Aircraft Retirement Trends & Outlook

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Avolon is an international aircraft leasing company. Headquartered in Ireland, with offices in Stamford CT, Hong Kong, Shanghai, Singapore and Dubai, Avolon provides aircraft leasing and lease management services. Avolon's investors include three of the world's leading private equity firms Cinven, CVC Capital Partners and Oak Hill Capital Partners and one of the world's leading sovereign wealth funds, Government of Singapore Investment Corporation (GIC).

Avolon has established itself as one of the leading global players in the aircraft leasing sector, leveraging off the strong financial backing of its owners and the extensive trading history and senior industry relationships of its management team. The primary asset focus of the business is on young fuel-efficient aircraft such as the Airbus A320, A320neo and A330 families, the Boeing 737NG, 737 MAX, 777 and 787 families; and, the Embraer 190 family. Avolon has a committed fleet of 164 aircraft serving 34 customers in 22 countries. Avolon's fleet is also the youngest large lessor fleet in the world with an average aircraft age of 1.7 years. See www.avolon.aero

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Dick Forsberg has over 40 years' aviation industry experience working in a variety of roles with airlines, operating lessors, arrangers and capital providers in the areas of business strategy, industry analysis and forecasting, asset valuation, portfolio risk management and airline credit assessment. Prior to Avolon, he was Head of Strategy at RBS Aviation Capital, where responsibilities included defining the trading cycle of the business, creating and maintaining an asset valuation capability, setting portfolio risk management criteria and determining capital allocation targets. Prior to RBS, Dick worked with IAMG, GECAS and GPA following a 20-year career in the UK airline industry. Dick has a Diploma in Business Studies and in Marketing from the UK Institute of Marketing and is a member of the Royal Aeronautical Society. Dick is also a Director of the Board of ISTAT (The International Society of Transport Aircraft Trading).

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Executive Summary

From time to time, generally when the industry is faced with heightened uncertainty, questions are raised around the aircraft economic life assumptions made by investors and financiers and whether a permanent shift is taking place in the underlying trends surrounding the long-term values ascribed to specific, or even all, commercial jets. This is one such time and, given the extensive level of investment that now exists in the global commercial aircraft fleet and the future requirements of the industry for further sustained funding from lessors and financial institutions, a comprehensive review and analysis of commercial aircraft economic lives and retirement patterns is urgently needed.

As an experienced industry participant, Avolon is well-placed to provide thoughtful insights on industry issues based on empirical evidence, analysis and experience gained over decades and several industry cycles. This paper, which is the first in a series that will deal with a range of industry issues, considers how trends in aircraft retirement have changed over time and identifies key differences between the behaviour of specific aircraft types. In depth analysis looking back over more than half a century includes all jet airliners that have been delivered for non-military use, tracking their build years, delivery dates and ultimate retirement. Aircraft that have been withdrawn from use due to major incidents or destroyed in even more major accidents are excluded. The analysis also factors in the impact of long-term storage of ageing aircraft that ultimately never fly again.

After taking all of these factors into account, the average retirement age for all commercial jet aircraft is close to 26 years, with 60% of delivered aircraft still in service at 25 years of age. Both of these numbers, which have increased steadily over time, now appear to have stabilised.

Some striking patterns emerge that confirm that the underlying trends have been, and remain, consistent and positive, although some recent developments, especially in regard to single aisle retirements, may suggest otherwise and require closer examination.

The paper concludes with Avolon's forecast of retirements over the next ten years, which takes account of the underlying long-term trends as well as more recent activity and the potential for further changes in market behaviour. 8,000 aircraft are expected to be retired over the next ten years, more than all of the commercial jet retirements that have taken place to date. As current generation aircraft are retired in greater numbers, their ageing profiles, which appear shorter than heretofore, will develop to more closely resemble those of prior generations.

Overall, this analysis supports the thesis that the in-service lives of core single- and twin-aisle fleets are not experiencing material diminution and that the industry's economic life assumptions and depreciation policies will remain valid over the next decade and beyond.

Note

NB refers to Narrowbody aircraft such as the Airbus A320 family or Boeing 737 family
WB refers to Widebody aircraft such as the Airbus A330 family and Boeing 747 and 777 families

Background

Over 31,000 jet airliners have been delivered since the dawn of the jet age and two thirds of them are in service today. The vast majority (96%) have been operated for commercial purposes by airlines over most, if not all, of their lives which, on average, have spanned 25.6 years.

Most retirement decisions are a direct and simple function of age, when an operator concludes that the cost of maintaining and operating an aircraft exceeds the financial contribution it can earn. Often the decision is triggered by a specific event, usually the requirement to complete a costly major maintenance event. This economic inflection point may be accelerated if a new, more efficient alternative is introduced as a result of advances in technology, however the inability of the OEMs to deliver this new technology in quantity significantly dilutes the impact on retirements, as replacements cannot all be supplied at once.

At certain times in an industry cycle, the value of an aircraft, even a relatively young one, may be exceeded by the value of its major components, especially engines, causing owners (though not usually operators) to retire the asset prematurely for part-out. This decision is more likely to be taken if significant expenditure is required, perhaps at the end of a lease term, or if there is localised market demand for high value components, and is limited to small numbers of aircraft.

Until the mid-1970s most aircraft were ordered directly by airlines and paid for by those airlines or by their owners, which for the significant majority meant national governments. Whilst commercial banks might have been involved in the financing process, their role was purely as a lender. Apart from any security interest that they may have required under the terms of the financing, financial institutions did not participate in investment or ownership of aircraft. In the world before leasing companies, life was simple; airlines acquired aircraft to meet operational requirements, financed them directly, or with support from their government, operated them until the end of their structural or economic lives and sold them for scrap. There were no intermediaries trading aircraft as investments, no complicated SPC ownership structures, no opportunities to leverage aircraft as tax shelters, etc, etc.

