Aircraft Retirement and Storage Trends

Economic Life Analysis Reprised and Expanded

Dick Forsberg
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AVOLON

Dick Forsberg
Head of Strategy, Avolon

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 disciplines of business strategy, industry analysis and forecasting, asset valuation, portfolio risk management and airline credit assessment.
As a founding executive and Head of Strategy at Avolon, his responsibilities include defining the trading cycle of the business, primary interface with the aircraft appraisal and valuation community, industry analysis and forecasting, driving thought leadership initiatives, setting portfolio risk management criteria and determining capital allocation targets. Prior to Avolon, Dick was a founding executive at RBS (now SMBC) Aviation Capital and previously 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 is a member of the Royal Aeronautical Society and also a Board Director of ISTAT (The International Society of Transport Aircraft Trading).

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Executive Summary

In September 2012, Avolon published a White Paper[1] that analysed aircraft retirement trends to determine whether there was any evidence to support a view that aircraft economic life was getting shorter. The conclusion was that retirement behaviour and economic life expectations had both stabilised over the past decade or more, with the average age at which commercial jets are retired holding steady at around 26 years and a stable outlook.

The White Paper, which examined in detail the retirement profiles of all major models and categories of commercial jets, was widely read and, we believe, helped to clarify the industry's understanding of economic life trends, as well as generating informed debate which has continued to this day. The analysis then, and now, did not set out to investigate the related changes in aircraft values through their economic lives, but focussed on the physical movements of aircraft fleets.

Over two years on, with examples of relatively young aircraft being parted out still occurring from time to time, it is appropriate to revisit the data and update the analysis to include retirement activity that has taken place over the intervening period. As before, the analysis takes full account of storage time when calculating retirement ages, using data as at December 31, 2014.

The approach taken and methodology used in this analysis remain unchanged from the original White Paper. The data cover more than half a century and include all jet airliners that have been delivered for non-military use, tracking their build years, delivery dates, storage and ultimate retirement. Aircraft that have been destroyed or withdrawn from use due to accidents or major incidents are excluded. Importantly, the analysis nets off any long-term storage of aircraft prior to their ultimate formal retirement against their actual age at retirement.

The principal conclusion of the updated analysis is that the broad retirement picture for all of the main categories of commercial jets has remained very close to the range observed in 2012, with no indications of material deterioration in the retirement circumstances surrounding any individual aircraft type and retirement activity continuing to play out along the forecast trends indicated in the 2012 paper.

The average retirement age for all commercial jet aircraft is 25.7 years (compared to 25.9 years in 2012), with 60% (unchanged) of delivered aircraft still in service at 25 years of age. Within the total fleet, narrowbody aircraft are retired at an average age of 26.6 years (27.0) and widebody aircraft at 24.6 years (unchanged), with 65% (67%) and 59% (59%) respectively remaining in service after 25 years.

Isolated cases of premature retirement of current generation aircraft have continued to occur since 2012. However, the 44 large commercial jets retired at 15 years or younger over the past two years represent less than 4% of the total, with the 11 instances that occurred in 2014 making up just 2.5% of the total.

In addition to updating the earlier White Paper, this study has been expanded to include a detailed analysis of aircraft storage trends, identifying patterns of aircraft movements into and out of storage facilities over the past 20 years and mapping those patterns onto the current stored fleet to predict future "re-activation" activity.

The historical patterns confirm that the ability of airlines and owners to return stored aircraft to active duties is significantly diminished with the passage of time. This can be linked to the technical costs involved in preparing aircraft for service induction, which rise rapidly beyond a storage period of two years and can reach $1.5 million for a narrowbody type and $3.5 million for a widebody if overhaul calendar time limits are reached and components require replacement. Over the past 20 years, 90% of stored aircraft returning to active service have done so within two years of being parked - only 1,200 aircraft out of 18,000 have resumed flying after more than two years in storage.

The analysis further concludes that the potential for additional stored aircraft to be returned to active service in the event of sustained lower fuel prices amounts to no more than 200 aircraft (less than 1% of the world fleet), since the majority of eligible aircraft will already be included in the natural ebb and flow of stored fleets.

Finally, the White Paper examines the potential for deferring the normal retirement of in-service passenger aircraft in the event that fuel price remains low, estimating that an additional 150 to 200 aircraft a year could be retained rather than retired.

Taking storage re-activation and deferred retirements together, the impact on new and young aircraft fleets is considered low, with the net level of additional capacity representing only 5% to 10% of new aircraft deliveries, well within the capabilities of the OEMs to manage.

1. Available on the Avolon website at www.avolon.aero

Background to retirement and storage patterns

By the end of 2014, over 34,000 jet airliners had been delivered, of which two thirds are in active service today with an average fleet age of 11 years. Over 2,000 passenger aircraft are currently inactive and in storage, with an average age of 21 years. Over 60% of these (and almost 80% of those over 15 years old) will not return to commercial service due to their age, the length of time spent in storage and the cost associated with returning them to a serviceable condition.

To date, more than 8,500 aircraft have been retired from use, at an average age of 27.2 years, which is reduced to 25.7 years when time spent in storage prior to retirement is factored in. As Table 1 shows, 75% of these retirements are concentrated in 10 aircraft fleets.

Table 1:
Commercial Jet Aircraft Retirements by Fleet

Boeing 727	**1525**
Boeing 737-100/200	**777**
DC-9	**738**
Boeing 747	**664**
Boeing 707/720	**649**
Boeing 737 Classic	**601**
MD-80	**457**
DC-8	**433**
Airbus A320 family	**264**
DC-10	**261**
Airbus A300	250
Lockheed L-1011	225
Caravelle	216
BAe 1-11	208
Fokker F.28	164
Boeing 767	136
Bombardier CRJ 100/200	121
Airbus A310	117
Trident	99
Boeing 757	84
BAe 146	81
Comet	64
Fokker 100	60
Convair 880	49
Boeing 737NG	43
Airbus A340	42
VC10	34
Convair 990	25
FD328JET	19
MD-90	17
Airbus A330	15
BAe Avro RJ	13
Boeing 777	10

Most retirement decisions are a direct function of age, when an operator concludes that the cost of maintaining and operating an aircraft at an acceptable level of utilisation exceeds the financial contribution it can earn. Often the decision is triggered by a specific event, such as 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 the aircraft in question has a limited or niche application, or if significant expenditure is required, perhaps at the end of a lease term, following a lessee default and early termination or if there is localised market demand for high value components, and remains limited to small numbers of aircraft.

