Best Industry Practices for Aircraft Decommissioning (BIPAD)
Aircraft Decommissioning Workshop

Optimize the realization of residual value from aircraft decommissioning

About 700 aircraft are being retired each year, with a growing trend. If undertaken in a timely and appropriate manner, decommissioning can allow recovery of a good residual value from re-used parts and recycled material, whilst minimizing environmental and safety risks. Timely retirement is an essential part of the fleet renewal process. However, for most airlines and other aircraft owners, such as lessors, limited experience is available on managing aircraft decommissioning as a controlled process.

In this 2-day workshop you will receive guidance on business processes, operational experiences and best practices in the industry, reinforced with exercises, discussions, and role play to equip you with the knowledge to optimize the residual value from aircraft decommissioning.

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Foreword

The research, development and production of new aircraft is very much in the public eye, but much less is known about what happens to an aircraft at the end of its operational life. However, an entirely new industry has grown up around this process and has achieved impressive performance in recent years. Today, around 700 aircraft are decommissioned every year, a number that is only set to increase. Up to approximately 90% of the parts of a decommissioned aircraft can be either re-used as spare parts for other aircraft or recycled if best practices are applied.

However, many aircraft owners and operators have limited information on the best practices around the aircraft decommissioning process which would ensure that the residual value of parts and material are maximized while respecting the environmental impact.

IATA, in its mission to represent, lead and serve the airline industry, has recognized the need to address this issue. This Best Industry Practices for Aircraft Decommissioning (BIPAD) manual has been developed to help airlines and other aircraft owners in their decision to decommission an aircraft, in the criteria to look at for the selection of an appropriate facility and in the steps of disassembly, dismantling and re-use of parts. For each step, information is provided on the operational and economic, regulatory and legal, safety and environmental aspects.

For the development of this manual, IATA has been working closely with a multi-stakeholder industry group consisting of experts from airlines, their maintenance branches and other maintenance, repair and overhaul companies, aircraft and engine manufacturers, lessors, disassembly, dismantling and recycling companies and their global association, AFRA, and parts traders.

I hope this manual will help its readers, across all interested stakeholder groups, to gain new insight into the aircraft end-of-life process and to contribute to making aviation more sustainable by properly taking care of aircraft which have reached the end of their operational life.

Michael Gill

Director, Aviation Environment
International Air Transport Association
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Definitions

To avoid confusion and ambiguity, the following key words are defined in this document as below:

**Abandoned aircraft**: Refers to the aircraft permanently parked without a storage maintenance program. In some cases, the aircraft has been deregistered and it may be impossible to identify the owner.

**Aircraft owner**: In this manual, this term includes the person or organization that has control over whether an aircraft is to be sold or decommissioned.

**Decommission**: Refers to the whole process of retiring, disassembling and dismantling the aircraft.

**Disassemble (part out)**: After the aircraft has been retired, the action of removing all the valuable parts and components from an aircraft, which are intended to be reused in the aviation industry.

**Dismantle**: After disassembling the aircraft, the action of taking out other parts for non-aviation purposes and tearing down the rest of the aircraft for recycling purposes.

**Retire**: The action of the aircraft owner to withdraw the aircraft from active service permanently. This does not include the process of disassembling or dismantling the aircraft.

**Stored aircraft**: Refers to the aircraft temporarily parked under a storage maintenance program. The aircraft could return to active service or be decommissioned afterwards.
Abbreviations

737CL  737 Classic
737NG  737 Next Generation
AC      Advisory Circular
AD      Airworthiness Directives
ADIG    Aircraft Decommissioning Industry Group
AFRA    Aircraft Fleet Recycling Association
AiMeRe  Aircraft Metal Recycling
AMM     Aircraft Maintenance Manual
AOC     Air Operator Certificate
APU     Auxiliary Power Unit
AR      As removed
ARC     Authorized Release Certificate
AS      Aerospace (Quality) Standards
ASA     Aviation Suppliers Association
AWG     Aviation Working Group
BMP     AFRA Best Management Practice for Management of Used Aircraft Parts and Assemblies and for Recycling of Aircraft Materials
CAA     Civil Aviation Authority
CAAC    Civil Aviation Administration of China
CAEP    Committee on Aviation Environmental Protection
CC      Combustion Chamber
CFC     Chlorofluorocarbons
CoA (or CofA) Certificate of Airworthiness
CoC (or CofC) Certificate of Conformity
CVR     Cockpit Voice Recorder
DOA     Design Organization Approval
DSG     Design Service Goal
DSO     Design Service Objective
EASA    European Aviation Safety Agency
ECS     Environmental Control System
ELT     Emergency Locator Transmitter
ELV     End-of-Life Vehicle
EMAS    Eco-Management and Audit Schemes
EMS     Environmental Management System
EoL     End of Life
EOL     End of Lease
ESDS    Electrostatic Discharge Sensitive
ESG     Extended Service Goal
ESN     Engine Serial Number
ETS     Emission Trading Scheme
EU      European Union
EURATOM European Atomic Energy Community
FAA     Federal Aviation Administration
## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>FDR</td>
<td>Flight Data Recorder</td>
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<tr>
<td>FOD</td>
<td>Foreign Object Damages/Debris</td>
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<tr>
<td>GAAP</td>
<td>Generally Accepted Accounting Principles</td>
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<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>GHG</td>
<td>Greenhouse Gas</td>
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<td>HAZMAT</td>
<td>Hazardous Material</td>
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<tr>
<td>HCFC</td>
<td>Hydrochlorofluorocarbons</td>
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<tr>
<td>HFC</td>
<td>Hydrofluorocarbons</td>
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<tr>
<td>HPC</td>
<td>High Pressure Compressor</td>
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<tr>
<td>HPT</td>
<td>High Pressure Turbine</td>
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<tr>
<td>HSE</td>
<td>Health, Safety and Environment</td>
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<td>HWM</td>
<td>Hazardous Waste Materials</td>
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<td>IAEG</td>
<td>International Aerospace Environmental Group</td>
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<td>IAF</td>
<td>International Accreditation Forum</td>
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<tr>
<td>IATA</td>
<td>International Air Transport Association</td>
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<tr>
<td>ICA</td>
<td>Instruction for Continued Airworthiness</td>
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<td>ICAO</td>
<td>International Civil Aviation Organization</td>
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<tr>
<td>ICS</td>
<td>Incident/accident Clearance Statement</td>
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<tr>
<td>IFE</td>
<td>In-flight Entertainment</td>
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<tr>
<td>IFRS</td>
<td>International Financial Reporting Standards</td>
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<td>ISO</td>
<td>International Organization for Standardization</td>
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<tr>
<td>ISTAT</td>
<td>International Society of Transport Aircraft Trading</td>
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<tr>
<td>JCAB</td>
<td>Japan Civil Aviation Bureau</td>
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<tr>
<td>LHT</td>
<td>Lufthansa Technik</td>
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<tr>
<td>LLP</td>
<td>Life Limited Part</td>
</tr>
<tr>
<td>LOV</td>
<td>Limit of Validity</td>
</tr>
<tr>
<td>LTCS</td>
<td>Lufthansa Technik Component Service</td>
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<tr>
<td>MoU</td>
<td>Memorandum of Understanding</td>
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<tr>
<td>MR</td>
<td>Maintenance Reserve</td>
</tr>
<tr>
<td>MRO</td>
<td>Maintenance, Repair and Overhaul, or Maintenance and Repair Organization</td>
</tr>
<tr>
<td>MTBR</td>
<td>Mean Time Between Removal</td>
</tr>
<tr>
<td>MTBUR</td>
<td>Mean Time Between Unscheduled Removal</td>
</tr>
<tr>
<td>NiCd</td>
<td>Nickel-cadmium</td>
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<tr>
<td>NIS</td>
<td>Non-Incident/accident Statement</td>
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<tr>
<td>OEM</td>
<td>Original Equipment Manufacturer</td>
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<tr>
<td>OHSAS</td>
<td>Occupational Health and Safety Management System</td>
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<tr>
<td>PAMELA</td>
<td>Process for Advanced Management of End of Life of Aircraft</td>
</tr>
<tr>
<td>PCB</td>
<td>Polychlorinated biphenyl</td>
</tr>
<tr>
<td>QMS</td>
<td>Quality Management System</td>
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<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
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<tr>
<td>REACH</td>
<td>Registration, Evaluation, Authorization and Restriction of Chemicals</td>
</tr>
<tr>
<td>RoHS</td>
<td>Restrictions on Hazardous Substances and Chemicals</td>
</tr>
<tr>
<td>SARPs</td>
<td>Standards and Recommended Practices</td>
</tr>
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Abbreviations

SB  Service Bulletin
SMM  Safety Management Manual
SPV  Special Purpose Vehicle
STC  Supplemental Type Certification
SUP  Suspected Unapproved Parts
SV  Serviceable
TC  Type Certification
TIPs  Technical Implementation Procedures for Airworthiness and Environmental Certification
THSA  Trimmable Horizontal Stabilizer
TSLO  Time Since Last Overhaul
UAE  United Arab Emirates
ULB  Underwater Locater Beacon
VAT  Value Added Tax
WEVEE  Waste Electrical & Electronic Equipment
WFD  Widespread Fatigue Damage
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Executive Summary

The aim of this manual is to provide guidelines for airlines and other aircraft owners/operators to manage aircraft decommissioning in a controlled process, while considering environmental, safety and economic aspects.

Operational and business conditions and fleet management strategies strongly vary among aircraft owners/operators, and they operate under different regulatory conditions depending on the country of registration. Therefore, no standard procedures can be defined that would be widely applicable to all situations. As a result, the BIPAD manual only provides best practices, process descriptions, information about relevant regulations, other background information and recommendations. It does not mandate procedures to follow.

The Aircraft Fleet Recycling Association (AFRA) has published its Best Management Practices (BMP) for application by specialized aircraft dismantling and recycling companies. The BIPAD manual primarily addresses a different target group, namely aircraft owners/operators, and is, therefore, complementary to the AFRA BMP.

The BIPAD manual covers all phases of the aircraft end-of-life process, from the decision to take an aircraft out of service to the final dismantling, recycling and reuse of parts. Accordingly, after Chapter 1 (Background and Introduction), its structure follows the various aircraft end-of-life process phases:

1. Decision to Decommission
2. Selection of Facilities
3. Disassembly Process
4. Dismantling Process
5. Parts Distribution and Recertification

Each main chapter (2 – 6) is divided into four sections:

x.1 Economic and operational aspects
x.2 Regulatory and legal aspects
x.3 Safety aspects
x.4 Environmental aspects

Aircraft decommissioning is a multi-disciplinary activity and it is important for airlines and other industry stakeholders to consider the aircraft end-of-life process holistically.

The following paragraphs give a summary of the relevant content in the BIPAD manual.

In Chapter 1 (Background and Introduction), a breakdown of the aircraft end-of-life process is provided, showing a clear split between the aerospace domain, which comprises all process steps while aircraft components are still certified for airworthiness, and the non-aerospace and waste domain, which includes the process steps after components have lost their airworthiness certification. An overview of the aircraft disassembly, dismantling and recycling activities worldwide is given, indicating the growing business volume, the trends observed for the aircraft age at retirement and some expected future developments.

Economic and operational aspects (Section 1 of Chapters 2 to 6) are the main drivers in an aircraft owner/operator’s decision to retire an aircraft from operational service, putting it either into storage for potential later reactivation, or directly into disassembly or selling the entire aircraft. The main influencing parameters are fleet planning considerations, upcoming maintenance needs for the aircraft in question, the availability of technologically advanced replacement aircraft, the general economic situation, the applicable depreciation rules, and considerations of the value of the aircraft as a whole and of its parts.

Several criteria should be taken into consideration in the selection of a disassembly and dismantling facility. The most important aspects are its technical capabilities and compliance with quality and environmental management systems. The possibility of aircraft storage is relevant in some cases. Other aspects include regulations in the respective jurisdiction, climate, and the market for part sales, taxation, and other costs (e.g. ferry flight).
The main operational and economic aspects during the disassembly, dismantling and parts recertification process are the realization of residual value, supply/demand and time to find a buyer (movement speed) for reusable components, storage conditions for these components (especially high-value components), and support from original equipment manufacturers (OEMs).

The sections on regulatory and legal aspects (Section 2 of Chapters 2 to 6) describe how new standards relating to aircraft certification, for example, the environmental standards in ICAO Annex 16, and their incorporation into domestic law through civil aviation regulations are drivers for fleet modernization and renewal, which in turn encourage the retirement of older aircraft that do not comply with newer standards. Some States have set an airframe age limit on standard category aircraft that may be added to their registry, typically varying between 15 and 25 years. The ICAO cross-border transferability (XBT) working group has identified a list of States applying such regulations. ICAO has recently engaged in the aircraft end-of-life process and concluded a Memorandum of Understanding (MoU) with AFRA.

National waste handling regulations are applicable once an aircraft is dismantled. Further regulatory and legal aspects linked to aircraft decommissioning include: potential liability for damage caused by aircraft dismantling activities (especially by releasing hazardous substances), protection of ownership rights for parts, and applicable tax regulations. For international parts sales, bilateral airworthiness safety agreements on the recognition of airworthiness certifications between the countries of origin and destination may be relevant.

Section 3 of Chapters 2 to 6 describe safety and certification aspects. For the selection of facilities, the main safety aspects are the facilities’ commitment to health and safety codes and quality systems (including AFRA accreditation), as well as personnel requirements and training.

During the disassembly, dismantling and parts recertification process, the safety and airworthiness of the parts to be reused needs to be maintained, and safety conditions for workers and external persons are to be ensured. Attention needs to be given to the risk of components having lost their certification as well as suspected unapproved or counterfeit parts being introduced into the spare parts market.

The sections on environmental aspects (Section 4 of Chapters 2 to 6) begin with a general overview of environmental issues related to aircraft decommissioning (i.e. waste generation, hazardous waste, noise, dust, wastewater, emissions to air and soil contamination). Next, the impact on greenhouse gas (GHG) emissions in the aircraft end-of-life process versus keeping an old aircraft in service is considered. Environmental aspects are also an important factor to be considered in the selection of suitable facilities for aircraft disassembly and dismantling. The AFRA BMP and other environmental management systems such as ISO (International Organization for Standardization) 14001 or eco-management and audit schemes (EMAS) provide relevant methods, processes and procedures for disassembly facilities.

Aircraft disassembly generates a substantial amount of parts and components made of a large variety of materials. Procedures are provided to properly manage these materials, parts and components, especially hazardous materials (HAZMAT) and hazardous waste on the one hand, and reusable components and recyclable materials on the other. Aspects of remanufacturing parts and components for other purposes outside aviation, as well as new recycling processes for certain materials such as carbon fiber are also considered.
Join AFRA, the leading global organization for developing and promoting safe and sustainable management of end-of-life aircraft and components, as we work to...


• Focus on Circular Economy-Related Aspects of the Aircraft End-of-Life Industry

• Collaborate with Industry Representatives in Association Initiatives to Continue Improving Management of End-of-Life Aircraft

Learn More: AFRAassociation.org
Contact Us: info@AFRAassociation.org
Chapter 1—Background and Introduction

1.1 Background

More than 15,000 commercial aircraft have been retired worldwide in the past 35 years. In recent years, about 700 aircraft are retired annually, with an average age of around 27 years. Currently, there are more than 27,000 commercial aircraft in service globally and the average airframe age is about 13 years, with more than 20% older than 20 years. It is estimated that 12,000 aircraft will be retired in the next two decades.

![Figure 1: Historical aircraft retirements (1980-2017)](http://www.sgiaviation.com/wp-content/uploads/2018/05/IATA_Aircraft_Decommissioning_Study_May-2018.pdf)

If undertaken in a timely and appropriate manner, decommissioning can allow recovery of residual value from reused parts and recycled material, while minimizing environmental and safety risks.

It is therefore desirable to provide aircraft owners or operators with guidance on business processes and operational experiences from best practices in the industry.

1.2 Scope

The aim of the BIPAD manual is to provide such guidelines. The operational, business and regulatory conditions vary widely between aircraft owners and operators, each having its own strategies. Therefore, no standard procedures can be defined that would be widely applicable to all specific situations. As a result, this document only provides recommendations instead of mandating procedures to follow.

The BIPAD manual and the AFRA BMP are complementary in nature as the primary stakeholder groups by both documents are different, the AFRA BMP being aimed at aircraft disassembly, dismantling and recycling companies.

For some topics covered by the BIPAD manual, regulations, guidelines and/or extensive studies are already in place. In this case, this document only presents a summary of the topic and refers to the specific sources.

After reading this document, the reader should be aware of what should be considered from the decision to decommission an aircraft to the process of returning parts to the aviation market.

---

1.3 Introduction to the Aircraft Decommissioning Process

The process of aircraft decommissioning, following industry practices and regulatory requirements is illustrated in Figure 2. In this figure, four categories of aircraft going into disassembly are distinguished:

- a. In-service aircraft retired from operations
- b. Stored aircraft
- c. Abandoned aircraft
- d. Aircraft previously involved in accidents

For these aircraft, the decision of the owner to disassemble and dismantle them are represented by the process 1, 2, 3 and 4, respectively. Upon making the decision, the aircraft will enter the disassembly process (process 5), the purpose of which is to remove the valuable components from the aircraft. The removed components, depending on their technical condition, will either return to the aviation market directly (process 7) or need to be inspected and maybe repaired or overhauled by an approved repair shop before returning to service (process 6). These activities must be performed by approved organizations that have authorization to return parts to service.

Once the aircraft has permanently lost its airworthiness certification (process 8), it will not be considered as an aircraft under the State of registry’s responsibility anymore. Depending on its owner’s decision, it may be considered waste instead. Usually, this occurs once the last aircraft owner has sold the aircraft to the dismantling company and all parts intended for reuse have been disassembled. Then, it enters the waste business section. Through the process of dismantling (process 9), reuse of some parts of the aircraft can be feasible in non-aerospace businesses, either directly (process 10) or after making some changes (process 11). The rest of the aircraft will be considered as waste, which will be extracted and transferred for further processing.

\(^2\) Source: Airbus

\(^3\) See Definitions at the beginning of this document.
treatment (process 12). Recyclable wastes will be processed and batches will be prepared (process 13) for recycling (process 15), and, likewise, non-recyclable wastes will be prepared (process 14) for disposal (process 16).

The BIPAD manual is structured in a similar way.

*Chapter 2 - Decision to Decommission* provides insights mainly on the aircraft owner’s decision to disassemble and dismantle an aircraft; and *Chapter 3 - Selection of Facilities* offers several key considerations when selecting the disassembly and dismantling facility. Together, they cover processes 1 to 4 in Figure 2.

Suggestions on the disassembly process (process 5) has been provided in *Chapter 4 - Disassembly Process*. *Chapter 5 - Dismantling Process*, in addition to addressing the dismantling process (process 9), includes processes 10 and 11 for non-aerospace use and processes 12 to 16 for waste treatment.

Lastly, practices on returning parts to the aviation market are presented in *Chapter 6 - Parts Re-certification and Distribution*, providing details for processes 6 and 7.

In each section, to provide a comprehensive overview, considerations of the following four aspects are presented:

- Economic and operational aspects (i.e. fleet planning, maintenance, aircraft value and supply/demand of parts).
- Regulatory and legal aspects (i.e. standards and regulations set by national or international authorities, tax regulations and regulations on ownership rights protection).
- Safety and certification aspects (i.e. airworthiness of parts and components, quality management, facility accreditation, staff qualification, health and safety requirements).
- Environmental aspects (i.e. treatment of hazardous substances and materials and recycling).

### 1.4 Overview of the Sector

#### a) Aircraft retirement characteristics

Figures 3 and 4 indicate a distribution of aircraft retirement age from 1980 to 2017 and the percentage of retired fleet by ages. The median retirement age for commercial aircraft over the last 36 years is 25 years, with more than half of the aircraft retired between the age of 20 and 30 years. This general distribution is also applicable to retirements in the last few years.

About 10% of aircraft were retired before the age of 17 years and about the same percentage were retired after 35 years of age. The first group consists mainly of small aircraft, while the latter is largely made up of freighters (see Figure 5). It is notable that the number of retirements for technical reasons (e.g. metal fatigue) before the age of 17 years, which was quite common in the 1980s, has decreased significantly in recent years (only accounting for 1.3% of total retirements), and retirement after the age of 37 years is becoming slightly more frequent. On the other hand, early retirement for mainly economic reasons is not uncommon today. A recent example is the retirement for part-out of a 10-year-old A380 returned by Singapore Airlines to its lessor.
82% of total aircraft retirements are passenger aircraft, 17% are freighters and the remaining 1% is attributable to combi aircraft. Distribution of retirement age by aircraft usage indicates that there are significant differences between passenger aircraft and freighters regarding retirement behaviors. As shown in Figure 5, freighters tend to be retired later than passenger aircraft. The average retirement age of freighter aircraft is 32.5 years and 25.9 years for passenger aircraft.

It is worth mentioning that conversion of passenger aircraft into freighters can extend the in-service time of these aircraft. On average, this conversion takes place when the aircraft is about 18 years old – an age that coincides with a major structural aircraft heavy check. Typically, aircraft can gain 10 to 20 years of extra life by conversion. The incentive behind freighter conversions can be linked to the much lower utilization of freighters compared to passenger aircraft. Due to this utilization profile, freighter operators achieve a lower operational cost by extending the aircraft life cycle. In recent years, there has been an increasing trend to freighter conversions and a corresponding increase in the average conversion age.