Periodic step changes in aircraft and engine technology were more the norm back then than today, when gradual evolution of performance through a model's production life is more commonplace. In the 1950s and '60s, airframe and engine technologies were in their infancy and embarked on a steep learning curve. The design lessons of the Comet were carried over into every pressurised aircraft subsequently developed. The involvement of governments in commercial procurement decisions sometimes led to compromised designs and lacklustre sales performance (e.g. the Trident). By the 1970s, however, most of these First Generation (FG) types were being replaced by more efficient and often larger models that were being mass-produced, mainly in the US, in commercial quantities. This era

Commercial Jet Aircraft Retirements by Fleet			
Boeing 727	1356	Boeing 767	80
DC9	657	Airbus A310	72
Boeing 737-100/200	643	HS Comet	60
Boeing 747	505	BAe 146	51
Boeing 707	497	Boeing 757	50
DC8	402	Convair 880	49
Boeing 737 Classic	313	Fokker 100	42
MD80	295	VC10	29
DC10	236	Convair 990	26
Caravelle	218	Boeing 737NG	13
Lockheed L-1011	215	Airbus A340	10
Airbus A300	209	MD90	5
One-Eleven	202	BAe Avro RJ	3
Fokker F.28	141	Boeing 777	2
Airbus A320 family	131	Airbus A330	1
Boeing 720	130	Boeing 717	1
HS Trident	99	FD328JET	1
Bombardier CRJ 100/200	83		

also saw the emergence of the widebody, made possible by the development of large turbofan engines which more than doubled the available thrust. The first 747 was delivered to Pan Am in 1969, with L1011s and DC10s entering service in the early 1970s.

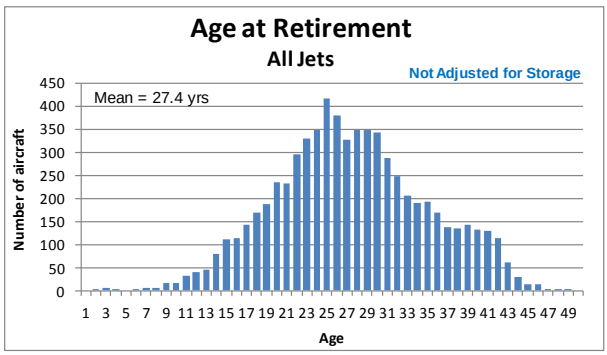
Soon thereafter, technical advances and the quest for greater efficiency (which began in 1973 with the first oil shock) led to new products or variants being developed to replace and augment those already in service. Stretch (and shrink) models were more quickly developed and the family concept was born. A growing awareness of environmental issues put pressure on noisy, as well as thirsty, aircraft and progressively tougher ICAO CAEP rules on noise and emissions have been impacting aircraft operations since the first industry standards were drafted in 1986. Significant advances in performance to address these twin concerns were made possible by further technology developments on the part of the engine manufacturers and the first of the high bypass ratio small turbofans revolutionised the narrowbody market beginning in the early 1980s.

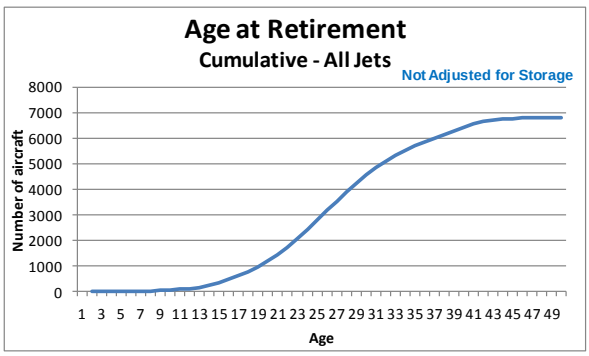
More recently, as noise and emissions rules have become more stringent (and expensive to flout) and as fuel price has become an ever more significant part of airline DOCs, the benefits from smaller performance improvement steps have become more material and change will potentially move at a similarly rapid pace in the future. However, there is an important counterbalance to this, namely that the R&D costs associated with even minor design improvements have become very significant, leaving the OEMs to weigh carefully the demand-led pros of launching a new replacement product against the business cons of disrupting an established cash flow from well-established and widely operated models.

All of these factors have, with varying weight, influenced the pattern of aircraft retirement over the decades and will continue to do so, raising important questions for the industry. How do retirement patterns change over the years? Are economic lives getting shorter? Has there been a shift of gears in recent years and, if so, is it permanent or a temporary phenomenon arising from the specific economic tsunami that the world has been recently facing?

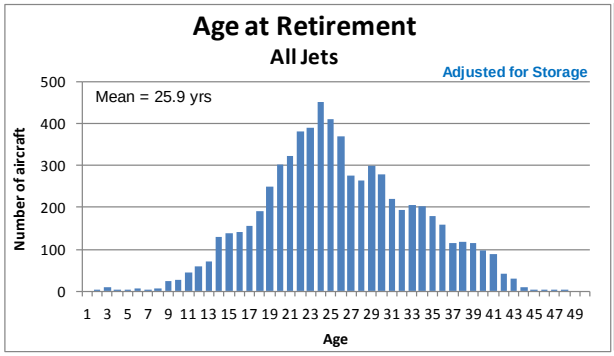
Analysis – Global Fleets and Trends

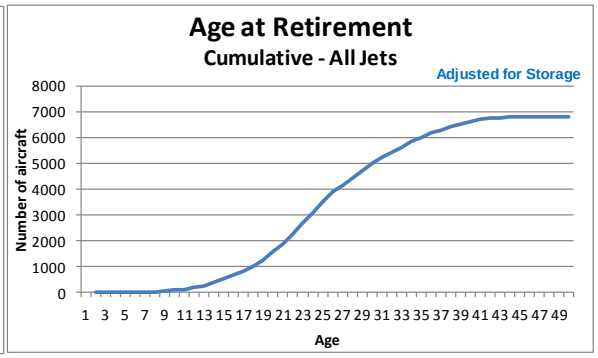
As already noted, the average age of aircraft at the point of their permanent withdrawal from use is 25.6 years. This increases to 27.4 years if "involuntary" retirements (i.e. accidents and incidents where the aircraft is written off) are excluded. In total, 6,800 aircraft have been retired out of the 30,500 that are included in this analysis.



