Aircraft Decommissioning Study

Final report

May 2018

Amsterdam

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Executive summary (1/4)

- At the request of IATA, SGI Aviation (SGI) is appointed to analyse the current status of aircraft decommissioning and the mechanisms used by the stakeholders, and identify the key issues for future best-practice solutions. This report provides the findings of the study of these three elements.
- With a compounded annual growth rate of more than 4%, aircraft retirements have gradually increased over the past decades. More than 15,000 commercial aircraft have been retired worldwide in the past 36 years. In the early 2010s, between 700 and 900 aircraft are retired on an annual basis;
- Historical trends shows that the average aircraft retirement age has increased from 18.8 years in 1980-1984 to 29.4 years in 2005-2009. The retirement age dropped to 27.6 years in the last six years due to the record-high oil prices in early 2010s.
- Aircraft retirements are generally governed by a number of principles:
  - More than half of the aircraft which are utilized for commercial operations are retired between the age of 20 and 30 years;
  - Freighters accounted for 17% of all the commercial aircraft retirements. Freighters tend to retire later than passenger aircraft. The average retirement age of a freighter aircraft is 32.5 years and for a passenger aircraft 25.1 years. Meanwhile, freighter conversion could extend the aircraft life for typical ten to twenty years;
  - In terms of aircraft sizes, the retirement share of narrow body (NB), wide body (WB) and small (SM) aircraft is 47%, 14% and 39% respectively. Only subtle differences show on the average retirement age among these three groups, but WB aircraft tend to have double retirement peaks at age 23 years and 29 years. This phenomenon is driven by expensive maintenance events;
  - Of all retired aircraft, 38% were retired in North America and another 33% in Europe (of which 63% in the former USSR and current CIS);
  - Aircraft types for which the largest portion has been retired (e.g. 727, 737-100/-200 and An-24) will not be the main retirement focus in the future. Instead, types which are at sunset of the life cycle (e.g. 747, 737CL and MD-80) will dominate the short-term dynamics in the market;
  - The combination of a large number of new aircraft produced, a low retirement rate so far and the introduction of the follow-up models will drive a retirement wave in the long-term future for aircraft such as 737 NG, A320 family, 777 and A330.

Executive summary (2/4)

- Analysis revealed the following retirement drivers:
  - The effect of changing oil prices is noticeable on aircraft retirements and therefore is one of the main drivers for aircraft retirements;
  - Development of new aircraft models with improved technology has a significant impact on the aircraft retirement activities;
  - Components which are high valued and are in demand can also influence the retirement curve.
- The largest share of storage and disassembly locations is situated in southern states of the USA, as they provide dry conditions which reduces the risk of corrosion (e.g. Arizona);
- Based on historical retirement distributions and aircraft production data, more than 15,000 aircraft will be retired in the next 15 years. However, it should be noted that the number of retirements is highly fluctuated, depending on many external factors;
- Out of the total aircraft retirements, 42% is retired short or directly after operation. Once the aircraft is stored it remains in storage for an average period of 3,5 years before it is retired;
- Currently there are no specific regulations governing aircraft decommissioning. ICAO and national governments are expecting industry to set and improve best practices;
- Several projects have been conducted related to this field, e.g. PAMELA, AiMeRe, which set up the preliminary practices for the industry;
- A moderate but growing number of aircraft decommissioning companies have obtained certification under various standards, including AFRA BMP, EMS (e.g. ISO14001) and QMS (e.g. ISO9001).

Executive summary (3/4)

- Aircraft operators focus on the internal factors when decommissioning an aircraft, such as fleet planning and organisational & strategical changes. Aircraft owners and part out companies are driven by the opportunities in the market and the value of the aircraft, typically when costly maintenance events of an aircraft are due;
- Tax regulations, i.e. import tax and sales tax on aircraft and components, are the major burdens to part out an aircraft;
- Generally, the industry believes that aircraft types for which a large number are still in operation and which have a follow-up model, such as 737NG and A320 family, will be in high demand for disassembly in long term;
- When selecting facilities to store, part-out or dismantle an aircraft, aircraft operators and owners will consider a number of elements: costs (including the import tax and ferry cost), facility location & climate (in case of storage), capability & credibility of the facility, saleability of parts in the geographic market, legal protection of ownership rights and the environmental aspects;
- Stored aircraft (in general) have a lower market value than aircraft in operation, although this principle is influenced by current market conditions;
- The most hazardous element of the aircraft disassembly process is the removal and disposal of fuel & oils and other hazardous wastes (e.g. uranium & asbestos, chromate paint & primers, and batteries);
- Parts trading companies focus on components which generate high return of investment. It is estimated that only 20% of all components removed from an aircraft can be sold within in the first eighteen months after disassembly. Whether a part could be sold quickly depends on the reliability of parts, current market supply & demand of parts, mandatory technical changes and OEM polices on different parts;
- Incorrect estimation of part values at purchase or parts which are beyond economical repair are the major risks during the part recertification process, followed by industry acceptance of parts from a dismantled aircraft, reliability of parts and different standards for release to service certificates in the world.

Executive summary (4/4)

- The following recommendations and best practices could be beneficial for the industry:
  - As aircraft operators only incidentally touch the process of retiring aircraft, it is recommended to have workshops and guidance materials for operators and other relevant parties to improve the procedures of aircraft decommissioning;
  - To further optimise the retirement process, it is suggested to have guidance on how to handle hazardous materials (e.g. fuel and oils), new materials (e.g. carbon fibres) and parts used on aircraft;
- The following recommendations concern the interaction between governmental bodies and industry:
  - Given the fact that the Incident Clearance Statement (ICS) has a high impact on the value of a part, it is recommended to further explore its usage and requirements;
  - Improve the acceptance level of parts removed from a disassembled aircraft is suggested;
  - Create more uniformity within major aviation regulatory regimes to allow acceptance of foreign release certificates, for both new parts and used parts;
  - A more accurate and comprehensive database of the actual aircraft status is suggested, which would help to trace aircraft and parts movements. This would decrease 'aircraft dumping' practices and bogus parts entering the market;
  - To track the status of aircraft, on top of aforementioned the database, it is recommended to research the feasibility of a Certificate of Retirement (or equivalent), which will be issued when an aircraft is retired or disassembled;
  - Advise on the governmental restrictions on aircraft age and environmental issues related to aircraft operations is suggested. This would allow aircraft operators to optimise the aircraft usage;
  - It is recommended that a comparison of regulations of import tax and sales tax on aircraft and components in different countries would provide a valuable in-sight in these practices and aircraft movements.

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Introduction

The increasing world fleet will result in an increase of aircraft retirements over the next decades

- The world fleet of aircraft has slowly increased over the past decades to more than 27,000 commercial aircraft operating world wide at the end of 2015, with an average age of 12.6 years;
- As a result of the growing world fleet and lower average age, there will be an increasing number of aircraft removed from service and subsequently decommissioned in the upcoming years;
- Controlled decommissioning should allow the owner to benefit from the residual economic value through the reuse of spare parts and recycling of metals and carbon fibre, thereby reducing the risk linked to hazardous materials used in aircraft;
- As a trade association of world's airlines and a new strategic thrust, the International Air Transport Association (IATA) has been asked to engage with relevant stakeholders to assess the current state of play and influence the global best practices for aircraft decommissioning;
- IATA appointed SGI Aviation (SGI) to analyse the aircraft decommissioning trends. The analysis consists of three part:
  - An initial high level review of current aircraft decommissioning trends, review of relevant regulations and guidelines and discussions with part out facilities on current trends;
  - An assessment of the financial mechanisms, which govern the aircraft decommissioning process;
  - Identification of important issues for future best-practice solutions which should be agreed across stakeholders.
- This report provides a high level overview of:
  - The current aircraft decommissioning status and trends, including the current regulations and industry best practices;
  - The conducted industry research, for which interviews were held to assess the industry practices and financial mechanisms in the process of aircraft decommissioning;
  - The conclusions and recommendations following from the aforementioned studies.

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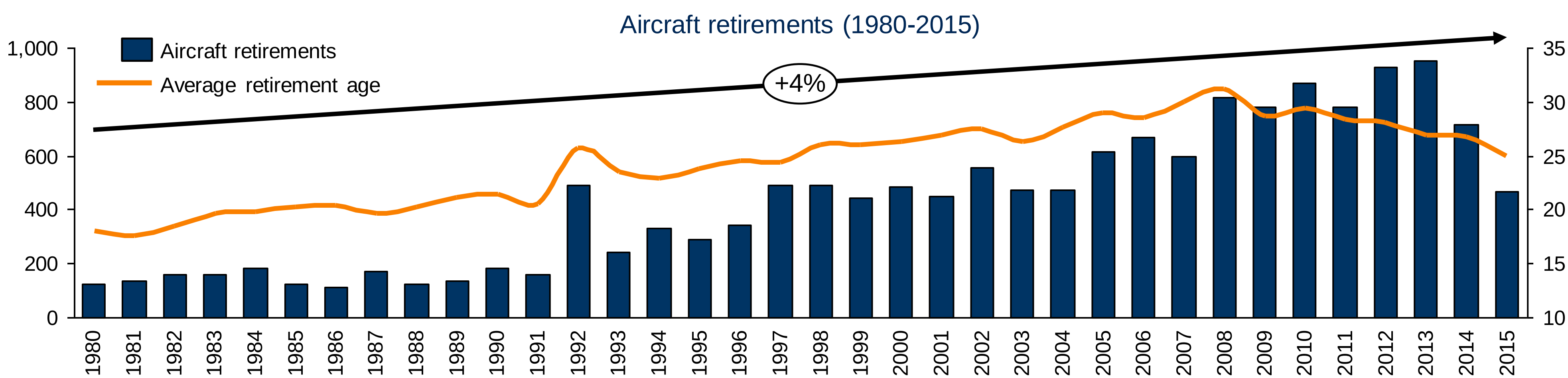
Aircraft retirements

With a compounded annual growth rate of more than 4%, aircraft retirements have increased slowly over the past decades

- From 1980 to 2015, more than 15,000 commercial aircraft have been retired world wide;
- During the period of 2010-2014, between 700 and 900 aircraft are retired on an annual basis, with an average age of around 27 years. From 1980 till 2015 the compounded annual growth is more than 4%;
- Even though the number of aircraft retirements has grown steadily over the past 36 years, there are large fluctuations in the number of retirements, mostly linked to external influences;
- These fluctuations in aircraft retirements provide a valuable in-sight in what drives these numbers and will be analysed in more detail in the retirement drivers section of this report;
- The average aircraft age at moment of retirement has decreased over the last 7 years, after a continuous increase over several decades.



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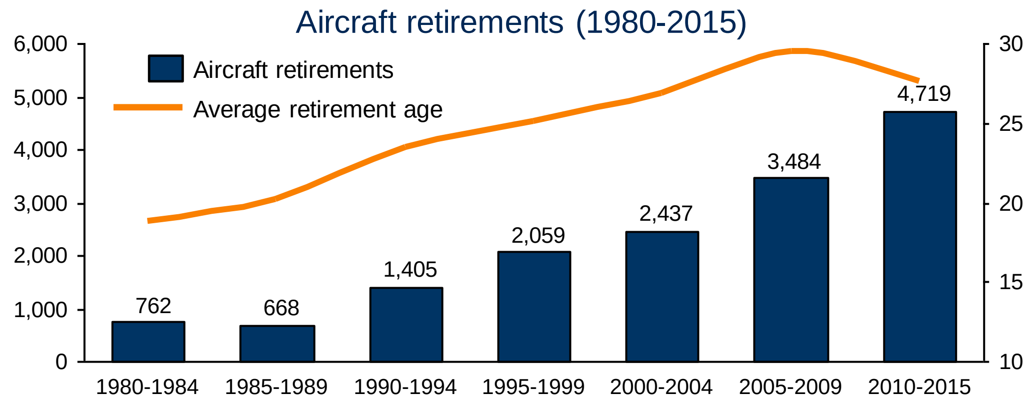
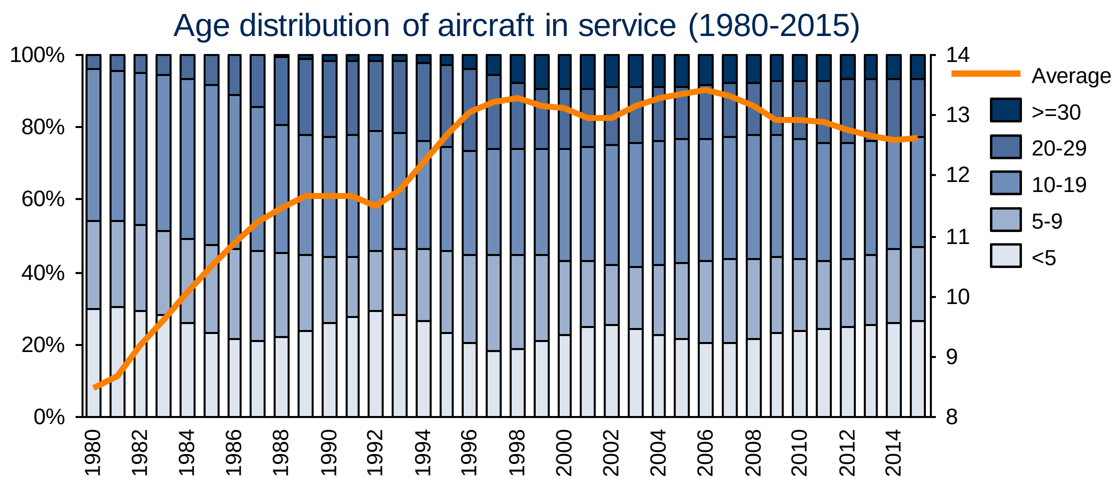
Historical trend

Trend reveals that the number of aircraft retirements has increased by six times over the last 36 years





- With the exception of the period 1985 to 1989, the absolute number of retirements has increased continuously over the last 36 years:
  - More than 4,500 aircraft have been decommissioned in 2010-2015 and there has been more than a six-fold increase in retirements.
- The average aircraft retirement age has also increased from 18.8 years in 1980-1984 to 29.4 years in 2005-2009:
  - There has been a drop to 27.6 years in the last six years;
  - One of the reasons of this decrease of average retirement age is the record-high oil prices in early 2010s and the limitation of technological developments over the respective period of time.
- The average age of commercial aircraft in service has been relatively stable for the last 15 years and slightly decreased in the recent 6 years. This can be explained by an increase of production rates and aircraft being retired younger.