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4 Source: SGI Aviation, ibid.
5 Source: SGI Aviation, ibid.
b) Aircraft retirement environmental and safety performance

Overall, the state of the aircraft retirement industry is a positive example of responsible environmental practices. Today, 85% to 90% of the content of retiring aircraft is reused or recycled. Between 40% and 50% of the weight of dismantled aircraft is returned to the parts distribution pipeline. The remaining unserviceable material is repurposed, disposed of or recycled, and returned to the supply chain as raw materials. As both aircraft parts and scrap material represent significant value, there is strong competition for both. Many environmental benefits are driven by these market dynamics resulting in the high reuse and recycling rates, which also help to avoid landfill. The reuse and recycle rates can fluctuate with commodity prices and market conditions, but overall, it is a competitive and robust business.

c) Opportunities for increased environmental and safety performance for aircraft retirements

Aircraft owners wanting to ensure their aircraft are retired with adherence to strict environmental and safety protocols have the option to require decommissioning service providers to follow industry best practices such as those contained in the AFRA BMP. These require responsible practices in many areas, from tagging/documentation to HAZMAT disposal (see Subsection 3.3.4).

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7 See e.g. https://www.airport-technology.com/features/featureaircraft-recycling-up-to-the-challenge-5710942
Assuming a typical aircraft lifetime of approximately 25 years, most of the aircraft retiring by 2040 will still primarily be the types that are currently in service today, which are primarily of aluminum construction. By 2050, assuming the global fleet size doubling approximately every 20 years, older aircraft are expected to be retiring at the rate of almost 2,000 per year (compared with about 700 per year today). By 2060, when the newly designed types of today will have come into age in large numbers, retiring aircraft will feature high amounts of composites and other new structural materials.

The disassembly industry and aircraft manufacturers are actively developing strategies to optimize reuse and recyclability potential for these aircraft. Recycling carbon fiber has become possible as well, as innovative, scaled technology solutions to reuse both uncured and cured material have been developed recently. Experts expect that current aircraft recycle rates will be able to be maintained with advanced materials as well.

Manufacturers do consider recyclability in product design. The clear majority of parts from modern aircraft is recyclable or reusable today. The remaining portions of the aircraft (about 10%) that cannot be recycled tend to be mostly carbon fiber components, as mentioned above, as well as cabin interior components with embedded flame retardants, as required by safety regulations. Today, no technology is available to successfully extract that content, so it is usually landfilled. However, significant research and development is ongoing in this area, and carbon fiber recycling methods are close to implementation.

The main decision makers in the aircraft end-of-life process are aircraft owners/operators (i.e. mainly airlines and lessors), as well as specialized disassembly companies. They all can support further improvements in aircraft recycling by promoting the application of industry best practices. Appropriate policy support can further contribute to the development of aircraft recycling technology and to the implementation of a circular economy.

d) ICAO and the aircraft end-of-life process

The International Civil Aviation Organization (ICAO) supports activities related to aircraft end-of-life and recycling. At its 39th Assembly in 2016, States were requested to: “consider policies to encourage the introduction of more fuel-efficient aircraft in the market, and work together through ICAO to exchange information and develop guidance for best practices on aircraft end-of-life such as through aircraft recycling”.

ICAO has signed a Memorandum of Understanding (MoU) with the Aircraft Fleet Recycling Association (AFRA) to enhance cooperation and development of best practices for the management of aircraft end-of-life processing.

In its Environmental Report 2016, ICAO has further reiterated the need for aircraft life cycle assessments which includes a report of best practices implemented by AFRA and Bombardier in managing an aircraft’s end-of-life.
Chapter 2—Decision to Decommission

Aircraft owners consider decommissioning an aircraft when it is approaching the end of its operational life, which can be defined in two ways:

- Technical life
- Economic life

The technical life for many airframes is based on the evidence of fatigue tests, which are part of aircraft design approval and type certification, as the likelihood of the occurrence of fatigue damage in the structure increases with aircraft usage. When designing a type of aircraft, a certain amount of flight hours and/or flight cycles will be established by the manufacturer, during which the principal structure will be reasonably free from significant cracking, including widespread fatigue damage (WFD), provided the approved maintenance program is adhered to. This is often called the design service goal (DSG) or design service objective (DSO). To ensure safe operation of aircraft, the National Aviation Authority (NAA) responsible for issuing the type certificate and providing regulatory oversight over the type certificate for a particular aircraft make and model approves the limits defined by the designer of the aircraft for the aircraft’s technical life. An individual aircraft may not operate beyond the limitations prescribed in the Type Certificate that applies to the make and model of aircraft unless an extended limit of validity (LOV) is approved by the NAA.

However, it is observed that many aircraft retire before reaching the end of their technical lives. The lifespan of such aircraft is often regarded as the economic life of the aircraft. Unlike the technical life, there is no widely accepted definition of economic life of an aircraft in the industry. In this document, the lifespan of an aircraft that retires due to reasons other than reaching its certified safety limitations is regarded as the economic life of the aircraft. Throughout Chapter 2, these reasons will be presented, providing guidance for aircraft owners to make the decision to decommission an aircraft.

Decommissioning an aircraft normally involves two decisions:

- First, the decision by the operator to withdraw the aircraft from the active fleet
- Second, the decision by the aircraft owner to disassemble and dismantle the aircraft

When the owner/operator decides to withdraw the aircraft from its active fleet, he has several options available. The owner may decide to keep the aircraft in flying condition and lease or sell it to a third party. However, depending on the aircraft type and age, leasing or selling the aircraft could be challenging. In such cases, the owner has the following main alternatives:

- Converting the aircraft to a freighter, if it is a passenger aircraft
- Store the aircraft, either for later usage or permanently
- Disassemble and dismantle the aircraft

If a decision is made to disassemble and dismantle the aircraft, there are five possible scenarios for the owner:

1. Selling the complete aircraft to an independent broker, who intends to disassemble and dismantle the aircraft, in “as is, where is” condition without any minimum delivery conditions. This requires little time and effort from the owner. However, the marketability of the aircraft depends on its condition and the quality of the records.

2. Selling the complete aircraft to an independent broker, who intends to disassemble and dismantle the aircraft, with minimum delivery conditions. This requires some effort from the owner, as it will have to ensure that the airframe and parts meet these conditions and that the records are in line with industry standards. It might be necessary to upgrade the aircraft’s maintenance status.
3. Selling the aircraft parts on a consignment basis. In this scenario, the disassembly and dismantling company takes care of the decommissioning process and the sale of the individual parts. The aircraft owner retains ownership of the removed parts until the sale has taken place. As parts are sold, the owner might have to update the records of the parts. When compared to the previous scenarios, consignment requires more time.

4. Selling the major components (e.g. engines, auxiliary power units (APU), landing gear) and the airframe to individual brokers. All these components and their records should meet industry standard delivery conditions. This requires even more effort and time.

5. Storing the aircraft and selling it on a piece-by-piece basis to relevant buyers such as brokers or airlines. If the owner is an airline, it could supply its own fleet with the removed parts. This scenario requires extensive effort and time from the owner, as well as specific expertise and infrastructure to perform the disassembly. The airframe, parts and their records should meet minimum delivery conditions.

The decision to withdraw the aircraft from the operator’s fleet is normally driven by fleet planning considerations by the operator, which is briefly covered in Subsection 2.1.1. The focus of this document is on the decision by the aircraft owner to disassemble and dismantle the aircraft. Considerations on economic, operational, regulatory, legal, safety and environmental aspects are discussed in detail and recommendations are provided throughout Chapter 2.

2.1 Economic and Operational Aspects

This section describes a range of economic and operational aspects that can influence the decision to retire an aircraft from operational service: First, an operator’s fleet planning considerations will drive the decision to retire an aircraft from its active fleet and potentially decommission it. Technical life limitations and potential additional costs for measures to extend the aircraft’s operational life, as well as the technical status of the aircraft and its upcoming maintenance schedule, have an important impact on the aircraft’s further usability and residual value. The decision to decommission an older model aircraft is clearly favored when new, technologically more advanced aircraft models are available to replace it. The macroeconomic situation, air traffic demand and fuel prices, which are related, also influence whether it is economically worth keeping an aircraft in operation. Accounting principles and depreciation methods have a strong impact on an aircraft’s book value. Several significantly different rules can be applied depending on national legislation and the airline’s choices. Finally, an overview of different aircraft value concepts and their relevance for determining the business case for decommissioning is given.

2.1.1 Fleet Planning

Internal fleet planning is the main reason for an operator to retire aircraft from its fleet. Many elements should be considered during the fleet planning process and each operator may have different approaches based on its situation. The aim of this subsection is not to provide fleet planning guidance. Therefore, the detailed fleet planning process is not presented here. Instead, a few key considerations are outlined below.

The consideration as to whether the aircraft can generate an acceptable revenue or financial return to the owner/operator is paramount. Globally, when the cost of operation exceeds an acceptable revenue, it may be time for the owner/operator to consider selling or decommissioning the aircraft. However, this consideration needs to be made on a case-by-case basis by each owner/operator. Each will have a different business model, such that there can be cases where the owner/operator continues to use older aircraft (and trade in older aircraft). Alternatively, the choice may be to regularly renew their fleet. Airlines with a strong sustainability-oriented corporate strategy tend to make efforts to retire older aircraft before they become too inefficient, and to maximize reuse and recycling rates.

Key factors to consider in this decision are:

- **Technical** - the aircraft’s remaining operational lifetime and maintenance status
- **Economic** - the macroeconomic conditions and the applicable accounting rules
2.1.2 Operational life

As already mentioned in the introduction to Chapter 2, aircraft, as well as engines and numerous aircraft components, have life-limiting design service objectives (DSG/DSO) that prevent them from being used indefinitely, unless instructions for continued airworthiness (ICAs) are applied. Extending the technical life of an aircraft by applying ICAs may be an interesting alternative to decommissioning. DSG/DSO are generally derived from 20 years or 25 years of utilization. They are generally part of the aircraft’s certification, to be found in the relevant aircraft manuals (where applicable) and are typically expressed in flight cycles, calendar time or flight hours. The DSG/DSO can be extended (referred to as an Extended Service Goal, or ESG) by performing specific maintenance actions (i.e. inspections and/or modifications) as prescribed by the OEM in the ICAs. Furthermore, the maintenance actions needed to reach the optional ESG might be mandated by airworthiness directives (AD). As each specific case is different, an aircraft owner should ask the OEM for all necessary information to evaluate if it is worthwhile for them to apply relevant ICAs. The ESG-related maintenance actions may require a substantial investment from the owner/operator and, therefore, might result in the owner deciding not to extend the operational life. However, if managed carefully, such programs can extend the aircraft’s operational life substantially and be a worthwhile investment.

Figure 6 below shows, for the example of the Boeing 737 Classic, that an operational life extension has taken place for a large percentage of the 737CL fleet. 96% of all retired 737CLs have been retired after the DSG/DSO, and 47% of all 737CLs still in operation have exceeded the DSG/DSO.

For older aircraft, the achievable residual value is very much influenced by the actual maintenance state of the aircraft, the availability of technical engineering support, the timely availability of parts, the implementation of regulatory advisories etc. An aircraft which does not have any life remaining on the major life-limited components will be valued less than one which has 100% life remaining. This mechanism becomes more important toward the end of its life as it becomes likely that the individual components will be traded (rather than the aircraft). This may also be true of the overall condition of components.

2.1.3 Maintenance Cycle

In addition to the remaining operational lifetime of the aircraft and its key components, the upcoming aircraft maintenance cycle plays a large role in the decision of aircraft owners/operators to decommission an aircraft. This maintenance cycle is described in the maintenance program and consists mainly of:

- C-checks or equivalents
- Structural checks (or heavy airframe checks – commonly known as D-checks or equivalents)
- Shop visits/maintenance required for its major components

The major components are the engines, APU, landing gear and thrust reversers, of which the engines have the highest value and maintenance costs. The required maintenance checks have different intervals, based on the number of flight hours flown, the number of aircraft cycles and/or calendar time. Furthermore, these maintenance checks usually contain numerous tasks, such as lubricating, modifying, testing and inspecting (parts of) the aircraft.

14 Source: SGI Aviation, ibid.
The costs involved with the maintenance of aircraft usually increase as the aircraft ages (Figure 7). Aircraft maintenance cost normally increases in the first few years of operation after entry into service, then it comes to a relatively stable level when it reaches maturity. As the aircraft keeps aging, its maintenance costs tend to grow further. Depending on the aircraft type and the operation of the aircraft, the timing of these three phases varies. For indication purpose only, the newness period is typically the first 4 to 6 years of the aircraft life, and the maturity is roughly when the aircraft is between 6 to 15 years old. The ageing phase is the time afterward. This is partially because expensive structural, corrosion and zonal checks would take place during this period. More details can be found in the IATA document *Maintenance Costs for Aging Aircraft*\(^\text{16}\), such as critical individual maintenance events and creating spikes at certain time points rather than having a smooth curve as depicted in the simplified diagram in Figure 7.

The cost may further be subject to utilization (i.e. the number of operated flight hours and flight cycles, the ratio between flight hours/cycles and the areas of operation, the structural/heavy maintenance checks and other significant maintenance activities, such as engine shop visits). Please note that the maintenance costs of an individual aircraft (tail number level) will have certain cost spikes due to the cost of specific expensive maintenance events.

To determine the most cost-efficient moment for retiring an aircraft, the following factors impacting operational costs of ageing aircraft should be considered in detail:

**a) Additional required maintenance**

Depending on the type of aircraft, the aircraft manufacturer and the aircraft maintenance program, additional inspections and tasks might be required for older aircraft (e.g. airworthiness limitations, service goals). Several structural inspections will be performed at a higher aircraft age, a higher total number of flight hours and/or a higher number of flight cycles. Not only can the performance of the inspections be costly due to their structural nature and the increased complexity of gaining access to certain areas, the potentially high costs for the corrective actions of possible findings need to be considered.

**b) Possible modifications**

Based on the operational status of the aircraft (mainly for passenger aircraft), the cost of commercial modifications should be evaluated. These include, but are not limited to: passenger-to-freight conversion, cabin upgrade or reconfiguration, painting.

Decommissioning an aircraft can be the preferred option if the investment in future maintenance, including the risk of unplanned events, is not significantly lower than the revenue it is expected to generate in its future operation. Other considerations for this decision are aircraft value, both the individual aircraft’s value depending

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\(^{15}\) Source: SGI Aviation, ibid.

on its preservation status (see Subsection 2.1.7) and the benefits of new, more technologically advanced aircraft models replacing the one in question (see Subsection 2.1.4).

For more information on aircraft maintenance costs and ageing aircraft, please refer to various publications of the IATA Maintenance Cost Task Force (MCTF)\(^\text{17}\).

### 2.1.4 Technological Improvements

If a new, more modern aircraft model is available to replace an older one, the likelihood of selling the latter on the second-hand market is usually low. However, the demand for its components as spare parts may be high if many aircraft of the same family are still in service. This supports the decision to decommission an aircraft as part of the normal fleet renewal process.

Newer aircraft models are technologically more advanced than the aircraft they replace, which improves fuel efficiency, allows more environmentally friendly operations and offers marketing advantages. Furthermore, many technological improvements increase the reliability of new aircraft and their components (e.g. by introducing new materials such as composites). For all these reasons, it is difficult to resell older aircraft if more advanced alternatives exist. This drives the decision and timing to decommission older aircraft. As a mitigation, some of the new technologies can be offered for retrofit on older in-service aircraft (e.g. avionics).

The opportunity to sell high-demand aircraft components with high value (see more in Subsections 6.1.1 and 6.1.2), particularly if their availability on the spare parts market is low, could result in the retirement of an aircraft to serve the current operating fleet with spare parts. By early or timely retirement, a certain value for the aircraft parts and components can be retained. Timing is important, as an excess of part availability on the market could reduce the realized value.

The example below shows the strong correlation between entry into service of aircraft follow-up models with new technologies and retirements of predecessor models. A similar situation was observed during the 1970s and 1980s, when noise legislation drove retirements of first and second-generation jet aircraft (e.g. 707, 727, Trident, Caravelle).

\(^\text{17}\) IATA Maintenance Cost Task Force: [www.iata.org/mctf](http://www.iata.org/mctf)
Examples from SGI Aircraft Decommissioning Study

It took approximately twenty years after the introduction of 737-100/200 aircraft for in-service levels to stabilize. Just before the peak, the follow-up aircraft type, the 737 Classic (737CL), was introduced to replace the current aircraft. This decreased the production rate of the 737-100/-200 and increased its retirement rate in the next few years. The same decreasing effect on the 737CL service levels can be observed after introduction of the 737NG.

A similar trend can be seen on the Airbus A300/A310 after the introduction of the Airbus A330. Soon after the introduction of the A330 in the early 1990s, the A300 in-service levels started to decrease. Moreover, when the production efficiency of the A330 increased in 2005, the in-operation rate of A300 aircraft plunged from 80% to 50%.

Source: SGI Aviation, ibid.
2.1.5 Economic Conditions

Macroeconomic conditions, essentially through their impact on air traffic demand and fuel prices, strongly influence aircraft owners’ decisions to retire older aircraft.

Like most industries, aviation is highly impacted by the peaks and valleys of macroeconomic cycles. Within the aviation industry, aircraft retirement dynamics fluctuate with economic changes as well. When the economy booms, flight capacity demand rises, hence aircraft demand is high and the aircraft retirement rate remains low. During an economic downturn, the situation reverses and the number of retirements climbs.

Although GDP growth and traffic volume are strongly correlated, some deviations are observed because of the time delay between aircraft orders and deliveries. Many aircraft are ordered during times of significant economic growth. They will be delivered several years later, however, when the economic growth period might be over. Additional uncertainties are linked to actual delivery dates (e.g. launch customers for new aircraft and early operators may face certification, production and other technical delays).

It is possible that a cycle valley is short-term or regional, so consideration would need to be given to assessing the short to medium-term market conditions. In this case, an alternative to decommissioning could be parking or storing an aircraft.

Another major element that may stimulate aircraft retirements is the fuel price. Fuel typically accounts for 30% to 40% of the total operating cost of an airline. High fuel prices add cost to airline operations and could even drive inefficient operators out of business. It also urges airlines or aircraft owners to replace old aircraft with more modern and fuel-efficient types, thus triggering the retirement of older aircraft. On the other hand, low fuel prices enable airlines to expand their capacity and deploy older and less fuel-efficient aircraft, which results in a decrease in retirement activities.

Fuel price and other macroeconomic factors are clearly the most important factors driving overall aircraft retirement trends. However, in addition, each aircraft owner/operator is subject to several operational influences driving the decision to decommission a specific aircraft.

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18 IATA, Economic Briefings, 2010 to 2016
Example from SGI Aircraft Decommissioning Study

Figure 10 shows world GDP growth as an indicator of the world economic situation and the percentage of retirements in the total world fleet as the reference of the aircraft retirement status, from 1980 to 2015. During this period, noticeable recessions or their characteristics are presented: the early 1980s recession, the recession caused by the dissolution of the Soviet Union in 1991, the 1997 Russian and Asian financial crisis, the 9/11 attack in 2001, the US economic slowdown in 2005 and 2006, the 2008 financial crisis and the EU debt crisis in 2010-12. All these events, depending on their severity, have triggered economic downturns and driven up aircraft retirements to a certain degree.

As further described in Figure 10, in the late 1980s when the fuel price was about half the price in the early 1980s, even with the fluctuation of the world GDP growth, the percentage of aircraft retirements of the total world fleet remained low compared with that in the early 1980s. In 2008, in addition to the slumping economy, when the fuel price reached a record high, the aircraft retirement percentage soared to a new level of more than 2.5%. The rate remained the same until 2014 when the fuel price started to slump.

![Figure 10: World GDP growth and the price of crude oil affecting the percentage of aircraft retirements in the total world fleet (1980-2015)](image-url)

Source: SGI Aviation, ibid.
2.1.6 Accounting Principles

One of the financial parameters influencing the business case for aircraft decommissioning is the aircraft's book value at the moment of retirement, which depends on the applicable accounting principles and depreciation methods. It is, therefore, important for aircraft owners considering decommissioning an aircraft to observe the rules relevant to them.

For airlines owning their aircraft, the main considerations when purchasing an aircraft are of an operational nature (e.g. performance, reliability, comfort). The residual value of the aircraft at the end of the expected operating period is usually a secondary aspect at purchase and throughout the aircraft’s life. However, for an investor, whether this is an institutional investor or a commercial company such as a lessor, the focus is on the current and residual value (future value) of the asset and its marketability.

Regardless of the type of investor, accounting standards require an asset to be depreciated over its useful life to its residual value. There is a significant divergence in useful life and residual value assumptions used across the industry and between jurisdictions, which can cause significant differences in depreciation expense and influence the decision of the aircraft owner about when to remove the aircraft from its asset register and balance sheet. For lease aircraft, the accounting principles of maintenance reserves (MR), also sometimes classed as supplemental rent, play a significant role and the aircraft lessee and lessor should be able to understand the impact of MR management in the financial statements. Changes in the International Financial Reporting Standards (IFRS) may also have an impact on the treatment of leased aircraft.

Depreciation methods and residual value estimates are disclosed in financial statements. Generally, aircraft assets are depreciated over 15 to 25 years with a residual value of between 0% and 20%. The straight-line method of depreciation is the most commonly used. Small changes in useful life and residual value estimation can have a significant impact on the aircraft owner’s bottom line\(^\text{19}\).

Care must be taken in distinguishing between accounting depreciation curves and any forecast future value depreciation curves. The accounting depreciation curve is generally set by an owner/operator (and agreed by its auditors) and generally follows a recognized accounting standard (e.g. GAAP, IFRS). A forecast future value depreciation curve is generally an opinion of an expected residual value that may (or may not) be attained at a particular time in the future, and reflecting a particular appraiser model, which is discussed in Subsection 2.1.7. Figure 11 provides examples of accounting depreciation curves, reproducing data from the IATA Airline Disclosure Guide: Aircraft acquisition cost and depreciation in graphic form. Please refer to this document for more guidance on aircraft-related asset accounting principles.