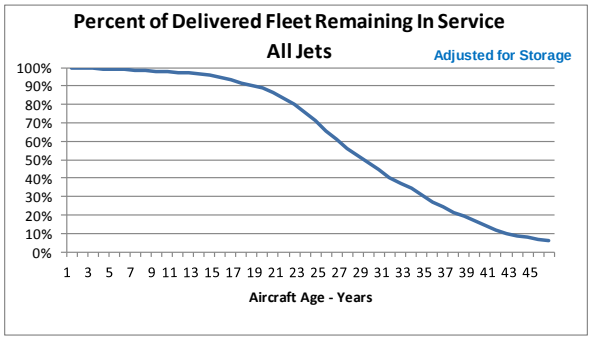


One significant factor influencing retirement trends still needs to be removed from these data, however. Many ageing aircraft transition to retirement via a period in storage which, in some cases, can be protracted. Whist the average time spent in storage prior to retirement is just 1.5 years, 35% of all retirees had been previously stored for more than 5 years. From an investor's standpoint, this down-time is of little or no value and the analysis should therefore start the retirement clock at the point of initial storage. This further, but critical, adjustment reduces the average age at retirement by 1.5 years to 25.9 years.

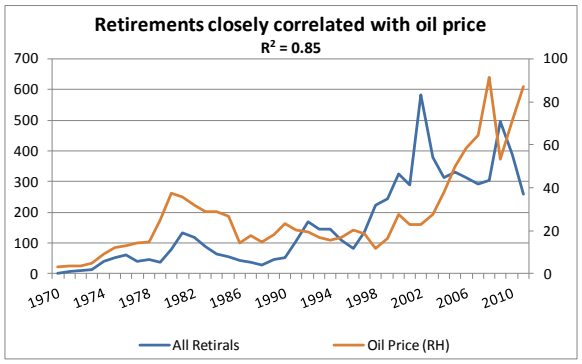




The flip side of this analysis is the fact that, on average, slightly over 60% of delivered aircraft are or were still in service at 25 years of age, with 50% remaining 28 years after delivery.



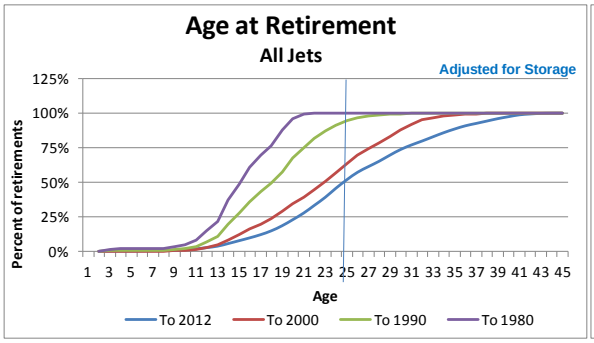
Fleet age is clearly and obviously the greatest single driver of retirals, with a very high statistical correlation (R^2) of 0.96. Regression analysis also confirms that fuel price has played a significant role in the retirement decision process over the past decades, with an R^2 correlation of 0.84. However, in recent years the pattern has been changing - considering retirements over the last decade, the age correlation has fallen to 0.91, suggesting that other factors have started to impact more on retirement decisions – incremental operating efficiency being the obvious candidate.

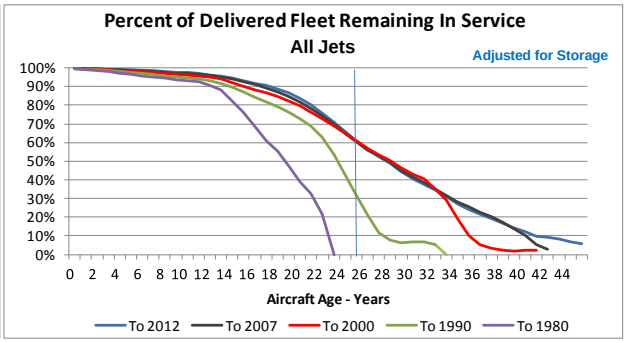


Looking back across several decades, it is nevertheless clear that there has been a steady upward trend in retirement age across the jet fleet as the performance and economic life characteristics of successive generations of aircraft deliveries have improved.

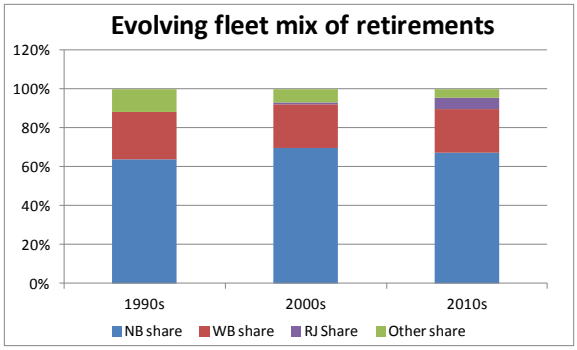
The chart below left shows how the pattern of cumulative fleet retirements has changed over time. Whereas only 5% of all commercial jets that had been retired by 1990 were more than 25 years old at the time of their retiral, by 2000 this percentage had reached 37% and by 2012 it was 48%. The inverse pattern is shown in the right hand chart, where the proportion of the delivered fleet still in service having reached 25 years of age has increased from 30% in 1990 to 60% today, with no

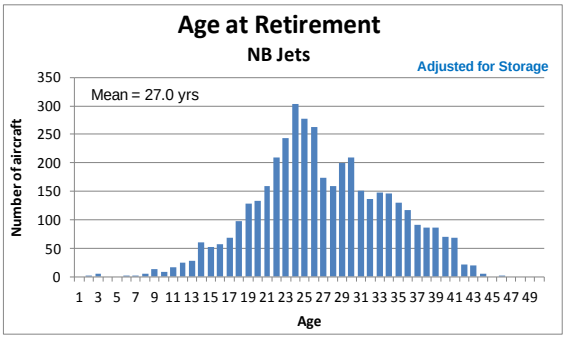
material change taking place over the past decade. However, this high level status quo is in part being maintained through changes in the mix of NB and WB fleet retirement in recent years.