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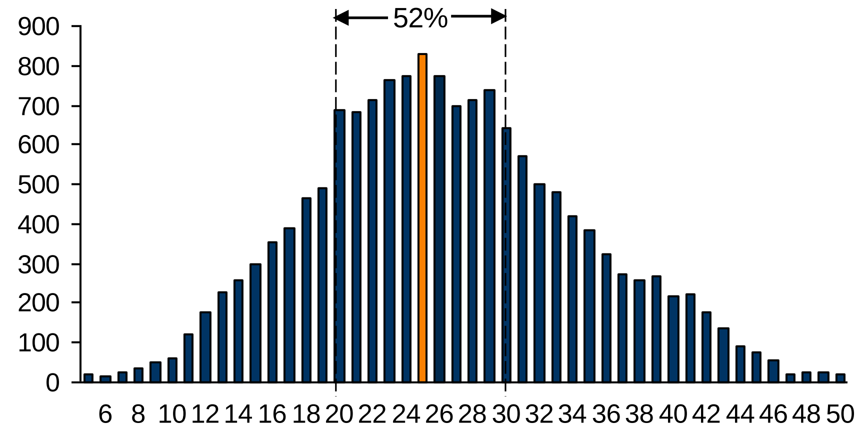
Retirement age distribution (1/3)

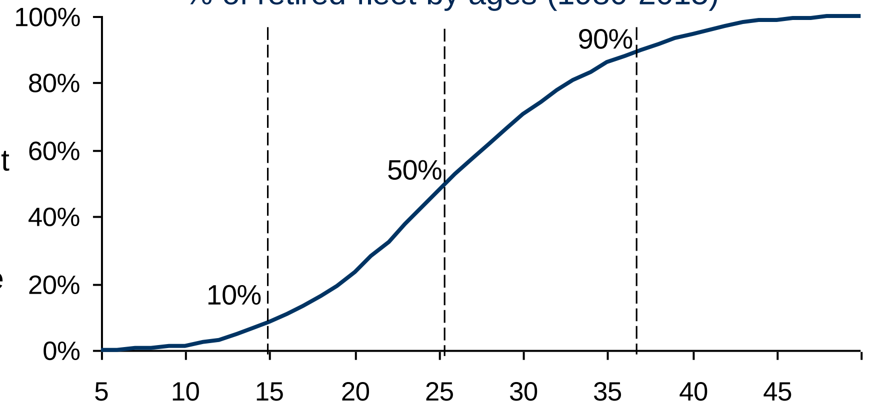
More than 50% of the aircraft are still in operation at the age of 25 years

- The average retirement age for commercial aircraft over the last 36 years is 26.5 years;
- More than half of the aircraft are retired between the age of 20 and 30 years;
- About 10% of the aircraft were retired before the age of 17 years during the analysed term:
  - Among these aircraft, 66% are small (SM) aircraft[1], meanwhile 52% are older types designed between 1960s and 1970s;
  - 11% of the total share was decommissioned as a result of an accident or incident (e.g. damaged beyond economical repair);
  - The percentage of aircraft retired before the age of 17 years in the total retired fleet has decreased, with 27% in 1980s to 8% in 2010s.
- Another 10% of the aircraft went out of service after the age of 37 years:
  - Among these aircraft, 42% are American built (e.g. DC-9, 727 and DC-8);
  - Freighters account for 17% of the aircraft retirements throughout the last three and a half decades. However, of this age group, more than 50% retirements are freighters;
  - Retirements after the age of 37 years are becoming more common. The percentage rose from 2% of the total retired fleet in the 1990s to 14.4% in first five years of 2010s.

Aircraft retirement age distribution (1980-2015)



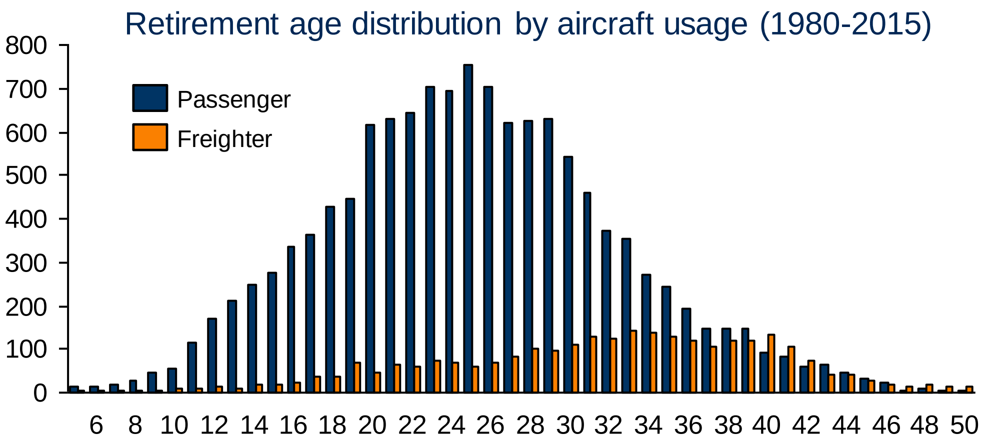
% of retired fleet by ages (1980-2015)

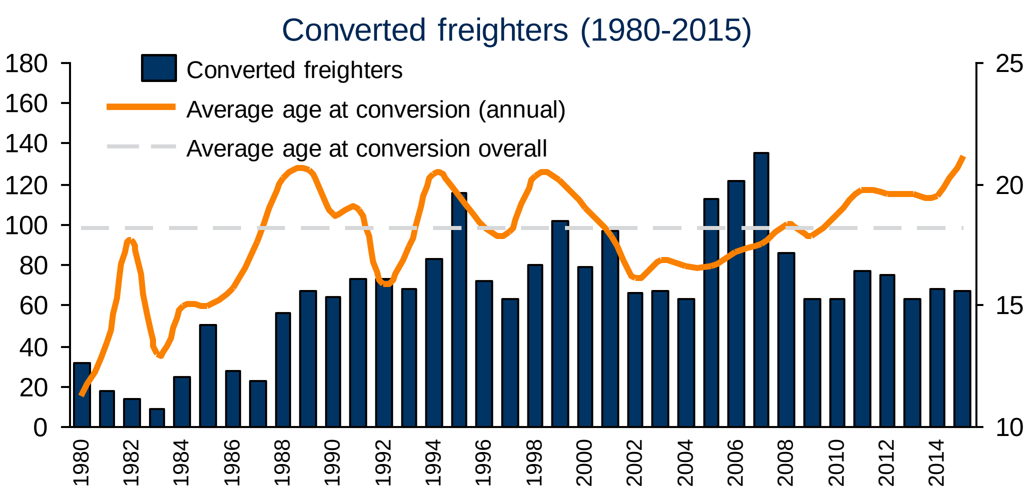


1. Small aircraft are defined as aircraft with less than 100 seats. Detailed assumptions are listed in the Annex.

Retirement age distribution (2/3)

Freighters tend to be retired later than passenger aircraft



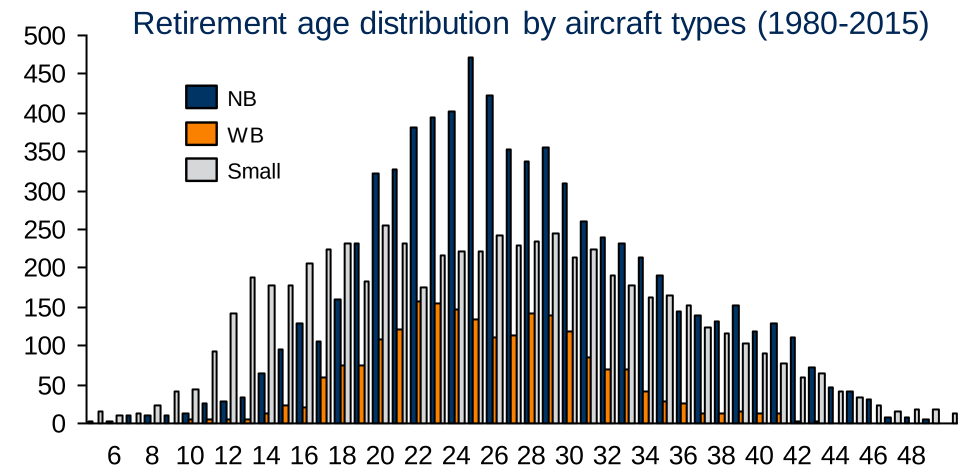


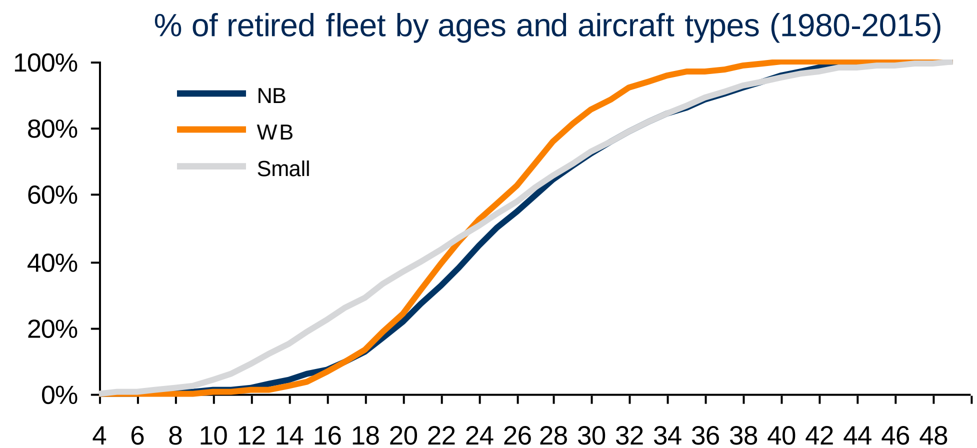
- In the last three and a half decades, passenger aircraft account for 82% of the commercial aircraft retirements;
- Freighters accounted for 17% of the retirements:
  - Of this group, 39% (1046 aircraft) were converted freighter aircraft.
- There are significant differences between passenger and freighter aircraft retirement behaviours:
  - Freighters tend to be retired later than passenger aircraft. The average retirement age of a freighter aircraft is 32.5 years and for a passenger aircraft 25.1 years;
  - More than half of the freighters were retired after 33 years of operation, whilst less than 13% of passenger aircraft are still in service at this age.
- The freighter conversion extends the aircraft in-service time. On average the conversion takes place when the aircraft is eighteen years old. Typically, the aircraft can gain ten to twenty years extra life by conversion;
- In addition, the differences can be linked to the much lower utilisation of freighters compared to passenger aircraft. Due to this utilisation profile, freighter operators achieve a lower operational cost by extending the aircraft life cycle.

Retirement age distribution (3/3)

There are differences in retirement age for narrow body, wide body and small aircraft

- When analysing all aircraft retirements, narrow (NB) aircraft take up the largest portion with 47%. The second largest retirement group is the small (SM) aircraft with a 39% share. The smallest retirement group is the wide body (WB) aircraft with a 14% share;
- The average retirement age for each group differs slightly:
  - NB aircraft have the highest retirement age with an average age of 27.4 years;
  - Small aircraft are retired at an average age of 25.6;
  - This is closely followed by WB aircraft with a retirement age of 25.5 years.
- For NB aircraft, retirements are clustered around age 25 whereas the WB aircraft tend to have double retirement peaks at age 23 and 29. Small aircraft do show earlier retirement peaks between age fifteen and twenty, and secondary peaks appear around age 26, which is mostly driven by Russian built aircraft;
- Aircraft tend to be decommissioned right before expensive maintenance events to avoid cost. As a result, it creates secondary retirement peaks after the main retirement peak, which averages between six to eight years.

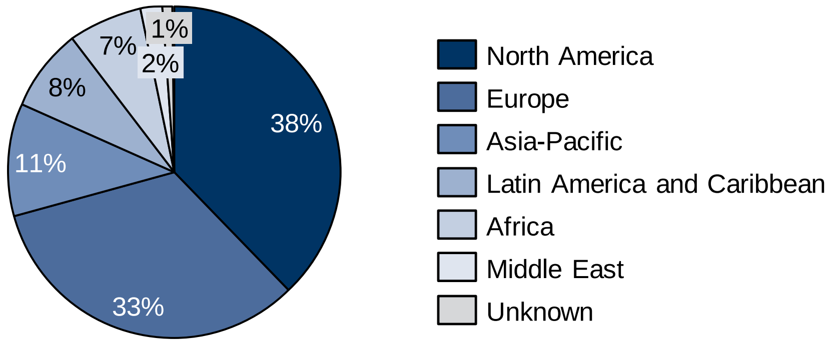




Retirement areas

Retired aircraft were mainly on an US registration at the moment of decommissioning

Retirement areas[1] breakdown (1980-2015)



- Of all retired aircraft, 38% are retired in North America and 33% were retired in Europe (of which 63% in the former USSR[2] or current CIS[3]):
  - This is partly due to the large aviation market in the US and the dissolution of USSR;
  - In addition, the main storage and decommissioning facilities are situated in the US.
- Aircraft retired from the top twenty countries/regions accounts for 78% of the total retired fleet.

Top 20 countries/regions of retired aircraft (1980-2015)

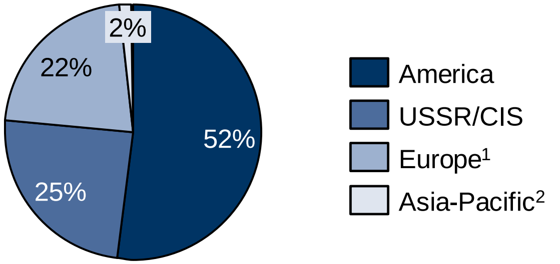
Country/Region	# of Retired	Average Retirement Age
United States	5555	26.6
USSR/CIS	3620	24.9
United Kingdom	488	25.2
Indonesia	302	26.9
Canada	295	27.6
France	234	23.6
China	213	17.6
Mexico	194	33.7
Nigeria	190	29.1
Venezuela	173	31.8
Congo (Democratic Republic)	167	32.8
Ireland	164	25.2
South Africa	161	31.5
Brazil	161	30.2
Germany	151	23.7
Australia	144	24.9
Colombia	113	29.5
Spain	102	27.0
Philippines	99	30.8
Netherlands	93	22.5

1. Retirement areas are represented by the last operating country.
2. USSR = Union of Soviet Socialist Republics.
3. CIS = Commonwealth of Independent States, including Russia, Ukraine, Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Tajikistan, Uzbekistan and Turkmenistan.

Retired types of aircraft (1/2)

Aircraft types for which are at sunset of the life cycle will dominate the short-term future dynamics

Manufacturer's locations of retired aircraft (1980-2015)



- Aircraft manufactured in America make up the largest portion of retired aircraft (52%):
  - This is mainly caused by the large number of aircraft manufacturers in this region (e.g. Boeing & McDonald Douglas).
- USSR/CIS produced aircraft form the second largest retirement share of 25%. However since production rates have dropped after the dissolution of the USSR, this number is not consistent with retirement rates for the last twenty years;
- Aircraft types for which the largest portion has been retired (e.g. 727, 737-100/-200 and An-24) will not be the main retirement focus in the future. Instead, types which are at sunset of the life cycle (e.g. 747, 737 CL and MD-80) will dominate the short-term dynamics in the market.

Top 20 aircraft retired (till 31/12/2015)

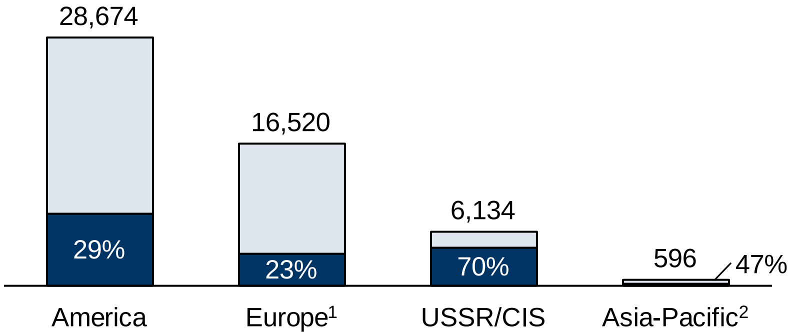
Aircraft Type	# of Retired	Retirement rate	Average Retirement Age
727	1492	84%	31.4
737-100/-200	810	75%	30.3
An-24	760	69%	30.3
DC-9	725	78%	35.2
747	714	48%	27.1
737 CL	670	34%	22.7
Tu-154	648	78%	22.9
Yak-40	629	67%	25.9
MD-80	490	41%	24.0
707	456	63%	24.5
Tu-134	453	82%	25.4
L-410 Turbolet	453	61%	16.8
Il-18	440	83%	24.1
DC-8	430	78%	31.7
A300	276	49%	24.5
Viscount	273	62%	21.7
DC-10	268	71%	30.3
A320	266	6%	20.1
F.27	253	57%	32.2
L-1011 TriStar	221	89%	26.8

1,2. In this context, Europe and Asia-Pacific exclude USSR and CIS countries.