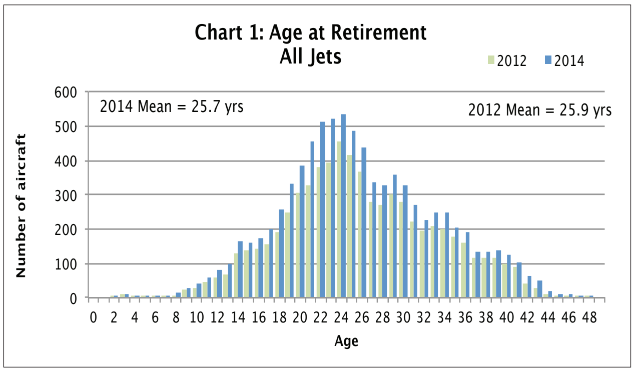
A frequently-used “halfway-house” for airlines or owners facing such asset value issues is to place aircraft into a storage facility, either for a planned short period until market demand picks up, or for a longer, often open-ended, period which requires a greater level of technical “mothballing” to protect the critical high cost structures and components. These stored fleets provide some degree of capacity safety valve for the industry, although the reality is that relatively few aircraft emerge from long-term storage to fly again. Over the past 20 years only 20% of all aircraft stored for more than 3 years have been returned to active service and, of these, fewer than 10% were passenger aircraft over 15 years old.

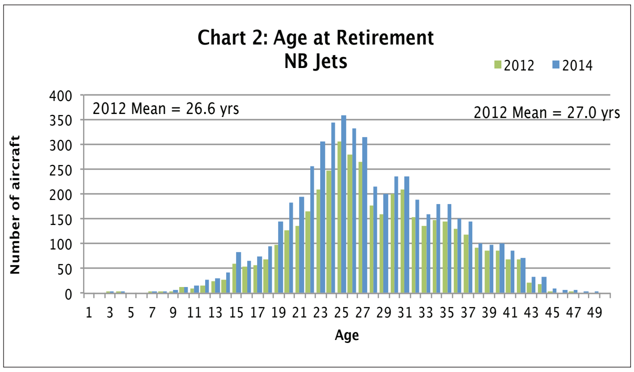
A wide range of factors, not all cycle related, continues to influence the pattern of aircraft retirement and fleet replacement, raising important questions for the industry. Have the approaching technology transitions in all three aircraft size categories started to impact retirement patterns? Are the economic lives of current generation types getting shorter? Will the current lower oil price environment result in more aircraft being brought out of storage? Will retirements of older fleets be deferred at the expense of new deliveries?

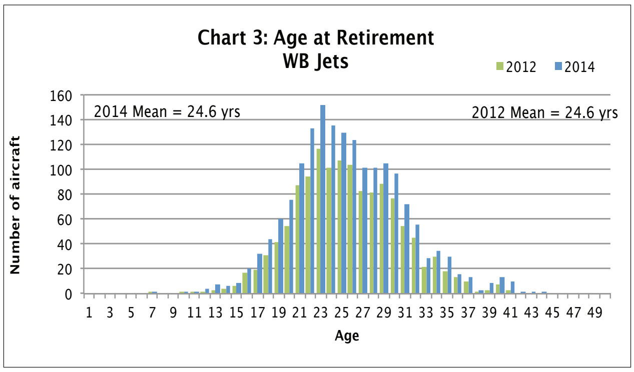
Analysis – Global Fleets and Macro Trends

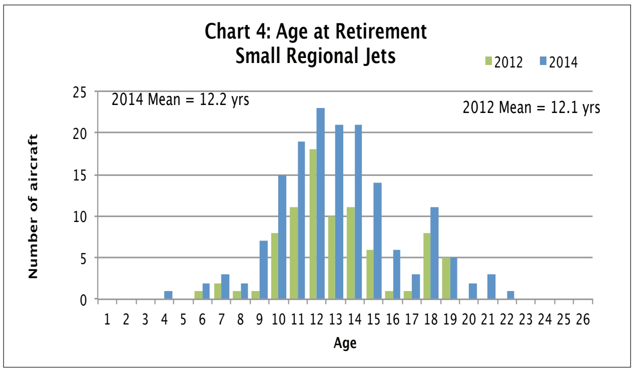
The average retirement age for all commercial jet aircraft remains slightly less than 26 years. The narrowbody fleet average is around a year more and the widebody average is a year less, with minimal variation in the cumulative figures over the past two years in any of the three main category groupings, as shown in Charts 1 to 4.

The most striking change in retirement profile has taken place in the Small Regional Jet fleets, where the number of retirements has increased by 90%, but still stands at well below 200 aircraft, with an unchanged average retirement age slightly over 12 years.









Over 2,000 passenger aircraft are currently inactive and in storage, with an average age of 21 years. Over 60% of these (and almost 80% of those over 15 years old) will not return to commercial service.

Analysis – Global Fleets and Macro Trends (continued)

Notwithstanding the evident long-term consistency across all of the groups, a declining trend can be seen in the average age of retirements taking place in more recent years (Chart 5). Comparing retirements during the past two and preceding two year periods, the average retirement age has shortened by around 6 months for narrowbodies and a year for widebodies (Chart 6).

Chart 5: Average Age at Retiral

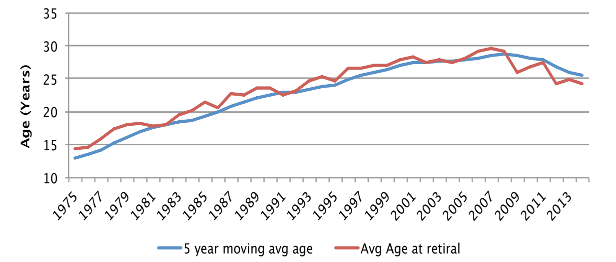
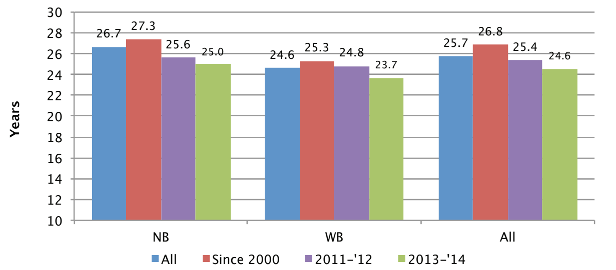


Chart 6: Average Retirement Age



However, this does not mean that aircraft are being retired earlier, rather that the mix of fleet types is changing, with fewer of the oldest early generation DC9s, 727s 737-200s, DC10s, 747-1/200s, etc., but more 737 Classics, MD80s and 767s and a rising, though still small, number of A320s and 737NGs. In fact, as described in the following section, the average retirement age within most fleets continues to increase. For example, the average retirement age of A320s increased from 19.9 years in 2011 and 2012 to 20.4 years in 2013 and 2014. Over the same periods, the average 737 Classic retirement age remained steady at around 22.5 years, 737NGs (still only 43 in total) increased from 10.5 years to almost 14 years and 767s from 23.5 to 24 years. Whilst none of these changes individually is material, the trend is, contrary to first impressions, stable or slightly upwards.

Another, and arguably more traditional, way to think about economic life is in terms of survival curves and Avolon's analysis in 2012 examined the proportion of delivered fleets remaining in active service at or beyond 25 years of age. In this regard too, the overall picture remains unchanged, with more than 60% of commercial jets still in service beyond their 25th birthday (Chart 7).

