Key Findings on Airplane Economic Life

Helen Jiang
Associate Technical Fellow
Aviation System Analysis
Boeing Commercial Airplanes

March 2013

Key Findings on Airplane Economic Life

Boeing Commercial Airplanes

March 2013

About the Author

Helen Jiang is an aviation system analyst at Boeing Commercial Airplanes in Renton, Wash., where she and her teammates provide expertise in market analysis and research, forecasting, modeling and simulation to support Boeing's business planning and production decisions. Trained as an aerospace engineer in China, Jiang holds a master's degree in aerospace engineering from MIT, and an MBA from the University of Washington. She joined Boeing in 2005 after career work in China as a strategy and airline analyst at both Aviation Industry of China (AVIC) and Airbus Industrie China. Jiang has particular expertise in survival analysis and holds a U.S. patent on methodology for fleet and airplane retirement forecasting. Her work earned her the distinction of being named a Boeing Associate Technical Fellow in 2011.

Defining the Debate Parameters

The terms "airplane economic life", "airplane useful life", "airplane service life", and a host of variations on these terms occur frequently in industry literature and discussions. Within the air transport industry there is a sense that we know what these terms refer to. Yet a recent casual survey indicated that even experts are hard pressed to precisely define these terms in a way that can be quantified. Further, analysts use a variety of surrogate measures as the basis for quantifying airplane economic life. There is no industry standard for which surrogate is appropriate for a particular context. This leaves room for considerable confusion and misinterpretation of data when conclusions based on one surrogate are compared to those based on another surrogate. Boeing conducted an in-depth study on airplane economic life, in part to address recent speculation that the expected life span of the latest generations of commercial airplanes may be declining. The following report summarizes our findings on the use of terminology, the quantification of airplane economic life, and the stability of airplane economic life spans.

Executive Summary

The terms airplane economic life, airplane useful life, and airplane service life, have appeared frequently in the media and industry reports recently. Speculation or concern that the economic life of modern commercial aircraft may be shortening lies at the heart of these discussions. A significant shift in the life expectancy of commercial aircraft would have profound and long-lasting impact on all players in the industry.

Boeing closely monitors the evolution of the commercial fleet and trends in airplane retirements. Yet, in a recent exhaustive study, we did not identify a standard metric to quantify airplane economic life. We observed that:

- The concept of airplane economic life appears to be contextually defined, based on multiple parameters specific to the entity making the assessment (e.g., airline business model, fleet planning, geographical operation study, local economic factors, acquisition timing, etc.).
- Measures, such as the average age of airplanes when they are permanently withdrawn from service or the average age of in-service airplanes at the point in time when 50% of an original cohort of airplanes has been retired, provide surrogate measures of airplane economic life.

Further, our study revealed that whichever surrogate one chooses to measure airplane economic life, the evidence suggests that the measure has remained stable for more than 15 years.

Moreover, fleet evolutions of the current-generation of airplanes, such as the Next Generation 737 and A320, are following the same trend as previous generations of airplanes. Boeing has found no evidence of a meaningful change in airplane economic life over the last two decades, or going forward.

Background

The Boeing study was rigorous and comprehensive in scope, covering all commercial jets – 31,032 units in total – that were built and delivered by western manufacturers since the start of the jet age. Study data begins with delivery of the first de Havilland Comet in 1952 and tracks the status of each individual aircraft “tail” annually from date of delivery until the year-end 2012. The data source used was the Flightglobal Ascend database. A technical paper that elaborates the data process and analysis results in depth will be available shortly.

Analysis

Our extensive research could not identify a standard metric that quantifies airplane economic life.

One of our initial efforts set out to find a quantifiable definition of airplane economic life to be used in the calculation. The example in the textbox below illustrates the challenge in this seemingly straightforward quest. Although the International Society of Transport Aircraft Trading (ISTAT) definition describes the concept, it does not specify how to formulate an evaluation.

Example:

Given a cohort of 6 airplanes (all exactly the same and produced in the same year), having the following status:

1. scrapped at 20 years old
2. scrapped at 22 years old
3. scrapped at 24 years old
4. scrapped at 26 years old
5. scrapped at 35 years old
6. flying at 36 years old

One can calculate:

- The average age of this cohort is 27.2 years and <u>growing</u>, (20 + 22 + 24 + 26 + 35 + >36)/6. It is important to note that the average age of this cohort will continue to grow as there is still one airplane flying.
- The average useful life of this cohort is 27.2 years and growing, the calculation is the same as above.
- The 50 percentile survival age is 24 years, at which half of the cohort is scrapped.