Retired types of aircraft (2/2)

American and European built aircraft with low retirement rates are projected to shape the long-term market

Retirement rate by manufacturer's locations (till 31/12/2015)



- Among all delivered aircraft, 70% of USSR/CIS built aircraft are already retired, whilst more than 70% of American and European built aircraft are still in active service:
  - Till 2015, 55% of the total delivered aircraft are American built, 32% originated from Europe and only 12% were manufactured in USSR/CIS.
- The combination of a large number of aircraft produced, a low retirement rate so far and the introduction of the follow-up models will drive a retirement wave in the long-term future for aircraft such as 737 NG, A320 family, 777 and A330:
  - As retirement rates ramp up, the average retirement age of those aircraft is projected to increase gradually.

Top 20 aircraft delivered (till 31/12/2015)

Aircraft Type	# of Delivered	# of Retired	Retirement rate	Average retirement age
737 NG	5478	54	1%	12.6
A320	4115	266	6%	20.1
737 CL	1979	670	34%	22.7
727	1775	1492	84%	31.4
747	1492	714	48%	27.1
A319	1382	23	2%	14.0
777	1355	20	1%	16.8
A330	1222	21	2%	16.9
A321	1210	18	1%	19.1
MD-80	1190	490	41%	24.0
Dash 8	1123	69	6%	17.9
An-24	1100	760	69%	30.3
737-100/-200	1078	810	75%	30.3
767	1064	160	15%	24.5
757	1039	101	10%	24.3
CRJ Regional Jet	1021	146	14%	14.2
Yak-40	942	629	67%	25.9
DC-9	931	725	78%	35.2
Tu-154	834	648	78%	22.9
ATR 72	814	31	4%	19.6

1,2. In this context, Europe and Asia-Pacific exclude USSR and CIS countries.

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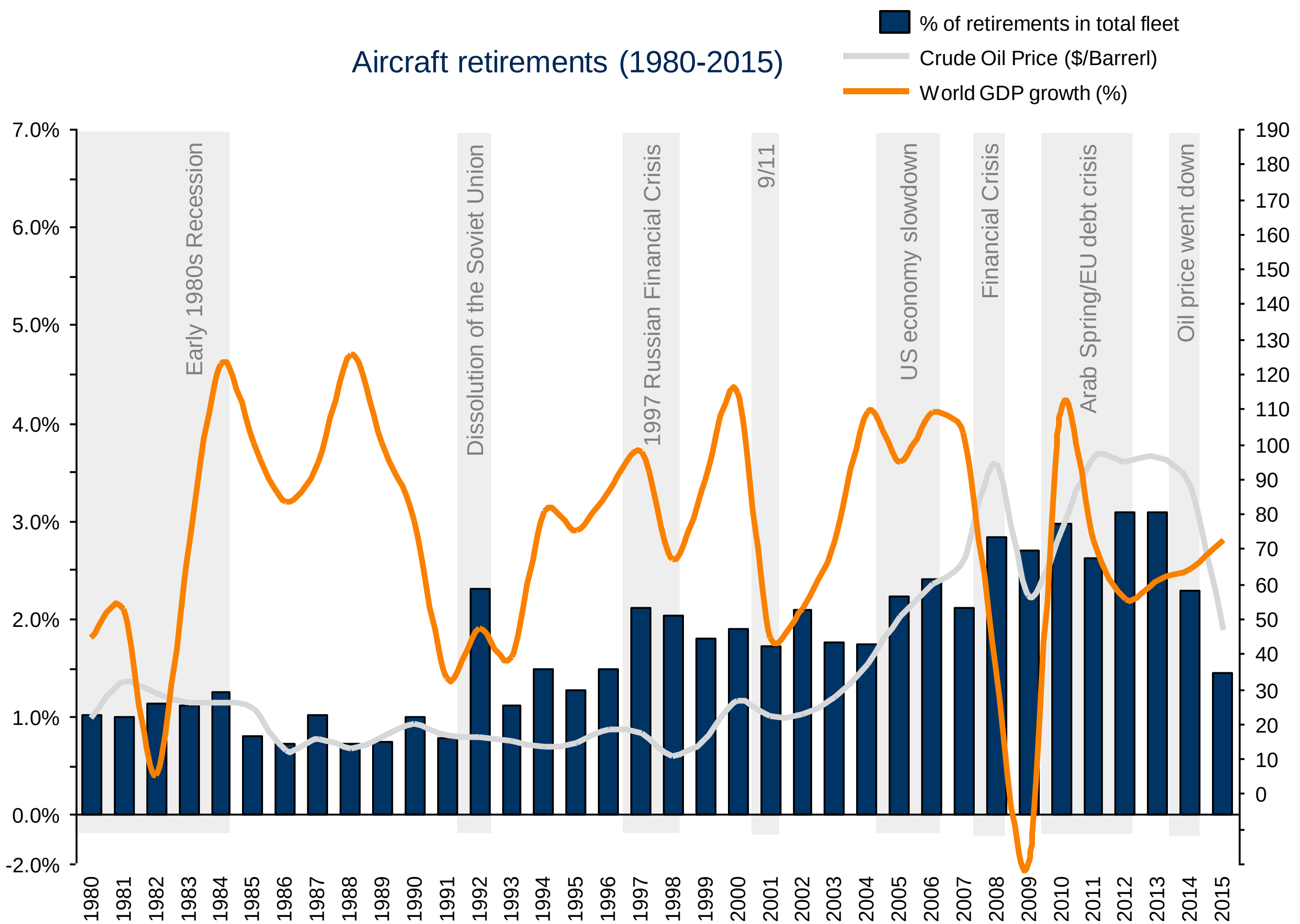
Economy and oil prices

Aircraft retirement trends are influenced by several macro economic factors

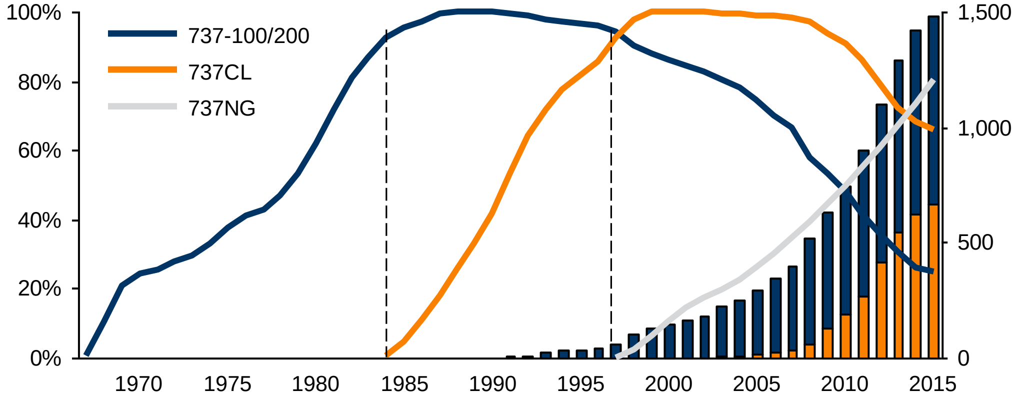
- Aircraft retirements have always fluctuated over the past decades;
- Comparison of the retirement rates with relevant (macro economic) factors such as the world GDP growth and Oil price show that there is a correlation;
- Airline bankruptcies correlate with the variation of GDP and Oil prices;
- Although these factors do not exclusively influence the retirement trends, their effect is noticeable;
- Retirement rates are also influenced by other relevant factors, such as:
  - Political events (e.g. the dissolution of USSR in 1991);
  - Aviation related disasters (e.g. 9/11 in 2001).
- The effect on aircraft retirements with increasing oil prices is noticeable and therefore a main driver for aircraft retirements.



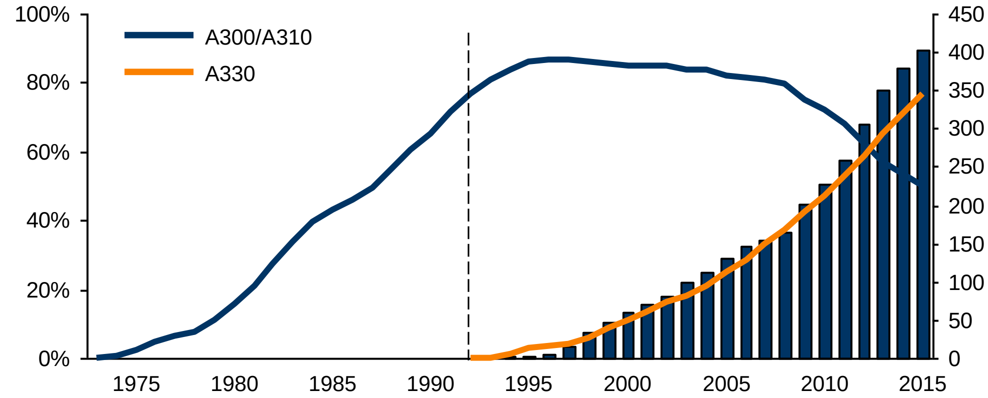
Introduction of new aircraft

Development of new aircraft models with improved technology is an important aircraft retirement driver

737 family in service rate & total retirement (till 31/12/2015)



A300 and A330 in service rate & total retirement (till 31/12/2015)

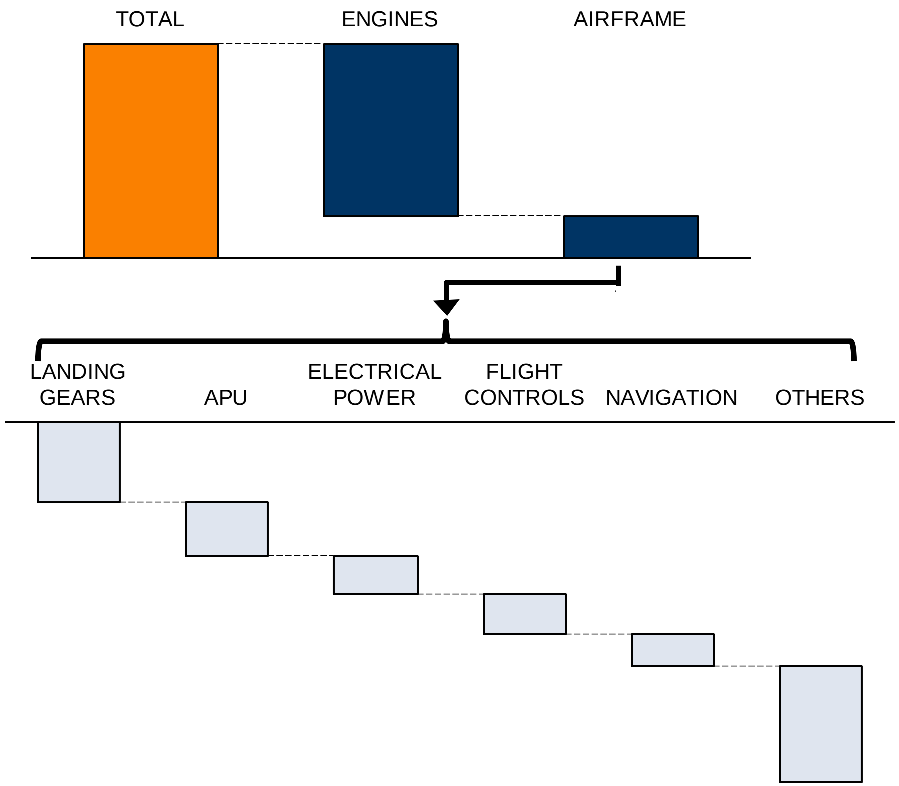


- It took approximately twenty years after the introduction of 737-100/200 aircraft, for production levels to level off. Just before the peak, the following-up aircraft type, the 737CL, was introduced to replace the current aircraft. This decreased the production rate of the 737-100/-200 and increased the retirement rate of it in the next few years;
- The same decreasing effect on the 737CL in service levels can be observed after introduction of the 737NG. Additionally, the introduction of the sub-sequential aircraft model occurs at a faster pace than its predecessors and the steep decrease of the 737CL in service level is measured earlier when compared to the aforementioned;
- The same effect on the Airbus A300 can be seen after the introduction of the Airbus A330. Right after the introduction of the A330 aircraft the A300 in service levels started to decrease.

Components value and demand

Components with a high value and which are in demand can also influence the retirement curve

Value breakdown of a part-out candidate aircraft



- The residual value of an end of life aircraft is the sum of the value of its individual components minus the cost to decommission it.
- Pending on its condition and maintenance status, engines account for the largest portion of the residual value (on average 80%). This makes it an important factor in the decision of disassembly of an aircraft. The part-out value of an engine depends on various factors like the engine type, the engine time since last performance restoration/overhaul (TSLO) and the LLP life remaining. Additionally, the engine condition and the standard of high cost parts such as fan blades, HPC blades and vanes, combustion chamber, HPT blades and vanes will affect the value.
- In addition to the engines, several components show a relatively high value. The top five high value components are the landing gears, APU, electrical power (e.g. generators), flight controls and navigation systems. Together, they make up to about 70% of the value of the airframe excluding the engines;
- Other influencing factors with respect to residual value are; regulatory environment, compulsory upgrades and existing airworthiness directives;
- Components with high value and high demand could also result in the retirement of an aircraft, in order to serve the current operating fleets.