The same consistency applies equally to aggregate narrowbody and widebody fleets, with a high level of conformity also present in the less mature regional jet fleet (Charts 8 to 10).

Chart 7: Percent of Delivered Fleet Remaining In Service All Jets

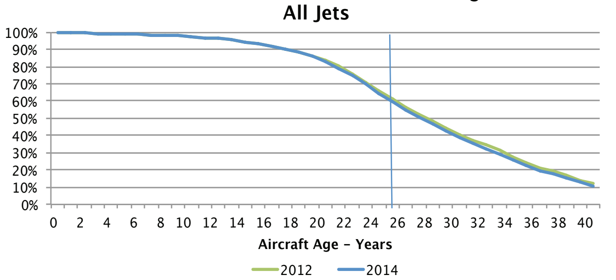


Chart 8: Percent of Delivered Fleet Remaining In Service All NB Jets

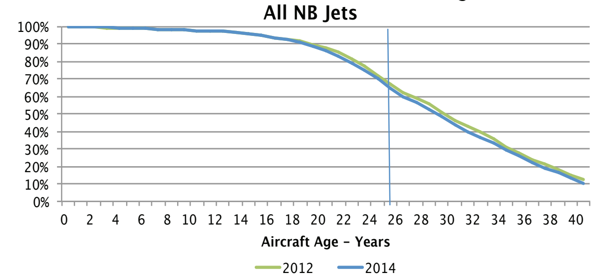


Chart 9: Percent of Delivered Fleet Remaining In Service All WB Jets

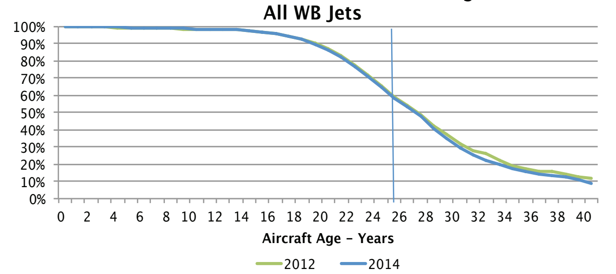
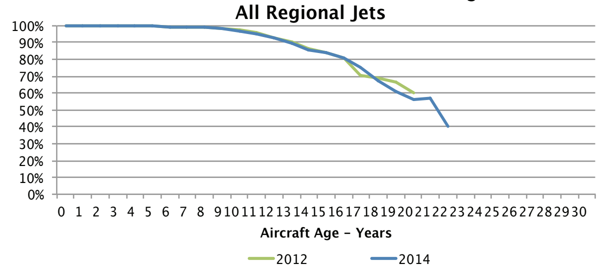


Chart 10: Percent of Delivered Fleet Remaining In Service All Regional Jets



Fleet-specific Analysis

The oldest fleets

Starting with the oldest remaining fleet populations, the rate of retirement for "second generation" single aisle types such as the 727, DC9 and 737-200 has slowed considerably in the past two years as the active installed base is now very small, at less than 300 aircraft. Similarly, first generation widebody types such as the L1011, DC10 and 747-100/200/300 are by now mostly retired, with the last commercial passenger DC10 flight taking place in 2014. More than 85% of this group of aircraft has now been retired, at an average age of over 29 years (Table 2). Half of the remaining examples are in storage, with two-thirds of those still in service operated as freighters. Those remaining have an average age of 36 years.

Table 2: First wave fleet retirements

	Delivered	Retired	2011/12 Retirals	2013/14 Retirals	Avg. age - all retirals	% Retired*
Boeing 727	1828	1525	76	57	29.7	90%
DC-9	940	738	36	21	33.5	90%
Fokker F.28	235	164	44	4	27.7	87%
Boeing 737-100/200	1120	777	55	34	28.6	80%
Lockheed L-1011	248	225	8	2	24.0	94%
Boeing 747-100/200/300	717	557	46	21	26.9	84%
DC-10	386	261	20	13	28.1	76%
Total	**5474**	**4247**	**285**	**152**	**29.3**	**86%**

** including total losses*

Recent past production fleets

The next "wave" of aircraft coming through the retirement window are those that are most recently out of production or, in the case of long-lived programmes, the earliest examples of types that are still being produced, but in small numbers (the 767s). This category includes 737 Classics, 757s, MD80, Fokker 100s and BAe146/Avro RJs, plus widebody fleets of A300s, A310s, 747-400s, 767s and MD11s.

The most obvious feature of this group of aircraft (Table 3) is that the overall level of retirement is still low - just 27% on average and with the most actively retired fleets barely 50% depleted. Also, the level of annual retirements has been maintained over the past two years relative to the preceding two, reflecting the steady stream of candidate aircraft still remaining to enter the retirement window. Since the average age of this large remaining cohort is less than 20 years, a similar rate of retirements can be expected to be maintained for some time.

Table 3: Second wave fleet retirements

	Delivered	Retired	2011/12 Retirals	2013/14 Retirals	Avg. age - all retirals	% Retired*
BAe 146	217	81	8	7	19.7	42%
MD-80	1191	457	78	66	22.4	42%
Boeing 737 Classic	1988	601	172	135	21.8	33%
Fokker 70/100	322	62	18	4	17.2	25%
MD-90	116	17	4	7	12.5	17%
BAe Avro RJ	170	13	1	5	16.0	12%
Boeing 757	1048	84	12	27	23.4	9%
Boeing 717	155					
Airbus A300	559	250	15	27	22.8	51%
Airbus A310	253	117	25	17	22.2	51%
Boeing 747-400	690	107	35	49	20.5	17%
Boeing 767	1053	136	19	42	22.6	14%
MD-11	198	19	5	14	19.2	14%
Total	**7960**	**1944**	**392**	**400**	**21.7**	**27%**

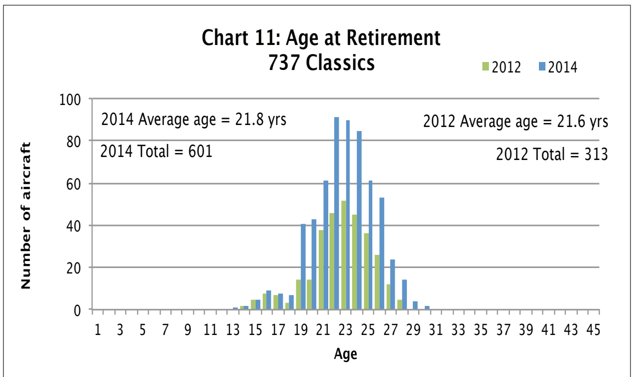
** including total losses*

Fleet-specific Analysis (continued)

At just under 22 years, the average retirement age of this group is quite a bit lower than for the previous wave, which benefitted, in economic life terms, from a lack of "replacement" aircraft for a significant period of time combined with an economic environment where i) profitability was not a major consideration for many of the world's airlines and ii) very low fuel prices did not justify the introduction of more efficient technology. The low average age, however, is not an accurate indicator of future expectations for this group of aircraft, which analysis (discussed in detail in the September 2012 White Paper) suggests will mature to at least 25 years. This conclusion is based upon an assumption that the remaining 6,000 aircraft, with an average age of 20 years, will be retired evenly over at least the next ten years. The resulting average retirement age for these aircraft will, therefore, be around 25 years. This, when blended with the already retired aircraft, produces a combined average age of 25.5 years.