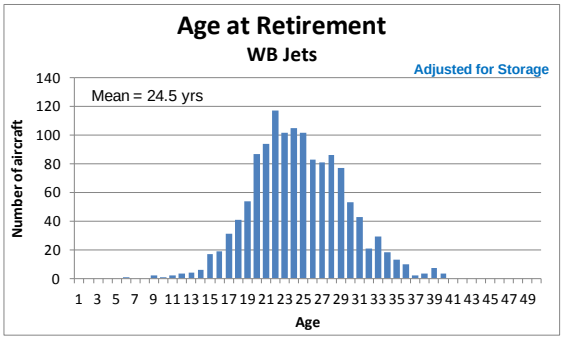




Nevertheless, the same long-term patterns are also evident in both narrowbody and widebody fleets, where the average retirement age for NBs stands at 27 years and WBs at 24.5 years. As the charts below show, widebody jets tend to be retired within a tighter age band than narrowbodies, with a higher proportion of the latter remaining in service for well over 35 years, despite the cargo conversion benefits ascribed to several of the widebody families.

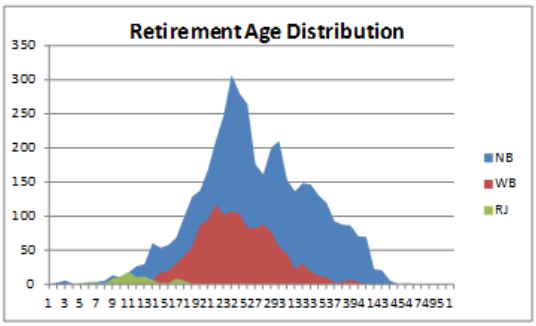


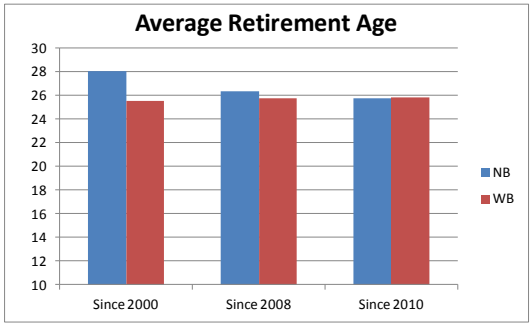




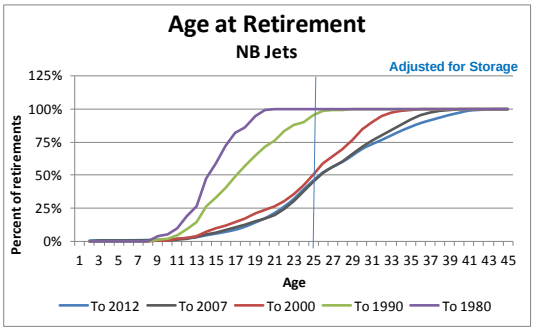
The pattern of retirements follows similar profiles for the NB and WB fleets, with a marked shift to the left in the case of RJs, which account for by far the smallest proportion of retirements.

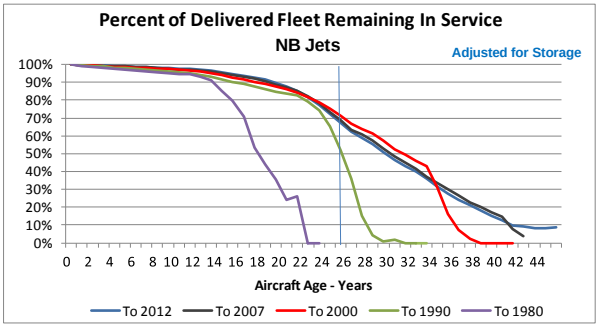
To date, 50% of all narrowbodies have remained in service for more than 25 years before they are retired and close to 70% of NBs are still in service at 25 years of age. This is a slight reduction compared to a decade ago, with subsequent retirement trends also slightly accelerated, a shift that has stabilised however over the past five years.

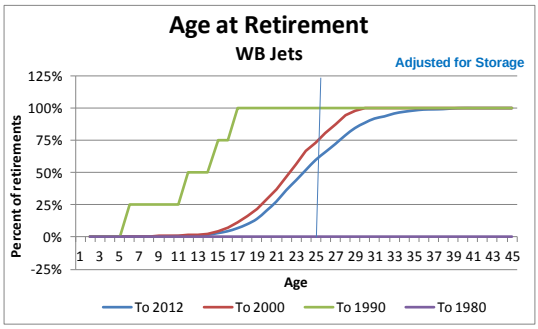


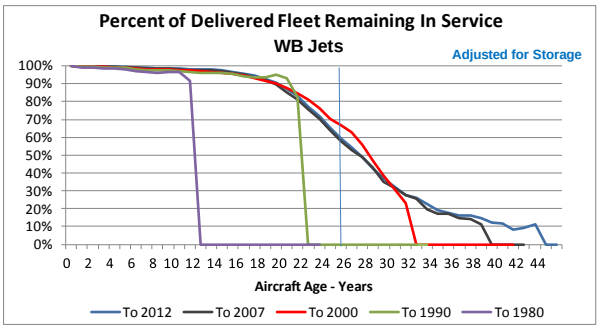


Widebody retirement activity shows similar patterns, although there is less history due to their more recent introduction. From 2000 to 2012, the proportion of widebody retirees surviving beyond 25 years increased from 25% to 40% whilst the percentage of the delivered fleet remaining in service after 25 years declined from 67% to 60%. Stability is again evident over the past five years, with no earlier step-down evident.