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\(^{19}\) IATA, Airline Disclosure Guide. *Aircraft Acquisition cost and depreciation*, 2016.
2.1.7 Aircraft Value Concepts

Aircraft value is one of the significant economic factors to consider in the aircraft owner’s decision to disassemble and dismantle an aircraft. Different definitions of an aircraft’s value apply, however, depending on the circumstances. This subsection provides definitions of various aircraft value metrics and describes the factors influencing them to help aircraft owners/operators in their decision.

a) Aircraft Value Definitions

The determination of aircraft value is initially driven by whether the decision is made to continue operating or to decommission an aircraft. In addition, the value determination is dependent on its timing. From an appraiser’s point of view, the value is determined by evaluating the sale or transaction value at a certain point in time.

Aircraft value metrics as defined by the International Society of Transport Aircraft Trading (ISTAT) are widely acknowledged in the aircraft appraisal industry. The sale or transaction could take place during operations or lease, for which the terms Market Value (or Current Market Value) and Base Value are used for the appraisal of the aircraft. The definitions from ISTAT are below, and Table 1 summarizes their differences:

*Market Value (or Current Market Value if the value pertains to the time of the analysis) is the Appraiser’s opinion of the most likely trading price that may be generated for an aircraft under the market circumstances that are perceived to exist at the time in question.*

*Base Value is the Appraiser’s opinion of the underlying economic value of an aircraft in an open, unrestricted, stable market environment with a reasonable balance of supply and demand, and assumes full consideration of its “highest and best use.”*

<table>
<thead>
<tr>
<th>Aircraft time status (if not new)</th>
<th>Base Value</th>
<th>Market Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usually mid-time, mid-life</td>
<td>Usually as found</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aircraft physical condition (if not new)</th>
<th>Base Value</th>
<th>Market Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usually average considering type and age</td>
<td>Usually as found</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Open, unrestricted market</th>
<th>Base Value</th>
<th>Market Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td></td>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>State of market balance</th>
<th>Base Value</th>
<th>Market Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reasonably stable, reasonably balanced</td>
<td>As perceived at the time</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Market Value and Base Value

More applicable to aircraft decommissioning is the value determination of an aircraft at the end of the operation, lease or life. Amongst others, the residual value, salvage value (also called parting-out value in the industry) and scrap value are applicable to this scenario. Definitions taken from ISTAT are the following:

*Residual Value is the value of an aircraft, engine or other item at a future date, often used in connection with the conclusion of a lease term.*

*Salvage Value is the actual or estimated selling price of an aircraft, engine or major assembly based on the value of marketable parts and components that could be salvaged for reuse on other aircraft or engines.*

*Scrap Value is the actual or estimated market value of an aircraft, engine or major assembly based solely on its metal or other recyclable material content with no saleable reusable parts or components remaining.*

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20 ISTAT: https://www.istat.org/
21 ISTAT Handbook: https://members.istat.org/d/do/382
Both Residual Value and Salvage Value consider the value of an aircraft, engine or other item at the end of an operational cycle of the asset or at the end of a lease term. The difference between the two values is that the former accounts for the aircraft as a whole, while the latter is the sum of values of the marketable components from a disassembled aircraft. In contrast to these two, the Scrap Value is the sum of the values of the materials in the dismantling process (see Table 2). Subject to the dismantling and disposal costs, the Scrap Value could be zero or negative if the dismantling and disposal costs are greater. For example, HAZMAT or composite assemblies might be difficult and expensive to recycle.

<table>
<thead>
<tr>
<th>Aircraft status</th>
<th>Residual Value</th>
<th>Salvage Value</th>
<th>Scrap Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>As a whole unit</td>
<td></td>
<td>Disassembled to the parts and components level</td>
<td>Dismantled to the materials level</td>
</tr>
</tbody>
</table>

Table 2: Residual Value, Salvage Value and Scrap Value

b) Influence on aircraft owner's decision

When the current or future market value (residual value) of the aircraft is less than the sum of the salvage value and scrap value of the aircraft, which means selling the aircraft as a whole is less valuable than disassembling and dismantling it, the aircraft owner may consider decommissioning the aircraft.

Market value and scrap value are subject to many factors: The main factors influencing the market value of the aircraft are presented in the above subsections (2.1.3, 2.1.4 and 2.1.5). The factors influencing salvage value are discussed in Section 6.1.

During the decision process, the possible potential profit of continuing operation of the aircraft should also be considered. If the owner is an operator, this means considering the potential operational profit of flying this aircraft. If the owner is a lessor, the potential profit generated by leasing out the aircraft should be included, which includes the MR or the end of lease (EOL) payment.

Recommendations from Section 2.1:

When making the decision to decommission an aircraft, from the economic perspective, it is recommended to:

- Fully understand the influence and risks of the above-mentioned factors impacting aircraft decommissioning.
- Continuously track these influencing factors.
- Assess the maintenance investment required on the aircraft, such as major airframe structural checks, components (e.g. engine), shop visits and other modifications. If the investment on maintenance is not positive, it may be considered a good opportunity to disassemble the aircraft.
- Assess the development of new aircraft types, as well as the differences and commonalities with current models.
- Revisit the accounting principles (e.g. depreciation method) used by the company, especially the useful life and the residual value, at least once a year. Adjust the residual value of the aircraft in accordance with the market value to avoid unanticipated gap in the values.
- Assess the market value and scrap value of the aircraft, together with the potential future operational profit generated by the aircraft, when considering to disassemble an aircraft.
2.2 Regulatory and Legal Aspects

2.2.1 Civil Aviation Regulatory Requirements

Regulations and standards at the international, regional (e.g. EU) and national level may influence decisions on aircraft decommissioning. Of interest in this context are technical (e.g. environmental) standards that might not be met by older aircraft and regulations related to aircraft age. While none of these prescribe aircraft decommissioning, they may drive the aircraft owner's decision to decommission an aircraft.

a) Environmental standards adopted by ICAO

ICAO’s environmental aircraft certification standards (Annex 16) currently comprise standards on noise (Vol. I), emissions affecting local air quality, such as nitrogen oxides (NOx) (Vol. II), carbon dioxide (CO2) emissions (Vol. III), and global market-based measures (Vol. IV). These can impact aircraft value and usability in several ways:

- The standards in Annex 16 Vol. I to III apply to new aircraft or engine types. Sometimes they also include a production cut-off as an additional measure (e.g. for engines not meeting the ICAO Committee for Aviation Environmental Protection - CAEP/6 NOx standard). While the use of in-service aircraft of these types is not directly affected, these standards can have an impact on their second-hand value as well as on the demand for spare parts.

- Furthermore, in some cases, ICAO environmental (especially noise) standards are used in certain countries as a basis for operating restrictions, although this is recommended by ICAO in its “balanced approach” to aircraft noise management as a last recourse only. These directly restrict the use of aircraft types not meeting these standards and may lead aircraft owners to retire them from service. An example for such restrictions is the operating ban on aircraft certified under Chapter 2 of the ICAO Annex 16 noise regulations, but not meeting the more recent Chapter 3 standard, in force in the EU since 2002.

- Since the introduction of the first ICAO noise standard (Annex 16, Vol. I) in 1973, its stringency has increased in several steps (Chapters 2, 3, 4 and 14). Aircraft types that do not comply with newer, more stringent noise certification levels usually have a lower market value and are more likely to be decommissioned. A reduced market value may also be expected in the future for aircraft not meeting the new ICAO aircraft CO2 emission standard (ICAO Annex 16, Vol. III), which will apply to new aircraft type designs from 2020 and to aircraft type designs already in production as of 2023.

b) Import restrictions on aged aircraft

Another driver for early retirement is the restrictions set by some countries on the import of ageing aircraft. Some countries have set an age limit on aircraft that are added to their registry, typically varying between 15 and 25 years. Appendix D shows a list of ICAO Member States that apply age restrictions when accepting imported aircraft to their civil aviation aircraft register, documented by the ICAO cross-border transferability (XBT) task force. This list should, however, be treated with caution as information is constantly changing and States change regulations regularly, and may not necessarily inform international bodies. These restrictions are often considered as a measure to improve safety.

The effect of the age-related import restrictions is that older aircraft cannot be remarketed anywhere in the world. Especially when they are coupled with operating restrictions such as those described in Subsection 2.2.1.a above, which usually also target older aircraft, an owner of such an aircraft may decide to sell the aircraft to another region without such regulations, or decide to decommission it.

For more information on importing aircraft and the safety of ageing aircraft, please refer to various publications by the Aviation Working Group (AWG) on cross-border transferability.

25 AWG, Cross-border Transferability: www.awg.aero/projects/aircrafttechnicalrequirementsimpactingtransferability
### Examples of age restrictions on aircraft imports

**India**

Civil Aviation Requirements, Section 2, Series F, Part XX, Issue II 29.07.1993, Age of Aircraft to be imported for Scheduled / Non-Scheduled including Charter, General Aviation and other Operations

3.1 Pressurized Aircraft intended to be imported and used in scheduled, non-scheduled and general aviation operation should not have completed:

i) 15 years of age or 75% of design economic life or 45000 pressurization cycle or

ii) 18 years of age or 50% of design economic pressurization cycle.

iii) In case aircraft above 15 Years of age, the aircraft shall have flown at least for 100 Hours during last six months.

**Egypt**

Egyptian Civil Aviation Regulations, Part 47: The Requirements for Registering Aircraft in the Egyptian Aircraft Register

47.5 Each Aircraft owned or leased by an Egyptian citizen for a period not less than six months shall be registered in the Egyptian civil aviation register and possess a certificate of registration as shown in Appendix (A) under these conditions:

1) Aircraft max. take-off weight less than 5700 kg should not exceed 10 years from manufacture date.

2) Passenger aircraft max. take-off weight over 5700 kg should not exceed 17 years from manufacture date.

3) Cargo aircraft max. take-off weight over 5700 kg should not exceed 20 years from manufacture date.

### Recommendations from Section 2.2:

While there are no specific international obligations or national laws requiring aircraft decommissioning, various international standards and national laws exist, which impact the usability and value of certain aircraft types and thus may lead to a decision to decommission such aircraft.

It is recommended to aircraft owners considering aircraft decommissioning to examine the impact of applicable laws and regulations, such as environmental laws and age restrictions on aircraft imports.
2.3 Safety Aspects

2.3.1 Declarations for Continued Use of Parts

Realizing an acceptable value from selling parts of a retired aircraft is a key aspect in the decision to decommission an aircraft. An important criterion for the value of an aircraft, engine or part, in addition to the required maintenance records, is whether the aircraft/engine/part is acceptable for continued use, even if it has been subjected to an accident or incident. The IATA Incident/Accident Clearance Statement (ICS)\textsuperscript{26} may be used for this purpose. Please refer to Appendix A - Incident/Accident Clearance Statement, and Appendix B - Examples of dangerous and hazardous materials to be removed and treated from aircraft.

Although not a specific regulatory requirement, it is commonly accepted that an ICS (adapted by IATA and the AWG to replace the former Non-Incident/Accident Statement (NIS)) should be provided by the last aircraft operator since the last shop visit. The ICS has been introduced to eliminate inefficiencies arising in the marketplace. It clearly states that the part has been maintained according to the appropriate maintenance manual(s). Furthermore, components from aircraft operated by military organizations (e.g. government aircraft or other air force transport aircraft) will be accepted as spare parts for commercial aviation use only if the government-owned/operated aircraft was maintained to civil registration regulations. During the last shop visit, the engine/APU/gear should be fully removed, the parts inspected and repaired as necessary and their serviceability restored. It is, therefore, assumed that any part affected by an incident, accident, or otherwise, has been replaced or properly repaired.

The purpose of the ICS is to shift the focus from whether an aircraft/engine/part has been subjected to an incident or accident, to whether the aircraft/engine/part has been deemed and declared acceptable for continued use after such incident or accident. It should be emphasized that the ICS (and the NIS previously) is NOT proof of the part’s serviceability. It is the EASA or Transport Canada Form 1, the 8130-3 Airworthiness Approval Tag and equivalents that define the part’s condition.

Two document templates have been designed, one for aircraft and the other for engines. The engine template could also be used for individual parts in circumstances where incident/accident clearance statements are required.

Recommendations from Section 2.3:

In order to provide a means to acknowledge and declare an aircraft/engine/part acceptable for continued use, whether or not it has been subjected to an incident or accident, the IATA Incident/Accident Clearance Statement (ICS) is recommended.

\textsuperscript{26} IATA, Guidance Material and Best Practices for Aircraft Leases, 3rd edition, 2016
2.4 Environmental Aspects

2.4.1 General Overview

This subsection aims to provide a general environmental overview of aircraft decommissioning, including waste generation, recycling, hazardous waste, noise, dust, wastewater, air pollution and soil that might be taken into account in making a decision to decommission an aircraft.

a) Introduction

The decision to decommission an aircraft requires consideration of the environmental aspects of end-of-life operations. Some examples that illustrate the need for better practices include: aircraft stored in deserts without maintenance and/or proper decontamination processes and aircraft abandoned at airports or simply dismantled for aluminum recovery regardless of other materials that could be recovered, such as electronics or plastics.

Responsible decommissioning of aircraft should minimize environmental impacts, seek to use resources in a sustainable manner, comply with environmental regulations, openly collaborate with authorities, and communicate relevant information to stakeholders involved (i.e. service providers, employees, the public and customers). The disassembly and dismantling phases generate hazardous waste materials (HWM) that must be safely controlled and sorted to minimize risks to the environment. Likewise, emissions to air, such as paint dust containing heavy metals (e.g. lead, cadmium) during the dismantling phase (e.g. sawing), and emissions to soil, such as fuel spills and wastewater, must be taken into consideration. Moreover, the growing volumes of waste generated by an increasing number of retired aircraft could become a problem if not disposed of in a controlled manner.

Risk analysis and identification of mitigation actions to manage these risks should take place before decommissioning an aircraft. The following questions could assist:

• What are the environmental hazards/activities that could have negative impacts and what is the likelihood of their occurrence? What control measures would prevent these?

• How can all the materials be identified and appropriately treated once they are removed from the aircraft?

• Are there any concerns regarding the availability of suitable waste treatment facilities and related waste volumes?

Details are found in Sections 3.4, 4.4 and 5.4.

Finally, the growing demand for aircraft storage can also have an impact on land use when new paved areas are created instead of taking advantage of existing airfields.

b) Greenhouse Gas (GHG) and emission regulations

A factor worth considering when decommissioning an aircraft is the related GHG emissions that could be avoided through decommissioning versus maintaining an old aircraft. Between 15% and 20% of fuel reduction generally occurs with new generation aircraft. Therefore, the same proportion of GHG emission will likely be reduced. This environmental benefit is an important consideration, especially where GHG emissions regulations or emissions trading schemes (ETS) are in place. From 2021, a large part of international air traffic will be subject to the Carbon Offset and Reduction Scheme for International Aviation (CORSIA), agreed at the 39th ICAO Assembly, requiring aircraft operators to buy carbon offsets for their carbon emissions exceeding a 2020 baseline. These effects should be considered in fleet planning to support decisions about decommissioning.

2.4.2 Circular economy

The concept of a circular economy is becoming more and more widespread in developing industry strategies and processes. It could, therefore, be an influential factor in an aircraft owner/operator’s decision to decommission an aircraft.

A circular economy, as an alternative to a linear or traditional economy, is defined as an economy where waste is minimized and the value of materials and resources are maintained in the long term. In other words, the old concept of “take, make, dispose” no longer guarantees the sustained, unlimited exponential growth and prosperity that has been experienced since the Industrial Revolution. Finite resources, environmental pollution, conflicts, limited production, etc. have made it clear that a smooth transition toward a circular economy is essential to create new opportunities for sustainable growth.

The global economy has relied, for a long time, on cheap resources readily accessible by transporting them across the planet at low cost. The used products are then discarded as waste, losing most of their value and often ending in landfills or abandoned sites, etc. This not only puts an extensive load on the environment, but also indirectly impacts the supply, end-user, customer, etc. The current trend, however, is changing and the transition phase has started. New regulations/guidelines are introduced each year, fostering efforts and pushing for a more restorative-based value chain across the world. In line with this momentum from regulators, each business sector can proactively promote its own measures.

Recommendations from Section 2.4:

Please find below some general recommendations regarding environmental considerations when deciding to decommission an aircraft:

- Evaluating the environmental impacts, direct and indirect, of aircraft decommissioning.
- Planning - control measures related to the risks identified.
- Analyzing the environmental consequences and benefits (CO2 emissions, waste production, regulations) of the decision as to whether or not to decommission an aircraft or fleet.

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SGI Aviation is the knowledgeable party for decisions on aircraft end of life optimization.

SGI Aviation can determine current and part-out value of the aircraft.

SGI Aviation can determine the optimal time for continuing operation.

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Chapter 3—Selection of Facilities

After the decision to decommission an aircraft is made, the next step is to select the facilities to carry out the related activities. As more and more aircraft are retired, an increasing number of disassembly and dismantling facilities will emerge. This section provides considerations and suggested factors to assist the selection of suitable facilities.

Aircraft owners should typically consider the following aspects when selecting facilities for aircraft storage, disassembly and dismantling:

- Facility location (i.e. country/jurisdiction, existing business relations, climate (for storage),
- Capability and accreditations (safety, quality, environmental) of the facility,
- Marketability of part-out components in the geographic market,
- Legal protection of ownership rights,
- Environmental aspects, and
- Financial aspects, such as local operational costs, taxation and accounting rules.

3.1 Economics/Operational Aspects

3.1.1 Facility Location and Climate

The first consideration to take into account is the facility’s location and, if needed, its suitability for aircraft storage. If the option to put the aircraft back into service at some stage is to be kept open, a facility with storage capability should be chosen, which is not necessary if the decision to retire the aircraft definitively has already been made.

Many airlines have associated MRO facilities capable of disassembling and potentially dismantling aircraft. This makes it convenient and efficient to reuse disassembled parts and components in the airline’s fleet. However, for evaluating the suitability of a decommissioning facility, the same scrutiny needs to be applied to an airline’s own MRO facility as to any external one, in particular regarding the compliance with safety and environmental requirements in the dismantling process.

Key factors in selecting a facility are the legal requirements of the jurisdiction in which the facility is located, for example tax rules and protection of ownership regulations (see Subsections 3.2.1 and 3.2.2).

Many facilities involved in the storage of aircraft are typically situated in arid locations. A dry climate, low salt content in the air (sufficient distance from the sea) and small differences between day and night temperatures are ideal conditions for aircraft storage. Not only does the climate influence the structure of the aircraft (corrosion or delamination), it also influences the way in which the removed components should be stored (see Subsection 4.1.1 and the AFRA BMP for more details).

A study on the current status of aircraft decommissioning done by SGI Aviation\(^{30}\) shows that the largest share of storage and disassembly locations are situated in dry areas of the southern United States (e.g. Arizona). Most of the European facilities are situated in the UK, France and Spain (Figure 12). If the climate conditions for aircraft storage are favorable, the aircraft or components can reenter service more easily and, if the aircraft is retired, its components retain their residual value for a longer period. Furthermore, remote airports with little traffic are commonly used as storage and disassembly locations because parking fees are relatively low and there is sufficient space available.

\(^{29}\) SGI Aviation, ibid.
\(^{30}\) SGI Aviation, ibid.
Due to differences in national or local regulations (e.g. waste treatment) facilities have different work processes, quality levels and environmental protection requirements. To ensure maintaining asset value and minimizing the risk of environmental impact, it is important for aircraft owners to select facilities with capabilities and a level of reputation in line with their intentions. If it is uncertain whether the aircraft will be put in service again, a facility with the capability of aircraft storage and light maintenance will be preferred. In practice, it is often seen that many aircraft entered storage before being decommissioned, while fewer aircraft were decommissioned directly after being withdrawn from service.

To illustrate this, from 1980 to 2016, more than 24,000 aircraft storages have been recorded. Since 2001, the total number of commercial aircraft in storage has been approximately 4,000 at any given moment, whereas the number of newly stored aircraft is around 1,500 annually. More than 2,000 aircraft went into storage in 2001 and 2008 because of 9/11 and the financial crisis, respectively. Storage trends are consistent with retirement trends, but the amount of aircraft entering storage each year is almost double the number of retirements (Figure 13).

As a result, more and more aircraft are put into storage before they are decommissioned. The decision to select a facility, therefore, includes consideration of the capabilities of that facility to perform aircraft maintenance. This will mainly concern storage maintenance, but the ability to perform heavier aircraft maintenance is also weighed in. This is to be able to return the aircraft to service after the storage period and/or deliver it to an operator. Storage procedures should be followed as per OEM recommendations by an approved maintenance organization (AMO) to guarantee a smooth return to service after the storage period. Note that if the storage recommendations by the OEM are not followed, it is still possible to return the aircraft in an airworthy condition. To do so, however, it will be necessary to consult with the civil aviation regulatory authorities which will be responsible for registration of the aircraft and issue of the airworthiness certificate. Requirements will most likely include compliance with special instructions from the OEM.

Figure 12: Geographic distribution of selected aircraft storage and disassembly facilities

31 SGI Aviation, ibid.
Sometimes, aircraft are disassembled and parked in an obviously unflyable state at the edges of larger commercial airports that are not dedicated storage or disassembly facilities, easily visible by aircraft passengers and airport neighbors. It should be kept in mind that the impression of seeing unflyable aircraft “wreckages” close to the operational areas of the airport may be aesthetically unpleasing and represent a reputational risk to airlines and airports.

### 3.1.3 Accreditations

Accreditations are important decision criteria for the selection of a facility. The typical accreditations related to quality, safety and the environment include: AFRA, ISO9001, ISO14001, AS9100, AS9110, AS9120, ASA-100 and EMAS. These accreditations ensure the facility removes the components in accordance with a certain set of policies and procedures, which will increase the marketability of the components. This subsection provides general information about accreditations for decommissioning facilities, whereas Section 3.3 focuses on safety and quality aspects and Section 3.4 on environmental aspects.