Question: How would you evaluate the economic life of this cohort?

LIFE, ECONOMIC USEFUL (from ISTAT Handbook)

As it pertains to an aircraft or engine, the economic useful life is the period of time over which it is (or is expected to be) physically and economically feasible to operate it in its intended role. Periodic maintenance and repair will usually be required in order to preserve safety and efficiency during the economic useful life.

Concerning the definition and calculation of airplane economic life, we observed that:

- The definition of airplane economic life must be deduced in the context of the report or analysis at hand. Various industry entities, including airlines, airplane financiers, leasing companies, airplane manufacturers, and aviation suppliers, use specialized definitions of the concept, based on multiple parameters of interest specific to the entity (e.g., business model, fleet planning, geographical operation factors, local economic conditions, acquisition timing, etc.).
- Either of two common surrogates for airplane economic life can be used to quantify the concept: (1) the average age of airplanes when they are permanently withdrawn from service; and (2) the interval of time between delivery of a cohort of airplanes and the date when 50% (or some other fraction) of the cohort has been retired.

To ensure a meaningful quantitative analysis, it is imperative to specify which surrogate for airplane economic life will be used.

Whichever surrogate one chooses as their measure of airplane economic life, our study indicates that the measure has remained stable for more than 15 years.

Our study investigated all major surrogates commonly used in quantification of airplane economic life. Representative examples of two popular formulations are presented below.

Exhibit 1 shows historical trend lines for airplane cohort survival rate between 1980 and 2012. The vertical axis represents the number of years between delivery of a typical cohort of airplanes and the date at which 50% of the airplanes in that cohort have been retired. Single-aisle cohorts are represented in light blue and twin-aisle cohorts in dark blue. The dotted lines track the total surviving fleet, including in-service and parked airplanes. The solid lines track just the revenue-generating fleet, which includes only in-service airplanes. As stated earlier, each line shows that airplane retirements have remained stable for more than 15 years. In analyzing data like this, one must always be cautious to ensure that nominal volatility in the data does not indicate a trend line, so we carefully look at the long-term trends of the data.