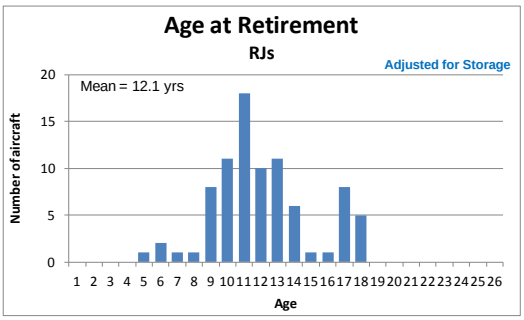








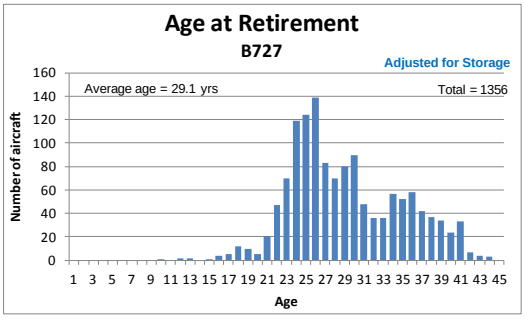
The regional jet category, which essentially comprises only CRJs and ERJs, appears to display very different characteristics, with an average retirement age of 12 years. However, with only 84 retirals in total to date, all of them CRJs, this sub-fleet is too young for a definitive pattern to have developed, despite the apparent disconnect with the larger fleet categories, although shorter economic lives are likely to be seen for these fleets.



Analysis - Narrowbody Fleets

Despite being by far the most populous sub-fleet, there are still relatively few narrowbody fleets large enough to demonstrate meaningful retirement trends and the types of most interest to investors, lessors and financiers are those in current production that, by and large, have not yet started to be retired in quantity.

Nevertheless, it is possible to see evolving trends in the pattern of fleet retirements over time. The earliest fleet to analyse is the 727, of which over 1800 were delivered between 1963 and 1984. 1356 (or 75%) have been retired, with an average age at retirement of 29.1 years.



Close behind, chronologically, is the 737-200, with more than 1100 deliveries between 1967 and 1988, 643 (or 58%) of which have been retired, with an average age at retirement of 28.4 years. Their replacement, the 737 Classic, sold around 2000 aircraft between 1984 and 2000, over 300 of which have been retired at an average age of 21.6 years.

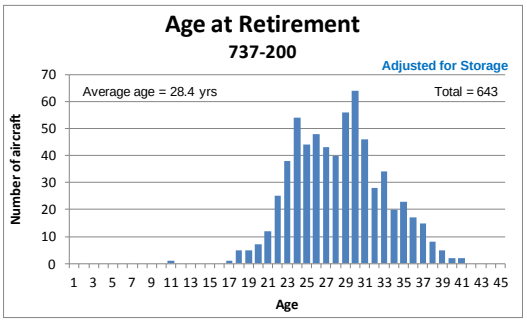
295 out of almost 1200 MD80s delivered from 1980 to 1999 have now been retired, at an average age of 22 years. Finally, 130 A320s family members out of close to 5,000 deliveries starting in 1988 have been retired at an average age of 18.3 years.

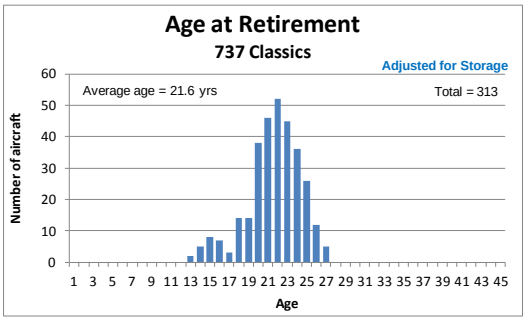
One specific factor that has impacted A320 family retirement performance is the recent incidence of A318 (x7 ex-Frontier) part-outs, driven by a combination of lack of leasing demand, maintenance condition and lack of spare CFM56 availability. If those aircraft are excluded from the A320 family database, average age at retirement increases from 18.3 years to 19.1 years. For A320s only, the average age is 19.4 years.

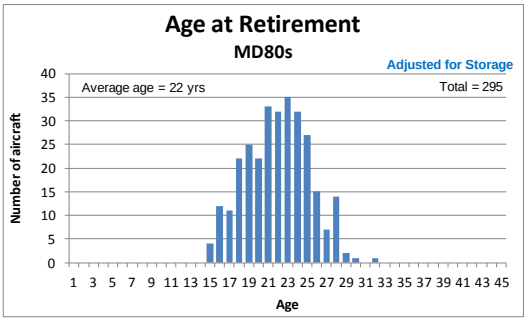
A similar recent incidence of premature retirement of a dozen or more 737-600s and -700s has also been driven by market demand for spare CFM56-7 engines.

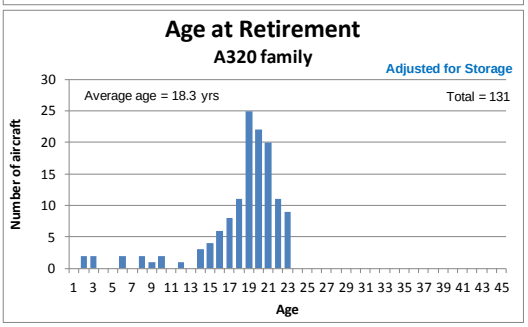
Across the NB fleets the pattern is apparently clear – the more recent families of NB aircraft are being retired earlier, on average, than their predecessors. There is an apparent shift between the first and second generation of aircraft, where 727s & 737-200s (averaging 28-29 years at retirement) gave way to 737 Classics, MD80s and A320s (between 18 and 22 years). However, more than 75% of the 737 Classic and MD80 fleets are still less than 25 years old, as is the entire A320 family, so that the truncated tails to the right of their respective charts can be expected to fill out in the future, with corresponding increases in average retirement ages.