Often, a facility operates in multiple business sectors. For instance, a disassembler usually handles the disassembly and removal of components, but may also take care of dismantling the airframe as well as recycling and component distribution. In some cases, the facility also has its own maintenance organization, occasionally supplemented by a production organization to design and manufacture components to support its maintenance activities. Based on this, several of the types of accreditations listed in Table 3 could apply to one organization.

Subsections 3.3.4 and 3.4.2.a provide more details about the AFRA BMP. Additional information on quality management systems is found in Subsection 3.3.3, and on environmental management systems in Subsection 3.4.2.b.

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32 SGI Aviation, ibid.
### Table 3: Accreditations per business sector

<table>
<thead>
<tr>
<th>Business sector</th>
<th>AFRA</th>
<th>ISO9001</th>
<th>AS9100</th>
<th>AS9110</th>
<th>AS9120</th>
<th>ASA-100</th>
<th>ISO14001</th>
<th>EMAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disassembler</td>
<td>A</td>
<td>Q</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Dismantling</td>
<td>A</td>
<td>Q</td>
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<td>E</td>
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<tr>
<td>Recycler</td>
<td>A</td>
<td>Q</td>
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<tr>
<td>MRO</td>
<td>Q</td>
<td>Q</td>
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<td>E</td>
<td>E</td>
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<tr>
<td>Parts trader</td>
<td>Q</td>
<td></td>
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<td></td>
<td></td>
<td>Q</td>
<td>E</td>
<td></td>
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<tr>
<td>OEM</td>
<td>Q</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Q</td>
<td>E</td>
<td>E</td>
</tr>
</tbody>
</table>

A = Applies to the sector  
Q = Quality Management System (QMS)  
E = Environmental Management System (EMS)

#### 3.1.4 Marketability of Components

**Example from Lufthansa Technik**

Currently, there are about 20 aircraft in storage from the Lufthansa group fleets with German registered aircraft. There are different reasons for the storage of an aircraft:

- The aircraft is not needed for a certain time due to the actual or planned number of passengers or cargo.
- A major overhaul or lifetime extension is pending and no slot for a major overhaul is available.
- An aircraft is planned for phase-out and decommissioning but is still kept as reserve in case of delivery delay of new ordered aircraft or unexpected need of transport capacity.
- An aircraft is planned for sale.

All these aircraft are kept on the Air Operator Certificate (AOC) because it is much easier and cheaper to reactivate the aircraft or to prepare it for a final flight to a specific facility for decommissioning.

During the storage, the aircraft is maintained mainly according to the Aircraft Maintenance Manuals (AMM) storage program. Useful deviations due to the storage situation and time can be approved under the Lufthansa Technik - Design Organisation Approval (LHT-DOA) privilege. When the storage ends, the flight to a maintenance facility (in the case of re-entry into service) or to a decommissioning facility will be performed under Permit to Fly with approved flight conditions. LHT-DOA has the privilege to approve these flight conditions.

During storage, the aircraft remains essentially unchanged, with the exception of seat removal.
An important factor for the selection of a facility is the marketability of components in the jurisdiction where the facility is located. Bilateral agreements (see more in Subsection 6.2.1) between the jurisdictions of EASA (EU), FAA (US) and TCCA (Canada) simplify the movement and use of parts between them. Working arrangements also exist with other large aviation jurisdictions such as CAAC (China) and JCAB (Japan), which are, however, less comprehensive. If it is decided to decommission aircraft originating in one of those countries, the most sensible solution would be to choose a facility within the respective country. The aviation authority and the language in which the records are kept are influencing factors in this process. For instance, the parts removed from aircraft originating in China are far more likely to be accepted in serviceable condition and be maintained and certified for further installation on Chinese aircraft than on aircraft in another country. This circumvents the need for costly recertification shop visits and additional lead time for the parts, which would be required if they were installed on aircraft in another jurisdiction.

3.1.5 Local Operational Costs

An important consideration when selecting a decommissioning facility is the local operational cost, including costs of storage, disassembly and dismantling, import tax and ferrying. The cost aspect, however, must be weighed against other criteria. For example, although a facility located in Asia or the United States is likely to charge lower fees, a facility in Europe may still be worth of consideration due to a previous business relationship, quality of work or the intention to distribute components locally, thus saving on transportation costs. The location or operating area of the aircraft is one of the most important reasons for the choice of a facility, as ferry flight costs can be significant and, in the case of leased aircraft, may not be provided for within the return conditions of a lease agreement.

Historically, the US has been a popular region to decommission aircraft, in part due to its supportive tax regime on the import of aircraft from abroad. In addition, local governments give significant benefits to companies stimulating employment in the area. In recent years, the EU has changed the sales tax (VAT) and customs regulations, which reduced the difference between associated costs of disassembly in the EU as compared to the US. More changes are planned in the future, which could further narrow the tax gaps of the EU and US in this field.

3.1.6 Aircraft Decommissioning with Mobile Unit

A significant number of aircraft throughout the world have become unable to fly for various reasons: technical incidents, removal of important parts, loss of airworthiness after long storage without proper maintenance, or business termination of the last owner/operator. In the past, many old aircraft were sold to airlines (mainly domestic) in least developing countries, which led to a high number of aircraft being immobilized there. Restoring airworthiness or obtaining a special flight permit from a competent aviation authority for a ferry flight to a decommissioning facility may not be an option. In these cases, the logical alternative is to decommission the aircraft on site.

While removal of hazardous substances and disassembly do not require heavy machinery, such equipment is needed for the initial step of fragmenting (cutting) the aircraft into chunks that are small enough to be transported by truck to a shredding and recycling facility. Appropriate equipment meeting the specific requirements for aircraft fragmenting may be difficult to find in the destination country. A mobile unit is, therefore, advantageous.

For aircraft dismantling with mobile equipment, it is important to provide a suitable dismantling area. This area needs to have at least an enclosed hard surface for the dismantling activities. In most cases, it will be part of an operational airfield. Therefore, it is necessary to comply with a number of aviation-related regulations. In addition, an appropriate recycling site needs to be identified to accommodate the material of the dismantled aircraft.

The first important steps of a mobile aircraft decommissioning process are to determine the on-site safety conditions, to define precautions for handling HAZMAT, and to identify routes for material recycling and waste disposal. See Subsection 3.4.4 and Appendix B for further information about hazardous fluids and materials. After disassembling parts for further reuse, all HAZMAT and fluids should be removed. Specific precautions are to be taken in the case of mobile dismantling. In particular, suitable tanks or containers are needed to collect hazardous substances, and an ad hoc logistical structure should be put in place to ensure their safe and environmentally friendly disposal.

33 See e.g. Working arrangement EASA/CAAC: https://www.easa.europa.eu/easa-and-you/international-cooperation/easa-by-country/countries/china
Once all liquids and hazardous substances have been removed from the aircraft, the rest of the dismantling process is normally not particularly challenging if suitable dismantling equipment is available. The following case study describes an operational mobile dismantling process more in detail.

Case-Study by MORE-AERO

In a project named MORE-AERO, supported by the German Federal Ministry of Education and Research (BMBF), a consortium of industry and research institutes developed and assembled a mobile unit for aircraft dismantling, including extraction of HAZMAT and fragmenting, and identified ways for recycling and reuse of the materials. The unit consists of two shipping containers housing a grab and a cutter mounted on a quick-change system for multiple excavator systems as well as all other equipment needed to dismantle an aircraft. Additionally, they hold tanks to safely remove liquids from the aircraft. Following the selection of a suitable hard surface area, a two-meter-high movable fence is installed around the dismantling area, considering the prevailing wind direction and the distance to the runway.

Relevant airport departments get involved in the project in a timely manner, especially the fire service and the environment and security officers. Additional requirements are considered. Specifically trained experts are needed, such as a safety engineer, as well as a radiation and an explosives adviser as radioactive or explosive substances can be found in aircraft.

An aircraft contains various hazardous liquids that have to be handled carefully (see list of hazardous fluids contained in an aircraft and their European waste codes in Appendix B). To prevent corrosion and the formation of explosive mixtures of air and fuel vapors, as well as for weight balancing, aircraft in storage mode are generally kept fully fueled. A Boeing 747 can be fueled with over 200,000 liters of kerosene. This makes a separate tank necessary for defueling. To empty the tanks, a defueling station with probes is used as part of the mobile unit. After this procedure, forced ventilation of the tanks with compressed air is done. To ensure a nonexplosive atmosphere in the tanks, gas analyses from within the tanks are taken during and after the ventilation.

Another important issue is the handling of the pressurized hydraulic oil systems. The system is depressurized and the liquids are stored in special containers.

After having removed the fluids, other HAZMAT are taken out manually. Special attention is paid to parts containing radioactive materials. These comprise smoke detectors, fluorescent signs and ballast weights made of depleted uranium (in older aircraft manufactured until the early 1980s). These parts are treated under nuclear laws (for Europe: the Atomic Energy Act) rather than national waste regulations.

It is of utmost importance to ensure that experienced expert personnel handle HAZMAT. For personnel qualification requirements see Subsection 3.3.5

For example, glass fiber material for cabin insulation manufactured before 1995 has hazardous properties similar to asbestos. Employees working with this kind of material wear the required special equipment, including protective clothing (anti-static), work boots (anti-static), gloves, special masks, helmets and safety glasses.

For hazardous fluids marked with an asterisk in the European Waste Catalogue (see Appendix B), a record of waste disposal is necessary. The record of waste disposal is a robust proof of the orderly disposal of the waste. It has proven useful to handle waste disposal records per aircraft, indicating the manufacturer’s serial number (MSN) on the record.

The objective of the developed process is to allow the aircraft to be dismantled to reach the state of “end of life vehicles, containing neither liquids nor other hazardous components” . It is then possible to take the next process step, namely fragmenting the aircraft on the dismantling area and following the beneficiation process for that material. That means the aircraft is ready for cutting and the next recycling step.

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34 Asbestos Index of substances that can cause cancer, genetic changes or limit reproductive capability, TRGS 905
35 European Waste Code 160106, see Appendix B
**Case-Study by MORE-AERO (continued)**

Before the fragmenting process starts, a second gas check takes place to ensure a nonexplosive atmosphere. If the analysis shows that fuel explosion risk is excluded, the cutting process starts. First, the excavator cuts off the vertical stabilizer to reduce the aerodynamic drag of the aircraft from wind and to improve stability. The next steps are to cut off the wings and the center tank section.

The fragments are loaded into containers to reduce the risk of wind-blown dispersal of light-weight material. The customer gets a proof of waste disposal with a complete dismantling certification and documentation of the process. This is labelled with the registration marks and the specific MSN of the aircraft. This is an important step to prevent suspected unapproved parts (SUP) or counterfeit parts ("bogus parts") entering the spare parts market.

To ensure safe and fast customs procedures, a best practice for the transport of the mobile dismantling unit and the scrap and waste material for several countries with strategic importance was developed and serves as the basis for the logistical part of the undertaking. Included in the considerations are legislative framework conditions, regional cooperation arrangements and on-site handling of material and equipment.

To make mobile aircraft dismantling a profitable business model, it is necessary that all the involved parties and trades work hand in hand. This means they need to develop a specific way of working together, and an agreement between all participating companies to offer competitive services.

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**Recommendations from Section 3.1:**

When selecting a decommissioning facility, it is recommended:

- Not only to take expenses into consideration, but also the facility location, climate (for storage), storage and maintenance capability if needed, future marketability of the components and available accreditations. For details about safety and quality accreditations, please refer to the recommendations in Section 3.3 and for environmental accreditations to Section 3.4.

- For expenses, to take the following potential expenses into consideration: ferry cost, import tax, storage cost, disassembly and dismantling cost, sales tax, etc.

- For questions on taxation, such as import and sales taxes, to seek professional advice.

- For decommissioning aircraft unable to fly to a decommissioning facility, to consider using a mobile disassembly and dismantling unit.
3.2 Regulatory and Legal Aspects

3.2.1 Protection of Ownership Rights

The purpose of this subsection is to identify the potential regulatory issues relating to the protection of aircraft ownership rights and to assess their importance to the facility selection decision.

After deciding to have an aircraft disassembled and dismantled by an external company, the aircraft owner may choose to either sell the aircraft as a whole to a specialized disassembly and dismantling company, or consign such a company to perform the disassembly and dismantling service for the owner (see more in Subsection 4.1.1).

In this context, it is important to consider that in many cases, aircraft are not owned as a complete unit. Important components such as engines or APU’s are leased or subject to financial security arrangements separately from the airframe. The aircraft operator, therefore, cannot freely make decisions regarding the decommissioning of these components.

From an operator’s point of view, it is important to have safeguards in place to ensure the property possession and control arrangements with the owner(s) of separately leased components are clear.

When planning to decommission an aircraft, it is necessary to consider the terms of the agreements governing the leasing or financial arrangements relating to the components. In some cases, the components may be required to be returned to the possession of the holder of the financial interest.

As described in the introduction of Chapter 2, an aircraft owner planning to decommission an aircraft may select to sell it to a decommissioning company or broker, or to place the aircraft into consignment with a decommissioning company. In the latter case, the owner should insist that the facility provider agree with the owner’s continuing legal interest in the individual parts and materials of the decommissioned aircraft. There must be clarity documented in an agreement on whether it is only the airframe, or the aircraft including engines, that needs to be decommissioned, since that may also have a bearing on the owner’s rights and financial interest. Furthermore, where it is agreed that only the airframe is to be decommissioned, the owner must verify and further agree with the facility provider that it can perform such a task safely without damaging the engines. It is also important to agree who owns the waste and recyclable materials and who is liable for their processing and/or disposal according to regulations in force.

While the above-mentioned terms in the agreement specifically provide for the protection of owner’s rights in selecting a facility, other relevant terms that may sway an owner’s decision in selecting a facility could be those that address liability, the facility provider’s obligations, and quality monitoring.
**Case Study**

Airline C ceased operations due to financial difficulties and parked two of its aircraft on the edge of an airport. Airline C eventually folded and the assets of the company have been held in long-term storage at the airport, accruing large maintenance and parking fees. Bank A is acting as the special liquidator for Airline C and has agreed to sell the aircraft to Airline D. Airline D wants to know the risks of negotiating with Bank A for the purchase of the aircraft.

Airline D needs to ensure that the aircraft are unencumbered and can be used in airline operations under its air operator certificate (AOC).

Airline D needs to ensure that Bank A provides information about the airworthiness of the aircraft, and their regulatory oversight during operations and subsequent storage to ensure that the aircraft can be operated.

Airline D should ask for full disclosure regarding the circumstances under which Airline C ceased operations and whether any of those circumstances relate to the ownership, airworthiness or operations of the aircraft.

Airline D will also need to verify and conduct checks to determine what other financial interests there may be regarding the aircraft and what claims creditors of Airline C may have (i.e. airport company, owner of the land the aircraft are situated on, passengers, staff, service providers, regulator/government).

Airline D should determine what regulatory requirements there are relating to the transfer of ownership of the aircraft, including registration, airworthiness certificates and import airworthiness certificates.

There are many legal rights in the aircraft that have not been disclosed, but may take precedence over the bank’s purported sale. There may be obligations relating to a registered financial interest depending on whether the holder of a financial interest perfected its rights in the International Registry of Mobile Assets. This is the registry operated under the legal framework of the Cape Town Convention and Aircraft Protocol adopted on 16 November 2001, which protects international financial interests in aircraft.

### 3.2.2 Tax Regulations

Tax regulations could have a significant impact on selecting the facility to disassemble and dismantle an aircraft because the aircraft and its parts may be subject to various taxes in different countries. The tax implication of each transaction can differ on many variables such as, but not limited to:

- Nationality of owner/seller of the aircraft
- Nationality of buyer of the aircraft
- Jurisdiction where the transaction occurs or even above international waters
- Nationality of the aircraft (country of registration)
- Jurisdiction of the aircraft’s homebase
- Jurisdiction where (some of) the components will be sold

For all taxation issues, it is recommended to seek professional tax advice on the local and international tax regulations before selecting a facility to disassemble and dismantle an aircraft.
**Examples from AFRA**

In the US, every state has a different tax regime. Consequently, both the location of aircraft storage prior to the dismantling and the selection of a dismantling facility requires careful inspection.

The EU offers more certainty in this context where, although there remains a difference in the enforcement of the tax regulations, the general rules of taxation are harmonised. However, the harmonised tax regulations need to be balanced with the actual cost that the aircraft owner may incur. In the EU, the tax on parking the aircraft is considerably higher than it is in Turkey. Additionally, VAT may be imposed within the EU on various stages that may further influence an owner’s decision on selecting a facility.

In the UAE, taxes are imposed depending on the permanence of the organisation (i.e. whether the site has a temporary or a long-term use). Also, in addition to the imposition of customs import tax, the regional taxes, such as those on environmental licences or radiation safety, are open to different interpretations by the customs officers, thus leading to uncertainty and further caution for the owners in selecting a facility in the UAE.

**Recommendations from Section 3.2:**

It is recommended to:

- Elect to either sell the aircraft as a whole to a specialised disassembly and dismantling company or consign such a company to perform the disassembly and dismantling service for the owner. In the latter case:
  - Insist that the facility provider agree with the owner’s continuing ownership of the individual parts and materials of the decommissioned aircraft.
  - Specify which part of the aircraft will be disassembled (e.g. only the airframe, engines or both).
  - If only part of the aircraft will be disassembled, agree with the facility provider that the task will be performed without damaging the other parts.

- Seek professional advice on the applicable tax regulations, considering the aspects described above.
3.3 Safety Aspects

This section describes the requirements and criteria that disassembly and dismantling facilities should fulfil in terms of ensuring safety and quality. Local aviation regulations exist for those facilities that hold approved maintenance organizations certification by the local civil aviation authority. Health and safety codes relevant to the jurisdiction the facility is located would apply to working conditions. Quality systems should be in place. AFRA accreditation is a voluntary standard that includes safety and quality requirements. Requirements for personnel qualification and training are also given.

3.3.1 Commitment to Safety & Quality

The aim of this subsection is to provide guidance for determining whether the selected decommissioning facility commits to safety and quality, including a commitment to ethics and compliance. It is in the interest of the aircraft owner’s and operator’s reputation to contract only with facilities giving these commitments.

Regardless of whether the facility is an approved maintenance organization or not, it is recommended to consider only facilities that have implemented a Safety Management System (SMS) as described in ICAO’s Safety Management Manual (SMM)36:

• According to the SMM and within the context of aviation, safety is: “the state in which the possibility of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and safety risk management.”

• Today, safety is viewed from a systemic perspective, which encompasses organizational, human and technical factors, as organizational culture and policies have an impact on the effectiveness of safety risk controls. This approach is based on the routine collection and analysis of data using proactive and reactive methodologies to monitor known safety risks and detect emerging safety issues.

There should be a documented safety policy – including roles and responsibilities – that is communicated to all employees with the intent that they are made aware of their individual safety and quality obligations. The accountable manager’s terms of reference should indicate his/her overall responsibility for all safety issues.

If the decommissioning facility has been certificated by a civil aviation authority as an approved maintenance organization under the relevant local civil aviation regulatory requirements, it will be required to have a safety and quality policy. For example:

• In Europe, EASA Rule Part 145.A.6537 requires the implementation of a safety and quality policy, including a statement committing the organization to:
  - Recognize safety as a prime consideration at all times
  - Apply human factors principles
  - Encourage personnel to report maintenance-related errors/incidents
  - Recognize that compliance with procedures, quality standards, safety standards and regulations is the duty of all personnel
  - Recognize the need for all personnel to cooperate with quality auditors

• In the United States, FAA 14 CFR 145.21138 requires establishing a quality control system acceptable to the FAA that ensures the airworthiness of the components on which the repair station or any of its contractors performs maintenance, preventive maintenance, or alterations.
  - A quality safety policy will require that the approved maintenance organization personnel follow an approved quality control system when performing maintenance, preventive maintenance, or alterations under the FAA repair station certificate and operations specifications.

37 EASA, Maintenance Organisation Approvals – Part 145, Revision August 2012
The company should also develop and publish a code of conduct concerning ethics and compliance. These statements favoring ethics and compliance should outline the guiding values for conducting the day-to-day business of the company, as well as the relationships with business partners, employees, customers and authorities. Additionally, the code of conduct should address environmental, health and safety aspects.

### 3.3.2 Health and Safety in Employment Regulatory Requirements

This subsection aims to provide general recommendations about standard rules for health and safety conditions for aircraft decommissioning facilities.

Safety conditions for workers are provided for in the domestic law of the territory in which the facility is located.

It is recommended for decommissioning facilities to implement a health and safety standard in line with the new ISO 45001, *Occupational health and safety management systems – Requirements*. This standard was developed by a committee of occupational health and safety experts, and follows other generic management system approaches such as ISO 14001 and ISO 9001. It takes into account other international standards in this area such as the Occupational Health and Safety Assessment Series’ OHSAS 18001, the International Labour Organization’s ILO-OSH Guidelines, the ILO’s international labor standards and conventions, and various national standards. ISO 45001 was published in March 2018 and replaces OHSAS 18001, the former global reference for workplace health and safety.

### 3.3.3 Quality systems

The aim of this subsection is to provide general requirements for the quality management system of the decommissioning facility, regarding the organization and its responsibilities (e.g. designated persons, quality assurance, inspection and release). In addition, this subsection aims to provide an overview of the general processes for which procedures need to be developed and maintained.

With respect to aircraft decommissioning, there are two different quality management processes, namely the quality management of the disassembly process and the quality management of the dismantling process. They should both be considered when selecting the facility. For more details, please refer to Subsection 4.3.3 Quality Management.