Exhibit 1

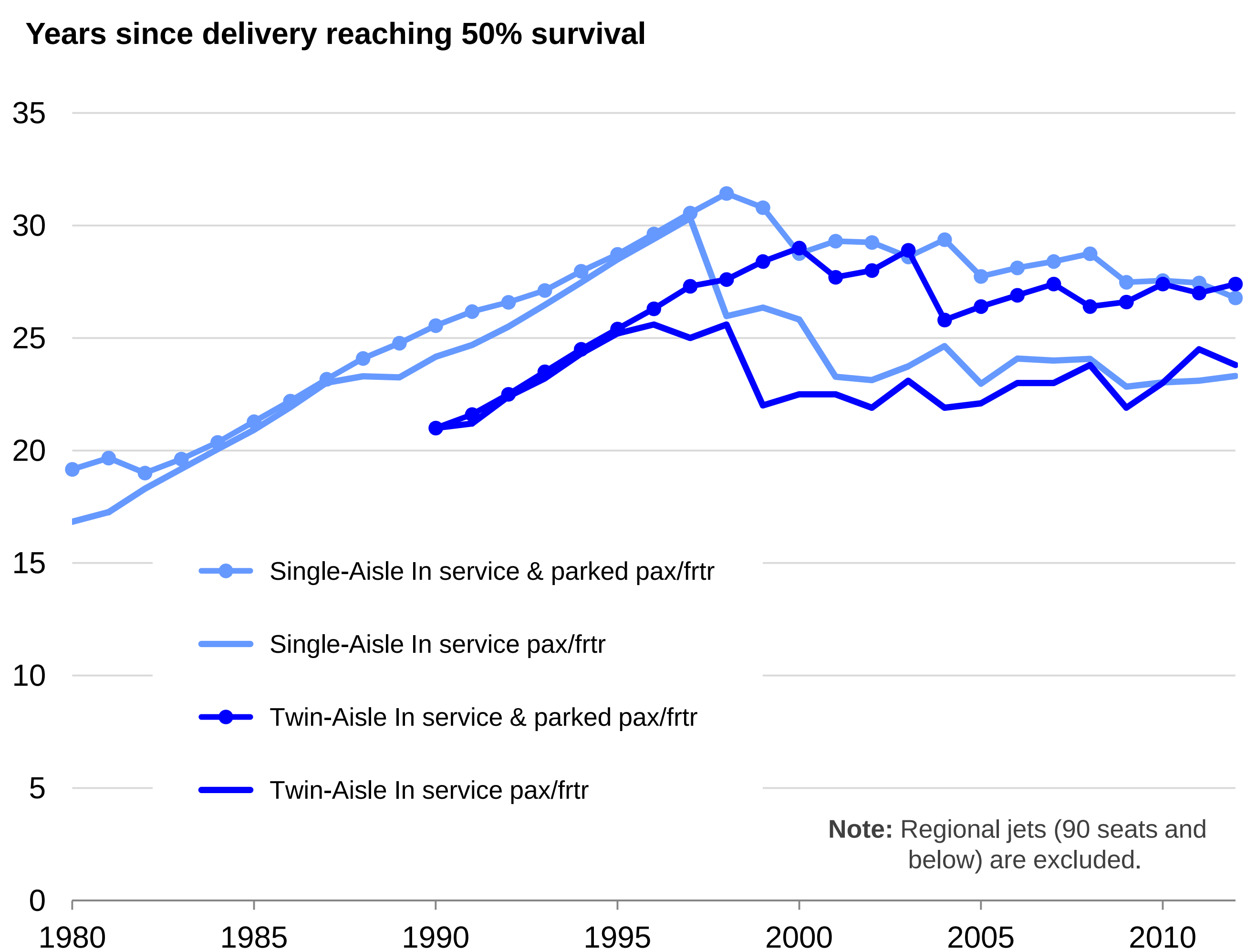


Exhibit 2 depicts the trends of the average age of single-aisle and twin-aisle airplanes that have been permanently removed from commercial service. The solid lines represent the average age at which the airplanes leave service. The dashed lines represent the average age at which the airplanes are scrapped. The difference between the solid lines and the dashed lines reflects the time that the airplanes are in storage prior to being scrapped. The trend lines show that the average airplane age at end of service has remained stable for more than 15 years, gradually increasing as technology advances have been implemented. Over time, significant events, regulation and technology shifts have had impactful influence on the data, although often over only limited periods. These help to explain some of the variation and data noise in the trends observed. The decline in average age of retired airplanes over the last 2-3 years is very likely caused by the combined outcome of trend correction, impact of the Great Recession, a weak cargo market, and parting-out some young airplanes. At present, the industry is experiencing the initial wave of 737 Classic, MD80, and A320 retirements; and the volume of 737 Classic and MD80 retirements echoes their delivery cycle. Consequently, the average ages of passenger airplanes at the time of their leaving service and being scrapped are likely to fluctuate as this wave passes through. Nonetheless, the pattern of their retirements has behaved much the same as that of their predecessors, discussed in Exhibit 4 later.