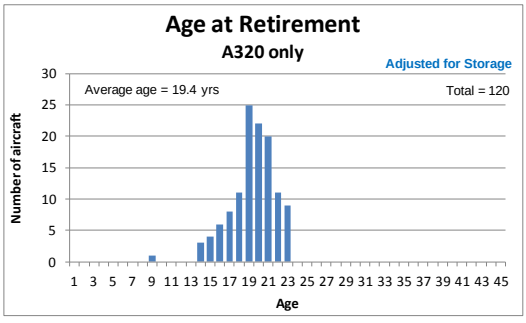
These fleets all have a long way to go in their retirement cycles, with 3% of A320s, 15% of 737 Classics and 25% of MD80s retired so far. Most previous generations of aircraft have seen average

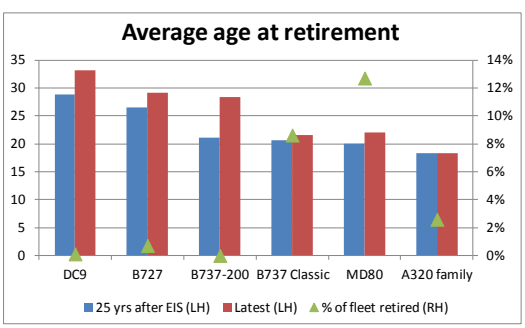








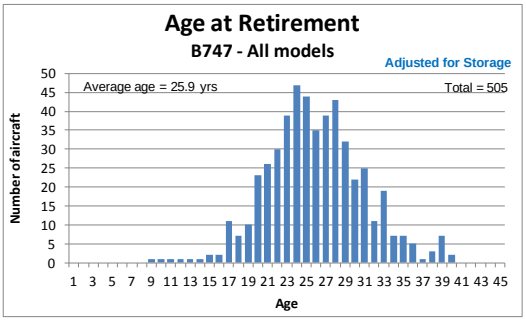


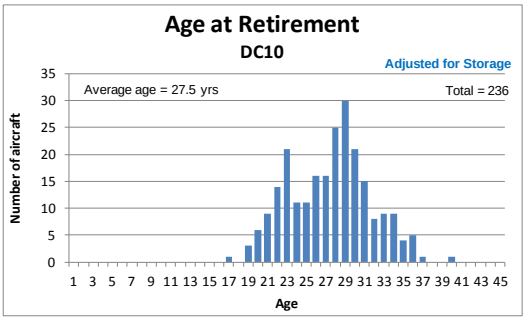


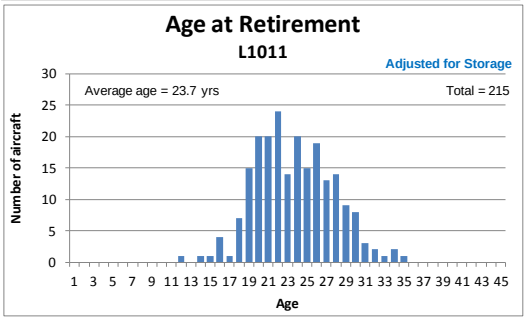
retirement age increase as more aircraft are retired. On average, the overall retirement age for narrowbody fleets increases by 12% from the 25 year in service point to the mature position. Whilst a very low percentage of early NBs were retired within 25 years of the model's service entry, later generations started to retire earlier in greater numbers. The MD80 is likely to remain an outlier at the higher end of the retirement spectrum due to the fuel burn factor, but the A320 family, only now about to celebrate its 25th birthday, has less than 3% of the fleet retired and sits much closer to the 727/737-200 end of the range than its chronologically closer peers.

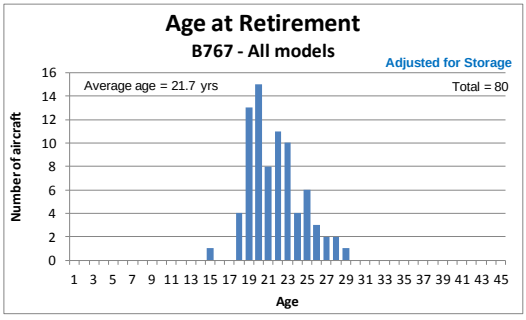
Analysis - Widebody Fleets

The significantly lower volume of widebody retirement activity makes fleet by fleet analysis difficult, as only the 747, DC10 and L1011 families can be measured in sufficient numbers to be meaningful. Since service entry in 1969, over 1,400 747s have been delivered across all models, of which 500 have been retired, at an average age of 26 years. Like the narrow body fleet trend, the average retirement age has increased since passing the 25 years since service entry date (1994), when aircraft were being retired at 22 years on average. This may be partly explained by the development of more efficient 747 variants - the younger sub-fleet of 747-400s, of which only 30 aircraft have yet been retired, has an average retirement age of 19 years, whilst earlier generations of 747 have been retired at an average age of 26.5 years.









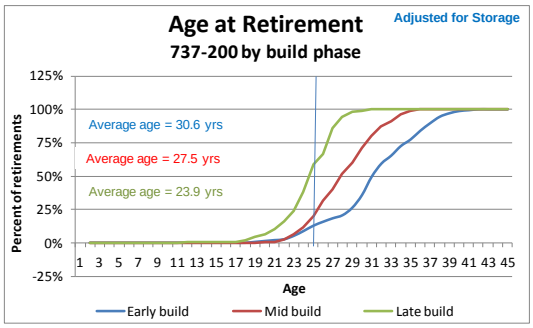
Other first generation widebodies show similarly extended longevity relative to newer types. The DC10 family, with 236 retirals representing 61% of the delivered fleet, has an average retirement age of 27.5 years. L1011s have been retired at an average age of 23.7 years, with close to 90% of the fleet now out of service. However, the 767 family, which has only 80 retirals to date representing 8% of the delivered fleet, has so far been retired earlier, at an average of 21.7 years.

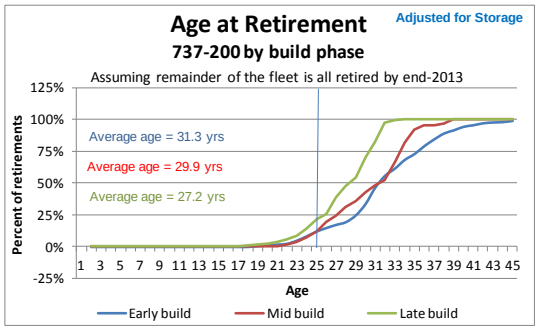
Thus the pattern seen in the narrowbody fleets is repeated for widebodies, suggesting that, whilst the early generations of commercial jets avoided competition from more efficient alternatives for some time, recent trends towards efficiency improvement, amplified by fuel prices that represent a far greater proportion of an airline's operating costs than before, are fuelling more rapid fleet replacement and this will likely accelerate as new 787s and A350s enter service.