A quality management system (QMS) is a system that provides processes, procedures, and responsibilities for achieving quality policies and objectives. It helps coordinate and direct an organization’s activities to meet customer and regulatory requirements and improve its effectiveness and efficiency on a continuous basis.

The ISO 9001 standard is the most widely implemented QMS. To add competitive advantages, many companies in the aviation industry have been ISO 9001-certified, including airlines, airports, OEMs, MROs, disassembly and dismantling companies, recyclers and parts traders. Aerospace Standards (AS) dedicated to quality management are based on ISO 9001, but tailored to aviation needs. They include: AS9100 (QMS requirements for aviation, space and defense organizations), AS9110 (QMS requirements for Aviation Maintenance Organizations) and AS9120 (QMS requirements for parts traders). AS9100’s key aspects include safety, airworthiness, product conformity and reliability of aircraft products, and is widely adopted by OEMs and their suppliers. Major OEMs and suppliers even require compliance and/or registration of AS9100 as a condition of their suppliers. AS9110 focuses on the control of repair schemes, maintenance plans and configuration management, which is specifically designed for MROs. In the MRO industry, there are many organizations that rely on inspection and testing for their quality controls. An MRO with AS9110 certification will ensure safety, reliability and airworthiness of the components. Note that AFRA relies on its own BMP requirements for accrediting member companies and does not require ISO/AS accreditation from them to avoid significant costs for some companies.

Another accreditation created for parts traders is the Aviation Suppliers Association’s ASA-100 (ASA Quality System Standard). ASA-100 was created to comply with the FAA Advisory Circular (AC) 00-56, titled Voluntary Industry Distributor Accreditation Program emphasizing issues such as impartiality, competence, and reliability, specific to the regulated needs of the aerospace industry.

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39 American Society of Quality, [www.asq.org](http://www.asq.org)
40 ISO, [www.iso.org](http://www.iso.org)
3.3.4 AFRA Accreditation

This subsection aims to provide general requirements according to AFRA’s best practices. Specific details on environmental aspects can be found in Subsection 3.4.2.a.

One of AFRA’s objectives is developing and promoting the safe and sustainable management of end-of-life aircraft and components. It offers a voluntary standard program for environmentally responsible certification for companies disassembling and recycling aircraft. The AFRA BMP is a collection of recommendations concerning best practices for the management of parts that are removed from an aircraft, engine or other asset during the disassembly of the asset at the end of its service life, and for the recycling of parts and materials that are recovered from an aircraft, engine or other asset during the recycling of the asset at the end of its service life. Decommissioning facilities may be registered and certified by AFRA to demonstrate compliance with the AFRA BMP.

The AFRA BMP is an auditable standard. The process to become accredited for dismantling or recycling includes application, an on-site audit, and completion of a Quality Manual and Checklist. Certificates are valid for three years.

The standard contains best practices for the following topics:

- Facilities selection and management, including:
  - Infrastructure and management processes
  - Location characteristics
  - Identification and compliance with relevant standards
  - Security
  - Storage and segregation of materials
  - Inventory accounting and audits
  - Process flow and management
  - External transportation of materials

- Training

- Documentation and records, including:
  - Asset, material and transaction records
  - Reference manuals
  - Tagging
  - Parts

- Tooling

- Parts and materials management during processing, including:
  - Receiving inspection for materials for recycling, screening, tagging and staging during asset disassembly
  - Segregation during recycling stages
  - Containerization
  - Shipping

- Environmental protection

- Accountability to the customer

AFRA’s BMP requires that companies be expected to evolve their own quality systems beyond the Minimum Standards to meet the intent of the BMP standards. As the industry evolves, AFRA expects that the AFRA BMP Committee will further develop the Minimum Standards.

The AFRA BMP also represents a collection of recommendations concerning best practices for the management of parts and materials that are:

a) removed from an aircraft, engine or other asset during the disassembly of the asset at the end of its service life; or

b) recovered from an aircraft, engine or other asset during the recycling of the asset at the end of its service life.42

The activities of a decommissioning facility should be limited to the dismantling or recycling of aircrafts, if it has no maintenance organization approval (according to FAA 14 CFR 145 or EASA Part 145, or equivalent), even if it is registered and certified by AFRA.

Regarding the safety and airworthiness of an aircraft, it is recommended to keep its disassembly under the responsibility of an approved maintenance organization only, with the aim to minimize the risk that suspect or counterfeit parts may enter the aviation market.

### 3.3.5 Personnel Requirements and Training

This subsection provides the requirements for the qualification of the employees of the decommissioning facility (e.g. technical, managerial, safety and quality aspects).

If the decommissioning facility is certified by a competent civil aviation regulator43 there will be personnel requirements related to such certification.

The AFRA BMP require that an AFRA-accredited decommissioning facility, whether it is an approved maintenance organization or not, ensures that the personnel have received appropriate training related to the functions they perform, including, but not limited to, use of equipment/machinery and materials identification techniques.44

Generally, it is recommended that all employees of a decommissioning facility attend the following training on a regular basis with the aim to improve their safety awareness:

- Human factors
- Fuel tank system safety
- Oxygen systems
- Suspected unapproved parts (SUP)
- Foreign object damages/debris (FOD)
- Safety, health and working conditions

Training with regard to human factors should cover at least the following (e.g. according to EASA45):

- Safety culture
- Organizational factors
- Human error
- Human performance and limitations
- Environment
- Communication and teamwork
- Procedures, information, tools and practices
- Professionalism and integrity

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43 e.g. according to FAA 14 CFR 145, EASA Part 145, or equivalent
45 EASA Part 145 Human Factors - Initial Training (GM145.A.30)
Training with regard to safety, health and working conditions should cover the following as a minimum (e.g. according to the Joint Industrial Safety Council\textsuperscript{46}):

- Safety and health when handling technical equipment
- Workplace conditions, lighting and noise
- Chemical risks to health
- Ergonomics
- Work organization and working time
- Routine activities for safety and health

Training plans and certificates of completed trainings must always be available on request.

Finally, the company must ensure the continuation and further development of the qualifications of the employees.

\begin{table}[h]
\centering
\begin{tabular}{|l|}
\hline
\textbf{Recommendations from Section 3.3:} \tabularnewline
\hline
Regardless of whether the facility belongs to an approved maintenance company or not, it is strongly recommended for the facility to: \tabularnewline
\hline
  \begin{itemize}
  \item Implement a Safety Management System according to ICAO's Safety Management Manual, where recommendations are given for the implementation of a Safety Management System, including: a safety policy and a commitment to ethics and compliance;
  \item Implement a globally accepted Health and Safety Standard, such as BS OHSAS 18001 (formerly) and ISO 45001;
  \item Implement a quality system; for more details, refer to Subsection 4.3.3 Quality Management;
  \item Fulfil the personnel requirements (e.g. technical, managerial, safety and quality aspects) and ensure the continuation and further development of the qualifications of the employees.
  \end{itemize}
\hline
\end{tabular}
\end{table}

For the customer of a decommissioning facility, it is recommended to consider a facility's accreditations as well as the standards and quality/safety management systems that it has implemented as important criteria in the selection of a facility.

3.4 Environmental Aspects

3.4.1 Environmental Compliance

This subsection presents the key elements to consider when selecting facilities from an environmental compliance standpoint (e.g. local environmental regulations and authorizations regarding licenses for waste water or waste production and HAZMAT).

Environmental regulations and their applicability differ from one region to another. For example, the European Union has been implementing several environmental regulations and directives, largely based on the precautionary principle\(^{47}\), whereas the voluntary approach and market deregulation has generally been the trend in North America for the past decades. Therefore, facilities can follow different environmental practices depending on which territories they are located in.

It is highly recommended to select a facility with proven environmental records to dismantle an aircraft. The following information may assist in making this selection:

- Existing permit/license to operate demonstrating engagement with authorities and possible controls by competent authorities,
- Environmental certification (e.g. EMS, ISO, EMAS, AFRA),
- No public information about breach of existing environmental regulations.

The activities generally covered by environmental regulations concern transport, storage and treatment of HWM or discharge of wastewater. Other areas that are important to verify include those related with phased-out chemicals and dangerous materials (such as asbestos or depleted uranium) contained in some decommissioned aircraft of older types, and new international standards regarding, for instance, waste regulations and emissions to air and water. Some environmental authorities publish the list of companies holding valid certificates on their websites. It can be worth verifying those websites as well as registering to receive their newsletter to be up-to-date on their latest activities and legal developments. It is the responsibility of the aircraft owner/operator to select a facility that has all the necessary compliance requirements.

Here is a non-exhaustive list of areas of legislation and regulation that could apply to the facilities:

- Air quality
- Asbestos products
- Dangerous materials
- Electrical waste and electronic equipment (such as the WEEE Directive in the EU)
- Environmental permits (license to operate)
- Environmental quality or protection
- Halocarbons
- International regulations related to the environment (e.g. hazardous waste, nuclear waste, climate change)
- Landfilling and incineration of residual materials
- National fire code
- Noise
- Nuclear substances
- Radioactive products
- Storage tank systems for petroleum products and allied petroleum products
- Used tire storage
- Waste management (recovery, reclamation and shipments)
- Water discharges and wastewater treatment

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\(^{47}\) The precautionary principle refers to a risk management approach “whereby if there is the possibility that a given policy or action might cause harm to the public or the environment and if there is still no scientific consensus on the issue, the policy or action in question should not be pursued.” Precautionary Principle, European Union law [www.eur-lex.europa.eu/summary/glossary/precautionary_principle.html](http://www.eur-lex.europa.eu/summary/glossary/precautionary_principle.html)
3.4.2 AFRA and Environmental Management Systems

The AFRA BMP for both used aircraft parts and assemblies as well as recycling of aircraft materials, and other environmental management systems like ISO 14001 or EMAS, provide relevant tools and procedures for disassembly facilities. This subsection aims to present these tools and procedures.

a) AFRA

As described in Subsection 3.3.4, AFRA offers a voluntary best practices standard for the disassembly, dismantling and recycling of aircraft.

Regarding the environmental aspects, the BMP presents three general best practices summarized below (Article VIII – Environmental Protection – Best Practice (VIII) 1 to 3):

1. The environment should be protected from unexpected releases of fluids and HAZMAT
2. Discarded parts that are not meant to reenter the civil aviation marketplace shall be rendered unusable for their original intent and recycled
3. Fluids contained in the aircraft or the remaining parts of the aircraft must be drained, managed and disposed of according to the requirements of local jurisdictions

A provision is also indicated for the periodic verification of the quality of recycled materials for the recycling facility (Best Practice (III) (d) 3).

For a disassembly facility, it is specified that “the disassembly facility shall have a procedure for evaluating and selecting a recycling Facility that can adequately meet the Facility’s recycling goals”, “coordinate with the recycler to ensure that parts intended for recycling are processed in a manner that support the recycling goals of the Facility”, “have a procedure for verifying that the recycling facility fully implements the recycling agreement between the recycling facility and the disassembly facility and/or Customer” and “take reasonable care to contain Materials for Recycling, and Recycled Materials, from being released to the environment” (Article VIII – Best Practice (VIII) 4 to 7).

For a recycling facility, a series of best practices are identified. These concern:

- Security to Prevent Unwanted Material from Entering the Facility (Article III b)
- Storage and Segregation of Materials (Best Practice (III)(c) 4 to 5)
- Inventory Accounting and Audit (Best Practice (III) (d) 6)
- External Transportation of Materials (Best Practice (III)(f) 1 to 2)
- Training (Best Practice (IV)(a) 4)
- Material and Transaction Records (Best Practice (V)(b) 1 to 6)
- Reference Manual (Best Practice (V)(c) 2)
- Receiving Inspection for Materials for Recycling (Best Practice (VII(a) 1 to 3)
- Segregation during Recycling Stages (Best Practice (VII)(c) 1)
- Environmental Protection (Best Practice (VIII) 7)

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b) **Environmental Management System**

An environmental management system (EMS) is a set of processes and practices that enable an organization to manage/reduce its environmental impact and increase its operating efficiency. The most widely used standard is ISO 14001, which is not limited to the aviation industry, but has been commonly implemented by airlines, airports, OEMs, MROs, disassembly and dismantling companies, recyclers and distributors. The European Commission has developed another system named Eco-Management and Audit Scheme (EMAS), which is, however, not widely used in the aircraft decommissioning sector.

The International Organization of Standardization (ISO) defines an environmental management system as “part of the management system used to manage environmental aspects, fulfil compliance obligations, and address risks and opportunities.” EMS provide strategic tools to minimize the environmental impacts of the facilities’ activities and operations. Most of these systems are based on the Plan-Do-Check-Act approach to continuous improvement (“Deming Wheel”, Figure 14). The most recent edition of ISO 14001 (2015) now addresses opportunities as well as managing environmental impacts and risk. The International Aerospace Environmental Group (IAEG) has published a useful ISO 14001:2015 Transition Document for those companies that are either transitioning to the most recent requirements or simply implementing the standard for the first time: [www.iaeg.com/iso14001](http://www.iaeg.com/iso14001).

Selecting a disassembly facility or dismantling/recycling facility that has implemented an EMS would represent a good practice to put forward. It means that the facility has conducted an environmental review of its operation to know what its impacts on the environment are and how they can be controlled and mitigated. It also means that it has reviewed all its legal and compliance obligations and set environmental objectives with targets in an environmental program.


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49 USEPA, [www.epa.gov/ems](http://www.epa.gov/ems)
3.4.3 Environmental Protection

This subsection provides the environmental conditions and protections the facilities must have to decommission an aircraft. Key elements such as a retention basin, spill kits, controlled HAZMAT areas as well as emergency plans are provided.

Below are best practices to verify with the facilities regarding environmental protection:

- The facility has an emergency response plan, including communication procedures in case of emergency (e.g. environmental authorities, contact person).
- The facility has a retention basin to collect fluids, and a valid license from the local authority (i.e. maintenance of the basin).
- The facility has spill kits that are appropriate to different type of spills. These kits are ready-to-use where the operational activities occur.
- The facility has designated storage zones for disposing of HAZMAT according to their compatibility.
- The facility can provide a certificate of destruction.

Additional questions to answer regarding HAZMAT and waste management will help select the right facilities:

- How is the HAZMAT managed? How is it removed and who is the waste contractor collecting it? Does the contractor hold all the licenses required to transport and dispose of all the types of collected HAZMAT?
- How will the facility ensure that the aircraft is properly decontaminated prior to dismantling? Is the facility able to deal with any unexpected contamination of the aircraft (e.g. depleted uranium, asbestos, fuel tanks, toilet tanks)?
- How will the dismantling operations be implemented? What type of machinery will be used and what are the risks associated with the tools operating in the aircraft (e.g. spills, fire, explosion)?
- How will the materials be sorted? Is there any procedure planned in that respect? Will it be done before or after the dismantling process?
- Where will the unrecyclable materials be disposed of? Is there information the facility can provide regarding its supply chain?

The disassembly facility needs to be able to identify all the HAZMAT contained in the aircraft and set up a proper method of disposal. This can be accomplished with pre-established check lists, the Aircraft Maintenance Manual (AMM) and the assistance of certified mechanics. The aircraft owner/operator must ensure a tight follow-up with the facility responsible for the decontamination process because not identifying all the HAZMAT seriously increases the likelihood of environmental and safety consequences. For further details, see Subsection 4.4.1.
The recycling facility can be selected according to its capacity to answer these criteria:

- Ability to provide a valid certificate of authorization from the environmental authorities and an environmental policy.
- Commitment to follow environmental management best practices (e.g. AFRA, ISO 14001).
- Ability to respond to aircraft owner/operator policies regarding the environment, ethics, professionalism and corporate social responsibility.
- Ability to document the decommissioning activities.
- Ability to provide a certificate of destruction.
- Ability and willingness to meet the requirements of the airport authorities or the decommissioning site authorities.

The AFRA BMP also provides environmental protection best practices for facilities dealing with aircraft decontamination and HAZMAT (see Best Practices (VIII) 1 and 3). The selected facility should have procedures for drainage, management, segregation, and disposal of HAZMAT. The following practices are suggested:

- Receiving inspections specific to fuels, liquids and lavatories.
- Having the right equipment to drain assets or materials for recycling.
- Having spill equipment and a spill prevention and management plan in place in the event of an unexpected release.
- Having an environmentally contained pad with an oil/water catching capacity large enough to contain the largest storage vessel of the asset or materials for recycling.
- Having an intact, impervious surface with runoff control and containment systems such as booms, pads, etc.
- Having a Spill Prevention and Control Plan and the equipment on hand that is stipulated in that plan.

Furthermore, all fluids contained in the aircraft must be drained prior to dismantling, including residual fuel in the jet engine. This operation might need to be done in a segregated area to control potential static discharges or other sources of sparks or combustion. It is, therefore, important that the selected facility has the following protection equipment:

- Ground surface fully impervious
- Storm water run-off pathways physically protected with spill barrier equipment (e.g. drains, culverts, channels)
- Pumping and storage capacity immediately accessible
- Oil/water separator
- Wastewater treatment with aircraft fluid capabilities
- Spill kits with sufficient absorptive materials
3.4.4 Aircraft Decontamination, Hazardous Materials and Hazardous Waste Materials

Prior to disassembling parts containing hazardous fluids and before starting the dismantling process, the aircraft owner/operator needs to ensure the decontamination of the aircraft. It should be clear from the start who from the aircraft owner/operator or the disassembly facility does what and how the follow-up is achieved regarding decontamination activities. For instance, the aircraft owner/operator may want to proceed to the major decontamination activities prior to the transfer of the aircraft to the disassembly facility. On the other hand, the disassembly facility may include this service in the contract or service agreement.

Roles and responsibilities should be well identified at the beginning of the decommissioning process. There are many cases where the decontamination process was overlooked and the last link of the supply chain ended up dealing with HAZMAT that should have been removed in the first place and caused serious environmental hazards or accidents. The HAZMAT handler should be carefully selected according to its legal compliance (i.e. licenses for treatment and transportation), its capacity to provide material traceability and its commitment to environmental best practices.

The methodology proposed to manage the HAZMAT could be based on the four-step risk management methodology: identify, assess, mitigate, monitor. Appendix B – Examples of dangerous and hazardous materials to be removed and treated from aircraft lists examples of dangerous and hazardous materials that need to be removed from the aircraft. The table in Appendix C - Framework for managing hazardous waste materials provides a framework for listing and managing the hazardous waste materials during decommissioning.

The research program for nuclear research and training in Europe (EURATOM) provides guidance and lists all radioactive products, such as depleted uranium for ballast weights, smoke detectors and fluorescent signs.

It is important to highlight that the facility managing the HAZMAT should get all the information on how to handle the waste, the associated regulations and risks. The facility should know what type of materials are in the parts and components it is handling and be aware of hidden risks and its liability.

3.4.5 Sustainability Factors and Challenges

This subsection provides a general overview of sustainability factors and challenges when selecting the facilities for disassembly and dismantling. Local conditions regarding material management, recycling facilities, job creation, transport of materials and resource efficiency could be useful considerations to support the selection of facilities. Challenges regarding material traceability, material flow and material characterization are also presented in this subsection.

a) Local conditions and local economy

Especially in cases where there is a small number of aircraft to be decommissioned, the aircraft owner/operator can give precedence to a local dismantling/recycling facility, so long as it has all the environmental compliance documents and basic experience with the aviation industry. This local approach can stimulate the local economy and avoid costs and environmental impacts related to ferry flights.

Decommissioning conditions also depend on the size of the fleet to tear down. For instance, aircraft owners/operators managing large fleets will have more important means and resources available (as well as higher risks to manage) than smaller ones who only have one or a few aircraft to decommission. In that respect, challenges related to local conditions will be completely different from one situation to another. It may not be essential to select world scale or foreign decommissioning facilities located far away if there is only one aircraft to tear down.

b) Challenges related to coordination of facilities

From a risk minimization approach, coordination of facilities can represent a challenge for the aircraft owner/operator. The aircraft owner/operator may be dealing with three different facilities or more: airport authorities, part-out companies (e.g. MRO located on the airport site) and dismantling/recycling companies (located somewhere else). This situation adds an extra burden for the aircraft owner/operator in terms of operation and coordination, especially when considering decommissioning is not a high priority. The different facilities are not necessarily well organized to work together, and in some case, the disassembly facility is not aware of (or does not know) the reality of the dismantling and recycling facility, and vice-versa. In the day to day operations, it is important that both the disassembly and the dismantling facilities communicate with each other, particularly regarding the decontamination process. Both facilities should also have strong communication with the airport authority if the dismantling occurs on such site. There is a learning curve to consider and perhaps extra human resources to calculate in the business case to ensure that operational activities are well integrated and managed together to minimize the risks to the environment and the workforce.

c) Challenges related to material traceability and sorting

Another factor to consider before selecting a dismantling/recycling facility is the capacity of the facility to sort the material in a sustainable manner to optimize the recycling rates and minimize the waste. It is therefore important to visit the facility prior selection to have a good understanding of their practices in terms of material management. Electronic recyclers may see greater benefits in sorting properly the different type of materials over general salvage companies, as some of the electronic devices contained in the cargo may have valuable recycling return.

Recommendations from Section 3.4:

Recommendations related to environmental aspects when selecting facilities:

- Verify the environmental compliance of the facilities, including the environmental authorization and certificate, when applicable.
- Select a facility having valid certificates of authorization from the environmental authorities and an environmental policy.
- Select a facility with appropriate protection equipment (see Subsection 3.4.3).
- Select a facility able to document the decommissioning activities (e.g. certificate of destruction, material traceability).
- Select a facility able to meet the aircraft owners’/operators’ environmental and corporate goals (e.g. recycling rates, waste minimization).
- Select a facility having an environmental management system in place (e.g. ISO 14001, EMAS) or AFRA accreditation.
- Ensure efficient coordination and communication between facilities to minimize risks on health, safety and the environment (HSE).
- Stay informed about changes in applicable environmental regulations (e.g. waste, air emission, HAZMAT).
Chapter 4—Disassembly Process

Disassembly is the process of removing all the valuable parts and components from an aircraft which are intended to be reused as spare parts. These parts and components provide most of the profitability of the decommissioning project.