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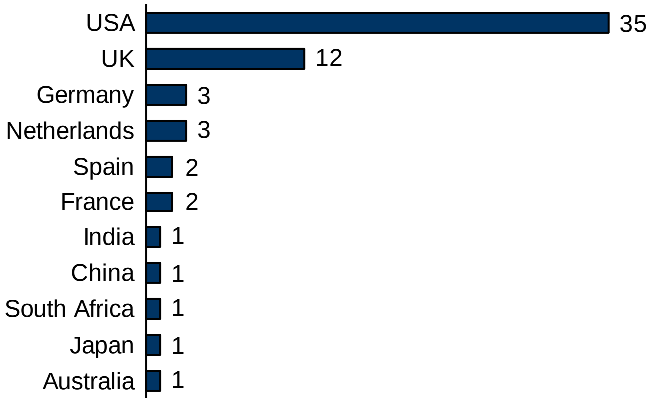
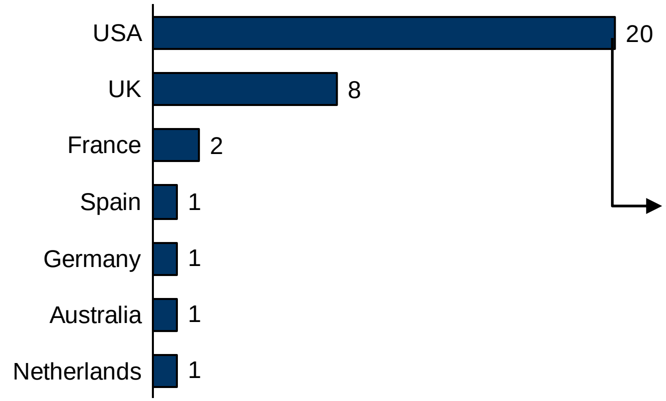
Geographical diversification and features of facilities

Main facilities are found to be in the USA and UK

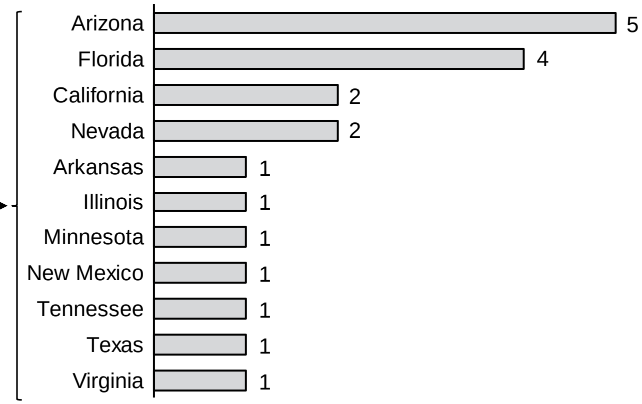
Total (total 62)



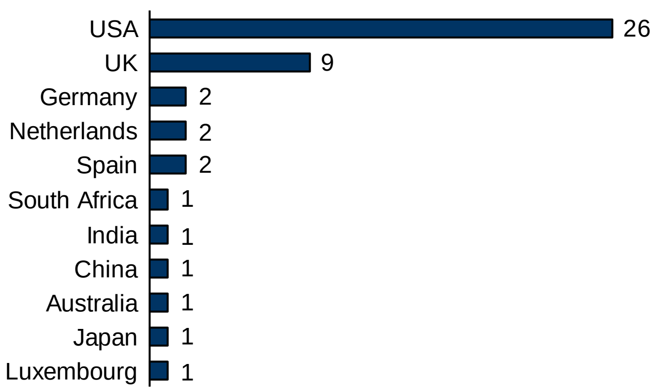
Disassembly facilities (total 34)



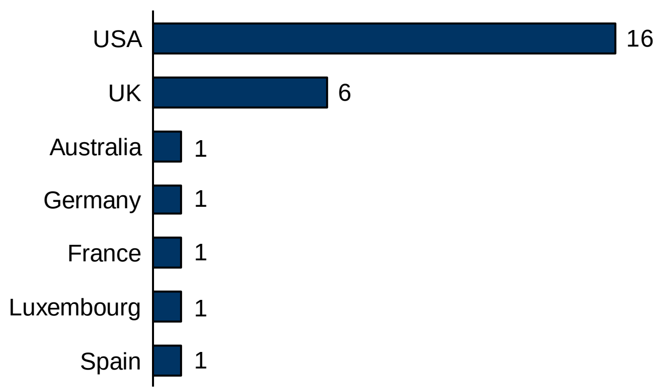
Disassembly facilities in the USA (total 20)



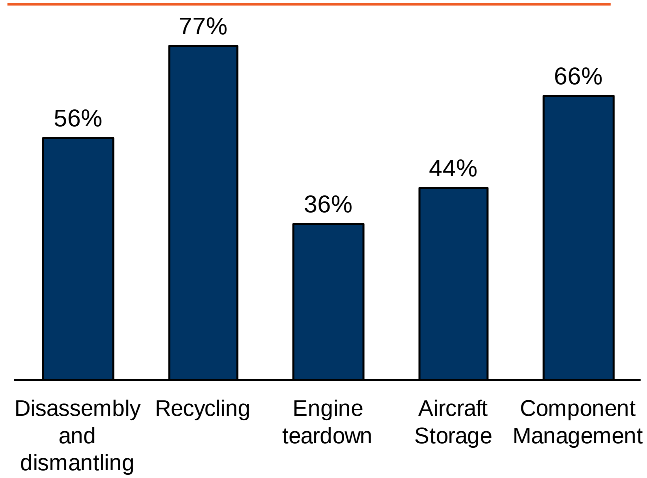
Recycling Facilities (total 47)



Storage Facilities (total 27)



Sub-division measured activities (total 62)

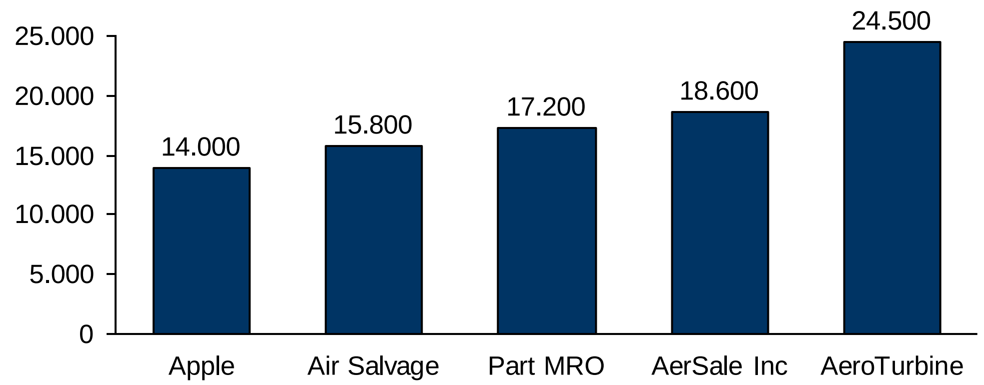


Geographical diversification and features of facilities

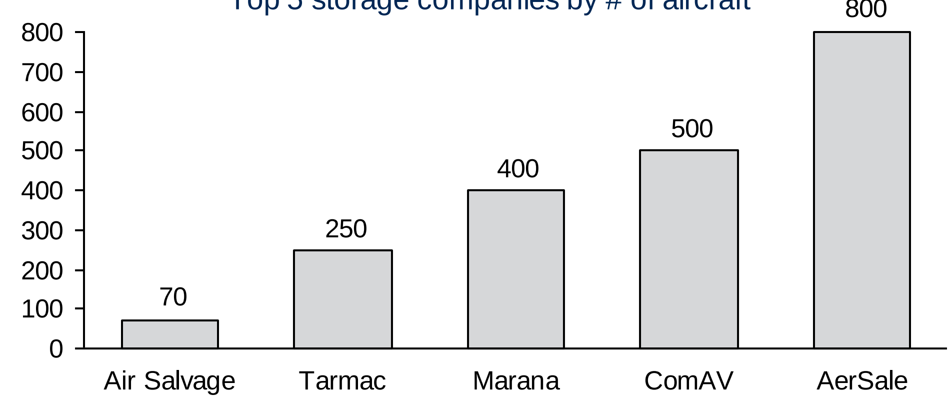
AeroTurbine and AerSale are the main players in the area of disassembly and aircraft storage

- The following can be concluded from the market analysis:
  - The largest share of storage and disassembly locations are situated in southern US, which provide ideal dry conditions in order to reduce corrosion (e.g. Arizona);
  - Deserted airports are commonly (re)used as storage and disassembly location as parking fees are relatively low and there is sufficient space available;
  - Many of these companies also provide additional services at location, which allows aircraft owners to disassemble the aircraft at their location;
  - Recycling companies generally do not limit their capabilities to the aviation industry and are active in other industries as well;
  - Main European locations are situated in the UK and France. No major sites are registered in the South-East Asia region.
- The largest disassembly company according to the desktop study is AeroTurbine (AerCap), followed by AerSale. The latter has the largest storage location.

Top 5 disassembly companies by facility size (in m²)

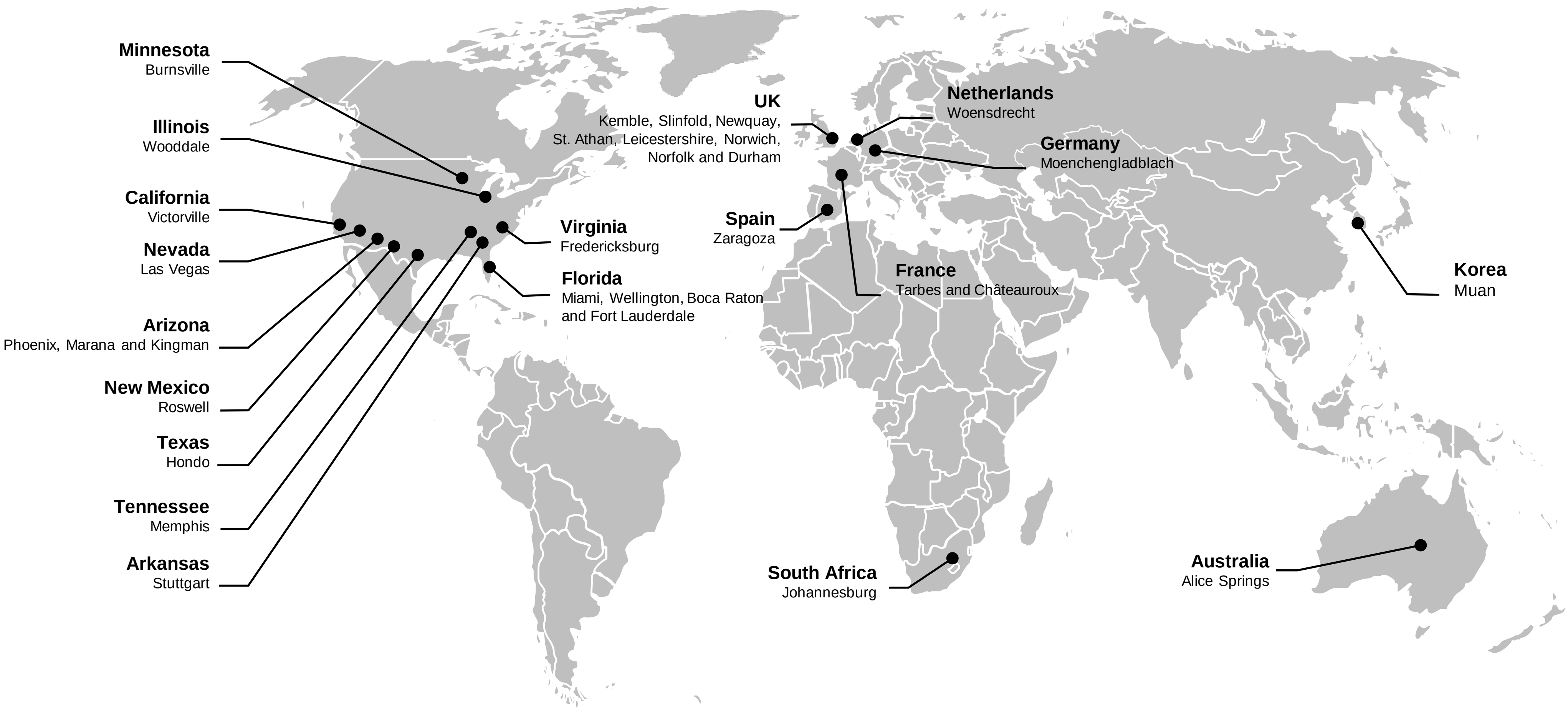


Top 5 storage companies by # of aircraft



Major disassembly airport locations

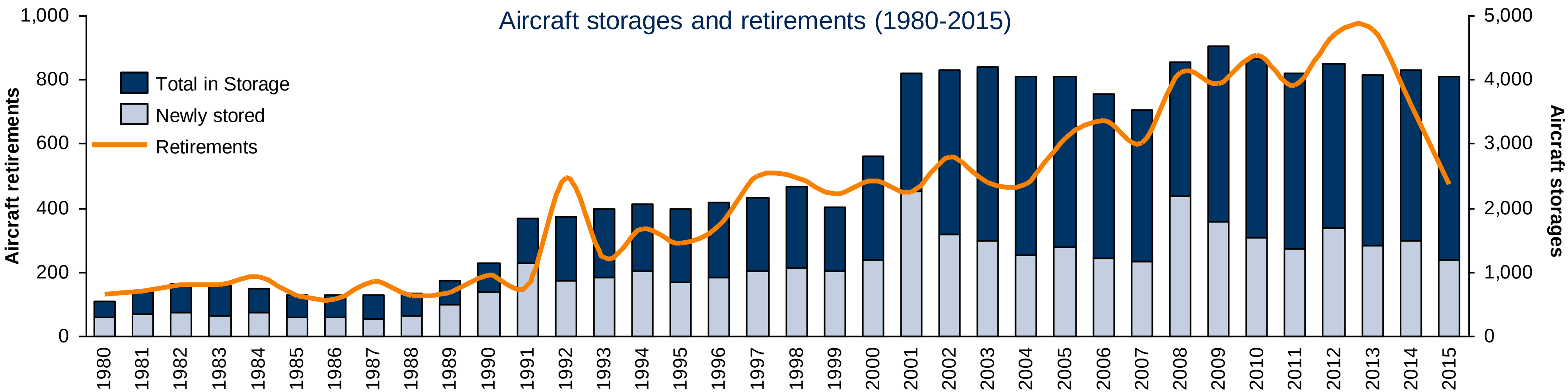
Major disassembly areas are mainly situated in the southern parts of the USA



Storage trends

At around 4,000 the total number of aircraft in storage has been relatively stable for the last 15 years

- From 1980 to 2015, more than 24,000 aircraft have been registered as stored;
- Since 2001, the total number of commercial aircraft in storage has been approximately 4,000; whereas the number of newly stored aircraft is around 1,500 annually. More than 2,000 aircraft went into storage between 2001 and 2008 respectively because of 9/11 and the financial crisis;
- More aircraft are put into storage than retirement each year;
- Storage trends are consistent with the trend of retirement and the storage wave is about 1 year ahead of that of retirement;
- There are in total 4,058 aircraft in storage as at 31/12/2015, with the average age of 24.8 and average in storage time of 3 years.



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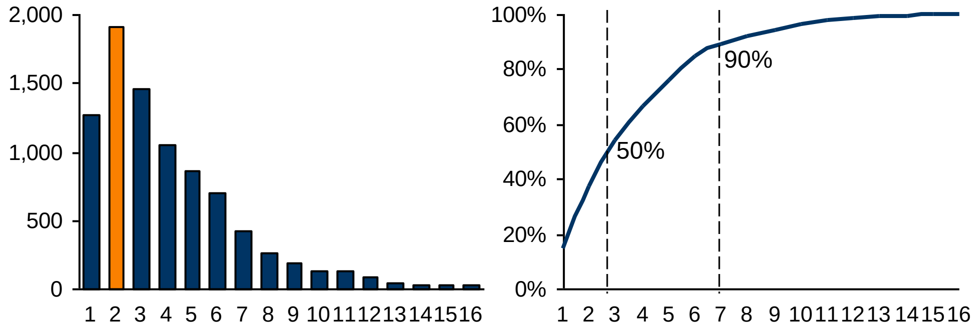
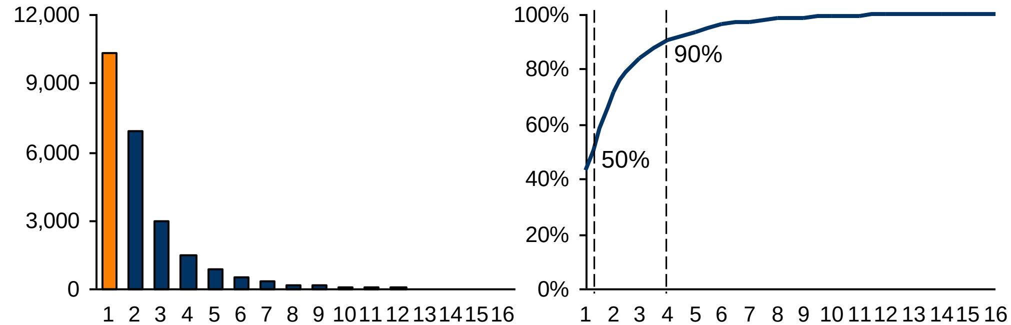
Retirement and return to service after storage

Hardly any aircraft remain in storage for a period longer than eight years

Storage time (in years)[1] before retirement (1980-2015)



Storage time (in years) before return to service[2] (1980-2015)



- From 1980 to 2015 more than 9,000 aircraft, equal to 38% of all stored aircraft, have been retired. This represents a 58% share of the total aircraft retirements (compared with direct retirement from service);
- For all aircraft retired after having been in storage:
  - Aircraft have been stored for 3.5 years on average before retirement;
  - Most of them went into retirement between 1 to 2 years in storage;
  - More than 50% of the aircraft retirements occurred within 3 years in storage;
  - Only 10% of aircraft are retired after inactivity of more than 7 years.