Exhibit 2

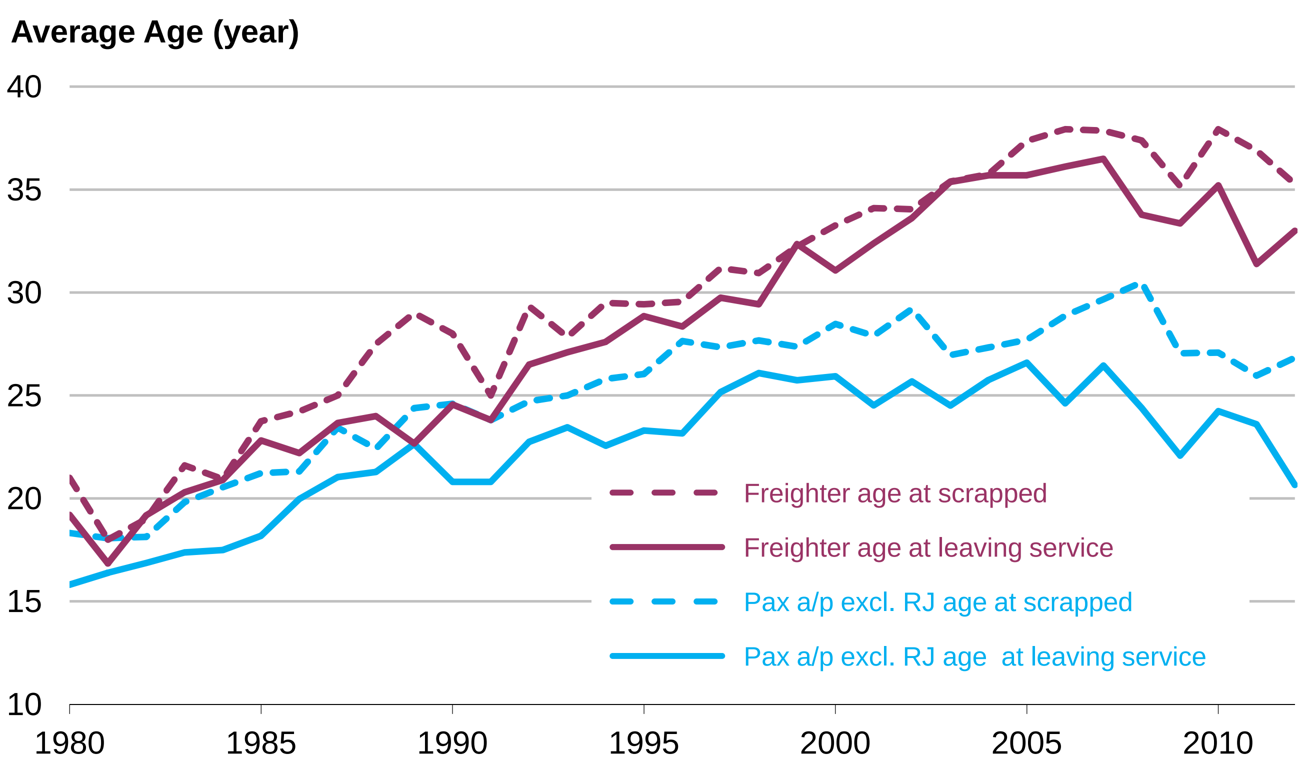
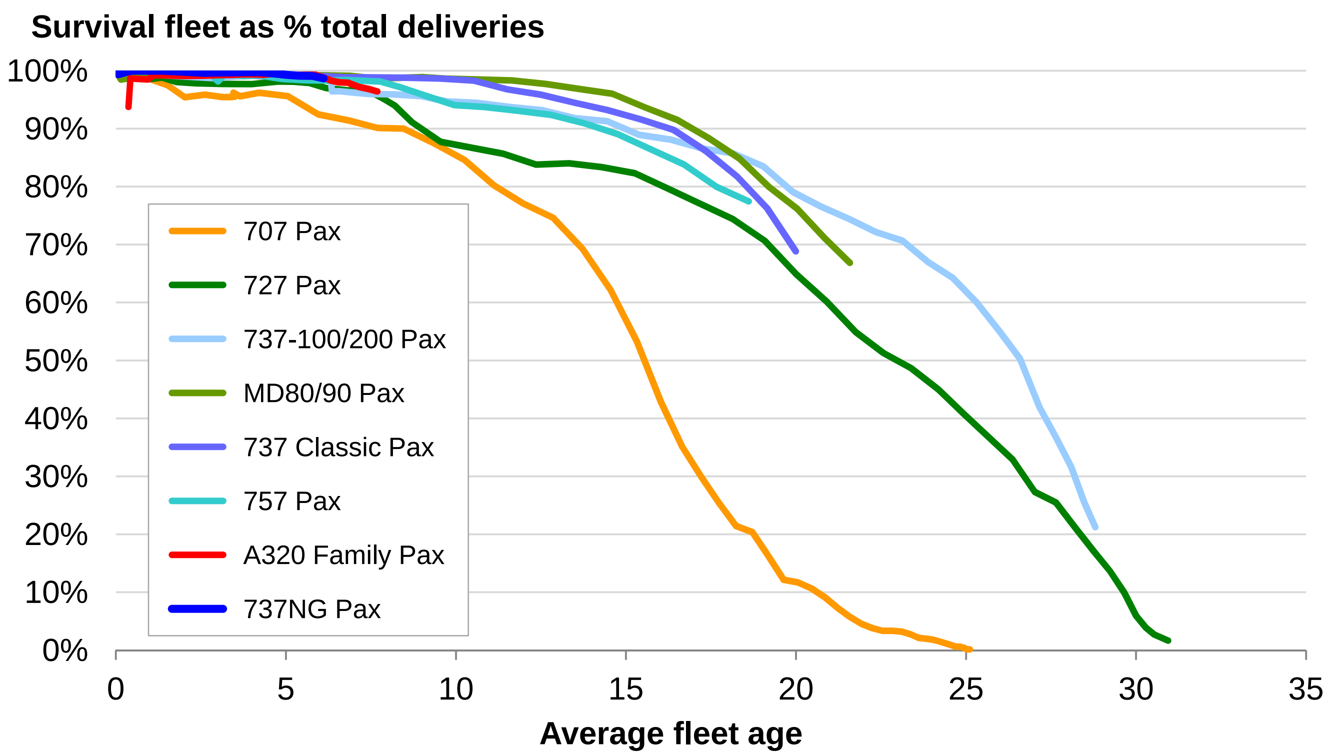