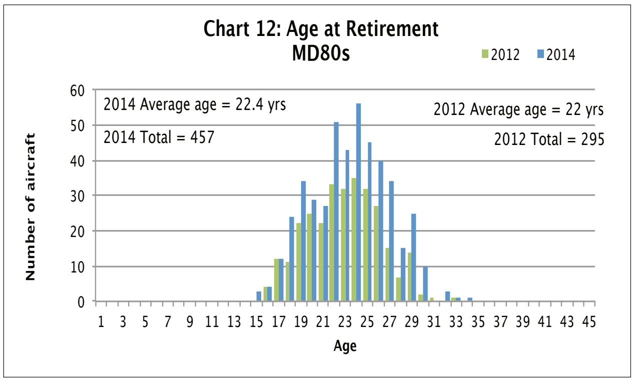
Within this wave, there are several aircraft types that are of interest to the broad investment, financing and trading communities, notably the 737 Classic, 757, MD80, 747 and 767 families.

Over the past two years, 737 Classic retirements have begun to accelerate, almost doubling the total since the previous analysis in 2012 (Chart 11).

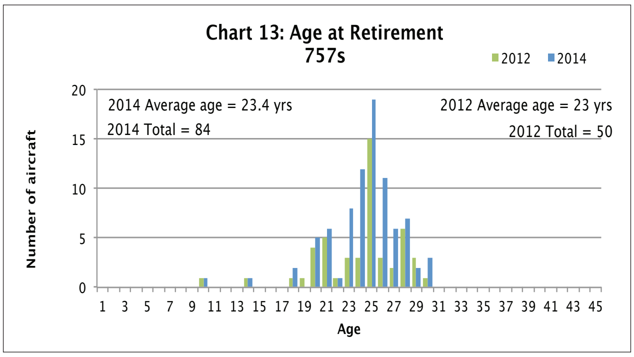


The average retirement age has also increased, taking the cumulative average retirement age to 21.8 years across 600 aircraft. 183 Classics were formally retired in 2013 and 2014, with an average retirement age of 22.7 years (adjusted for 48 aircraft that had been in storage during prior years). With only 1/3rd of the delivered fleet retired and almost 1,000 aircraft remaining in active service, this trend will continue for some time, with the age distribution tail skewing further to the right as the youngest remaining examples are now 15 years old and the oldest over 30.

MD80 fleet retirements have maintained a steady pace, with the total number increasing by 50% since the 2012 analysis, to over 450 by the end of 2014 (Chart 12). The average age at retirement has increased slightly, to 22.4 years across all retirements and was close to 25 years for the 124 aircraft formally withdrawn from use during 2013 and 2014 (adjusted for 58 aircraft previously in storage). 40% of the delivered fleet remains in active service, with a further 20% currently in storage, providing ample feedstock for retirements to maintain their current trend, with the age distribution tail moving slightly further to the right as the remaining fleet is between 16 and 34 years old.

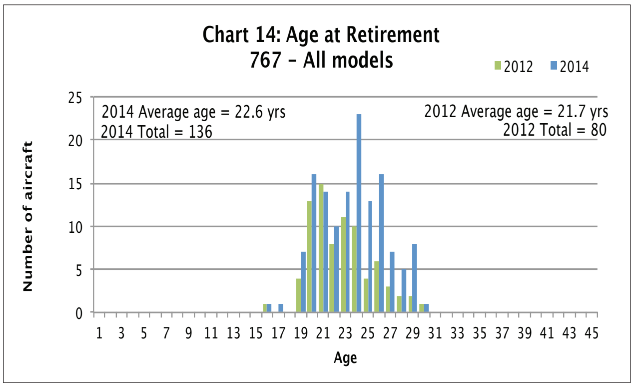


Despite all of the current OEM focus on 757 replacements, the 757 fleet has barely begun to be retired, with less than 10% taken out of service to date (Chart 13). Although the oldest 757 in service is now 32 years old, the youngest was only delivered in 2005, which will extend the retirement activity over a long period of time. In addition, the type has robust freighter potential, with 10% of the fleet already operating as such, supporting further life extension. The 84 aircraft that have been retired to date have an average adjusted retirement age of 23.4 years, with 27 retirements taking place over the past two years at an average age of 24 years. The age distribution profile is developing along familiar lines and, given the scale and deployment of the remaining fleet, the profile is expected to develop slowly, but normally.



Fleet-specific Analysis (continued)

The first 767 was delivered in 1982 and, with 1,100 deliveries made or due, the type remains in production, albeit with a low level of commercial demand, predominantly for freighters. Less than 15% of the fleet has been retired to date, 136 aircraft in total with an average adjusted retirement age of 22.6 years (Chart 14).



This average age has been increasing, with 42 aircraft retired in 2013 and 2014 at an average age of 24 years. With 787s and A350s now delivering in increasing numbers, the overhang of 767s that have been placeholders for the long-awaited new generation widebodies is expected to reduce, leading to accelerating retirements over the coming years. However, the feedstock of older vintages (almost half of the in service fleet is already more than 20 years old) should ensure that the retirement age distribution is maintained at or above the current average.

Current in-production fleets

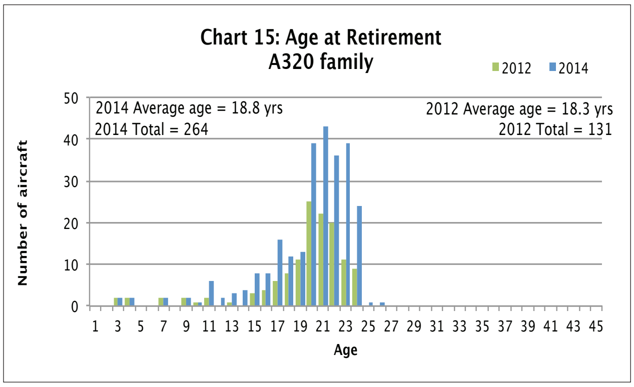
The third wave of aircraft retirements (Table 4) comprises fleets of aircraft that are currently in production, include A320s, 737NGs, A330s, A340s and 777s - most of which are directly relevant to the aircraft financing and investment community. Their relative youthfulness and the scale of their installed base means that only a small fraction of delivered aircraft has been retired, with 97% of the 14,000 aircraft delivered to date still in service, at an average age of 7.6 years. The 374 aircraft that have left the fleet did so at an average age of almost 18 years and 75% of retirements took place during the past four years.