- In total, some 16,000 aircraft in storage have returned to service at least once, which accounts for 66% of the total stored aircraft from 1980 to 2015;
- Among aircraft which have returned to service, 63% has re-entered service only once; followed by 26% which has entered service twice and the rest three times or more;
- More than 70% of return-to-service occurred within 2 years after entry. This is a cut-off point as it is often not economical viable to restore the airworthiness of an aircraft after 2 years storage;
- After 4 years in storage, less than 10% of aircraft will be put into serviceable condition again.

1. For aircraft which have entered storage more than once, only the last storage time has been considered.
2. No accurate date of return to service is provided by the database, it is assumed that every aircraft returned to service in the middle of a year.

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Future trends

In general, the number of aircraft retirements will grow in the long term future. However it strongly relies on many external factors, especially on the macro economy and oil prices.

- Based on historical retirement distributions and aircraft production data, more than 15,000 aircraft will be retired in the next 15 years. However, it should be noted that the number of retirements is highly fluctuated, depending on many external factors;
- The aircraft types for which the largest portion has been retired (e.g. 727, 737-100/-200 and An-24) will not be the main retirement focus in the future. Instead, aircraft which are still in the middle of the life cycle (such as A320, 747, 737 CL and MD-80) will dominate the short-term dynamics in the market;
- The focus with regard to the future trends and outlooks should be on American and European built aircraft;
- The combination of a large number of aircraft produced, a low retirement rate so far and the introduction of the follow-up models will drive a retirement wave in the long-term future for aircraft such as 737 NG, A320 family, 777 and A330;
- As mentioned that development of new aircraft models with improved technology is an important aircraft retirement driver. Currently new follow-up types are introduced by various manufacturers for a wide range of aircraft types/sizes, which will have an impact on the retirement waves in the future;
- Although the future macro-economy and oil prices are difficult to predict, it is certain that the fluctuation of aircraft retirement in the coming years will highly depend on these two factors;
- As no major disassembly and storage locations are situated in the South-East Asia region, it should be noted that this area will be an area of interest in the near future.

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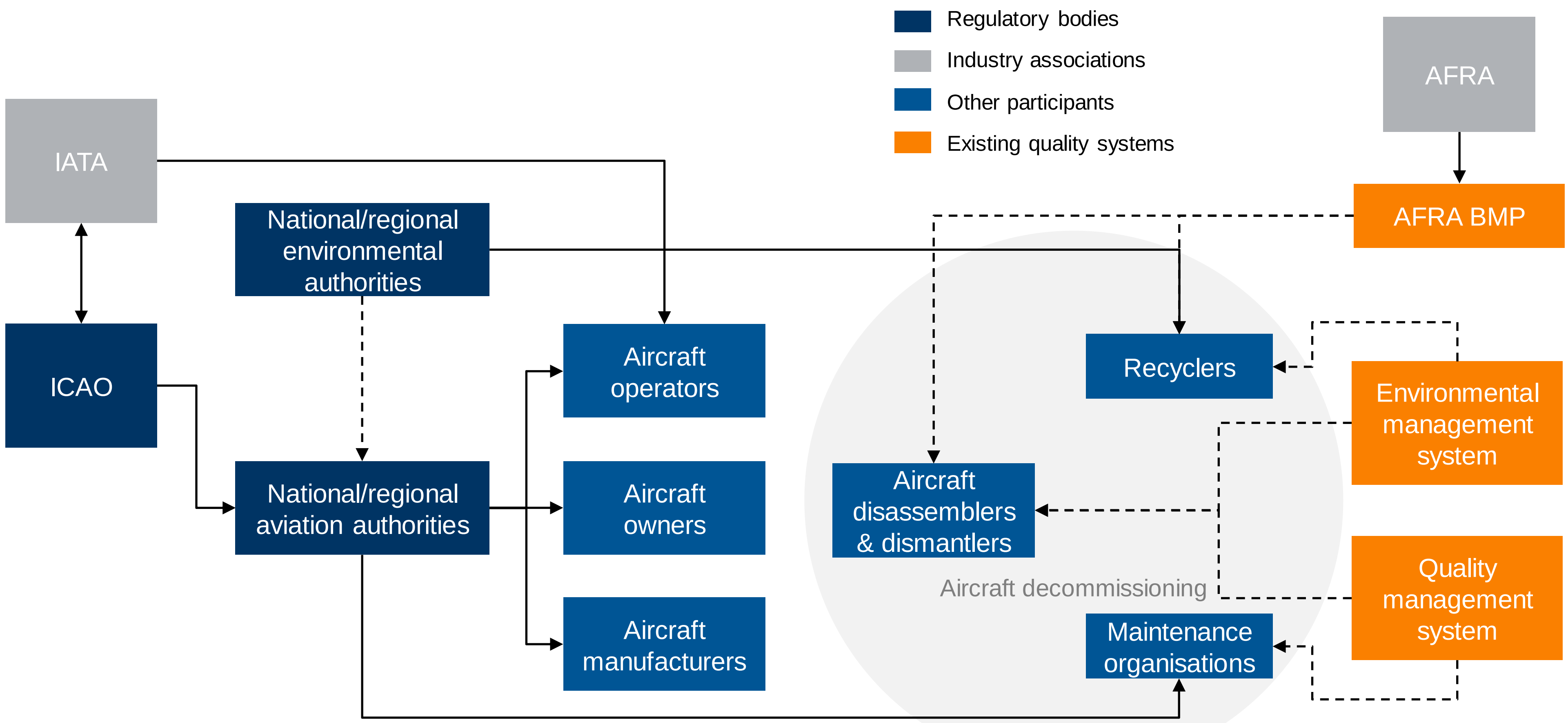
Participants[1] in aircraft decommissioning

The process of aircraft decommissioning is under very general and limited control



1. Multiple roles can be applicable to one participant - a hybrid company (e.g. an aircraft operator being aircraft owner, maintenance organisation and aircraft disassembler). In this section, only the roles are considered, rather than companies.

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Regulatory bodies

There are no specific regulations governing aircraft decommissioning

ICAO

- As an agency in the UN, International Civil Aviation Organisation (ICAO) is uniting national authorities to create a safe, efficient, secure, economically sustainable and environmentally responsible civil aviation sector worldwide;
- ICAO's Committee on Aviation Environmental Protection (CAEP) is set up to minimize the impact of aviation on the environment. So far the CAEP is working on aviation related global climate, noise and emissions;
- ICAO has recently put aircraft decommissioning on its agenda and views industry establishing best practices as a better option than governmental or ICAO regulations.

National/regional environmental authorities

- National/regional environmental authorities are in charge of the general environmental issues in a state. In term of aviation, the rules and regulations of non-airworthiness related subjects, e.g. aircraft navigation and the environment being noise and emissions are defined by national/regional authorities;
- A couple of authorities (e.g. US, UK and EU) published regulations for the dismantling and recycling process of end-of-life vehicles (ELV). Nevertheless, the definition of ELV only covers cars and ships so far;
- Several projects supported by the national/regional authorities in this field, such as Process for Advanced Management of End-of-Life of Aircraft (PAMELA) and Aircraft Metals Recycling (AiMeRe), are their initiative of aircraft decommissioning.

National/regional aviation authorities

- National/regional aviation authorities are in place to secure the airworthiness of the aircraft and components;
- It regulates the maintenance organisations which issue Authorised Release Certificates (ARC) to certify the compliance with the approved design of aircraft and components which may be removed during decommissioning of an aircraft;
- In comparison, the process of aircraft decommissioning is making aircraft un-airworthy, in which national/regional aviation authorities have very limited responsibilities.

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Industry associations

AFRA is an international aircraft disassembly and recycling association with the only industry developed best management practices

IATA

- As a trade association for the world's airlines, IATA supports many areas of aviation activities and helps formulate industry policy on critical aviation issues;
- IATA has set up a series of best practices for aviation industry, and has launched a project to develop best practices for aircraft decommissioning;
- Currently, IATA has been intensifying its focus on various environmental topics. It initiated IATA Environmental Assessment (IEnvA) program to evaluate and improve the environmental management of airlines;
- Being a well-respectable industry association to fulfil its environmental responsibilities, IATA is in a good position to drive the development of best practices for airlines to select time and process for retiring specific aircraft.

Aircraft Fleet Recycling Association (AFRA)

- As the leading international association representing the aircraft recycling industry, AFRA is developing and promoting the safe and sustainable management of end-of-life aircraft and components;
- It has created Best Management Practice (BMP) guidance on disassembling, dismantling and recycling processes, i.e. the responsibilities of the related specialized companies;
- AFRA members consist of a combination of OEM's like Boeing, Bombardier and Embraer, dismantling companies, recycling companies and companies involved in the parts aftermarket, including 5 of the top disassembly and storage companies (Apple, Air Salvage, AerSale, Marana and ComAV) mentioned in the previous part of this report;
- However, there are in total 60 members in AFRA, accounting for a very small portion of aviation industry. There are no airline members or regulatory bodies member of this association, it only represents the private sector.

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Other participants

Aircraft operators, owners and maintenance organisations should be more involved in the practices development

Aircraft operators

- Aircraft operators are one of the stakeholders influencing aircraft decommissioning: the utilisation and maintenance of aircraft are closely linked to the aircraft life cycle;
- In addition, aircraft are the image of operators. Therefore, how to properly decommission aircraft is a main concern of aircraft operators. However they are rarely involved in the process.

Aircraft owners

- Aircraft owners have limited liability in relation to the airworthiness of the aircraft, but they have the right to decide the timing of aircraft decommissioning, its location and the procedures applied;
- Controlled decommissioning will allow the aircraft owner to benefit from the residual economic value through the reuse of spare parts and recycling of materials.

Aircraft manufacturers

- In order to maximise benefits of aircraft owners and minimise pollution to the environment and safety risks, aircraft manufacturers are actively participating in the researches of aircraft decommissioning;
- Aircraft manufacturers took part in projects like PAMELA, AiMeRe and initiated the cooperation with AFRA, endeavouring to set up a common industry standard on aircraft decommissioning.

Aircraft disassemblers & dismantlers

- Aircraft disassemblers or dismantlers are directly involved in the part-out activities;
- However, no current rules regulate the procedures of aircraft disassembly nor dismantling;

  Some aircraft disassembling and dismantling companies have been involved in aforementioned projects to develop general practices for the industry.

Recyclers

- Recyclers reuse materials from a disassembled aircraft;
- In general their processes are supervised by the national and local environmental bodies;
- A few recyclers are also part of those experimental projects exploring the aircraft decommissioning business.

Maintenance organisations

- Maintenance organisations have the authority to issue Authorised Release Certificate (ARC) for aircraft components to be installed on an aircraft;
- They control the portal of used serviceable parts to re-enter the market;
- They are already under the governance of Part 145 of the national aviation regulations.

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Existing systems (1/2)

Three systems of environment, safety and quality are adopted by part of the aircraft decommissioning industry, leaving the economic guidance still blank

AFRA BMP

- AFRA offers accreditation to companies which passes audits of the compliance with the BMP with detailed directions on best environmental practice and technological solutions for the disassembling and recycling of aircraft airframes and engines;
- The BMP provides the guidance for facility (including infrastructure & management process), training, documentation & records, tooling, parts and material management during processing, environmental protection and accountability to the customer;
- About half of AFRA members (31) are accredited by AFRA. This includes four of the top disassembly and storage companies (Apple, Air Salvage, AerSale and ComAV).

Environmental management systems

- Several recognised environmental management systems (EMS) framework exist in the industry, including the IEnvA program. Most of them are based on the International Organization for Standardization (ISO)'s ISO 14001, which provides practical tools for companies and organisations to manage their environmental responsibilities;
- ISO 14001 is widely adopted by the aviation sector. According to a survey conducted by ICAO, approximately 22% companies in the global aviation industry have obtained the ISO 14001 certification;
- When it comes to aircraft decommissioning, only a few disassembly, dismantling and recycling companies hold this certification to prove their environmental management.

Quality management systems

- Similar to EMS, there are several quality management systems (QMS) but most of them originate from the most popular QMS ISO 9001, which is set up by ISO to provide guidance and tools for companies and organisations to ensure that their products and services consistently meet customer's requirements, and that quality is consistently improved;
- AS9100 and ASA-100 are two QMSs, based on ISO 9001, specifically developed for aviation manufacturers and suppliers;
- A few aircraft dismantling and recycling companies are ISO 9001 accredited. Meanwhile for part certifiers, they tend to choose AS9100 and ASA-100 in place to make sure the quality of aircraft components that they provide.

Existing systems (2/2)

The goal of these systems is to provide frameworks for more detailed practices

Principle of ISO		ISO 9001 - Quality	ISO 14001 - Environment	AFRA - A/C disassembly and recycling
Plan	Context of the organisation	• Understanding the organization and its context • Understanding the needs and expectations of interested parties • Determining the scope of the quality/environmental management system • Quality/Environmental management system		N/A
Plan	Leadership	• Leadership and commitment • Quality/Environmental policy • Organizational roles, responsibilities and authorities		N/A
Plan	Planning	• Actions to address risks and opportunities • Quality/Environmental objectives and planning to achieve them • Planning of changes		N/A
Do	Support	• Resources • Competence • Awareness • Communication • Documented information		• Article III Facility • Article IV Training • Article V Documentation & records • Article VI Tooling
Do	Operation	• Operational planning and control • Determination of market needs and interactions with customers • Operational planning process • Control of external provision of goods and services • Development of goods and services • Production of goods and provision of services • Release of goods and services • Nonconforming goods and services	• Operational planning and control • Value chain planning and control • Emergency preparedness and response	• Article VII Parts and materials management during processing
Check	Performance evaluation	• Monitoring, measurement, analysis and evaluation • Internal audit • Management review		N/A
Act	Improvement	• Nonconformity and corrective action • Improvement		N/A

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Summary of Industry Research (1/6)

Introduction

- This part of the study assesses financial mechanisms which govern the aircraft decommissioning process. A number of industry stakeholders have been interviewed in order to understand economic mechanisms and drivers which influence the retirement, storage and decommissioning process.
- SGI conducted 15 stakeholder[1] interviews, including aircraft operators, aircraft owners and part-out companies. Companies interviewed were:
  - Aircraft operators (6): Allegiant Air, All Nippon Airways, Avianca, Cathay Pacific, Finnair and South African Airways;
  - Aircraft owners (4): Compass Capital Corporation, Infinity Aviation Capital, VX Capital Partners and Erste Bank;
  - Part-out companies (5): AELS, AirSalvage and Delta Material Services, GA Telesis and TARMAC;

  This discussion focussed on four different sections;

  I. Decision to decommission an aircraft

  II. Selection of facilities

  III. Disassembly and dismantling process

  IV. Parts distribution and recertification

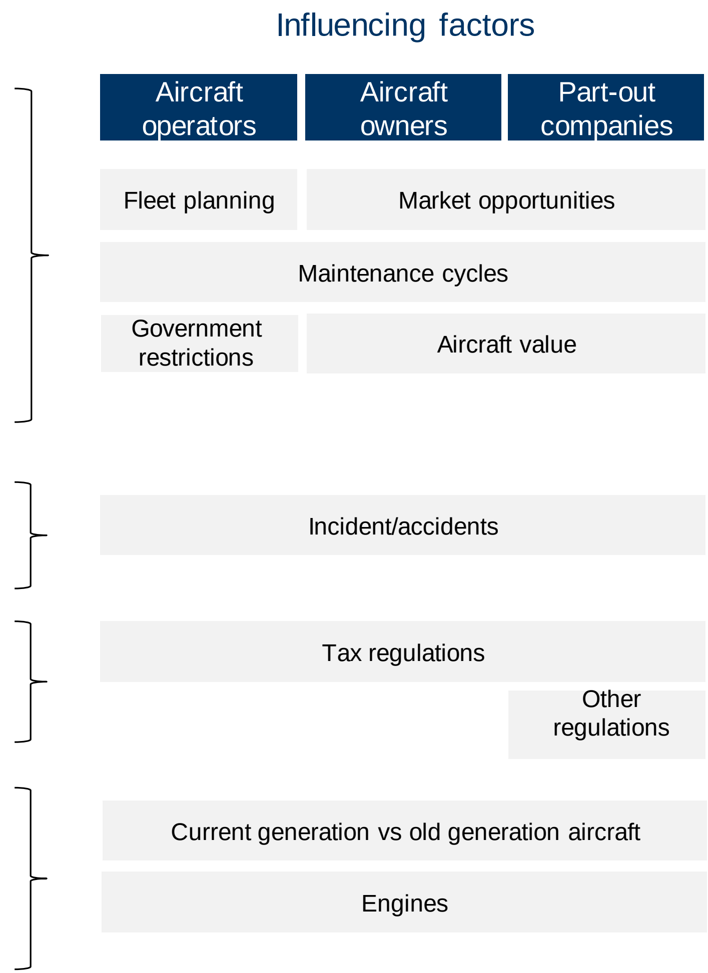
  This part of the report provides a summary of the feedback received from the different stakeholders structured in the different sections. Comments made by interviewees that were similar were consolidated into one summary statement, which is presented at the beginning of each section. Comments which were unique were included as solitary statements and were placed in the end of each summary. Overall, efforts were made to utilise the phrasing and wording used by the interviewees to keep their original meaning as closely as possible. The detailed interview records can be found in the Appendix section.