It is important to note the difference between the disassembly and the dismantling processes. As can be seen in Figure 2, disassembly is part of aerospace activities, whereas dismantling is not. Disassembly must be carried out by aircraft maintenance organizations approved for these specific activities, in order to maintain the airworthiness status of the disassembled parts (see details in Section 4.3). If disassembly is carried out by an organization not approved for aircraft maintenance, the entire aircraft will be considered waste. On the other hand, dismantling activities (after disassembly of all parts to be reused for aerospace purposes) need not necessarily be carried out by organizations holding a civil aviation certification such as a Part 145 maintenance organization. The dismantling process is described in detail in Chapter 5.

In this section, considerations and suggestions for the disassembly process are provided.

4.1 Economic and Operational Aspects

Once it is decided to disassemble an aircraft, the value of the aircraft should be considered at the component level, instead of as a whole. During this process, high-value components should be identified and handled with care, as these components will very likely eventually generate most of the revenue of the project. Details of high-value component identification are presented in Chapter 6 - Parts Re-certification and Distribution.

Most aircraft owners contract with specialized part-out and/or salvage companies for aircraft decommissioning activities. Many of them offer flexible and cost-effective solutions, including a wide array of services (e.g. storage and in-house MRO services). However, aircraft owners/operators with their own MRO business will commonly use their own facilities to perform decommissioning activities.

4.1.1 Realise the Residual Value

With regards to the handling of the asset aircraft and the components removed from it, several options are available to the aircraft owner:

- An aircraft can be sold as a whole or in parts (e.g. engines sold separately) to a company that is specialized in the disassembly process and ideally also provides dismantling infrastructure, as discussed in Chapter 5.

- The asset could be placed in a consignment arrangement, which is a trading arrangement between the owner of the asset and a consignment providing company (which could also be the disassembly company) The latter manages the whole decommissioning process and the sale of the components, while the aircraft owner remains the owner of the asset and the removed components until the sale has taken place.

- If the aircraft owner is also the operator of the aircraft (e.g. an airline), the owner/operator can elect to have the aircraft decommissioned to supply its fleet with the components and parts removed from the asset. The removal can be performed by the MROs that have contracts with the airline for their regular maintenance.

Proper procedures for disassembling the aircraft will help to maintain the value of the components and avoid unnecessary repair or maintenance. These components should have appropriate historical records (logbooks), be properly removed and tagged, serviced and stored according to the applicable set of airworthiness regulations. Otherwise, the value of the components could be significantly reduced. It is not mandatory to have an approved MRO to disassemble the aircraft when components are removed in as removed (AR) condition. If parts are removed by an approved MRO per the AMM from an airworthy aircraft, they could be reused directly.
(status “Serviceable (SV) removed”). Otherwise, all removed components must be inspected, overhauled and recertified by an approved MRO before being installed on another airworthy aircraft (i.e. declared SV). This re-certification will increase the cost of the decommissioning project, but will also increase the value of the components. In the market, the value of SV components recertified by a component MRO shop is higher than SV removed. This is further described in Section 4.3.

The typical high-value parts and components from an aircraft are (see more in Subsection 6.1.2):

- Engines
- Auxiliary Power Units (APUs)
- Avionics
- Flight control systems
- Engine control systems and thrust reversers
- Environmental Control Systems (ECS)
- Hydraulic systems
- Landing gear
- Safety equipment (e.g. slides)
- Wheels and brakes
- Pumps and electric motors

For the detailed procedures of disassembling an aircraft, the AFRA BMP⁵³ provides comprehensive best practices and recommendations. The Airbus PAMELA project⁵⁴ and the EU AiMeRe project⁵⁵ have also produced valuable information.

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**Example from Kalitta Air**

At our company, the residual value of the aircraft is often realized by removal of high-value parts. These include engines, avionics, cargo handing components, flight controls, APUs, etc., prior to recycling the aircraft for its basic metals. Those parts are then placed into inventory to support other aircraft. In the past, we have acquired aircraft strictly for parts, since these aircraft are assigned an FAA registration number, issued an Airworthiness Certificate, and listed on our company’s Ops Spec, we can remove those parts as needed to keep the other aircraft in the fleet flying.

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**Example of storage policy from Magnetic MRO**

Storage facilities should be clean, well ventilated and maintained at a constant dry temperature to minimize the effects of condensation. Ideal storage temperature: 15-25 degrees, humidity: 40-60%. Storage racks should be strong enough to hold aircraft components and provide sufficient support for large aircraft components so components are not distorted during storage. All aircraft components, wherever practicable, should remain packaged in protective material to minimise damage and corrosion. Manufacturers’ instructions in this regard should be followed. A thermo-hygrograph is mandatory for humidity monitoring - data must be logged on a daily basis. Rubber parts should not be exposed to strong light (e.g. direct rays of sun). The store rooms should be kept as dark as practicable. Certain electronic rotables and circuits can very easily be damaged by electrostatic discharges if they are not being protected and handled correctly. Such parts are called «electrostatic discharge sensitive (ESDS) devices». All ESDS rotables must be packed separately in antistatic bags. ESDS should not be stored on shelving covered with carpet, foam, vinyl or any other material that can store or produce an electrical charge. Appropriate warning and caution signs and decals must be placed in areas where ESDS are handled. ESDS can be handled only using approved grounding wrist straps and conductive desk mats. Wrist straps and grounding mats will be tested to ensure conductivity at regular intervals or prior to use.

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Disassembly Process

4.1.2 Reuse of Critical Assets (Halon)

Halons are stable compounds that are used in fire extinguishers. They have been linked to depletion of the earth’s ozone layer. Therefore, from 1 January 1994 onwards, the production and importation of newly manufactured halon was banned in developed countries through the Montreal Protocol. Because of ozone depletion, absence of new production and lack of efficient substitutes, halon needs to be properly removed and recycled.

On all aircraft, fire detection and suppression systems are mandatory. Currently, halon is used to extinguish and suppress fires in four applications on commercial aircraft:

- Halon 1211 in handheld fire extinguishers located throughout the cabin, flight deck, crew rest compartments, and accessible cargo compartments
- Halon 1301 in lavatory extinguisher bottles, cargo compartments, engines and APUs

When fire protection components are removed from the aircraft during disassembly activities, they may contain Halon 1301 and/or Halon 1211. Due to their very ozone depleting nature, halons have been subject to international bans and are no longer produced. Nonetheless they are considered an essential element of the aircraft’s fire protection system and overall airworthiness, i.e. an aircraft without adequate halon fire protection is not allowed to fly.

Aviation is the largest consumer of Halon 1301. With planning and the employment of best practice processes, the industry can help secure the future supply chain for this critical product, especially considering ICAO and the UN Halon Technical Options Committee’s ongoing work to determine existing and future demands on halon reserves.

Efforts to find effective replacements for Halon 1301 in aircraft fire-extinguishing and suppression systems have been challenging and much work remains. Therefore, it is critical the industry efficiently recovers and recycles all possible sources of halon on end-of-life aircraft. The advantages of this process to the global aviation industry from a fire protection, commercial and environmental point of view includes helping to future-proof as much as possible the industry with halon stocks. It prevents the possibility of halon being released to the atmosphere as a means of “disposing” it and it provides the opportunity for the re-use of fit-for-purpose parts.

To prevent inadvertent emissions and to disassemble halon fire protection systems safely, personnel responsible for these activities need to ensure that they use adequately trained and qualified staff, in particular regarding the following items:

- Components such as squibs that are commonly found on Halon 1301 cylinders (spheres) can create a safety risk to the person if these are not handled and disposed of correctly.
- Cylinders are under pressure. They should not be punctured or decanted - any decanting activity should be performed by a responsible halon recycling company.
- Cylinders that are within test date and are eligible for reuse can be placed back into the supply chain either to be returned to a manufacturer or a repair/parts station.
- Cylinders that are discontinued, damaged or out of test or no longer required should be sent to a responsible halon recycling company.
- Reputable and experienced halon recycling companies should be used to recover and recycle halons. The companies should be following a recognized code of practice to ensure minimal emissions and high rates of product returned are achieved.
- Equally important is the quality of the recycled halon. Subjecting the halon to a full analysis to recognized and approved industry standards, for example, ASTM D 5632 for Halon 1301 will ensure the purity levels have not been compromised during recycling activities and the halon’s performance is not affected.

56 https://www.epa.gov/ozone-layer-protection/international-treaties-and-cooperation
57 See e.g. https://www.harc.org/, http://www.halontrader.org/home.asp?r=1
• Routine leak monitoring and best practice management of recycled halon reserve stocks will also help secure the future supply to the industry, as any emissions will be detected early and addressed.

Recommendations from Section 4.1:

When disassembling an aircraft, it is recommended to:

- Have an approved maintenance organization (e.g. EASA/FAA Part 145 certificated organization) remove components from the aircraft, if components need to be removed in serviceable condition. This is not required if components are removed in “As Removed” condition.

- Make sure that the removed components have appropriate historical documentation, such as logbooks and maintenance records.

- Make sure that the removed components are stored properly and tagged.

- Follow the disassembly procedures of the AFRA BMPs.

4.2 Regulatory and Legal Aspects

4.2.1 Protection of Ownership Rights of Parts

Similar to Subsection 3.2.1, this subsection is only applicable when the aircraft owner decides to contract another company to disassemble the aircraft, instead of selling the whole aircraft to be disassembled.

While the protection of an owner’s interest in the aircraft remains integral during the disassembly process, any agreement on how that ownership interest would be protected should be reached between the parties (i.e. the owner of the aircraft and the facility provider) upon selecting the facilities.

The content of such agreements (previously described in Subsection 3.2.2) may vary depending on the interest and intentions of both the parties. For instance, one owner may want to sell the parts in its own capacity after the disassembly process, whereas another owner may want the facility provider to find suitable buyers for the parts. Similarly, where a facility provider could arrange a sale of the aircraft parts, it needs to be sure of its financial incentive in the agreement with the owner of the aircraft. However, as already provided, to obtain certainty, these specific matters should generally be addressed between the parties before the disassembly takes place.

For further details and recommendations, see Section 3.2. These issues are also addressed in the AFRA BMP.
4.3 Safety Aspects

4.3.1 Safety Conditions for Workers and External Persons

Prior to every disassembly, the following prerequisites need to be ensured. These measures may appear to be self-evident, but daily experience shows that safety aspects are often forgotten or neglected when dealing with routine activities.

- **Safety briefing:** Give safety instructions to ensure that all parties are aware of the risks and that they are doing their work carefully to avoid accidents and injuries.
- **Qualification of employees:** Verify that all parties are qualified, adequately prepared and approved for the work.
- **Protective clothing and equipment:** Verify that all parties involved wear the necessary protective clothing and equipment.
- **Safety equipment for emergencies:** Verify that emergency equipment is available.
- **Barrier around work area preventing access by unauthorized persons:** Ensure that the work area is locked and monitored to prevent unauthorized access.

4.3.2 Product Safety and Airworthiness

As the disassembly of an aircraft is intended to be done by an approved maintenance organization, it can be expected that all necessary procedures and qualifications are implemented to ensure the safety and airworthiness of the disassembled parts. Only approved maintenance organizations such as Part 145 maintenance organizations are authorized to do this. In particular, the following practices are recommended:

- **Registration and tagging of all disassembled parts**
- **Precautionary measures to prevent parts from being damaged or destroyed**
- **Precautionary measures to prevent parts from being lost**
- **Separate and secure storage of damaged or destroyed parts until a decision is made for further processing (e.g. maintenance, recycling, disposal)**
- **Ensuring that all removed parts are inspected**
- **Ensuring that all inspected parts are re-certified by authorized persons**

4.3.3 Quality Management

To be reusable and for safety and airworthiness, components and systems from a decommissioned aircraft must be inspected, maintained and re-certified by an approved maintenance organization. If they are being removed by an approved aircraft maintenance organization and found to be traceable and serviceable and certified in accordance with the organization's approved procedures, the component/system can be installed on another airworthy aircraft directly. However, if this is not the case, the component (with proper records) must be inspected, tested, modified, if necessary, and recertified by an approved aircraft maintenance organization to be installed on an airworthy aircraft.

It is essential to underline that any airworthiness credits for the status of the aircraft or its parts and components are conditional on the fact that the decommissioning work is performed by approved maintenance organizations. Normally the organization's approval would specify the scope of the work they are authorized to perform.
The basis for the approval of a maintenance organization are aviation regulations, for example FAA 14 CFR 145, EASA Part 145 or similar regulations in other jurisdictions.

a) FAA 14 CFR 145.211 requires the implementation of a quality control system. This quality control system must include:

1. A description of the system and procedures.
2. References, where applicable, to the manufacturer’s inspection standards for a particular article, including reference to any data specified by that manufacturer.
3. A sample of the inspection and maintenance forms and instructions for completing such forms or a reference to a separate forms manual.
4. Procedures for revising the quality control manual required under this section and notifying the certificate holding district office of the revisions, including how often the certificate holding district office will be notified of revisions.

d) EASA 145.A.65 requires the implementation of a safety and quality policy, maintenance procedures and a quality system. Furthermore, EASA 145.A.70 requires the establishment of a maintenance organization exposition, including:

1. A statement signed by the accountable manager confirming that the maintenance organization exposition and any referenced associated manuals define the organization’s compliance with 145.A.65 and will be complied with at all times. When the accountable manager is not the chief executive officer of the organization, then such chief executive officer shall countersign the statement.
2. The organization’s safety and quality policy as specified by 145.A.65.
3. The title(s) and name(s) of the persons nominated under 145.A.30(b).
4. The duties and responsibilities of the persons nominated under 145.A.30(b), including matters on which they may deal directly with the competent authority on behalf of the organization.
5. An organization chart showing associated chains of responsibility between the persons nominated under 145.A.30(b).
6. A list of certifying staff and support staff.
7. A general description of manpower resources.
8. A general description of the facilities located at each address specified in the organization’s approval certificate.
9. A specification of the organization’s scope of work relevant to the extent of approval.
10. The notification procedure of 145.A.85 for organization changes.
11. The maintenance organization exposition amendment procedure.
12. The procedures and quality system established by the organization under 145.A.25 to 145.A.90.
13. A list of commercial operators, where applicable, to which the organization provides an aircraft maintenance service.

59 EASA, Maintenance Organisation Approvals – Part 145, Revision August 2012
14. A list of subcontracted organizations, where applicable, as specified in 145.A.75(b).

15. A list of line stations, where applicable, as specified in 145.A.75(d).

16. A list of contracted organizations, where applicable.

**Recommendations from Section 4.3:**

- To be reusable and for safety and airworthiness, components and systems from a decommissioned aircraft must be inspected, maintained and re-certified by an approved maintenance organization.

- If it is being removed by an approved aircraft maintenance organization, the component could be installed on another airworthy aircraft directly. However, if this is not the case, the component (with proper records) shall be inspected, tested, modified, if necessary, and re-certified by an approved aircraft maintenance organization to be installed on an airworthy aircraft.

- An approved aircraft maintenance organization must meet the applicable aviation regulations, for example FAA 14 CFR 145 or EASA Part 145.
4.4 Environmental Aspects

4.4.1 Material Management during Disassembly

Aircraft disassembly generates an important quantity of different types of materials. The following topics will be addressed in this subsection:

- Manufacturer’s documentation for managing materials, parts and components.
- Retrofitted components and reusable materials and components.
- Remanufacturing parts and components.
- It should be noted that the waste hierarchy (prevention, reuse, recycling, recovery and disposal) is useful to help in material management, especially during the disassembly processes, and is often used as a framework to minimize waste. Figure 15 details the waste hierarchy.

![Figure 15: Waste Hierarchy](Source: ISO)
Disassembly Process

External providers can be helpful by providing support with the following:

a) Manufacturer’s documentation for managing materials, parts and components

There are many sources of documentation helping the facilities in the disassembly process, but the OEM’s documentation (such as the AMM) contains valuable information on the material inventory that will need to be managed and processed during the disassembly and dismantling. It is very helpful if the aircraft owner/operator can provide all the necessary information to the facilities so the disassembly process is easily managed and retains the full value of parts and components that will be sold again on the market according to transport regulations.

Among others, this information is helpful for identifying:

• The parts to be removed.
• The HAZMAT contained in the aircraft, including its approximate quantity, location and methods of removal.
• The weight and dimension of the aircraft, which is useful during the dismantling process.
• The different types of alloys and metals, which is useful for the mapping process.

Other useful documents during the disassembly process are the ground operation checklists, records and work order sheets. They can help track parts that have been removed and follow up on the environmental performance, such as the reuse and recycling rate. Adding these documents as a requirement in the service agreement helps improve current management practices.

b) Retrofitted components and reusable materials and components

To maximize the environmental and economic benefits, the aircraft owner/operator should recover parts and components for reuse as spare parts within the aviation sector (upon airworthiness compliances, see Chapter 6) or for potential other uses outside the aviation sector (see Subsection 5.1.2). As explained above, reusing parts and components is the most favored form of waste management in the waste hierarchy (after waste prevention). Reuse of an aircraft part saves the energy required to produce a new part as well as other environmental impacts, such as air emissions, waste and the use of new resources. However, managing spare parts requires the implementation of several processes and means of control, such as re-inspection and certification.

Depending on the reuse value of parts and components, the following processes are recommended:

i. Parts and components available for reuse and having a high value in the replacement market:

See Sub-sections 4.1.1 and 6.1.2.

ii. Parts and components requiring repairs and having a lower value in the replacement market:

Apart from the most valuable parts (e.g. engines, avionics, landing gear), there might be cabin interiors worth reusing or retrofitting: seats, luggage compartments and galleys are only a few examples. The aircraft owner/operator may also want to reuse some sections of the aircraft for training purposes, such as safety or emergency measures. The reuse of this equipment makes it possible to reduce the overall impact on the environment. Some maintenance companies also offer retrofitting of parts and components. MROs sometimes repair, certify and reuse equipment, such as seats, interior partitions, kitchens and luggage compartments. The aircraft owner/operator may want to verify these options.

iii. Parts and components having no value in the replacement market:

Under current practices, parts and components that have no value in the aftermarket are normally destroyed to avoid their illegal reuse in the aftermarket. The AFRA BMP provides specific practices regarding parts and components with no replacement value in the aviation market (see AFRA Best Practice (VIII) 2). It specifies that aircraft parts precluded from reentry into the civil aviation marketplace shall be rendered unusable for their original intent and recycled, and that a procedure should be in place to ensure that parts are rendered unusable. Specific recommended actions during disassembly and sorting activities are:

1. Material anticipated for destruction should be identified in a parts disposal schedule (e.g. in the written agreement between the facility and the customer or an appendix to the manifest).

2. The parts disposal schedule should be reviewed and approved by the owner of the asset.

3. The owner of the asset or materials for recycling should review the final list of parts to be scrapped (the parts disposal schedule, as amended) and should authorize the parts for destruction in writing.

4. Destruction of the parts listed in the parts disposal schedule should occur within a reasonable period after authorization.

5. When items are destroyed, destruction should be witnessed and the schedule of destroyed items should be certified as destroyed by the witness.

6. Remnants of the destroyed items should be disposed-of properly to preclude their rework back into apparently-viable parts – this may also be subject to the witness’ certification.

7. Identification items (like data plates) should be removed.

8. Provide notification to customer and any interested agency with jurisdiction that the Asset has been destroyed and the degree to which that the Asset has been recycled.  

iv. Re-manufacturing of parts and components

The common definition of remanufacturing in the aviation (and automotive) industries generally is the refurbishment of old parts by keeping their initial function and giving a second life to the components by minimizing their physical transformations. However, it can also mean to give another function to the product where new applications can be found from the airframe, cockpit and passenger cabin (see Subsection 5.1.2). Encouraging product remanufacturing can create high added value and jobs. Industrial designers demonstrate great creativity in that respect. Remanufacturing recovers a large share of the value initially added to the components compared to recycling or landfilling.

Recommendations from Section 4.4:

Recommendations regarding environmental aspects during the disassembly process:

- Providing the OEM’s documentation and other relevant documentation to the disassembly facilities to give all the necessary information during the disassembly and sorting activities.

- Considering airworthiness compliance, transport regulations and circumstances, prioritize the waste hierarchy: waste reduction, reuse, recycling, recovery, disposal.

- Verifying the options for reusing certain equipment for other functions (like training).

62 AFRA, AFRA Best Management Practice, Best Practice (VIII) 2, Version 3.2, March 8, 2016, p.60
HALON MANAGEMENT

Halon Decanting & Recycling

A-Gas manages halons as a critical asset to the aviation industry while being environmentally responsible. Using our expertise in halon management, recycling, and decanting we have been supplying the aviation industry for 25 years. Together we can responsibly manage your halon.

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Chapter 5—Dismantling Process

The Dismantling Process is to take other parts out of the aircraft for non-aviation purpose and tear down the rest of the aircraft for recycling purposes, after the aircraft has been disassembled. Normally this process takes place after the aircraft has been deregistered from the aviation authority and from this point onward the aircraft will be treated as waste. During this process, materials removed from the aircraft will be separated as recyclable and non-recyclable for further treatment. This section provides considerations and suggestions for the dismantling process.

As already noted at the beginning of Chapter 4, it is important to note the difference between the disassembly and the dismantling process. As can be seen in Figure 2, disassembly is part of aerospace activities, whereas dismantling is not. Contrary to disassembly, dismantling activities (after disassembly of all parts to be reused for aerospace purposes) are not necessarily to be carried out by an approved aircraft maintenance organization.