Table 4: Third wave fleet retirements

	Delivered	Retired	2011/12 Retirals	2013/14 Retirals	Avg. age – all retirals	% Retired*
Airbus A320 family	6280	264	79	93	18.8	5%
Boeing 737NG	5014	43	24	18	12.0	1%
Airbus A330	1124	15	3	12	17.1	2%
Airbus A340	367	42	8	25	17.0	12%
Boeing 777	1261	10	1	8	15.4	1%
Total	**14046**	**374**	**115**	**156**	**17.7**	**3%**

** including total losses*

Whilst still low, retirement of A320 family members has picked up in the past two years, during which time the number of aircraft leaving the fleet has doubled, to just over 260 (Chart 15). Retirement age has also been increasing, with an average age of 18.8 years overall and 19.4 years for aircraft retired in 2013 and '14. The age distribution chart confirms that the profile continues to move to the right and the trend is supported by the growing feedstock of aircraft that will be closing in on 25 years in the coming years.



Fleet-specific Analysis (continued)

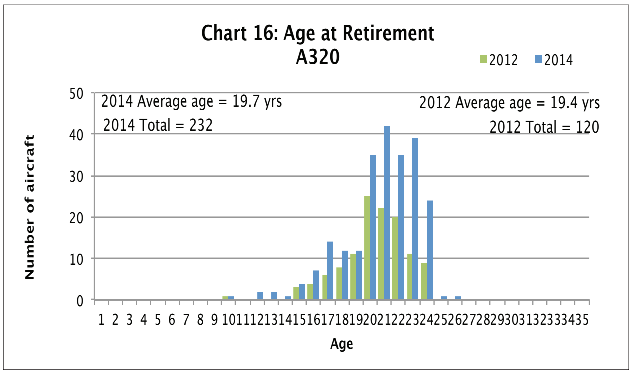
Within the A320 family, retirements are highly concentrated in the A320 itself, which accounts for 88% of the total (Table 5). A318 and A319 retirements total 11 of each variant and, whilst there has been a good deal of commentary around the parting-out of these aircraft early in their lives (at 6.4 years and 13.3 years respectively on average), the fact remains that these were opportunistic part-out events that were appropriate under specific and/or transient circumstances that are not generally applicable to the wider fleets.

Table 5: A320 family members

	Delivered	Retired	2011/12 Retirals	2013/14 Retirals	Avg. age – all retirals	% Retired*
Airbus A318	60	11	2	3	6.4	18%
Airbus A319	1356	11	4	7	13.3	1%
Airbus A320	3838	232	72	75	19.7	7%
Airbus A321	1026	10	1	8	17.1	1%
Total	**6280**	**264**	**79**	**93**	**18.8**	**5%**

** including total losses*

Taking the A320 model in isolation, a total of 232 retirements have an average age of 19.7 years (Chart 16), with 75 aircraft retired since 2012 at an average age of 20.4 years, helping to move the age distribution gradually to the right in a trend that supports the long-term forecast made in the 2012 White Paper.



Breaking the A320s down into even more detail (Table 6), it becomes clear that almost all A320 retirements relate to first generation, pre-1995 variants with CFM56-5A or V2500-A1 engines, which have a clear performance disadvantage over more recent engine variants and are also, by definition, closer in age to their natural retirement window. Over 40% of "First Engine Option (FEO)" deliveries have now been retired, including 54 since 2012 at an average age of 22 years.

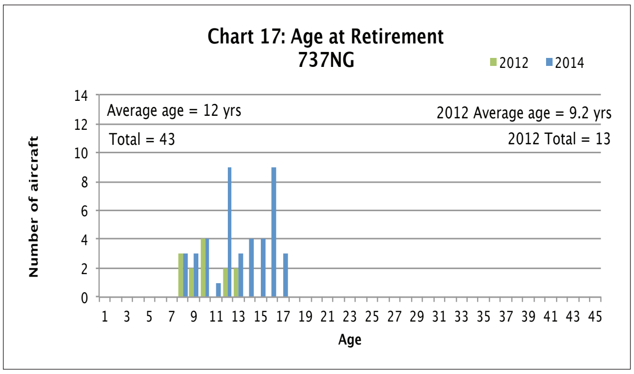
Table 6: A320feo vs ceo

	Delivered	Retired	2011/12 Retirals	2013/14 Retirals	Avg. age – all retirals	% Retired*
Airbus A320 feo	533	201	64	54	20.3	41%
Airbus A320 ceo	3305	31	8	21	15.6	1%
Total	**3838**	**232**	**72**	**75**	**19.7**	**7%**

** including total losses*

Conversely, minimal activity around the A320ceo fleet supports the thesis that only isolated retirement decisions are being made for these aircraft – typically driven by specific technical and economic circumstances pertaining to the assets. All but two of these aircraft were owned by lessors and at least 40% of them were returned off-lease in a default situation.

The 737NG family has experienced an even lower level of retirements, with a total of just 43 having an average age at retirement of 12 years (Chart 17). The pattern of retirements across the family members and over time maps very closely with the A320, suggesting that factors relating to the size and popularity of each model are driving retirement decisions rather than any wider issues affecting Airbus or Boeing narrowbodies.



Fleet-specific Analysis (continued)

With lessors owning 90% of the retired aircraft, the incidence of "prudent opportunity" is again highest for the smallest family members. 737-600s and -700s accounted for 40 retirements, leaving just 3 737-800s that have been retired to date (Table 7). Default lease returns preceded only 15% of NG retirement events, whilst aircraft returning from three airlines (Jet x13, Gol x8 and Malev x6) featured prominently in end of lease retirements, including the three -800s.

Table 7: 737NG family members

	Delivered	Retired	2011/12 Retirals	2013/14 Retirals	Avg. age– all retirals	% Retired*
Boeing 737-600	69	11	8	2	10.4	16%
Boeing 737-700	1121	29	16	13	12.8	3%
Boeing 737-800	3485	3		3	11.0	0%
Boeing 737-900/ ER	339					
Total	**5014**	**43**	**24**	**18**	**12.0**	**1%**

** including total losses*

In-production widebodies have not been retired in sufficient quantities to identify trends with any level of statistical confidence and, although the average age of those that have been retired is under 20 years (17 years for 15 A330s and 15.4 for 10 777s), the occurrences are too few and operator-specific to conclude that their retirement patterns are off-trend. However, as an increasing number of similar aircraft either begin to roll-off their first operating leases or approach expensive cycle-related milestones in airline operations, it may be helpful to link some of the salient points from the limited retirement activity to the remaining installed fleets.

12 of the retired A330s are low weight -300s that had been operated since new by two airlines (MAS and PAL). They are estimated to have clocked up an average of over 50,000 flight hours (FH) and 20,000 flight cycles (FC) and were traded by each of the airlines to an operating lessor for part-out. There are 61 low gross-weight -300s remaining in the world fleet, of which 24 have reached at least the same FH & FC levels and could therefore be considered next in line for retirement – these have an average age of 20 years. Less than 10% of the remaining 1,000-strong A330 fleet currently come close to the same utilisation levels, suggesting that the retirement pattern is following historical age- and specification-related norms, whereby the oldest and least capable typically get retired first.