Exhibit 3 shows survival curves of major single-aisle passenger aircraft. The horizontal axis represents the average fleet age, which includes all in-service, parked, and scrapped airplanes. The vertical axis represents the surviving fleet as a percentage of total deliveries. Survival curves for Boeing707, 727, and 737-100/200 demonstrate the impact of technology advances on airplane economic life. Survival levels of 737 Classic and MD80/90 are about 70% at present and their trajectories have followed trends of 727 and 737-100/200. As the fleets age, the survival curves will extend to the right, eventually crossing the 50 percentile threshold. Survival curves for Next Generation 737s and A320s are behaving like those of the previous generation. Although the Next Generation 737s and the A320s are still quite young fleets, their behavior, including a few retirements, are well within historical norms.

Exhibit 3



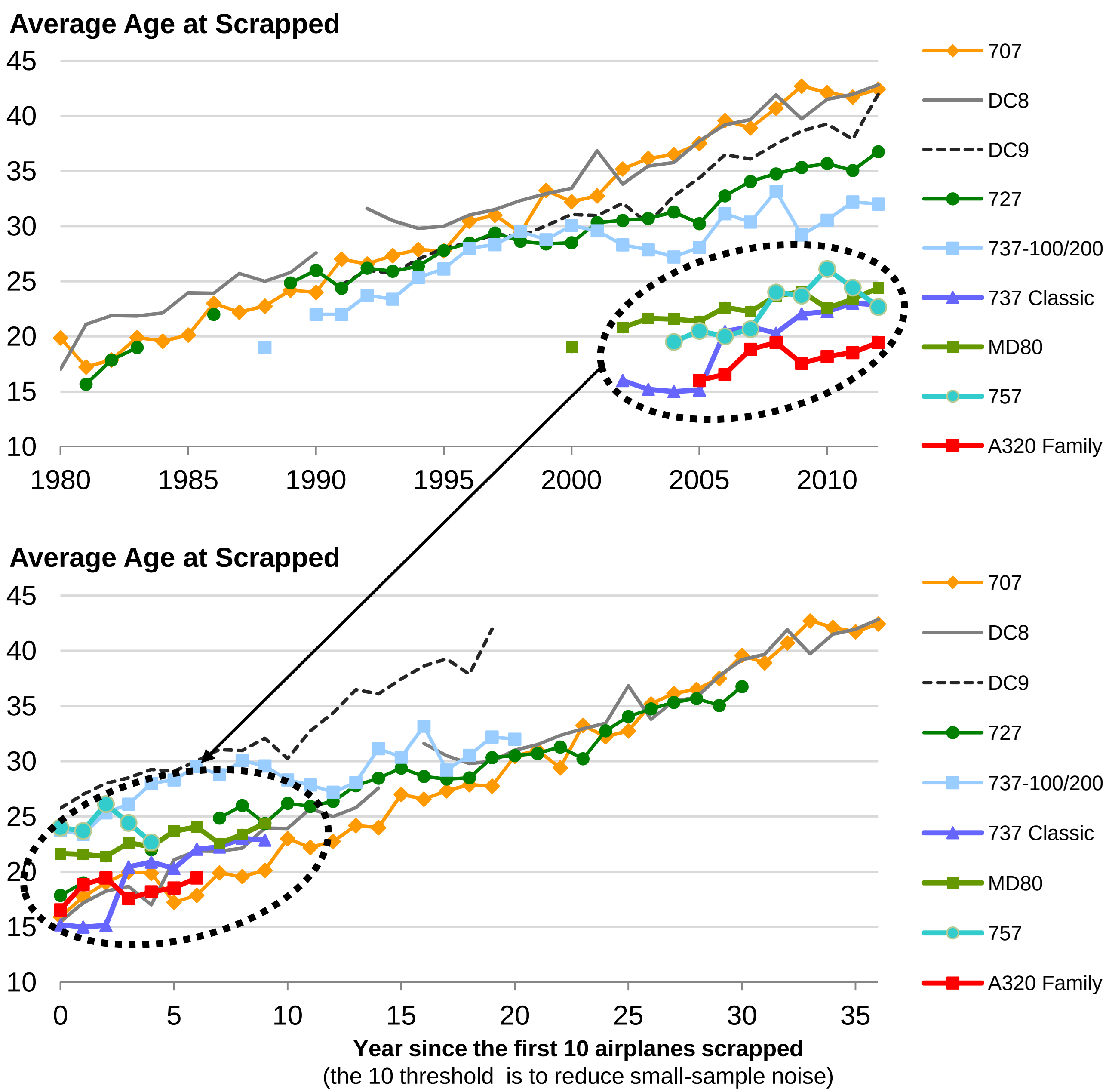
How does this view reconcile with widely reported perception of retirement age of 737 Classics, MD80s, 757s, and A320s?