[1] Multiple roles can be applicable to one participant - a hybrid company (e.g. an aircraft operator being aircraft owner, maintenance organisation and aircraft disassembler). In this section, only the roles are considered, rather than companies.

Summary of Industry Research (2/6)

I. Decision to decommission an aircraft

- Aircraft operators focus on internal factors when decommissioning an aircraft. These include fleet planning, organisational and strategical changes. They barely assess the aircraft value or have a less comprehensive evaluation system compared to aircraft owners. This is because generating revenue from the ownership of aircraft is not their core business. There are subtle differences between low-cost aircraft operators and state-owned aircraft operators. The former will consider the maintenance cycles of the aircraft to seize the end-of-life opportunities, whilst the later may be forced by governmental restrictions to retire a group of aircraft.
- For aircraft owners and part out companies, external market dynamics (e.g aircraft/parts demand & supply and fuel price) are the driving factor to retire an aircraft. Typically owners deploy multiple sources to continuously assess the market and value of the aircraft to create scenarios beforehand, particularly before purchasing an aircraft and when major maintenance events are going happen on older aircraft. Additionally, if there is high demand in the market for certain components, disassembly of an aircraft could be triggered as well.
- In terms of earlier retirement, the aforementioned elements as well as incidents/accidents are the root cause. However, incident/accident related aircraft or components have little to no value as the market is resistant to buy these parts.
- Tax regulations are highlighted as the major burdens preventing parties to disassemble aircraft in certain areas, i.e. import tax and sales tax on aircraft and components. For part-out companies, personnel, environmental, health and safety regulations and special national regulations (e.g. aircraft age restriction) increase difficulties with an aircraft disassembly.
- Generally, participants believe that aircraft types for which a large number are still in operation and which have a follow-up model, such as 737NG and A320 family, will be in high demand for disassembly in long term. It also should be noted that engines have a significant influence on the demand. Typically, aircraft with four engines are regarded as too costly to operate; engines installed on older aircraft which have commonalties with current engine types can push aircraft to disassembly. Engine OEM's with a large market share on a specific engine type, also control the part-out market. This makes certain aircraft types less attractive for part-out.



Summary of Industry Research (3/6)

II. Selection of facilities

- When selecting facilities to store, part-out or dismantle an aircraft, aircraft operators and owners will consider a number of elements: costs (including the import tax and ferry cost), facility location & climate (in the case of storage), capability & credibility of the facility, saleability of parts in the geographic market, legal protection of ownership rights and the environmental aspects. Many of the interviewees mentioned that they will take AFRA accreditation into consideration, however this is not a primary factor.

Influencing factors

Aircraft operators	Aircraft owners
Costs	
Location and climate	
Capability and credibility	
Saleability of parts	
Protection of ownership rights	
Environmental protection	
AFRA accreditation	

- Generally, aircraft operators and owners prefer not to store aircraft. They would like to avoid aircraft storage as much as possible. The reason is that stored aircraft (in general) have a lower market value than aircraft in operation, though this is also dependent on the current market conditions. Aircraft operators only store aircraft for a short term if it is sold. As for owners, they tend to create an exit scenario beforehand without having the aircraft go into storage. Nevertheless, short-term storage still takes place and the duration is influenced by the current market condition and the value of the aircraft.

Aircraft operators	Aircraft owners
No storage preferred	
Operational shift	Beforehand exit scenario
	Market condition
	Aircraft value

Summary of Industry Research (4/6)

III. Disassembly and dismantling process

- Currently there are no specific environmental regulations related to aircraft disassembly and dismantling. The process is only subject to generic national and local environmental rulings. In addition to that, health and safety regulations and parts recertifying and distribution regulations also apply. Part-out companies accredited by AFRA need to adhere the procedures as set by the organisation.
- All of the part-out companies indicated that the removal and disposal of fuel and oils is the largest risk in the tear down process, followed by other hazardous waste such as uranium and asbestos, chromate paint and primers, oxygen cylinders, electronics (particularly batteries) and carbon fibres. It should be noted that newer generations of aircraft mainly consist of recyclables, whilst for older aircraft the amount of recyclables is lower.
- Existing environmental regulations are considered to be adequate, but there is room for improvement with regards to the disassembly process. It is recommended to have more regulations relating to the storage conditions of system-critical electronics, as the improper storage has a negative influence on the reliability of the equipment. Furthermore, it is suggested to gain more insight and to develop improved process for disassembly and recycling of new aircraft systems and materials (e.g. carbon fibres).

Influencing factors

Part out companies

- General environmental regulations
- Health and safety regulations
- Parts recertifying and distribution regulations
- AFRA procedures

- Risk of fuel and oils removal and disposal
- Others risks

- Regulations on storage conditions
- Insight of disassembly of new aircraft

Summary of Industry Research (5/6)

IV. Parts distribution and recertification

Influencing factors

- Parts trading companies focus on components which generate high return of investment. The remainder of the aircraft has little to no value. It is estimated that only 20% of all components removed from an aircraft can be sold within the first eighteen months. The rest will stay in inventory and will ultimately get scrapped if not sold within a certain timeframe. The main driver for the speed of sale is based on the reliability of parts, the market supply & demand of parts, mandatory technical changes (e.g. avionics upgrades) and OEM policies on different parts.

Part out companies

- High value components
- Reliability of parts
- Market supply and demand
- Mandatory technical changes
- OEM policies

- All parts which are targeted to re-enter the market will be inspected and released to service by approved maintenance organisations in accordance with applicable regulations. Therefore, no regulatory risk or concerns are encountered during this process. The major risk involved is related to incorrectly evaluated part values at purchase or parts being beyond economical repair during recertification. Other risks include industry acceptance of parts from a dismantled aircraft, reliability of parts and different standards and requirements for release certificates in the industry.

- Parts value risk
- Acceptance risk of parts
- Reliability risk of parts

- It is suggested that there should be a master database to trace parts movement and incident/accident involvement in the whole industry. Secondly, due to the international characteristics of the market it is advised to extend the number of bilateral agreements on the acceptance of release certificates, e.g. a quint-release of FAA, EASA, TC, CAAC and ANAC.

- Parts database
- Bilateral agreements

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Summary of Industry Research (6/6)

Summary of key factors

I. Decision to decommission an aircraft

Aircraft operators | Aircraft owners | Part-out companies

- Fleet planning
- Market
- Maintenance cycles
- Government restrictions
- Aircraft value
- Incident/accident
- Tax regulations
- Other regulations
- Current generation vs old generation aircraft
- Engines

II. Selection of facilities

Aircraft operators | Aircraft owners

- Costs
- Location and climate
- Capability and credibility
- Saleability of parts
- Protection of ownership rights
- Environmental protection
- AFRA accreditation
- No storage preferred
- Operational shift
- Beforehand exit scenario
- Market condition
- Aircraft value

III. Disassembly and dismantling process

Part-out companies

- General environmental regulations
- Health and safety regulations
- Parts recertifying and distribution regulations
- AFRA procedures
- Risk of fuel and oils removal and disposal
- Others risks
- Regulations on storage conditions
- Insight of disassembly of new aircraft

IV. Parts distribution and recertification

Part-out companies

- High value components
- Reliability of parts
- Market supply and demand
- Mandatory technical changes
- OEM policies
- Parts value risk
- Acceptance risk of parts
- Reliability risk of parts
- Parts database
- Bilateral agreements

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Conclusions (1/4)

Current status

- With a compounded annual growth rate of more than 4%, aircraft retirements have gradually increased over the past decades. More than 15,000 commercial aircraft have been retired world wide in the past 36 years. In the early 2010s, between 700 and 900 aircraft are retired on an annual basis;
- Historical trends shows that the average aircraft retirement age has increased from 18.8 years in 1980-1984 to 29.4 years in 2005-2009. The retirement age dropped to 27.6 years in the last six years due to the record-high oil prices in early 2010s.
- Aircraft retirements are generally governed by a number of principles:
  - More than half of the aircraft which are utilized for commercial operations are retired between the age of 20 and 30 years;
  - Freighters accounted for 17% of all the commercial aircraft retirements. Freighters tend to retire later than passenger aircraft. The average retirement age of a freighter aircraft is 32.5 years and for a passenger aircraft 25.1 years. Meanwhile, freighter conversion could extend the aircraft life for typical ten to twenty years;
  - In terms of aircraft sizes, the retirement share of narrow body (NB), wide body (WB) and small (SM) aircraft is 47%, 14% and 39% respectively. Only subtle differences show on the average retirement age among these three groups, but WB aircraft tend to have double retirement peaks at age 23 years and 29 years. This phenomenon is driven by expensive maintenance events;
  - Of all retired aircraft, 38% were retired in North America and 33% in Europe (of which 63% in the former USSR and current CIS);
  - Aircraft types for which the largest portion has been retired (e.g. 727, 737-100/-200 and An-24) will not be the main retirement focus in the future. Instead, types which are at sunset of the life cycle (e.g. 747, 737CL and MD-80) will dominate the short-term dynamics in the market;
  - The combination of a large number of new aircraft produced, a low retirement rate so far and the introduction of the follow-up models will drive a retirement wave in the long-term future for aircraft such as 737 NG, A320 family, 777 and A330.

Conclusion (2/4)

Current status

- Analysis revealed the following retirement drivers:
  - The effect of changing oil prices is noticeable on aircraft retirements and therefore one of the main drivers for aircraft retirements;
  - Development of new aircraft models with improved technology has a significant impact on the aircraft retirement activities;
  - Components with a high value and which are in demand can also influence the retirement curve.
- The largest share of storage and disassembly locations is situated in southern states of the USA, as they provide dry conditions which reduces the risk of corrosion (e.g. Arizona);
- Based on historical retirement distributions and aircraft production data, more than 15,000 aircraft will be retired in the next 15 years. However, it should be noted that the number of retirements is highly fluctuated, depending on many external factors;
- Out of the total aircraft retirements, 42% is retired short or directly after operation. Once the aircraft is stored it remains in storage for an average period of 3,5 years before it is retired;

Conclusions (3/4)

Regulations and industry practices

- Currently there are no specific regulations governing aircraft decommissioning. ICAO and national governments are expecting industry to set and improve best practices;
- The only industry developed practices with regards to aircraft decommissioning so far is the Best Management Practices (BMP) set up by AFRA, an international aircraft disassembly and recycling association;
- Aircraft manufacturers, aircraft disassemblers & dismantlers and recyclers actively participate in experimental projects to develop improved processes of aircraft decommissioning. Meanwhile aircraft operators, owners and maintenance organisations should be more involved in this industry practices development;
- Several projects have been conducted related to this field, e.g. PAMELA, AiMeRe, which set up the preliminary practices for the industry;
- A moderate but growing number of aircraft decommissioning companies have obtained certification under various standards, including AFRA BMP, EMS (e.g. ISO14001) and QMS (e.g. ISO9001);
- The goal of these systems is to provide frameworks for more detailed practices. However, they only cover the environment and quality related issues, leaving the financial or economic aspects untouched.

Conclusions (4/4)

Industry Research

- Aircraft operators focus on the internal factors when decommissioning an aircraft, such as fleet planning and organisational and strategical changes. Aircraft owners and part out companies are driven by the opportunities in the market and the value of the aircraft, typically when costly maintenance events of an aircraft are due;
- Tax regulations, i.e. import tax and sales tax on aircraft and components, are a major burden for parties to part out an aircraft;
- Generally, the industry believes that aircraft types for which a large number are still in operation and which have a follow-up model, such as 737NG and A320 family, will be in high demand for disassembly in long term;
- When selecting facilities to store, part-out or dismantle an aircraft, aircraft operators and owners will consider a number of elements: costs (including the import tax and ferry cost), facility location & climate (in the case of storage), capability & credibility of the facility, saleability of parts in the geographic market, legal protection of ownership rights and the environmental aspects.
- Stored aircraft (in general) have a lower market value than aircraft in operation, though it is also dependent on the current market conditions;
- The most risky process of aircraft disassembly is the removal and disposal of fuel & oils and other hazardous wastes (e.g. uranium & asbestos, chromate paint & primers, and batteries);
- Parts trading companies focus on components which generate high return of investment. It is estimated that only 20% of all components removed from an aircraft can be sold within in the first eighteen months after disassembly. Whether a part can be sold quickly depends on the reliability of parts, current market supply & demand of parts, mandatory technical changes and OEM polices on different parts;
- The incorrect estimation of part values at purchase and parts being beyond economical repair are the major risks during the part recertification process, followed by industry acceptance of parts from a dismantled aircraft, reliability of parts and different standards for release certificates in the world.

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Recommendations

Recommendations concerning Industry and Governmental Bodies

- The following recommendations and best practices could be beneficial for the industry:
  - As aircraft operators only incidentally touch the process of retiring aircraft, it is recommended to have workshops and guidance materials for operators and other relevant parties to improve the procedures of aircraft decommissioning;
  - To further optimise the retirement process, it is suggested to have guidance on how to handle hazardous materials (e.g. fuel and oils), new materials (e.g. carbon fibres) and parts used on aircraft.
- The following recommendations concern the interaction between governmental bodies and industry:
  - Given the fact that the Incident Clearance Statement (ICS) has a high impact on the value of a part, it is recommended to further explore its usage and requirements;
  - Improve the acceptance level of parts removed from a disassembled aircraft is suggested;
  - Create more uniformity within major aviation regulatory regimes to allow acceptance of foreign release certificates, for both new parts and used parts;
  - A more accurate and comprehensive database of the actual aircraft status is suggested, which would help to trace aircraft and parts movements. This would decrease 'aircraft dumping' practices and bogus parts entering the market;
  - To track the status of aircraft, on top of aforementioned the database, it is recommended to research the feasibility of a Certificate of Retirement (or equivalent), which will be issued when an aircraft is retired or disassembled;
  - Advise on the governmental restrictions on aircraft age and environmental issues related to aircraft operations is suggested. This would allow aircraft operators to optimise the aircraft usage;
  - It is recommended that a comparison of regulations of import tax and sales tax on aircraft and components in different countries would provide a valuable in-sight in these practices and aircraft movements.