With respect to the 10 retired 777s, 4 of these came from the batch of early -200 variants delivered to BA and United. Averaging an estimated 40,000 flight hours and 13,000 flight cycles, the 10, which are all -200 or -200ER variants, include two at or above 50,000 FH and two with 1.25 hour average stage lengths.

Applying the A330 FH and FC criteria to the almost 500 777-200/ERs remaining in the world fleet, only 22 potential candidates emerge, with an average age of 20 years. All but one of these are non-ERs, again supporting an expectation of a traditional retirement profile.

Aircraft storage and re-activation patterns

In a significant expansion of the original 2012 White Paper analysis, a detailed review of fleet storage patterns has also been completed, so that historical activity may be used to inform an assessment of the potential for currently parked aircraft to be returned to service, especially those that may have been considered to be consigned to history in a high fuel price environment, but could be candidates for "re-activation" if fuel prices remain low for the medium-term. The analysis covers all commercial jets that entered storage during the past 20 years, many of them on several occasions, generating over 22,000 storage events in total. Aircraft that served time in military, corporate, VIP or Government-related roles were excluded to ensure that the results reflect the movement of true commercial passenger and cargo aircraft. Aircraft that remained in storage for less than 60 days have also been filtered out of the analysis, thereby removing the majority of aircraft transitioning between leases or undergoing routine heavy maintenance events. Aircraft re-entering service following freighter conversions are also excluded from the total. Removing these aircraft from the total brings the number of storage events down to almost 18,000.

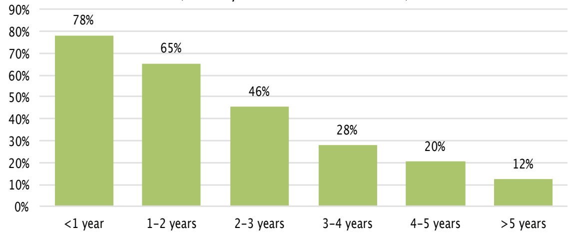
The patterns of storage and subsequent re-activation are similar for passenger aircraft and the commercial fleet as a whole - unsurprisingly, since passenger jets represent over 80% of all re-activation events. The pattern for pure cargo aircraft (17% of the total) is slightly different, partly due to the older age profile of many of the aircraft types active in the freighter fleet.

The historical re-activation patterns confirm both conventional wisdom and anecdotal evidence from several industry sources working directly for, or in association with, storage facilities such as Victorville, CA and Goodyear, AZ. In aggregate, 65% of all aircraft that spend more than 60 days in storage end up back in active service.

However, the probability of re-activation is clearly and directly related to the age of the aircraft in question and the time that they have spent in storage, as can be seen in Chart 18.

Chart 18: Percentage of stored aircraft returned to active service after time in storage

(last 20 years – all commercial uses)



Source: FlightGlobal Ascend

Note: time spent in cargo conversion is excluded

In aggregate, almost 80% of all aircraft stored for less than one year will return to active service, with 2/3rds of remaining aircraft returning after two years in storage. The likelihood of a return declines steeply thereafter, to less that 50% after three years down to little more than 10% beyond five years.

This profile directly reflects the costs incurred in bringing aircraft back to airworthy condition after periods of inactivity, with a C-check at least required beyond around 18 months. At this stage, technical costs may be limited to \$300-500,000 for a narrowbody and \$600,000 - 1 million for a widebody. After 4 or 5 years in storage, however, a heavy D-Check may be needed, which is usually a hard stop item for older aircraft. Even before that, calendar life-limited components such as landing gears may require overhaul, updated avionics databases and mandatory modifications may need to be incorporated. These requirements could take the technical costs up to \$1.5 million for a narrowbody and \$3.5 million for a widebody, with the potential to go higher if ADs and failed component replacements are required. In addition, aircraft consigned to long-term storage will typically have engines removed by the owner where there is green time remaining so that they can be utilised elsewhere in their active fleet, leaving a further cost to be covered in the event that a return to service is contemplated – that of sourcing two or more replacement engines.

Aircraft storage and re-activation patterns (continued)

The profile for dedicated freighter aircraft (Chart 19) is similar to the overall picture, but with a higher re-activation rate, which reflects not only the preponderance of older aircraft in the freighter fleet, but also the greater volatility of the air cargo market which drives a higher level of short-term capacity reductions facilitated by the temporary parking of freighters.

Looking at the age versus storage time relationships in more detail and concentrating on passenger aircraft returning to active service (in passenger configuration), the impact of the aircraft's vintage at the time of entering storage can clearly be seen in Chart 20, with aircraft age applying a substantial multiplier effect to the probability of re-activation – or not.

Very young aircraft that have been parked for less than 12 months will almost always become active again and most young and mid-life aircraft (up to 15 years old) will also be returned to service, even after relatively long storage periods. However, beyond 5 years' in storage, even aircraft that were youthful when they entered storage will often not re-enter service, whilst the probability of older aircraft becoming active again following prolonged storage diminishes steeply, to less than 5% for anything over 20 years of age.

The probability of aircraft being returned to active service is also influenced by whether the model is in production at the time of entering storage. As Chart 21 shows, there is a marked difference in the behaviour of in production and out of production aircraft, with the latter significantly less likely to fly again. Whilst over 90% of in-production types placed in storage over the past 20 years have subsequently emerged, only 56% of out of production aircraft have done so, a difference that becomes more marked as storage time increases.

Chart 19: Percentage of stored cargo aircraft returned to active service after time in storage
(last 20 years)

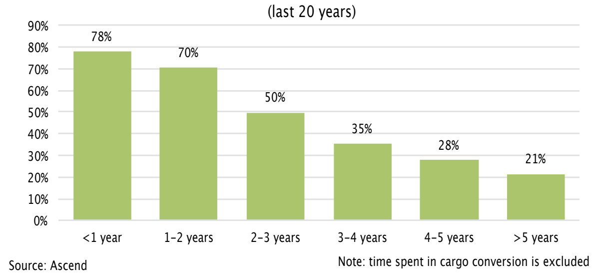


Chart 20: Proportion of stored aircraft returning to active service by age and time in storage
(last 20 years – passenger only)

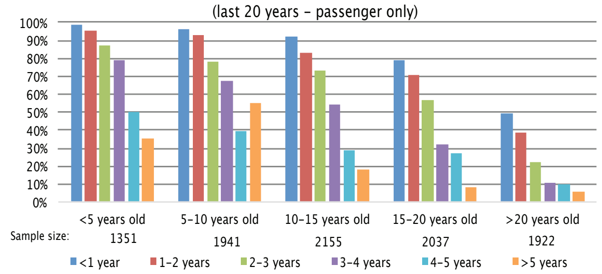
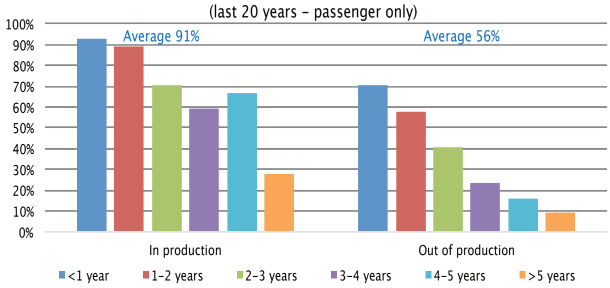


Chart 21: Proportion of stored aircraft returning to active service by production cycle phase
(last 20 years – passenger only)



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The probability of older aircraft becoming active again following prolonged storage diminishes steeply, to less than 5% for anything over 20 years of age.