"Last off the line" – the relevance of position in the production cycle

Analysis of retirement patterns for previous generations of commercial jets shows that early, mid and late production cycle[1] aircraft have had different retirement profiles, leading to a potential "last off the line" effect on aircraft values to reflect a shortening of economic life.

The effect can be seen clearly in the retirement profiles of 737-200s, which is one of only a few fleets that can be said to have a lineage that extends into current production aircraft and which has largely already been retired. The chart on the left, below, shows how the retirement profile and average retirement age of early, mid and late build 737-200s decline, almost synchronously, with a 6.5 year difference in average retirement age between the early and the late phase aircraft. However, the data exclude 350+ 737-200s that are either still in service or stored. When these remaining aircraft are included in total retirements, by making an aggressive assumption that they all retire in 2013 (or at the date of their storage), the separation between the first and last phases closes up considerably, to a 4 year difference in average retirement age.





Whilst not a negligible difference, it is also not as great as might have been expected, given the excitement that accompanies any discussion of last off the line impact. It is also arguable that future fleet retirements will not reflect as great a level of dispersion, for several reasons: i) a wave of retirals was forced on the 737-200 fleet by the introduction of more stringent noise limits which curtailed the operation of any remaining Stage II aircraft in North America and Europe. No such legislation will impact current generation fleets; ii) the adjusted retirement profile assumption is conservative – if the remaining aircraft are assumed to retire two years later, in 2015, the average difference reduces to 3 years; iii) the installed fleet of 737-200s peaked at around 1100 aircraft, whereas A320 and 737NG fleets will each be in excess of 6,500 aircraft by the middle of this decade. All things being equal, older, less efficient and lower valued aircraft will be retired first, with no shortage of candidates.

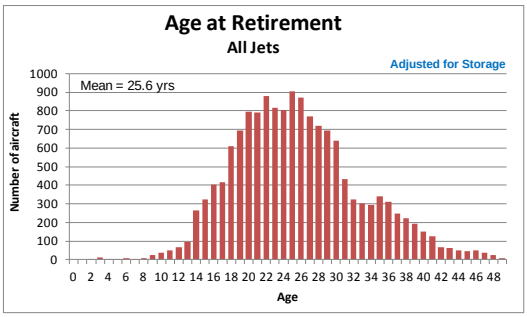
Future Trends

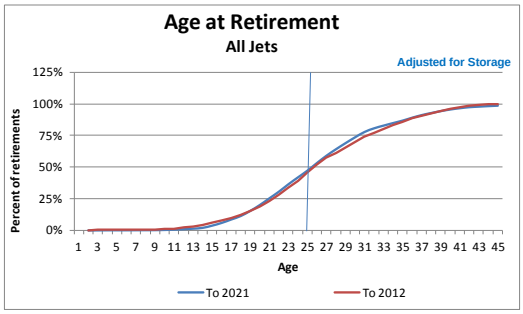
Avolon undertakes a comprehensive annual analysis and forecast of global fleet activity over a twenty year horizon, forecasting orders, deliveries and retirements for the worldwide commercial jet fleet broken out by aircraft type. The 2012 "World Fleet Forecast" projects that, over the next 20 years, more than 33,000 commercial jets will be delivered, of which 45% will be needed to replace retirements totalling 15,000 aircraft.

[1] Refers to three equal periods of time during which an aircraft type is in production, each representing 1/3rd of the total number of years in production

Over the next decade, Avolon expects more than 15,000 new aircraft to be delivered, of which 64% will be single aisle, 23% widebodies and 13% regional jets. During the same period 8,000 aircraft will be retired, in broadly the same proportions. This level of retirements is greater than all of the aircraft that have been retired to date since the beginning of the jet age, underscoring both the rate of growth within the industry and the longevity of commercial jets.

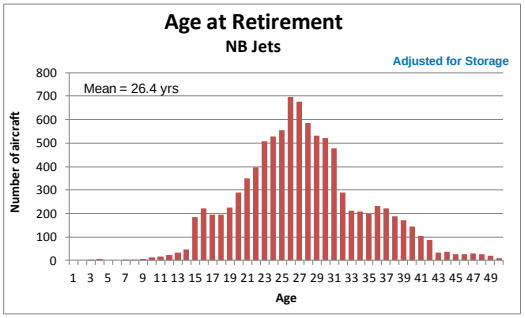
On an aggregated basis, these retirements, which have been forecast in detail using a methodology that takes account of the build year of each in service aircraft and both the underlying and cyclical influences on retirement activity, maintain an almost unchanged retirement profile, with the cumulative average age of aircraft at retirement falling only slightly from the current level to 25.6 years. This is despite the forecast including an assumption that there will be a material increase in the retirement of younger aircraft, with over 350 under the age of 15 prematurely leaving the fleet over the coming decade - at more than twice the rate seen over the past 5 and 10 years. Even so, the average age of the aircraft retiring during the next ten years (as opposed to the cumulative average of all retired jets) is forecast to remain above 25 years, at 25.4 years.

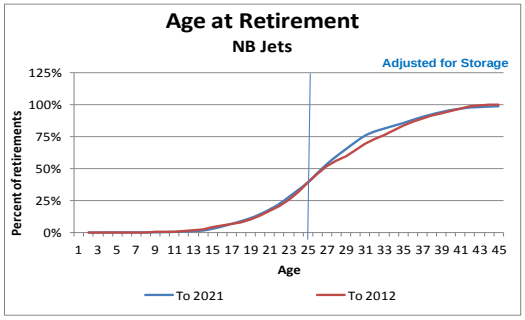




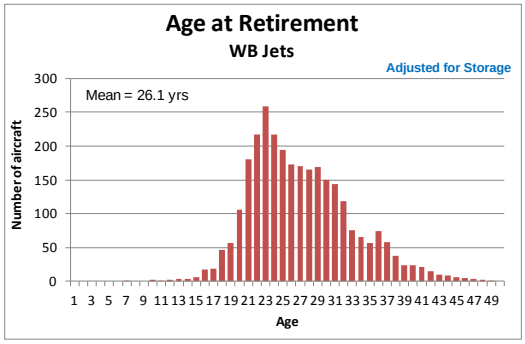
Consequently, the proportion of the installed fleet reaching 25 years or more before retirement also remains extremely steady relative to the current profile.