5.1 Economics and Operational Aspects

5.1.1 Realise the Residual Value

The removal of materials from the aircraft carcass for recycling is generally less profitable than the disassembly of aircraft parts that can be reused as spare parts. Often, there is a cost associated with the treatment of these materials. Even so, during the dismantling process of the aircraft, specialized waste disposal companies need to be involved, as materials need to be handled with care, in an environmentally responsible and safe way.

Example from Kalitta Air

Once all the parts of high value are removed, the aircraft is moved over to our dedicated scrapping area for demolition. The scrap is then turned over to a licensed waste hauler for final disposal. Currently, the market value for scrap aluminum is stagnant. There is an inherent problem with aircraft aluminum because it is "contaminated" with corrosion prevention compounds that must be dealt with during the smelting process. Engines and landing gear that are scrapped often realize a higher residual value, due to the specialized metal they contain.

5.1.2 Unconventional Usage of Components for Non-aviation Purposes

Several aircraft dismantling companies are involved in looking for creative uses for aircraft end-of-life components, even beyond the typical dismantling and recycling activities. For example, an AFRA member, VAS Aero Services, has requests for cockpits, aircraft seats and other components for use as art, gifts, furniture, trade show displays, movie sets/props, or for testing programs. While these sorts of creative reuse projects account for just a small portion of all the aircraft end-of-life materials, the following list shows some examples of companies being creative in trying to reuse or recycle as many components of the aircraft as possible in order to keep more materials out of landfills.

- [https://www.boeingstore.com/collections/custom-hangar](https://www.boeingstore.com/collections/custom-hangar)
- [https://www.planeindustries.com/products/](https://www.planeindustries.com/products/)
- [https://aeroartshop.com/](https://aeroartshop.com/)
- [http://www.skyart.com/](http://www.skyart.com/)
Example from Bombardier: Upcycling stories that drive changes

Upcycling is a process that transforms aircraft end-of-life parts into innovative and added-value products. It is one of the best ways to maximize aircraft recoverability. It encourages the reuse of parts that are more difficult to recycle and offers a better environmental performance. This practice represents a perfect example of a circular economy concept.

Bombardier, along with University of Montreal (UdeM) and the Consortium for Research and Innovation in Aerospace in Québec (CRIAQ), have successfully initiated a pilot project, called Eco-design of products, which is based on end-of-life aircraft parts. This project analyzes the challenges associated with upcycling and defines a sustaining plan for future design improvements.

The objective was to propose conceptual designs and prototypes with an integrated life cycle approach while using end-of-life aircraft parts. Key criteria included in the proposed concepts were:

- Investigating the complexity of using end-of-life aircraft parts in the development of new industrial products.
- Establishing a bank of ideas, as proof of concept, that could help develop future circular economy projects.
- Recognizing the net environmental benefit of using end-of-life aircraft parts to build new industrial products.
- Helping the public visualize how to reinvent new products based on end-of-life parts.

Among the various concepts introduced, some proposed concrete solutions that have captivated the public’s attention, including a bicycle, an ambiance stand light, a leather fashion jacket, a folding table, a desk light, and a wall clock. After performing a comparative life cycle assessment of some of these prototypes, we observed that upcycling the parts results in a smaller environmental footprint than recycling. The following images show how end-of-life aircraft parts with zero value or even with disposal costs could be transformed into new products with added value.
5.2 Regulatory and Legal Aspects

5.2.1 Protection of Ownership Rights
The content of Subsections 3.2.1 and 4.2.1 are applicable here.

5.2.2 Liability
Dismantling an aircraft will generate various materials. Whether HAZMAT or not, if not properly managed, the material could breach applicable regulations and, subsequently, create liability issues for the dismantling company and even for the aircraft owners. It is the responsibility of the aircraft owner and/or the dismantling company to make sure that the dismantling process complies with the applicable laws and regulations. It is important to agree liability issues in the contract between the aircraft owner and the dismantling company.

5.3 Safety Aspects

5.3.1 Safety Condition for Workers and External Persons
The content of Sub-section 4.3.1 is applicable here.

5.3.2 Product Safety and Airworthiness
The objective of dismantling an aircraft is to scrap the remaining structure with the aim of recycling this material. Therefore, this subsection aims to provide standard rules for the handling of this material, to guarantee that no item removed during the dismantling process will reenter the aerospace market.

Source: Bombardier
The process must ensure that all required qualifications are available and all necessary procedures are implemented at the recycling facility to ensure that no parts or material will reenter the aerospace market as unapproved or counterfeit parts.

It is recommended to consider, as a minimum, the requirements of the AFRA BMP\textsuperscript{64}. These requirements include, but are not limited to:

\begin{itemize}
  \item Ensuring that the aircraft has been deregistered and released for dismantling and recycling.
  \item Ensuring that all registrations and authorizations are available for the dismantling of the aircraft.
  \item Implementing protective measures to make sure that parts or material leave the work area in a controlled way (especially with mobile dismantling) to avoid foreign object damage (FOD) to other aircraft.
  \item Adopting precautionary measures to prevent parts or material from being lost.
  \item Implementing protective measures to prevent subsoil from being damaged (especially with mobile dismantling at airports)
\end{itemize}

### 5.3.3 Quality Management

The dismantling process follows the disassembly process. All valuable components and systems are removed before dismantling. The dismantling process relates only to that material which is intended to be recycled or disposed of.

During the dismantling process, the remaining parts may not be reused on an aircraft. These parts are not inspected, maintained or repaired and, therefore, are not going to be recertified.

As the parts are not recertified, their safety and airworthiness cannot be ensured. Therefore, their reuse in an aircraft is strictly prohibited. Consequently, it is recommended to keep the dismantling under the responsibility of the dismantling facility.

The dismantling facility needs to establish a quality organization, which implements a safety and quality policy like an approved aircraft maintenance organization. This quality organization must ensure that no remaining parts or systems may enter the aviation market as suspected unapproved parts (SUP) or even counterfeit parts ("bogus parts"). This aspect is covered in the AS/EN 91XX certification and implicitly also in the AFRA BMP. Facilities without a certification covering the handling of unapproved parts should implement related processes separately.

AS/EN 9100, AS/EN 9110 and AS/EN 9120 are quality management systems, based on ISO 9001, with specific requirements for the aviation, space and defense industries (see more in Subsection 3.1.3).

The AS/EN 9110 standard focuses on the requirements critical to the maintenance of all (commercial, private and military) aircraft. In addition to the requirements in AS/EN 9100, this standard includes additional criteria for MRO facilities for organizations.

AS/EN 9110 also covers the detection and prevention of unapproved and counterfeit parts, human factors, as well as safety management systems.

\textsuperscript{64} AFRA, AFRA Best Management Practice, Part III – Provisions applicable to recycling facilities, Version 3.2, March 8, 2016
5.4 Environmental Aspects

5.4.1 Material Management during Dismantling

Aircraft dismantling generates an important quantity of different types of materials. This subsection provides a framework and methodology to properly manage the materials. The following topics will be addressed:

- Hazardous waste material (HWM)
- Recyclable materials and components
- Non-recyclable materials and polymers as well as composite materials
- Insights into disassembly for new types of materials
- Material traceability
- Waste management regulations

a) Hazardous waste materials

As explained in Sections 3.4 and 4.4, the decontamination process is one of the crucial steps in ensuring safe and environmentally sound decommissioning. For the dismantling process, the aircraft should be entirely decontaminated. However, it is important that the dismantling facility verify that this is the case and that all HWM and emergency equipment are safely removed (e.g. fluids in the hydraulic ducts and in the fuselage, cylinders, emergency locator transmitter (ELT)).

b) Recyclable materials and components

Due to inefficient sorting methods and high treatment costs in many current dismantling processes, recycling is often not worth the effort from an economic point of view. However, there is great potential in minimizing waste to landfill by recovering a maximum of materials. An important step is to sort as much material as possible to allow a good quality of the recycled materials and, therefore, a better value on the recycling market.

The largest portion of the materials that can be recycled consists of aluminum (about 60%). A variety of aluminum alloys is used in aircraft. Identifying the different types of aluminum alloys prior to the dismantling operations, by mapping from the OEM’s documentation, allows them to be recycled separately and obtain higher quality end products. The more the material is sorted, the more efficient it is to recycle the different types of alloys separately. Several technologies are available to separate metals (ferrous and non-ferrous) and improve the recycling efficiency. Electronic components, wiring, connectors and titanium components contain metals and other chemical elements with significant value in a market facing material scarcity or supply difficulties due to geopolitical issues and global recycling challenges.

Recommendations from Section 5.3:

It is strongly recommended to:

- Follow the safety recommendations in Section 4.3;
- Consider, as a minimum, the requirements of the AFRA BMP for the dismantling facility;
- Ensure that the dismantling facility has processes in place that prevent suspected unapproved or counterfeit parts from re-entering the aviation market.
c) Non-recyclable materials and polymers as well as composite materials

At the end of the recycling process, the remaining sorted materials will most likely be non-recyclable. For some polymers, textiles or rarely used materials, no commercially available recycling technologies exist. The dismantling/recycling facility must, therefore, find a safe method of disposal for these materials to avoid soil and water contamination. Aircraft owners/operators may want to include contractual provisions with the recycling company in that respect.

The cockpit and cabin interior contain numerous components made of polymers (e.g. plastics, rubber, polyurethane). Although recycling technologies evolve at a steady pace for these materials, they are not yet commercially available on a global scale. Modern aircraft have an increasing share of composite components to reduce their weight and fuel consumption. As available recycling methods are still limited, components of polymers and composite materials are generally sent to landfill or incineration (see Subsection 5.4.1 d).

It should be noted that the cabin interior is replaced several times during an aircraft’s operational life. Considering an average aircraft life span of about 26 years, each aircraft might produce a minimum of about three to four obsolete cabin interiors during its use phase. The mass of a typical single-aisle aircraft interior is about five metric tons, whereas the larger B747 carries about double this mass. Today, the high proportion of composites renders the interior mainly non-recyclable. The same is basically true for the glass fiber insulation material attached to the structure, which is considered to be potentially carcinogenic if produced before 1995.

d) Insights into disassembly for new types of materials

As OEMs use an increasing share of carbon fiber to reduce aircraft weight and reduce emissions, they pursue innovative solutions for composite recycling.

As aircraft manufactured with large volumes of composites will start to be retired in the next few decades, the disassembly industry and the OEMs are actively developing strategies to optimize the reuse and recyclability potential for these aircraft. Cured carbon fiber, partially contaminated with non-ferrous metals, still presents challenges because of manufacturing requirements and technology barriers. However, innovative carbon fiber recycling technologies have been developed recently.

OEMs are engaged in several initiatives to address this challenge, including:

• Seeking to reduce excess material generation upstream through purchasing and operations, then to reuse or recycle the remaining material. For example, Boeing calibrates its procurement and tooling to buy and use only what is needed, and sells remaining uncured material on its surplus sales website at below-market cost.

• Collaborating with business partners to test ways to recover and recycle fibers. Aerospace companies are engaging with several leading technology development entities to help enable a commercially viable carbon fiber recycling industry, testing fiber recovery options through trials, R&D, and commercial ventures.

Technology is evolving rapidly, and the outlook is optimistic that commercial solutions at scale will be available in the coming years. The aircraft owner/operator may want to check the state of recycling technologies for new types of materials, when applicable.

e) Material traceability

One of the challenges in the dismantling process is material traceability once the materials leave the decommissioning site. For safety and environmental reasons, it is important to be able to keep track of the materials and know where their final stage ends in the value chain. Aircraft owner and dismantling company should agree upon the responsibility for material traceability. Environmental best practices should include global recovery rates and avoid waste transboundary movement and shipments in territories with low environmental and safety standards, a phenomenon commonly called “environmental dumping”.
An example of environmental dumping is when electronic components or non-ferrous metals are found outside the country where the decommissioning site is located and subsequently processed in territories where vulnerable populations attempt to remove valuable metals in order to sell them. These populations then risk being exposed to environmental hazards and accidents as well as health hazards (i.e. exposure to toxic waste, such as lead, cadmium, mercury) due to poor environmental and safety regulations.

f) Waste management regulations

Waste regulations and standards exist in numerous countries. An example is the EU Directive on waste (Directive 2008/98/EC) establishing a legal framework for treating waste on its territory with the aim to protect the environment and human health through proper waste management, recovery and recycling techniques to reduce pressure on resources and improve their use.

The European Commission adopted, in 2016, Commission Implementing Regulation (EU) 2016/1245 of 28 July 2016, “an implementing act setting out a preliminary correlation table between customs and waste codes”. This tool is intended to enforce the European Waste Shipment Regulation so that customs officials will be able to identify potential waste streams more easily. The aim is to reduce illegal exports of waste out of the EU.

In that perspective, material traceability is, therefore, related to business ethics and the aircraft owner/operator should include commitment and responsible practices by requesting and evaluating documents from the dismantling company that demonstrate reliable and efficient methods of treatment through sound EMS and material management tools. The dismantling facility’s quality department can ensure that control of the dismantling activities is integrated into a verification system.

From an aircraft owner/operator’s perspective, it is, therefore, recommended to add traceability provisions in the service agreement. They could include the name or the site of the subcontractors involved with the recycler or the dismantling company and the destruction and reclamation report issued to ensure safeguards and transparency of practices.

Traceability is an important part of best practices of the aircraft owner/operator. It is essential that each of the actors involved in the decommissioning process demonstrate best practices in the treatment of materials, especially as stringent aviation industry standards are applicable. As described in Section 6.3, for safety reasons, aviation authorities also have specific provisions regarding traceability of parts to prevent illicit resale of uncertified parts on the spare parts market. To ensure compliance with the provisions, the disassembly and dismantling facilities must provide the necessary documentations that are requested by transport authorities.

Recommendations from Section 5.4:

Best practices recommendations related to environmental aspects during the dismantling process:

- Ensuring that the aircraft is entirely decontaminated prior to dismantling;
- Evaluating and documenting the environmental performance (recycling rates, material traceability, environmental protection measures);
- Ensuring efficient sorting methods to minimize waste generation and increase the market value of the materials (electronics, aluminum, etc.);
- Including contractual provisions to ensure safe methods of disposal for non-recyclable materials to avoid environmental dumping, soil and water contamination;
- Including a provision for material traceability that includes the name and site of subcontractors.

Chapter 6—Parts Re-certification and Distribution

Aircraft parts removed during the disassembly process (Chapter 4) are intended to reenter the aviation market. Depending on their condition, parts may need to undergo additional maintenance and/or recertification depending on the proposed use in the aviation system. Certification requirements such as traceability must be met in accordance with end user regulations. This section provides an overview of the considerations and steps needed to support parts recertification and distribution.

6.1 Economics and Operational Aspects

6.1.1 Supply and Demand

Component supply and demand in the market ultimately governs the component value and the swiftness with which it can be sold. One of the most important factors that contributes to this supply and demand equilibrium is the typical life expectancy of the component itself. If a component needs be replaced often, it will have a higher demand in the market. On the contrary, components that rarely need to be replaced are less likely to sell in the market. This principle can be linked with the maintenance schedule of a component, which can be categorized into three groups:

- Life-limited parts
- Time-controlled components
- Other components

Life-limited parts (LLPs) are components that have a finite period of use determined by operating hours or cycles and such components must be removed from an aircraft and replaced at a certain interval as defined by the approved manufacturer’s maintenance manual and technical approval documents. At the time of such removal and replacement, the component must be disposed of in such a way that it does not reenter the aviation system. At the end of its life, such a component is considered unsalvageable and handled in accordance with local civil aviation regulatory requirements. The limitations on use of such components are usually expressed as a number of flight cycles, flight hours or calendar days. In fixed wing aircraft, most LLPs are found in engines and landing gear. To protect the value of LLPs, a back to birth history should be kept with the appropriate supporting documents in the prescribed form.

Time-controlled components (TCCs) embrace any component for which the maintenance schedule set out in the approved aircraft maintenance program requires the periodic removal for restoration, replacement, or quantitative inspection of a component’s performance (see for example EASA NPA 2014-04 M.A.305 (4)). Formerly, these components were categorized as “Hard Time” components and “Condition Monitoring” components. These components can often be safety critical. These components have a high value and are in demand.

There are other components that do not fall into the two categories listed above, but nonetheless are still valuable. They do not require such detailed maintenance records and they do not have a specific maintenance program assigned to them or required documentation. The tracking of components will vary between operators as it is not a regulatory requirement to track them as thoroughly. These components were previously described as “On Condition” components.

Other important factors that change the supply and demand dynamics of certain components include, but are not limited to:

- Commonality across aircraft types. Components from an old type of aircraft that could be used on a newer type of aircraft will be in demand, especially when the newer aircraft is still in an early stage of its life cycle.
- Regulatory requirements, such as airworthiness directives (ADs), modifications and upgrades, which could be urgent and costly. Affected components need to be modified or replaced. In either case, the demand for these components would be driven up in the market.
6.1.2 High-value Components

From a part-out company's perspective, the part-out value of an aircraft is the sum of the value of its individual components minus the cost incurred during the decommissioning process, including the cost of disassembly, dismantling, recycling, parts repair, recertification, and distribution. As a rough rule of thumb, about 90% of the total end-of-life aircraft value is generated by parts that can be reused as certified components. The value of recyclable materials amounts to only 10% of the aircraft value, although representing 50% to 60% of the aircraft weight. HAZMAT and other waste components typically have negative value due to their high disposal cost. See Figure 17 for an overview.

![Value chain for an aircraft dismantling project](image)

The value of the individual components is determined by the supply and demand in the market and part-out companies will often identify the high-value components by investigating the market value of the components via various online portals. A selection of the main parts trading portal providers, taken from a literature source, is listed in Table 4 below.
Subject to the aircraft type and the condition and maintenance status of the components, the value of the components varies. The general indication is that engines normally account for the largest portion of the value of a part-out aircraft, which makes it an important factor in the decision for the disassembly of an aircraft.

The part-out value of an engine depends on many factors, such as the engine type, the engine time since last performance restoration/overhaul (TSLO) and the remaining cycles on LLPs. Additionally, the engine condition, especially of high-cost parts, such as fan blades, high-pressure compressor (HPC) blades and vanes, combustion chambers (CC), high-pressure turbine (HPT) blades and vanes, will also affect the value.

Example from Magnetic MRO:

Generally, high-value components can be identified as those that individually would make up more than 1% of the total value of an end-of-life aircraft. In this case, our approach is to consider components with a market value of more than 20k USD (in ‘as removal’ condition) as high-value parts. Such evaluation is based on market analysis and previous experience.

Additionally, for components that have a market value of over 10k USD, the approach taken is to act as a mediator between repair shops and potential customers. It might be beneficial to first restore the condition of components before proceeding with further marketing.

Online platforms that can help to perform market analysis:

ILS (www.ilsmart.com)

PartsBase (www.partsbase.com)

145 (www.the145.com)

Table 4: Selection of main parts trading online portal providers

<table>
<thead>
<tr>
<th>Portal</th>
<th>Website address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobay</td>
<td><a href="http://www.aero-bay.com">www.aero-bay.com</a></td>
</tr>
<tr>
<td>Aeroexchange</td>
<td><a href="http://www.aeroexchange.com">www.aeroexchange.com</a></td>
</tr>
<tr>
<td>AOGsmart</td>
<td><a href="http://www.aogsmart.com">www.aogsmart.com</a></td>
</tr>
<tr>
<td>Aviation Mar</td>
<td><a href="http://www.aviationmart.com">www.aviationmart.com</a></td>
</tr>
<tr>
<td>ePlane</td>
<td><a href="http://www.eplane.com">www.eplane.com</a></td>
</tr>
<tr>
<td>ILSmart</td>
<td><a href="http://www.ilsmart.com">www.ilsmart.com</a></td>
</tr>
<tr>
<td>Locatory.com</td>
<td><a href="http://www.locatory.com">www.locatory.com</a></td>
</tr>
<tr>
<td>OneAeroMRO</td>
<td><a href="http://www.oneaero-mro.com">www.oneaero-mro.com</a></td>
</tr>
<tr>
<td>PartsBase</td>
<td><a href="http://www.partsbase.com">www.partsbase.com</a></td>
</tr>
<tr>
<td>StockMarket.aero</td>
<td><a href="http://www.stockmarket.aero">www.stockmarket.aero</a></td>
</tr>
<tr>
<td>145</td>
<td><a href="http://www.the145.com">www.the145.com</a></td>
</tr>
<tr>
<td>PartPilot</td>
<td>partpilot.com</td>
</tr>
</tbody>
</table>
It is noteworthy that engines have a relatively stable value over time, whereas the value of the entire aircraft continuously decreases with aircraft age. See Figure 18 for a comparison of the value of the Boeing 737-800 over time with the CFM56-7B engine used for that aircraft type.

In addition to the engines, the landing gear, APU, electrical power units (e.g. generators), flight controls and navigation systems are commonly high-value components compared to the rest. Together, they can make up about 70% of the value of the airframe, excluding the engines (see Figure 19).
High value components examples from Magnetic MRO:

- Engines (comprising 70-80% of end-of-life aircraft total marketing price by leasing companies)
- Landing gear
- APU
- Avionics
- Thrust Reverser Assemblies
- THSA (Trimmable Horizontal Stabilizer)
- Stabilizer Jackscrew and Gearbox – B737s
- Wheels/Brakes
- Flap Carriages for 737 Classic
- Escape Slides
- Flap Tracks (in Overhauled condition with good calendar and flight cycle remaining life)

Typical reasons influencing the value of components are its remaining life per applicable ADs, repetitive overhaul/restoration requirements or LLP discard requirements. One important item for a trustworthy recertification of components is that relevant maintenance records are available from the maintenance organization that has performed prior repairs/overhauls. For LLPs, all relevant maintenance records are normally required (often called track-to-birth traceability in the industry) and for other components, only the most recent overhaul/shop visit records should be requested.