Outlook for the current stored fleet

Turning to the stored fleet as of mid-March 2015, which numbers over 2,000 passenger aircraft[2], the foregoing learnings can be used to develop an estimate of the extent to which aircraft, especially those that are older and out of production, might re-enter active service as a consequence of sustained lower fuel prices.

60% of the stored fleet has been on the ground for less than two years, yet a detailed and informed analysis of the stored fleet suggests that less than 40% of all stored passenger aircraft, around 800 in total, will return to active service. This aggregate number includes the vast majority (84%) of in-production commercial jets, but a significantly smaller proportion of out of production types (31%).

When an age profile is applied to the stored fleet, 70% of currently stored aircraft under the age of 15 are likely to re-enter service, but the proportion drops to less than 25% of aircraft over 15 years old and 15% of those aged over 20 years.

As can be seen in Table 8, the largest single grouping of stored aircraft is 300 737 Classics, with an average age of 24 years and an average storage period of less than 2 years. Up to 30% of these are likely to see further active service under normal circumstances. Conversely, only 12% of the 200 stored MD80s, with an average age of 26 years and over 3 years in storage, are likely to re-emerge. The stored 757 fleet is closer to the 737 Classic profile, with 25% of the 150 parked aircraft potentially returning to active service, whilst the majority of the 100+ in-production A320ceo family aircraft will return to service, along with most 737NGs, but only a small number of first generation A320feos.

Table 8: Re-entry prospects for the largest stored fleets

Model	Production	Stored	Avg. Age (Yrs)	Avg. Storage time (Yrs)	Re-entry %	Re-entry #	Max. additional*
All passenger aircraft	All	2051	20.5	1.2	39%	800	174
In Production	In	312	12.4	0.4	84%	262	24
Out of Production	Out	1739	21.9	1.4	31%	538	150
>15 years old	Both	1330	24.8	2.1	23%	301	49
B737 Classic	Out	296	23.7	1.8	29%	87	23
MD80	Out	203	26.1	3.1	12%	25	3
Boeing 757	Out	155	23.8	1.4	25%	38	7
A320ceo family	In	107	11.2	0.6	87%	93	12
Boeing 737-200	Out	72	32.5	3.6	8%	6	
Boeing 737NG	In	68	10.1	0.4	96%	65	3
Airbus A320feo	Out	48	23.5	1.4	30%	15	0
Boeing 747	Out	65	24.7	2.2	22%	14	8
Boeing 767-300ER	In	59	21.0	0.9	52%	31	7
Airbus A340	Out	55	15.1	1.3	42%	23	20
Boeing 767 (ex -300ER)	Out	39	27.3	3.1	4%	2	1
Airbus A300	Out	32	25.0	1.2	25%	8	
Airbus A330	In	26	12.1	1.1	81%	21	3
CRJ200	Out	261	15.0	1.8	52%	136	62
ERJ145	Out	107	15.3	2.7	23%	25	12

* Less than 15 year old, stored for less than 3 years and not already included in re-entry total

2. In storage for more than 60 days

Outlook for the current stored fleet (continued)

The largest widebody model population in the parking lots is the 767, with 39 current generation -300ERs and 59 other variants in storage. The latter, having a significantly higher average age and longer time in storage, have a very low probability of seeing passenger service again, however over 50% of the 59 767-300ERs are re-activation candidates. Of the 65 various passenger model 747s, with an average age of 25 years and 2 years in storage, barely 20% are likely candidates to fly in passenger service again. Perhaps surprisingly, over 40% of the 55 stored A340s could take to the air again, along with 25% of the A300s and over 80% of A330s.

The small regional jets continue to pile up in storage, but still have a moderate chance of returning to service, although non-commercial roles are likely to account for a growing proportion.

The final column of Table 8 references the maximum additional number of stored aircraft for each of the main fleets that could conceivably be seen as re-activation candidates over and above the normal re-entry rates suggested by historical movement patterns. The cut off assumed for these additional aircraft is an age limit of 18 years (15 for RJs) and no more than 3 years in storage. This additional re-activation could occur in the event that fuel prices remain low for an extended period of time, but it is significant that the absolute number of incremental re-activation opportunities, at around 175, is low, representing less than 1% of the installed fleet, and limited to a small number of aircraft types, predominantly the A340, 50-seat RJs, 737 Classics and A320s, plus a handful of 747s, 757s and 767s.

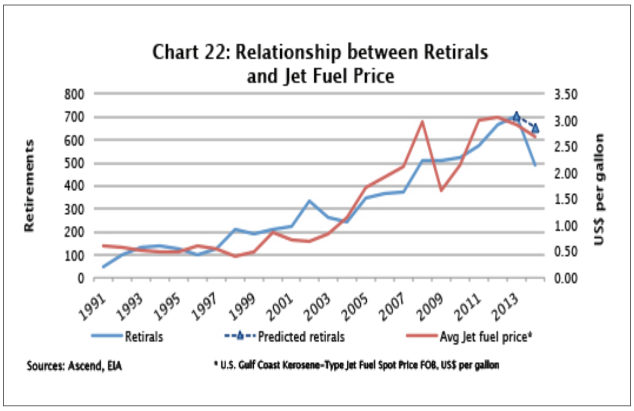
Raising the upper limits for re-activation by adding 2 years to the maximum age or to the maximum storage time does not significantly alter the number of additional aircraft, which increases to around 200 in either of the two alternative scenarios

> Less than 40% of all stored passenger aircraft, around 800 in total, will return to active service.

The potential for deferring retirements

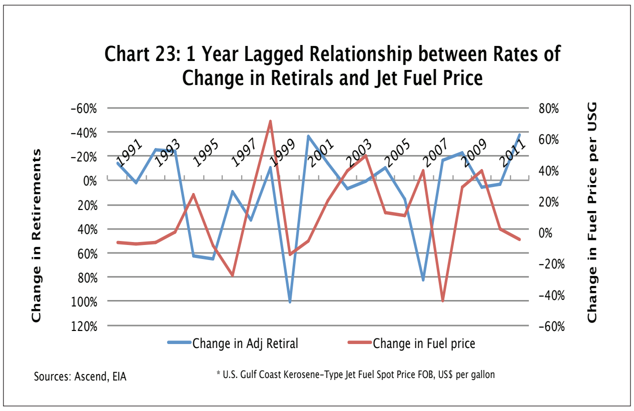
The last part of the fuel price impact question relates to the extent to which aircraft currently in service might be retained beyond their planned or expected economic life due to more attractive economics arising from a significantly lower fuel price.