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Appendix I

Assumptions

- This report is a desktop analysis and makes use of the following assumptions and principles:
  - Aircraft movements have been analysed for the period of January 1980 to December 2014, together with preliminary data of 2015. Data prior this period only has been included when it is necessary to cover the whole production cycle of aircraft.
  - The analysis focusses on retirement and decommissioning trends of commercial aircraft only. This includes all variations of passenger, freighter or combi aircraft;
  - All types of aircraft have been taken into consideration in order to make a complete analysis. This includes aircraft built in USSR, aircraft out of production and in production as well;
  - Aircraft with a retirement age of less than 5 years or more than 50 years have been excluded from the retirement analysis (which corresponds with 0.2% of the dataset respectively), as these incorrectly influence the analysis and these retirements should be treated on a case by case basis;
  - The division of small (SM), narrow body (NB) and wide body (WB) aircraft is based on the number of seats and industry knowledge: SM of up to 100 seats, NB of 100-200 seats and WB of more than 200 seats;
  - Corrections have been made for obvious outliers or anomalies. Any corrections or exclusions are listed below each graph;
  - The analysis of storage has only taken storage time from 6 months to 16 years into consideration. Storage of less than 6 months has not been taken into account for the purpose of this study to avoid the statistical inaccuracy.

Appendix II

References

- The analysis of this report is formed on the data and information from the sources as follow:
  - Information on aircraft storage facilities and part-out organisations have been based on publicly available data and studies. This includes:
    - The AFRA website (http://www.afraassociation.org);
    - The ASA website (www.aviationsuppliers.org);
    - Visiongain (2015) – Commercial Aircraft Disassembly, Dismantling & Recycling Market Report;
    - SGI Internal database and studies performed for other parties.
  - Aircraft trend data[1] is taken from the Ascend Fleet Database as well as internal SGI (proprietary) databases;
    - *Retirement* in Ascend Fleet Database is defined as:

"Ascend will retire an aircraft once they have confirmation from the operator/owner that the aircraft has been PWFU (permanently withdrawn from service/use), or Ascend sees physical evidence such as it being on pallets or being stripped for parts.

When Ascend has an aircraft that has been parked continuously for 5 years (not always in the same location) they will review the aircraft on a case by case basis and if they can find no evidence of it being readied for service or in an active storage program then they will deem it as being PWFU. If that aircraft then does return to service any time after that then Ascend rescinds the PWFU and return it to a parked status prior to its return to the air."

- *Storage* in Ascend Fleet Database is defined as:

"An aircraft that is not currently accumulating hours, whether that is long or short term. Aircraft that are parked for five days or more are generally classified as stored – however each msn is assessed on a case by case basis. "

- Regulation and industry practices information are obtained online from government and association portals, including ICAO, IATA, European Commission, US government, FAA, EASA, AFRA etc.

1. Aircraft trend data from Ascend Fleet Database does have a slight delay, compared with the real aircraft movement.

Appendix III

List of aircraft manufacturers per region[1]

Americas	Europe	Asia-Pacific	CIS
Aero Commander	Aerospatiale	A.S.T.A. (GAF)	Antonov
Aero Spacelines	Airbus	CAIC XAC	Ilyushin
Avcraft	Airbus Defence & Space	COMAC	Irkut Corporation
Boeing	Aircraft Industries - Let	Gippsland Aeronautics	Sukhoi
Boeing (McDonnell-Douglas)	ATR	Harbin	Tupolev
Bombardier (Canadair)	BAE SYSTEMS (Avro)	Hindustan Aeronautics	Yakovlev
Bombardier (de Havilland)	BAE SYSTEMS (BAC)	Indonesian Aerospace	
Bombardier (Learjet)	BAE SYSTEMS (HS)	Israel Aerospace Industries	
Carstedt Aviation	BAE SYSTEMS (Jetstream)	Mitsubishi	
Cessna	Bombardier (Shorts)	NAMC	
Eclipse Aviation	Dassault Aviation	RAI - Regio Aviasi Industri	
Embraer	Evektor-Aerotechnik	Shaanxi	
Fairchild	Fairchild/Dornier	Xian	
Fairchild (Swearingen)	Fokker		
General Dynamics (Convair)	Handley Page		
Gulfstream Aerospace	M.B.B.		
Harbin Embraer Aircraft Industry	Morane Saulnier		
Hawker Beechcraft	Romaero S.A.		
Lockheed	RUAG		
Rockwell	Saab		
Saunders	Transall		
Viking Air	UTA Industries		
	VFW		
	WSK-PZL Mielec		

1. The region refers to the location that the aircraft design originates from, instead of the location of manufacturer facilities.

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Appendix IV

List of top 40 storage airports[1,2] (1980-2015)

Rank	Storage location	IATA/ICAO code	Stored Aircraft	Rank	Storage location	IATA/ICAO code	Stored Aircraft
1	Roswell - Industrial Air Center, NM, USA	ROW	760	21	Kiev - Zhulyany, Ukraine	IEV	103
2	Victorville - S. California Logistics, CA, USA	VCV	716	22	Istanbul - Ataturk/Yesilkov Int'l, Turkey	IST	101
3	Marana - Pinal Airpark, AZ, USA	MZJ	706	23	Tehran - Mehrabad International, Iran	THR	100
4	Kingman, AZ, USA	IGM	541	24	Southend, United Kingdom	SEN	100
5	Phoenix-Goodyear - Municipal, AZ, USA	GYR	437	25	Dinard - Pleurtuit-St Malo, France	DNR	93
6	Mojave, CA, USA	MHV	407	26	Bangor - International, ME, USA	BGR	93
7	Tucson - International, AZ, USA	TUS	337	27	Tel Aviv - Ben Gurion International, Israel	TLV	90
8	Miami - International, FL, USA	MIA	235	28	Moscow - Domodedovo, Russia	DME	90
9	Johannesburg - O R Tambo Int'l, South Africa	JNB	184	29	San Antonio - International, TX, USA	SAT	89
10	Calgary - International, Alberta, Canada	YYC	155	30	Moscow - Vnukovo, Russia	VKO	89
11	Jakarta - Soekarno-Hatta International, Indonesia	CGK	151	31	Lasham, United Kingdom	QLA	89
12	Mexico City - Benito Juarez, Mexico	MEX	140	32	Exeter, United Kingdom	EXT	89
13	Toulouse - Blagnac, France	TLS	131	33	Lima - Jorge Chavez International, Peru	LIM	84
14	Lanseria, South Africa	HLA	122	34	Lourdes/Tarbes - Osun, France	LDE	84
15	Miami - Opa Locka, FL, USA	OPE	117	35	Kuala Lumpur - Sultan Abdul Aziz Shah, Malaysia	SZB	80
16	Woensdrecht, Netherlands	WOE	116	36	Zhukovsky, Russia	UUBW	79
17	Madrid - Barajas, Spain	MAD	116	37	Moscow - Sheremetyevo, Russia	SVO	79
18	Caracas - Simon Bolivar Int'l/Maiquetia, Venezuela	CCS	114	38	Las Vegas - McCarran International, NV, USA	LAS	77
19	Shannon, Republic of Ireland	SNN	110	39	Sofia - Vrajdebna/International, Bulgaria	SOF	76
20	Nashville - International, TN, USA	BNA	108	40	Rome - Leonardo da Vinci/Fiumicino, Italy	FCO	76

1. For aircraft which have been stored at more than one airports, only the last storage location has been taken into account.
2. Besides the top 40 storage airports, there are 4513 aircraft stored in unknown or unconfirmed locations.

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Appendix V

List of top 40 storage airports[1,2] (as at 31/12/2015)

Rank	Storage location	IATA/ICAO code	Stored Aircraft	Rank	Storage location	IATA/ICAO code	Stored Aircraft
1	Kingman, AZ, USA	IGM	253	21	Kuala Lumpur - Sultan Abdul Aziz Shah, Malaysia	SZB	21
2	Roswell - Industrial Air Center, NM, USA	ROW	224	22	Nairobi - Jomo Kenyatta, Kenya	NBO	20
3	Victorville - S. California Logistics, CA, USA	VCV	150	23	Nairobi - Wilson, Kenya	WIL	20
4	Marana - Pinal Airpark, AZ, USA	MZJ	114	24	Jakarta - Soekarno-Hatta International, Indonesia	CGK	20
5	Teruel, Spain	TEV	78	25	Sanford - Central Florida, FL, USA	SFB	19
6	Phoenix-Goodyear - Municipal, AZ, USA	GYR	63	26	Osh, Kyrgyzstan	OSS	18
7	Tehran - Mehrabad International, Iran	THR	56	27	Bangor - International, ME, USA	BGR	18
8	Tucson - International, AZ, USA	TUS	52	28	Jacksonville- Cecil Field, FL, USA	VQQ	18
9	Lourdes/Tarbes - Osun, France	LDE	37	29	Lanseria, South Africa	HLA	17
10	Fujairah - International, United Arab Emirates	FJR	31	30	Kinshasa - N`Djili Int'l, DR Congo	FIH	17
11	Johannesburg - O R Tambo Int'l, South Africa	JNB	29	31	Mexico City - Benito Juarez, Mexico	MEX	16
12	Caracas - Simon Bolivar Int'l/Maiquetia, Venezuela	CCS	28	32	Sabiha Gokcen, Turkey	SAW	15
13	Zhukovsky, Russia	UUBW	25	33	Karachi - Jinnah International, Pakistan	KHI	15
14	Calgary - International, Alberta, Canada	YYC	25	34	Dushanbe, Tajikistan	DYU	15
15	Moscow - Vnukovo, Russia	VKO	24	35	Surabaya - Juanda, Indonesia	SUB	14
16	Kansas City - International, MO, USA	MCI	24	36	Nashville - International, TN, USA	BNA	14
17	Blytheville - Arkansas International, AR, USA	BYH	23	37	Ulyanovsk - Vostochniy - North East, Russia	ULY	14
18	San Angelo - Mathis Field, TX, USA	SJT	22	38	Shymkent, Kazakhstan	CIT	14
19	Toulouse - Blagnac, France	TLS	21	39	Maastricht - Maastricht-Aachen, Netherlands	MST	14
20	Moscow - Domodedovo, Russia	DME	21	40	Mineralnye Vodij, Russia	MRV	13

1. For aircraft which have been stored at more than one airports, only the last storage location has been taken into account.
2. Besides the top 40 storage airports, there are 406 aircraft stored in unknown or unconfirmed locations.

Appendix VI

Interviews I. Decision to decommission an aircraft

What non-economical factors influence the decision making process to part-out an aircraft?

Aircraft Operators

For aircraft operators the main factor for aircraft retirement and disassembly is the internal fleet planning, such as new deliveries and fleet replacement; The value of aircraft itself is rarely taken into consideration. Aircraft operators with a lower cost base are the exception to the rule and they will include the end-of-life opportunities into their assessment and try to avoid the heavy airframe maintenance events and engine events. Some state-owned aircraft operators indicated that governmental restrictions, especially related to environment, could push a group of aircraft to the stage of retirement or tear-down. Another airline also mentioned that accidents could be an additional factor.

‘Matching aircraft deliveries and retirements to a desired fleet plan.’

Aircraft Owners

In contrast, the aircraft end-of-life economics dominate the asset owner’s decision. They evaluate the external market dynamics (e.g. aircraft/parts demand & supply and fuel price), assess the aircraft condition (e.g. reliability, regulatory compliance and heavy maintenance cost) and consider their own situation (e.g. financial condition of the company) to create scenarios beforehand, in an attempt to maximum return of the asset at the end of its life.

‘This is mainly market driven, including the earlier part-out.’

Part-out companies

All interviewed part-out companies strongly believe that the opportunities in the market (e.g. economy outlook, fuel prices, demand for air travel and components requests), are the primary factor (if not the sole reason) to disassemble an aircraft; On the other hand, the fact that aircraft operators commonly prefer younger aircraft is also driving up the number of aircraft retirements and disassemblies.

‘No other factors play a role. Pure economical – or opportunity and market driven.’

Appendix VI

Interviews I. Decision to decommission an aircraft

At which stages of an aircraft life is part-out considered to be an option?

Aircraft Operators

Most aircraft operators only consider retiring or parting out an aircraft in accordance with their fleet plan; while the operators who do evaluate end-of-life opportunities will opt for disassembly when the heavy airframe or major engine checks are due. If the aircraft has been involved in incidents/accidents or if there is urgent need for expensive or obsolete parts in the rest of the fleet, operators might also consider the tear-down. Sometimes the retirement or part-out is beyond operators' control, due to regulatory (national and international) restrictions.

'We do not look at each aircraft and decide whether to retire or not. As mentioned in before, we look at our business plan first and the fleet plan follows.'

'We look at maintenance cycles of the aircraft. As previous mentioned, we will try to avoid 12Y check of an aircraft.'

Aircraft Owners

Market conditions are the main driver when aircraft owners determine to part-out an aircraft. Some believe that aircraft age is irrelevant in this case, while others mainly focus on relatively old aircraft (e.g. 20 – 25 years). Typically major (and costly) maintenance events trigger the evaluation of scenarios for owners (e.g. continuing operation, freighter conversion or disassembly).

'This has changed a lot due to the large volume of aircraft produced, because the leading factor to part out an aircraft is the return on investment (the market). Normally aircraft with high cycles, or with many inspections due would be a candidate. Typically the disassembly will happen at the end of the maintenance cycles, such as heavy structural check.'

Part-out companies

Similar to aircraft owners, maintenance cycles play a key role in a decision of disassembling an aircraft in part-out companies' eyes, especially for aircraft older than 15 years. Moreover, one company pointed out that consciousness is growing within the industry in terms of the timing of parting out.

'Usually around the point that a major check for the airframe is due.'

'There is more and more competition in the disassembly and dismantling market and therefore more awareness within the industry on timing of disassembly and dismantling.'

Appendix VI

Interviews I. Decision to decommission an aircraft

What are the most common reasons causing earlier retirement of an aircraft?

Aircraft Operators

Reasons of earlier retirement of an aircraft vary in the operators' opinion. Internally, major changes in business plan could result in earlier retirement of aircraft, including mergers of companies, strategy changes and fleet replacement; on the external side, macro economic changes, for instance changes in fuel price and currency exchange rates, new aircraft types and incidents/accidents related issues may cause the aircraft retired earlier than expected. Generally state-owned operators will be less influenced by the external factors than other operators.

'Major change in business plan which leads to a particular aircraft or aircraft type replacement.'
'Economics of that aircraft type versus a newer, more capable aircraft type.'

Aircraft Owners

Again, market opportunities are the major driver for owners to retire an aircraft earlier. Additionally the following reasons could bring the retirement forward: costly maintenance events, distressed situations, technology improvement and higher operational cost than profit.

'Retirement of the aircraft is very market driven and it also influenced by the maintenance cycles. Technology improvement is absolutely another factor. It drives up maintenance cost and forces older aircraft out of service. '
'Everyone has responsibility on assets it owns and there should be regulations to force parties to part out aircraft instead of leaving them uncontrolled. '

Part-out companies

Demand for components within the fleet of an airline or in the market could incentivise earlier retirement of an aircraft. When there is less demand for capacity or for a certain type of aircraft (e.g. during economic downturn or introduction of a new type or model), aircraft will be pushed to be parted out. In addition, incidents/accidents and insurance related problems are another driving force.