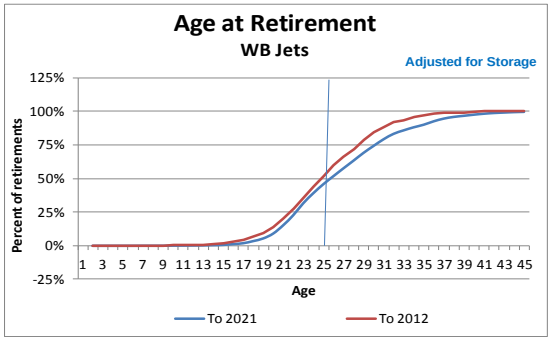
In fact, all of the decline occurs in the narrowbody fleet, where the average retirement age is forecast to fall from 27 to 26.4 years, a still modest 2% shift. The cumulative profile of NB retirements also barely moves until well past 25 years, when there is a slight fall in retirement age. The average age of NB retirements over the next ten years is forecast to be 26 years.



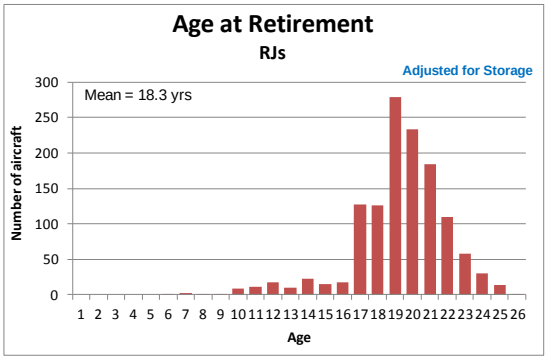


The average widebody retirement age continues to increase and, by 2021, is approaching that of the NB fleet at over 26 years. Consequently, the cumulative retirement curve shifts to the right, with less than 50% of WBs retired by the age of 25. The average age of WB retirements over the next ten years is more than 27 years.

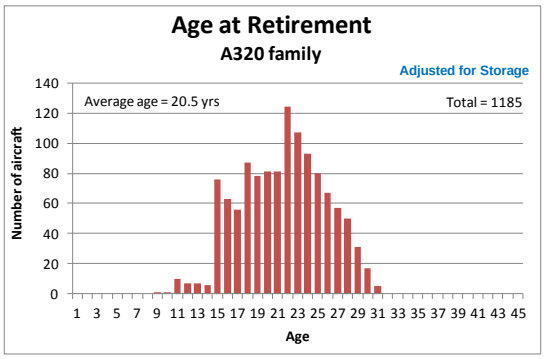




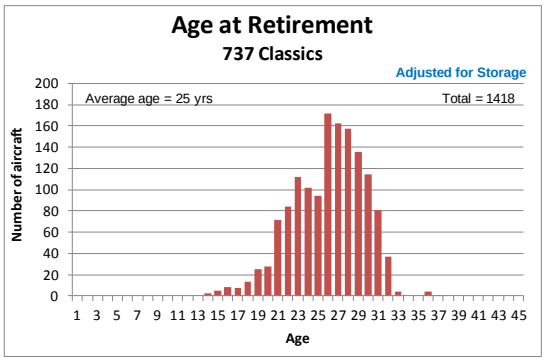
The pattern of regional jet retirements will undergo significant transformation over the next decade as the first generation of 50-seat ERJs and CRJs starts to be taken out of service in significant numbers. In addition, the larger regional jets, which have longer economic lives and, in value terms, behave more like larger airliners than regional turboprops, also start to appear in the retirement statistics. This results in a measurable up-tick in average retirement age, to 18.3 years, with the next ten years averaging close to 19 years.



With respect to the A320 family, over which most concern is currently being expressed, the retirement profile does indeed fill out over the coming decade, as predicted, with average age at retirement rising from the current 19.1 years to 20.5 years by 2021 and the ten year average also running well over 20 years, despite the inclusion of more than 200 “premature” retirements (as described above).



The retirement profiles of other fleets, including the 737 Classics, are also forecast to develop in a similar manner.



Conclusions

- At the global fleet level, in-service life and average retirement ages continue to support the industry's widely used 25 year depreciation assumption.

- Over successive decades, fleets have remained in service for longer and retired at greater ages.

- This trend has continued to the present day – however at least part of the continuing improvement can be explained by the changing mix of NB and WB retirements.

- At a sub-fleet level, the last decade has seen a slight deterioration in the core metrics around retirement for NBs in particular, although the shift has been slight and has been stable for the past five years.

- There is an apparent reduction in the longevity from the early generation fleets (727s, 737-200s, DC10s, etc) to more recent generations, with A320s seemingly the weakest performing fleet. However, with a large proportion of later generation fleets still to reach 25 years, both in-service time and average retirement ages will increase for these types, in line with historical trends for other models.

- Large numbers of aircraft remain in active service well beyond the 25 year mark, whilst instances of aircraft being retired very early in their lives remains extremely low and occur for specific, usually economic, reasons. They are irrelevant in the overall scheme of things.

- Small regional jets have performed significantly below retirement patterns for NBs and WBs. Whilst the numbers involved remain low, this is likely to remain an issue given the high fleet concentrations in North America and the adverse effects of high fuel prices.

- Even assuming that opportunistic premature retirement of younger aircraft continues to take place, and at a much higher rate than heretofore, the pool of older fleets of retirement candidates will ensure that the overall pattern of ageing and economic life is maintained at broadly historic levels.

- Last off the line effects are evident in fleet retirement profiles, but are less severe than might have been expected and should diminish as installed fleet sizes increase.

- As newer fleets, including current A320 and 737NG families, begin to be retired in greater numbers, their ageing profiles will develop to resemble those of older models that have already completed a significant part of their total retirement process.

- Whilst a small number of individual aircraft may suffer value impairment through early retirement, there is strong evidence that the broader patterns of fleet operation and ownership will continue to support current industry value retention assumptions.