The top chart in Exhibit 4 illustrates the average age at which those models, in addition to aircraft of prior generations, were scrapped. Comparing the average age when scrapped across aircraft types could lead to the conclusion that 737 Classics, MD80s, 757s, and A320s are retired at a younger age than their predecessors. However, this is a flawed interpretation of the data, as it ignores the fact that airplanes of prior generations are, by definition, older than those of the later generations. Thus, as the entire fleet ages, airplanes retired later from the fleet will be most likely older than those previously retired; and the average age when scrapped will continue to grow. This effect of natural fleet aging is readily visible in the upward slope of all the data.

A fair comparison must take into account the impact of fleet aging on retirement age over time. ***The lower chart in Exhibit 4*** shows the same set of data plotted against a relative time scale horizontal axis, where each aircraft program has its own clock, which starts to tick when the fleet starts to see steady retirements. On this axis, the data reveals that recent average retirement ages of 737 Classics, MD80s, 757s, and A320s, in fact, follow the same trend as many previous models, suggesting no meaningful shift from what we have seen in prior generations.

Our study observed the same phenomenon across the twin-aisle airplane fleet.

Exhibit 4



Summary

In summary, our extensive research did not identify a generally accepted standard metric to quantify airplane economic life. Rather, we observed that airplane economic life is defined contextually in accordance with the purpose of the assessment and perspective of the assessor (e.g., business model, fleet planning, geographical operation, local economic conditions, time period etc.). We found that several surrogates are used to quantify airplane economic life. Two commonly used surrogates are: (1) the average age of airplanes when they are permanently withdrawn from service; and (2) the time interval for a cohort of airplanes to be reduced by half.

Evidence showed that whichever surrogate one chooses to measure airplane economic life, the measure has remained stable for more than 15 years.

Trends of the current-generation airplanes, such as the Next Generation 737NG and A320, are in line with historical trends of their predecessors. Boeing has found no evidence of a meaningful change in airplane economic life over the last two decades, or going forward. Our Current Market Outlook long-term forecast (www.boeing.com/cmo) reflects the same view over the next 20 years. The airline industry will need 34,000 new airplanes, of which 41% fulfills the demand for replacement and 59% for growth.

A technical paper that elaborates the data process and analysis results in depth will become available in the near future, and we look forward to having discussions on this important subject.

Helen Jiang
Associate Technical Fellow
Aviation System Analysis
Boeing Commercial Airplanes
helen.jiang@boeing.com