'Need for engines only and not specifically airframes, within an airline or fleet of aircraft; Dependant on the market fitness of an aircraft (i.e. need in market and successor of an aircraft type); Insurance related reasoning (i.e. incident and accident related).'

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Appendix VI

Interviews I. Decision to decommission an aircraft

Do national regulations or financial regulations provide a burden in the dismantling process?

Aircraft Operators

Most operators believe that there is no specific regulation preventing them from dismantling an aircraft, apart from one airline indicating the fact that high import tax will restrict aircraft disassembly. One operator expressed concerns over the part-out project management which might impair their reputation if not handled properly.

‘No. Does not matter where the potential aircraft would be situated.’

‘I think the biggest barriers are project management burden and reputation. We don't want to get profiled as junkyard. National regulations would be tough but probably not impossible.’

Aircraft Owners

Tax regulations rank top of the list of factors which keep aircraft owners from disassembling an aircraft, i.e. the export/import tax and sales tax on aircraft and parts. During the selection of a part-out facility, owners will take the jurisdiction, location, capability and credibility of the facility into consideration.

‘There is no regulation preventing people/organisations from disassembling an aircraft. This is because the only regulated part of the process is the component recertification. Local tax regulations may have an influence on the purchasing and disassembly process’

Part-out companies

Part-out companies have more regulatory concerns. Import tax regime is a major reason preventing them from purchasing aircraft for disassembly. Next comes to national personnel, environment and safety regulations (e.g. regulations on hazardous materials) and special national regulations (e.g. age restriction). Incidents/accidents related regulations also decrease the number of aircraft being disassembled.

‘Import/Export regulations and related duty taxes (in Europe). Import regulations for serviceable aircraft which are purchased and flown to Europe for part-out purposes are not exempted from duty taxes. Other way around, importing/exporting serviceable parts are exempted from duty taxes, which is not consistent. ’

Appendix VI

Interviews I. Decision to decommission an aircraft

Which mechanisms are used within the industry to determine the residual value of the aircraft?

Aircraft Operators

Aircraft operators use different approaches of in-house knowledge and third party information to determine the residual value of an aircraft. Third party information includes market information, MRO software, stock information and RFP.

‘For the aircraft type that we are not familiar with, we use the 3rd party to determine the residual value; for aircraft we have experience, we use internal data only.’

Aircraft Owners

Residual value of an aircraft, together with the market situation, are closely monitored by the owners, in order to seize opportunities and maximize the return on investment. Generally the residual value is forecasted in advance, based on the appraised value, adjusted with the historical value and current market condition. It is noted that the residual value is highly dependent on market demand. Parts could be used on the current types of aircraft would be considered more valuable than the ones could not. PMA parts, missing records and the tightening OEM policies, have a negative effect on the value.

‘The valuation we do is based on an initial appraisal value in combination with scenario analysis. This scenario analysis is a comparison of the current market values and historical values. Later on, the current part-out value is estimated to anticipate the future, especially for the worst case situation.’

Part-out companies

Part-out companies determine the residual value by means of their internal database. Aircraft nearing the out-out-of-production phase generate the highest margins. Factors such as location of the facility, aircraft maintenance condition and operating region also play an important role in retaining value. When an aircraft has little residual value consignment could be used to mitigate the losses of the owner by sharing the risk with part-out companies, while disposing the aircraft properly. It is also applicable to newer aircraft, when the profits and risks are shared amongst the part-out facility and owners. It is suggested that additional guidance and rulings on incidents/accidents related components or aircraft would help to part out more aircraft as this affects the residual value negatively.

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Appendix VI

Interviews I. Decision to decommission an aircraft

Which aircraft types are in demand for part-out?

Aircraft Operators

The airline's point of view is largely dependent on their business process and operational model. Generally aircraft types for which a large number are still in operation with a follow-up model, or an unpopular type will be in demand for disassembly. It is noted that engines have a significant influence on the demand: aircraft with four engines are regarded as too costly to operate; and older aircraft with commonalties for the engines with current aircraft are in demand.

'Any aircraft type with a large operating fleet.'
'The 757 airframe, however the engines are high in demand for serviceability; More demand is generated for the A320 aircraft; MD-80 aircraft would only be profitable to dismantle if the disassembly of the airframe is combined with the engines.'

Aircraft Owners

Owners share a relatively common view that although the market is driven by supply and demand, they believe 737NG and A320 family will be in high demand for the long term. Aircraft with freighter conversion options will be modified instead of being disassembled (e.g. B757 and B767). Engine OEM's with a large market share on a specific engine type, control the part-out market. This makes certain aircraft types less attractive for part-out.

'This is supply and demand driven. In the time of 10 to 12 years, A320 and 737 NG will be in demand for disassembly.'

Part-out companies

From the part-out companies' perspective, there is high demand for parts of aircraft still in production. The component market is very competitive with regards to aircraft in the middle term of phase out (e.g. 737CL). It is noted that engaging in the disassembly of an aircraft type in an early stage is accompanied with high (value) risks and exposures (e.g. 737NG).

'Current in-production aircraft: not much supply of aircraft still in production, for which a high demand for parts exists.'
'We are currently in the transition phase towards the Next Gen aircraft, however market is still thin and can have higher risks and exposure when purchased now.'

Appendix VI

Interview II. Selection of facilities

What factors influence the selection of a storage, part-out or dismantling facility?

Aircraft Operators	Aircraft operators base their selection of a facility for storage or disassembly on a number of elements; cost (including import tax and ferry cost), facility location (e.g. close to an operational base) and reputation, saleability of parts in the geographical market, ground service facilities, partnerships and environmental aspects. *'Good reputation as a responsible facility, location, customs, ground services and partners.'* *'Always a function of cost; However, it is of importance to disassemble the aircraft close to an operational base of the airline.'*
Aircraft Owners	Likewise, owners will consider cost, facility location and climate (e.g. dry location, less corrosion). Additional factors such as capability and credibility of the facility, ability of selling parts quickly and the timing of project are also considered. Whilst these are the main drivers, some have indicated that legal protection of ownership rights is also elements of consideration. *'Credibility of the part-out company is an important factor when selecting the storage and dismantling facility.'*

Appendix VI

Interview II. Selection of facilities

How long is a typical storage period and what factors influence the duration of this storage period?

Aircraft Operators

Storage of aircraft is not preferred by aircraft operators as aircraft only generate revenue when flying. They will try to avoid storage as much as possible. Aircraft are only stored if they are sold, however an immediate sale is always favoured. Other than that, when an aircraft has to enter storage for reasons other than retirement, the duration could be influenced by the following elements; the lead time of modification kits if required, cost of storage and the qualifications and credentials of the storage location.

‘Try to avoid having non-productive assets, i.e. aircraft storage, as much as possible.’

Aircraft Owners

Aircraft owners prefer not to put aircraft into storage either, if better options exist. They tend to create an exit scenario without having the aircraft go into storage. Nevertheless, short-term storage still takes place and the duration depends on the current market condition and the value of aircraft.

‘This is market driven. Typically 6 to 8 months. Prefer not to have the aircraft in storage because of the costs to keep it airworthy.’

‘Will try to avoid to store aircraft as much as possible, by preparing exit scenarios in advance.’

Appendix VI

Interview II. Selection of facilities

Will the value of an aircraft be retained or decrease if an aircraft is in storage?

Aircraft Operators	Aircraft operators generally prefer not to store aircraft. One airline indicated that whether the aircraft value is retained or decrease depends on how the aircraft is being stored and if all the relevant OEM procedures have been followed. *‘Haven’t kept the aircraft in storage because of book value.’*
Aircraft Owners	Owners believe that the book value only depends on the aircraft type and age of the aircraft, thus storage has no impact in this case. However, stored aircraft generally have a lower market value than aircraft in operation as the lease represents a certain value. This is all heavily dependent on current market conditions at time of storage (securitized value vs market value). *‘Parked aircraft have less value than aircraft in operation. Book value is not used in this case.’*

Appendix VI

Interview II. Selection of facilities

Do you have in-house capabilities to part-out an aircraft? If not, which considerations are important for outsourcing these activities?

Aircraft Operators

Most aircraft operators do not have the capable to disassemble an aircraft in-house as this is not their core business. Environmental impact, the economics of the disassembly process and commercial partnerships are the main drivers in selecting a service provider. An AFRA accreditation is another important consideration, but likely not a primary factor.

‘Accreditations is an important consideration, however not binding.’
‘Environmental impact of disassembly (i.e. % of the aircraft that that is recycled), cost of the disassembly process and value generated from removed parts. ’

Aircraft Owners

The aforementioned thoughts were expressed by the owners as well. One additional note is that it is vital that legal protection of the assets is guaranteed in the jurisdiction where the facility is located.

‘No in-house capabilities; As mentioned, asset protection will be an important consideration.’

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Appendix VI

Interview II. Selection of facilities

Will international rules/regulations or best practices be required related to aircraft decommissioning?

Aircraft Operators

Most aircraft operators are satisfied with the current regulation system for aircraft decommissioning, particularly in the US and EU. Even though, improvement to regulations are suggested on parts and components trading, along with the environmentally friendly disassembly and dismantling process to recycle more parts of the aircraft at a reasonable cost.

‘Not required, particularly not in the US and EU; Regulations require the airline to have full trace of a component or parts used for operations. The current regulations test the market for parts and component trading.’

‘For the disassembly and dismantling process yes. A bigger push to recycle a higher percentage of the aircraft, in particular cabin and composites is required but at a sustainable cost.’

Aircraft Owners

The views of owners can be split into two groups. One thinks the existing regulations are sufficient, especially on the environmental issues though they are not aircraft specific. The other group feels that there should be more regulatory supervision. This is specifically the case for the smaller companies in the US. One common opinion from all owners is to further explore the usage and requirements of the ICS. A missing statement significantly reduces the value of parts, resulting in less aircraft being disassembled.

‘There are already regulations governing the environmental issues even though they are not aircraft specific; Incident related parts are from a regulatory perspective the same compared to non-incident related parts but they have a lower value in the market, leading to less incentive to part out an aircraft if the documentation is not available.’

‘The threshold to start a part-out company should be higher and there should be supervision to check if companies comply with all the regulations.’

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Appendix VI

Interview III. Disassembly and dismantling process

What environmental regulations does your company have to comply with?

Part-out companies

Currently there are no specific environmental regulations related to aircraft disassembly and dismantling. The dismantling process is subject to national environmental rulings related to, for instance groundwater protection and fluids disposal.

In the recent period, some regulators have also added requirements for aircraft. For instance, an environmental impact assessment. Part-out companies accredited by AFRA not only follow national environmental regulations, but also adhere to the AFRA procedures.

‘UK environmental regulations for base and mobile services; Adherence to AFRA procedures, also family member;’

Are there any other regulations that apply to the part out process?

Part-out companies

Besides national or local environmental regulations, part-out companies are also obliged to follow health and safety regulations for controlled removal of fluids, and the distribution process of parts. Many countries outside the EU and US do not have additional regulations on these processes.

‘The EU definition on waste is clear, which introduces issues related to waste versus asset transportation and licenses needed.’

Appendix VI

Interview III. Disassembly and dismantling process

How do you handle hazardous materials?

Part-out companies

Part-out companies follow both the national and international rules, as well the AFRA practices (if applicable), related to handling hazardous materials.

'According to local regulations and the practices as defined by the AFRA.'

Which areas of the tear down process have the largest impact on the environment?

Part-out companies

All parties indicate that the most risky element in the tear down process is the removal and disposal of fuel and oils. In addition, the following items also can have a substantial environmental impact: hazardous waste (such as uranium and asbestos, especially for older aircraft), chromate paint and primers, oxygen cylinders, electronics particularly batteries and carbon fibres.

It should be noted that for newer generations most of the aircraft consist of recyclables, whilst for older aircraft this is a lower percentage.

'There is no clear knowledge on risks related to recycling of carbon fibres.'

Appendix VI

Interview III. Disassembly and dismantling process

Can any part of the aircraft tear down process be improved?

Part-out companies

All tear down companies agreed that there is room for improvement with regards to the disassembly process. It is recommended to have more regulations relating to the storage conditions of system-critical electronics, and to gain more insight of the disassembly of new aircraft systems and technology (e.g. carbon fibres recycling). Existing environmental regulations are considered to be adequate. It is stated that if more regulations come into effect in the near future, then demand for high-quality services should be generated first.

‘By gaining more insight/outlooks in how the disassembly world would look like in the future (e.g. carbon fibre recycling).’

Appendix VI

Interview IV. Parts distribution and recertification

What are the risks related to parts during or after the recertification?

Part-out companies

The uncertainty related to the re-sale value of parts has been indicated as a major risk by the part-out companies, this is related to incorrect estimation of parts values at purchase or parts which are beyond economical repair during recertification process. This results in an impairment on return on investment.

Other risks include industry acceptance of the parts from a dismantled aircraft, reliability of parts and different standards for release certificates in the world.

‘If the aircraft had an airframe check quite recent, then the risk on finding unserviceable/BER components is smaller when compared to an airframe check which has taken place a longer period time ago.’

What external factors influence the fact that some parts sell quick than others?

Part-out companies

Reliability of parts is seen as the number one factor (i.e. MTBUR), followed by the current supply and demand of parts (i.e. parts availability) and mandatory technical changes such as avionics upgrades. OEM policies on different parts may also be part of the reason.

‘Reliability and MTBUR is the number one factor.’

‘Issuance of Airworthiness Directives /Service Bulletins which forces operators to replace components are an important factor. ’

Appendix VI

Interview IV. Parts distribution and recertification

Which materials (other than parts) are generally chosen to be recycled by the parts trader companies?

Part-out companies

Parts traders only focus on the main components, for example flight controls and thrust reversers. The remainder of the aircraft has little to no value as a result of high removal and processing cost. Generally part-out companies will try to offset the cost of recycling versus the income of main airframe components. The results are highly dependent on availability of equipment, capacity of the maintenance organisation and the location of facility.

‘Parts traders focus only on components. The remainder of the fuselage have no value (fluids etc.) – which costs money to remove and process. A scenario in which the profits of the recyclables and the costs of the non- recyclables are break-even is a general rule of thumb.’
‘Most components.’

How long does it take sell all the components of one aircraft?

Part-out companies

It is estimated that 20% of the components are fast movers (can be sold within the first eighteen months). The rest of the components will stay in inventory and get scrapped if not sold within a certain time frame as defined by the company. Generally speaking, it is unlikely that all components of an aircraft are sold.

‘20% of the parts/components are fast movers and considered high value components, which can be sold within 18 months; Components are kept in inventory for 5Y. If not sold, the parts will be scrapped. ’

Appendix VI

Interview IV. Parts distribution and recertification

What is the process to re-certify aircraft components which were removed from aircrafts?

Part-out companies

All parts which are going to re-enter the market will be inspected and are released to service by approved maintenance organizations (either internal or external) in accordance with the applicable regulations. As a result, no regulatory risk or concerns are encountered during this process.

‘We have our repair shop or external networks to re-certify parts in accordance to regulatory standards, say FAA or EASA.’

Are more rules/regulations or best practices required for parts distributions and recertification?

Part-out companies

- It is suggested that there should be a master database to trace every single part in the whole industry. Secondly, due to the international market it is advised to extend the number of bilateral agreements on the acceptance of release certificates, e.g. a quint-release of FAA, EASA, TC, CAAC and ANAC.

‘The biggest thing is the traceability of parts. There should be a master database which can trace all the parts in the whole industry. That is a topic I heard a lot from the industry.’

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