On the face of it, the relationship between fleet retirements and the price of fuel appears strong – over the past 25 years there is a statistical R^2 correlation of 0.65 between annual retirement numbers and the average jet fuel price in each year (Chart 22). Note that early reports of a sharp decline in 2014 retirements relative to 2013 are likely to be over-stated, as it typically takes 6 to 12 months for the full picture of actual retirement events to filter through to the FG Ascend database due to reporting delays. A predicted number for 2014 has therefore been included in Chart 22, based on typical variations seen in recent years.



However, since there is also frequently a delay between aircraft being removed from active service and their ultimate demise (seen in the 1.5 year shorter "adjusted" average retirement age in the earlier analysis), the true comparison should be between the adjusted retirement date and the then prevailing fuel price.

This generates a much weaker correlation, with an R^2 between 0.25 and 0.4 depending on the degree of time lag applied to the retirement date (the retirement event will normally occur some time after the fuel price has changed). An alternative thesis that retirement is influenced by the rate of change in fuel price rather than the absolute cost of fuel is also refuted by analysis, with no statistically meaningful correlation, even when a time lag is introduced (Chart 23).



So fuel price is, after all, not a primary driver of retirement decisions over the long term. There is only one example of a rapid and material change in fuel price being followed by a corresponding spike or dip in retirements. This occurred in 2000, when a 71% increase in the average price of jet fuel was followed in 2001 by a 100% increase in adjusted aircraft retirements, however the latter was triggered by the events around 9/11 and not as a response to a prior change in oil price.

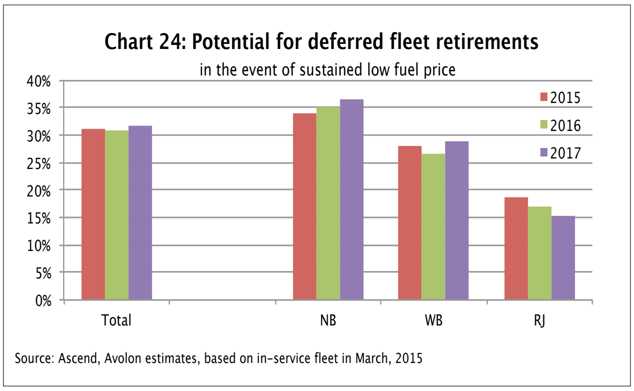
The potential for deferring retirements (continued)

Notwithstanding the lack of evidence for a consistent link between oil price and retirements, it is possible to model, to a limited extent, the level of potential retirement deferrals that could occur should fuel price remain low for the next 2 to 3 years. The analysis is significantly more challenging that trying to identify which stored aircraft might emerge, not only because the numbers of aircraft involved are much larger, but also because the key information that will ultimately drive decisions by owners and operators to retire aircraft - namely their maintenance status and associated levels of financial investment, including times since last airframe and engine overhauls, remaining utility on LLPs, etc. - is not available for the world fleet.

The methodology used in this analysis, which is applied to passenger aircraft only, relies on the application of filters based on aircraft type and age, linked to flight hour and flight cycle utilisation which is reasonably well reported in the FG Ascend fleet data.

The analysis takes all passenger aircraft over 18 years old (15 years for 50-seat RJs) as the baseline "potential retirement" cohort. The likelihood of being retained in active service rather than being taken out of service is calculated using a declining factor as time passes beyond an assumed 18 year major overhaul (a reasonably common maintenance threshold for many types). This is further refined by applying FH and FC limits to each aircraft category so that the lowest utilisation aircraft are retained first and longest.

The result of this inexact science is a broad conclusion that 30% of aircraft that might be considered retirement candidates could be retained for an extended active life in the event that their enhanced economic performance outweighed the incremental costs of extending their operating lives. The retained proportions are slightly higher for narrowbody types (35%), lower (25%) for widebodies and lowest (15%) for small regional jets, as shown in Chart 24.



Assuming an underlying level of 500 to 700 annual passenger aircraft retirements over the next several years, the implicit potential deferred element is 150 to 200 aircraft a year. When added to the total of 175 to 200 incremental re-activation candidates, the aggregate number of aircraft that might, in a low fuel price environment, be considered "displacers" of younger aircraft in any single year lies in the 200 to 300 range over the next three years. However, since demand stimulation as a consequence of the low fuel environment will absorb a proportion of these, the net displacement would likely be no more than 5% to 10% of annual production, which would be well within the capabilities of the OEMs to manage.

Conclusions

The foregoing analysis of retirement and storage patterns serves, firstly, to reaffirm the facts and trends associated with aircraft economic life that were identified in the original 2012 White Paper, secondly, to better understand the way that aircraft move in and out of storage at different stages of their lives and, finally, to estimate the extent to which aircraft use and retirement might be affected by extended low oil prices.

In summary, the following key conclusions may be drawn:

- **The patterns of retirement behaviour have not materially changed since the 2012 White Paper analysis, with average retirement age stable at or around 25 years and more than 50% of fleets remaining in service beyond their 25 year anniversary.**
- **Premature retirement of aircraft at significantly younger ages continue to be isolated occurrences, typically triggered by specific economic considerations relating to the maintenance condition of the aircraft in question and the prevailing market environment.**
- **A recent downshift in the average age of retirements on an aggregate annual basis has been driven by a changing mix of aircraft types and generations, not by reductions within individual fleet types.**
- **The average retirement age of most fleets has continued to increase over the past two years**
- **The retirement rate for current production aircraft continues to be very low and, where it is occurring, average retirement ages are continuing to move upwards, following the age distribution trends anticipated in the 2012 analysis.**
- **Historical storage patterns confirm that whilst young, in-production aircraft types will generally return to active service, even after several years in storage, older aircraft and out of production models are less likely to see active service again, with the probability of re-activation reducing with age and time in storage.**
- **2 to 3 years of storage represents a threshold beyond which the prospect of a return to active service diminishes significantly, largely determined by the costs associated with the necessary technical work required to put such aircraft back into airworthy condition. After five years in storage, the level of re-activation is very low, even for younger aircraft, averaging less than 10% and falling to just 5% for aircraft older than 20 years.**
- **A sustained period of lower fuel prices could generate a modest additional level of stored aircraft returning to active service, however the 175 to 200 incremental aircraft identified as potentially returning to operation is extremely small in the context of the global fleet.**
- **Sustained low fuel prices could also result in airlines and owners deferring the retirement of 150 to 200 passenger aircraft a year, but the aggregate displacement of younger aircraft in the operating fleet, net of additional demand growth, is not expected to exceed a manageable 5% to 10% of new deliveries.**

AVOLON

Avolon Holdings Limited
The Oval, Building 1
Shelbourne Road
Ballsbridge, Dublin 4
Ireland