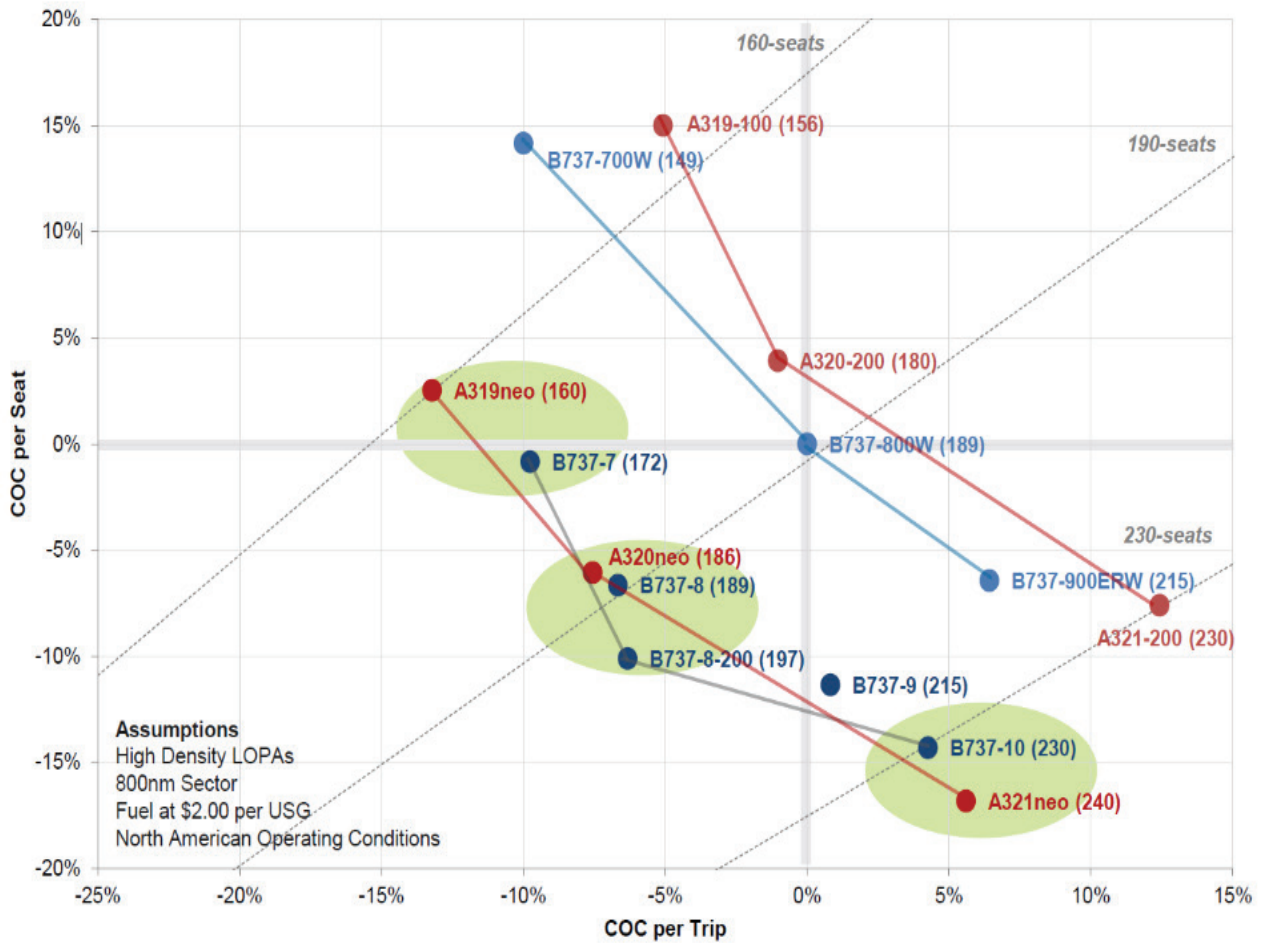
54% of 737NG operators who have previously taken ordered new aircraft directly from Boeing, do not have commitments for the **737 MAX**. With delivery slots unavailable, pent up demand exists which supports the placement of lessors' speculative orders.



**CFM** will deliver on its fuel burn commitment for the Leap engine, which will, however, be challenged to meet the cost performance of its predecessor, the CFM56. It is imperative that CFM puts commercial measures in place to allow the benefit of maintenance agreements to survive multiple operators and owners.



## Appendix A Aircraft Cash Operating Cost



**Assumptions**  
 High Density LOPAs  
 800nm Sector  
 Fuel at \$2.00 per USG  
 North American Operating Conditions

**Notes**

Data Source: Avolon Aircraft Economics Model  
 LOPA –Layout of Passenger Accommodations, COC –Cash Operating Cost, P&W powered A320 Family

## Appendix B

### Airlines without MAX Commitments that have previously ordered 737NGs

	NG Orders placed with Boeing		NG Orders placed with Boeing
Delta Air Lines	262	Hebei Airlines	9
Air Berlin	91	Tassili Airlines	7
Shenzhen Airlines	78	Luxair	6
Qantas	74	South African Airways	5
Shandong Airlines	65	TAAG Angola Airlines	4
All Nippon Airways	54	TAROM	4
Japan Airlines	46	Austrian Airlines	3
Pegasus Airlines	46	Belavia	3
KLM	42	Ceiba Intercontinental	3
Shanghai Airlines	38	SonAir	3
UTair Aviation	36	Air Austral	2
Jet2.com	34	Biman Bangladesh Airlines	2
SAS	33	Buraq Air	2
easyJet	32	Kenya Airways	2
Royal Air Maroc	31	Lineas Aereas Azteca	2
Air Algerie	27	RwandAir	2
Transavia Airlines	26	S7 Group	2
Egyptair	25	Sky Airlines	2
Air India	18	Somon Air	2
China Airlines	13	Sriwijaya Air	2
EL AL	13	Air Senegal International	1
Germania	12	Mauritania Airlines	1
Maersk Air	12	Midwest Airlines (Egypt)	1
Turkmenistan Airlines	12		





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