Other factors contributing to the value of components are the previous operator’s operational environment, quality standards and the availability of full back-to-birth traceability data for LLPs. LLP back-to-birth traceability has become an important commercial aspect that can potentially significantly influence the market value of the LLP (e.g. missing LLP historical non-incident/accident statements coverage will provide a potential buyer with an ideal opportunity to ask for a price reduction).

Example from Lufthansa Technik:

Until about 15 years ago, nearly all retiring aircraft of the Lufthansa fleet were sold to another operator. When Lufthansa started to phase out the 737 Classic, the first batch was sold to other operators. Later, Lufthansa started to sell the aircraft to Lufthansa Technik Component Service (LTCS) in Tulsa, Oklahoma, which had extended its capability to the decommissioning of aircraft.

In our LTCS facility, the aircraft are disassembled and dismantled. Components like engines, landing gear, wheels and brakes, pneumatics, hydraulics, avionics, emergency equipment as well as mechanical and structural components like slats, flaps, etc. are removed from the aircraft. Where Lufthansa Technik has not become the owner of the aircraft, the components are inventoried, packaged and shipped. The customer also has the option to have selected units tested/repaired, modified and recertified.

When Lufthansa Technik has become the owner of the aircraft, all components that are not beyond economic repair are repaired/overhauled or modified and recertified by LTCS or one of the other Lufthansa Technik Workshops depending on their capability and capacity. These overhauled and recertified components are stored in our warehouse from which we service more than 150 operators around the world.
Depending on supply and demand, some components sell faster than the others and these are called fast-movers in the industry. Parts with opposite trends are slow-movers. Most of the revenue of a part-out project is generated in the short-term by fast-movers after the completion of the disassembly and dismantling project. Components with few or no quote histories, or those with excessive stock, are regarded as slow-movers. Part-out companies typically will assign zero value to these components and will only invest in them on request. After a certain period, the excessive inventory is likely to be discarded.

### 6.1.3 Fast and Slow Movers

<table>
<thead>
<tr>
<th>Component</th>
<th>% of the total airframe components value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landing gears</td>
<td>22%</td>
</tr>
<tr>
<td>Flight Management and guidance computers</td>
<td>10%</td>
</tr>
<tr>
<td>Slides</td>
<td>8%</td>
</tr>
<tr>
<td>Wheels and brakes</td>
<td>7%</td>
</tr>
<tr>
<td>Air traffic service unit</td>
<td>4%</td>
</tr>
<tr>
<td>APU generator</td>
<td>3%</td>
</tr>
<tr>
<td>APU</td>
<td>2%</td>
</tr>
<tr>
<td>TOTAL</td>
<td><strong>56%</strong></td>
</tr>
</tbody>
</table>

Table 5: Approximate value of subassemblies

**Case study from an anonymous part-out company:**

Below is a list of the top seven high-value components extracted from two narrow body airframe part-out projects at the end of 2016. Note that the component value is highly dependent on its condition, which varies case by case.
Example from Magnetic MRO:
We consider fast-movers to be components and parts with constantly high demand in the market, which can usually be sold during the first two quarters (short-term) after aircraft disassembly. High demand is dictated by the market and aircraft part brokers based on the general aircraft-type fleet mean time between removal (MTBR), who are ready to purchase such components in ‘As Removal’ condition, later restore their serviceability in repair shops and proceed with selling components on the market (gaining additional margin in value and thus profit from such transactions). In relation to fast-movers, MTBR is highly applicable, as AD/ Repetitive Overhaul or Restoration/LLP Discard dictated removals or accidental unscheduled replacements are considered. This provides a constant demand for parts on the market.

The recommendation of our company, based on previous experience, is to add one additional category of parts to reflect their supply and demand. It could be named ‘mid-movers’. Generally, the salability of such parts can be well anticipated, but major sales activities (parts moving from the hands of a teardown organization to those of parts-selling companies) will happen during Q3 through Q8 post end-of-life aircraft disassembly. From our organization’s standpoint, it provides better revenue estimations and sales forecast not to categorize parts only into two categories (fast/slow). In the case of mid-movers, demand can be predicted, but it is not acute in nature and is influenced purely by mean time between unscheduled removals (MTBUR). Replacements of this kind do occur constantly, but there is generally a stock of such parts available on the market. A one-in one-out philosophy utilized by brokers will mean that parts brokers will seek such parts only after they sell one in possession.

Slow-movers are parts not in high demand in the market. Occasional sales on request post Q9 following aircraft disassembly.

6.1.4 Original Equipment Manufacturer Policies
OEMs are in a unique position to understand how both the design/manufacture and the effects of ageing impact the operation and ownership of commercial aircraft. In addition, OEMs have resources that are dedicated to managing the complete aircraft life cycle, including end-of-life. This experience and expertise translates into the ability to provide aircraft transition and retirement services efficiently and effectively.
**Case study from an anonymous part-out company:**

Figure 20 gives an example of the sales of two narrow body aircraft part-out projects combined. In the first two years, approximately 70% of the total sale revenue had already accumulated. The remaining 30% was spread out over a span of 3.5 years.

**Example from Boeing:**

Boeing Global Services, a division of The Boeing Company, has a range of capabilities that support the decommissioning of commercial airplanes. This includes the full teardown and parting out of airplanes enabling Boeing to process and deliver OEM-certified new and serviceable parts to the aftermarket that reduce customer maintenance costs while maintaining OEM reliability and warranty standards.

As a tailored life cycle solution, Boeing Global Fleet Care enables airlines, operators and lessors to simplify their fleet operations through customizable maintenance and reliability programs. Fleet Care can integrate parts, engineering and maintenance/MRO requirements to support customer-defined service-level commitments through regional Boeing technical operations centers and the affiliated Fleet Care MRO network. In support of our customers’ maintenance requirements, Boeing uses various levers to reduce customer costs, such as OEM-certified exchange programs, serviceable materials, modification programs and optimized maintenance programs.

**Recommendations from Section 6.1:**

It is recommended to:

- Identify high-value components (e.g. via online parts trading portals) to manage the revenue expectation of the decommissioning project.

- Distinguish the fast-movers, mid-movers and slow-movers based on MTBR and company experiences to forecast the future revenue flow.
6.2 Regulatory and Legal Aspects

6.2.1 Airworthiness Certification

When an aircraft component that is removed from a decommissioned aircraft is meant to be returned to the active aviation fleet, this needs to be done in accordance with the applicable airworthiness standards. The country of registration of the aircraft on which it is to be installed determines the applicable standards for airworthiness. When a component is removed from an aircraft, however, it is often unknown on which aircraft it will be installed in the future. To maximize the remarketing opportunities for components, it is important to know which states recognize each other’s airworthiness standards.

Through the Chicago Convention and the work of ICAO airworthiness, standardization has been achieved to some extent. The four aviation authorities in the major Western commercial aircraft manufacturing countries (FAA, EASA, Transport Canada and ANAC Brazil) have jointly developed an airworthiness form that is recognized by each other under certain conditions. This form, for which the generic term is Authorized Release Certificate (ARC), is alternatively known as:

- Form 1 (EASA)
- Form 8130-3 (FAA)
- Canadian Form 1 (Canada), formerly known as TCCA 24-0078
- SEGVOO 003 (Brazil)

The level of recognition of these forms between these four aviation authorities is laid down in the various bilateral agreements between them. Generally, if a maintenance organization residing in any of these jurisdictions has an approval issued by two of these four jurisdictions, it may issue a dual release, which means that a component may be transferred between these two jurisdictions without further certification.

Many other jurisdictions accept some or all of the above ARCs without further certification.

If a component is to be installed in an aircraft registered in a country that does not recognize the available airworthiness certificate of the component, it has to be recertified according to the airworthiness standards of that country in an approved maintenance organization (according to EASA Part 145, 14 CFR 15, or equivalent) that is authorized to inspect and certify the part or component as airworthy.

The following two sub-sections show examples of export airworthiness approvals, a generic approval process by FAA and an approval process by EASA based on a bilateral agreement.

6.2.2 FAA Export Airworthiness Approval Process

It is possible to get an export airworthiness approval for a complete aircraft (new or used), new aircraft engine, propeller or article that is planned to be exported by way of an Export C of A.

For an aircraft, the exporter or its authorized representative submits FAA Form 8130-1, Application for Export Certificate of Airworthiness, to the local FAA Flight Standards District Office having geographical responsibility for the applicant’s geographical area or the nearest international field office.

- FAA Form 8130-4, Export Certificate of Airworthiness, is issued for complete aircraft, but does not authorize operation of an aircraft.

For aircraft engines, propellers and articles, there is no FAA application form designated for requesting export airworthiness approvals. A product manufacturer may apply orally, or by other means, to a designated representative of the Administrator who is authorized to issue such approvals.

- FAA Form 8130-3, Authorized Release Certificate, Airworthiness Approval Tag, is issued for engines, propellers, and articles.

\(^{71}\) Please do not confuse with the Airworthiness Review Certificate, which uses the same acronym (ARC).
6.2.3 EASA Export Certificate of Airworthiness

On 15 March 2011, the EU and the US concluded an agreement on cooperation in the regulation of civil aviation safety. This agreement entered into force on 1 May 2011.

The purpose of the agreement is to enable the reciprocal acceptance of findings of compliance and approvals, promote a high degree of safety in air transport and ensure regulatory cooperation and harmonization between the US and the EU regarding airworthiness approvals and monitoring of civil aeronautical products, environmental testing and approvals of such products, and approvals and monitoring of maintenance facilities.

According to the agreement, after 1 May 2011, each new aircraft exported to the US with an airworthiness approval issued by a Competent Authority of an EU Member State, or EASA, shall be accompanied by an EASA Export Certificate of Airworthiness called EASA Form 27. In addition, each used aircraft exported from an EU Member State to the US shall have an EASA Export Certificate of Airworthiness (EASA Form 27).

Following a request from the National Aviation Authorities (NAAs) of the EU Member States on the applicability of this agreement, EASA has started coordination with FAA to agree on a transition period.

In the meantime, to permit NAAs to adapt procedures and tools, FAA has agreed to accept the current National Export Certificates of Airworthiness for aircraft until an agreed date.

6.2.4 Reuse of Standard Parts

According to current regulation (EASA Part 21, Part M and Part 145, FAA 8130), a new or overhauled part or component needs documentation (EASA Form 1, FAA 8130-3) to certify that the part or component is eligible for installation in an airplane or engine by an approved maintenance organization. Only parts manufactured according to a common industrial standard are exempted from this regulation.

Following requests by OEMs, airlines and maintenance organizations, EASA issued NPA 2017-19, which proposes new or changed regulations in Part 21, Part M and Part 145. NPA 2017-19 opens the possibility to install parts and components of a low criticality level without a Form 1, only with a Certificate of Conformity (CoC) issued by an organization/company without an aviation approval. Details are currently being defined. It is planned that these regulations will come into force at the end of 2019.

Recommendations from Section 6.2:

It is recommended to:

- Identify and follow the applicable airworthiness regulations for components depending on the aircraft they are to be installed in.

- Verify the existing bilateral agreements and other arrangements between countries to develop markets and facilitate more efficient components distribution.

- Ensure that all parts of a decommissioned aircraft, which are intended to be returned to the active aviation fleet, are inspected and certified by an authorized maintenance organization.
6.3 Safety Aspects

6.3.1 Uncertified Components/Bogus Parts

Disassembled engines and parts need to be inspected and formally released before further use. The handling of the LLPs and engines needs to be tracked to ensure their continued airworthiness. All practicable steps must be taken by the parties involved in the disassembly and in the dismantling process to ensure that neither suspected unapproved parts (SUP) nor counterfeit parts enter the market. This includes aircraft owners who may still have an ownership right on the parts until they are sold. This subsection aims to provide information about circumstances that could indicate the risk of SUPs and counterfeit parts. Recommendations for risk mitigation are also given. See also the indications on parts management in Subsections 4.3.2 and 4.3.3 for the disassembly process and in Subsection 5.3.3 for the dismantling process.

Despite the existing rigorous system of inspections, there are numerous sources of parts that do not meet applicable requirements, but still enter the aviation system. Collectively, these parts are colloquially referred to as unapproved parts and, similarly, approved parts is the colloquial term for parts that do meet all applicable requirements.

Counterfeit parts, which are a type of unapproved part, may be new parts that are deliberately misrepresented as designed and produced under an approved system or other acceptable method even though they were not so designed and produced. Counterfeit parts may also be used parts that, although produced under an approved system, have reached a design life limit or have been damaged beyond possible repair for aviation standards, but are altered and deliberately misrepresented as acceptable, with the intent to mislead or defraud.\(^\text{72}\)

To prevent parts taken from decommissioned aircraft that have lost their certification from re-entering the aircraft spare parts market, it is recommended to sell them only to reliable parts distributors.

As best practice, the FAA developed and published an Advisory Circular (FAA AC 00-56 Accredited Companies\(^\text{73}\)), which establishes a civil aircraft parts accreditation system. This advisory circular (AC) describes a system for the accreditation of civil aircraft parts distributors based on voluntary industry oversight and provides information that may be used for developing accreditation programs. The FAA strongly endorses participation of parts distributors in such a program to improve the ability of certified persons to establish the eligibility of parts and components for installation on type-certificated products.

Parts traders selling SUPs or even counterfeit parts present a high risk to the safety of aviation and these activities are strictly prohibited.

\begin{itemize}
  \item a) Suspected unapproved parts
  \item b) Counterfeit parts
\end{itemize}

Reasons for suspecting that an aircraft part is not approved for use on a type-certificated product may include a different finish, size, color, improper (or lack of) identification, incomplete or altered paperwork, or any other unusual or abnormal characteristic.

A few examples of indications that a part may be counterfeit are given below. These are commonly known in the aviation industry and are intended to help to identify potential suspected or counterfeit parts\(^\text{74}\).

\begin{itemize}
  \item The required or offered price is considerably lower than that of other suppliers.
  \item The delivery time is considerably shorter than that of the other suppliers, even though there is known to be a shortage of stock.
  \item The supplier is unable to provide drawings, specifications, repair manuals, or more detailed information on the parts that are maintained, that meet the applicable requirements.
\end{itemize}

\(^{72}\) FAA, Suspected 'Unapproved Parts' Program Plan, October 6, 1995

\(^{73}\) The FAA released FAAAC 00-56B – “Voluntary Industry Distributor Accreditation Program” on May 27, 2015 with an effective date of August 27, 2015. Any audit conducted after August 27, 2015 must be conducted to revision B.

\(^{74}\) LBA, Luftfahrtbundesamt B3120103.K, Rundschreiben Nr. 18-01/03-2, Braunschweig, 12.05.2003
• The supplier or maintenance company is not able to obtain official approval of the maintenance organization or the release certificate for the part.

• The buyer has the impression from the supplier that a very large quantity of parts is available.

• The payment method is unusual. For example, there is an unusual account or the supplier requires cash payment.

The incoming inspection should include:

• A visual inspection to determine whether there is the name of another manufacturer on the packaging or the part is not marked, or it is damaged.

• A comparison between the purchase order and the delivery note with regards to the exact part number and the manufacturing operation card\textsuperscript{75} of the part.

• A check for proper identification of the part (e.g. changed serial number, attached label is dirty, damaged or missing, engraving or serial numbers are located in unusual positions).

• A visual inspection for altered or unusual surfaces (e.g. absence of necessary surface protection, signs of previous use, scratches, old paint overpainted, attempted external repairs, corrosion).

• A control plan for the random examination of standard parts that are delivered in relatively large quantities in a common packaging.

• A check of the enclosed documentation. This must allow the complete tracking of the path of the part back to the manufacturer.

• A check for over-stamping of the part or serial numbers as indications of manipulation of the documentation.

It is expected that the new digital era will significantly transform the traceability of each aircraft and its components. IATA’s Paperless Aircraft Operations initiative (for more information: www.iata.org/pao) is pioneering improvements in aircraft and parts tracking. The initial aircraft parts list should be available electronically from the OEM and inserted in the operator’s Maintenance Information System (MIS). The operator should be able to ascertain the configuration of the aircraft and its parts at any time. Therefore, at the time of decommissioning, all the records of the parts on the aircraft will be available along with their status. Digitalization will improve the efficiency and integrity of the current processes and maintain the value of parts at their highest level.

\textsuperscript{75} A documentation of the production process of the part, also called manufacturing job card
Case Study

If Airline B purchases parts from Aircraft Owner A's decommissioned aircraft, what liability could arise from Airline B's use of such parts?

The safety regulatory system relating to the maintenance and operation of aircraft prescribes safety systems - standards, reporting requirements, technical specifications, obligations on engineers and operators - to ensure that the components used on aircraft are safe. Airline operators, licenced aircraft maintenance engineers, maintenance facilities and other civil aviation participants have duties to ensure the components that are used on aircraft deployed for air transport operations meet the internationally accepted airworthiness standards set out Annex 8 of the Chicago Convention and adopted into national law.

The components removed from Aircraft Owner A's decommissioned aircraft will have documentation necessary to establish their history, traceability and conformity with design. Accordingly, Airline B will need to ensure that any aircraft components purchased from Aircraft Owner A meet all applicable airworthiness requirements, or otherwise are sent to a repair station and restored and certified for airworthiness and have the required certification documents and log books.

It is important that the chain of documents for Aircraft Owner A's decommissioned aircraft and its components, right back to the appropriate national aviation authority, is maintained and demonstrated to Airline B before purchasing the parts. Factors that may disrupt the chain include:

- Deregistration of the aircraft and absence of a responsible civil aviation regulator to provide the necessary oversight.
- Improper storage of the parts.
- Failure to have the appropriately certificated engineer or maintenance facility complete the necessary documentation to remove the components from the aircraft and/or certify them before returning them to service.

Recommendations from Section 6.3:

To avoid parts taken from decommissioned aircraft re-entering the aviation parts market as suspected unapproved parts or counterfeit parts, it is recommended to:

- Thoroughly inspect disassembled engines and parts before being released for further use, using competent, well-trained and experienced engineers;
- Track the handling of these parts and engines to ensure their continued airworthiness;
- Sell parts only to reliable parts distributors.
6.4 Environmental Aspects

From both an environmental and a sustainable aviation industry perspective, parts recovery, distribution and recertification is a step that helps to reduce the carbon and resources footprint of aircraft and engine manufacturing significantly. It both minimizes waste and reduces the need for additional raw materials for new manufacture (as parts are reused within the industry).

The end-of-life management of aircraft includes having to deal with large structures containing HAZMAT, including oils, fuels and even radioactive components. Parts removed from an aircraft for resale can be contaminated, so it is essential that procedures are in place and information provided to purchasers to ensure that they are safely placed back into the market. This requires the use of a robust environmental management system to ensure that both the environment and employees are adequately protected. The ISO standard 14001 provides a framework to deliver such a system.

The transport of removed components and parts for reuse also causes a certain environmental impact, mainly in terms of GHG emissions. While only rough estimates of this effect are currently available, they show this contribution to be small. Thus, as stated above, the overall environmental impact of the reuse of parts is, in most cases, significantly lower than that of new manufacture. Further life cycle analysis could help in improving the understanding of the environmental impacts and their significance.
Appendix

Appendix A – IATA Incident/Accident Clearance Statement

(ON COMPANY LETTERHEAD)

Date

Incident/Accident Clearance Statement

To Whom It May Concern:

Aircraft [enter registration], details of which are specified below, has been operated by [insert company name] during the period from [enter delivery date] to [enter redelivery date]. The aircraft has a valid Certificate of Airworthiness from [insert country of registration] as of the date of this statement.

Configuration details as of date of this statement:

<table>
<thead>
<tr>
<th>Description</th>
<th>Type/Part No.</th>
<th>Serial No.</th>
<th>TSN</th>
<th>CSN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propeller</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Propeller</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

I hereby certify that, to the best of my knowledge, during the period stated above:

1. Neither the aircraft, nor any part installed have been;
   a. damaged during, or identified as the root cause of, a reportable incident or accident as defined by Annex 13 to the Chicago Convention, or
   b. subjected to severe stress or heat (such as in a major engine failure, accident, or fire) or has been submersed in salt water,

unless its airworthiness status was re-established by an approved maintenance organization in accordance with the applicable airworthiness regulations and instructions of the

- type certificate holder
- or an approved design organization
- and/or supplemental type certificate holder
- and/or OEM of the part,

and supported by an authorized airworthiness release certificate.

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76 Aircraft: [https://www.iata.org/whatwedo/workgroups/Documents/ALAG/ac-ics-w-guidelines.pdf](https://www.iata.org/whatwedo/workgroups/Documents/ALAG/ac-ics-w-guidelines.pdf)
2. No part has been installed on the aircraft, which was obtained from a military source or was previously fitted to a state aircraft as deemed by Article 3 of the Chicago Convention.

Authorized Airline Representative

Signature: ______________________

Name: ______________________

Position: ______________________
Appendix B – Examples of dangerous and hazardous materials to be removed and treated from aircraft

- Asbestos
- Chemical oxygen generator assembly
- Contaminated absorbent (oil and fuel)
- Coolant with fluorocarbon
- Depleted uranium (ballast weights in aircraft manufactured until the early 1980s)
- Engine/turbine oil
- Fire extinguisher (bromotrifluoromethane, halon 1301, carbon dioxide)
- Fuel
- Glycol-based deicer
- Hydraulic oil
- Hydraulic oil filters
- Lead-acid batteries
- Lithium batteries fitted to cockpit voice recorder (CVR) and flight data recorder (FDR)
- Material containing mercury (e.g. fluorescent tubes, beacon anti-collision lights, other types of lamps, breaking system, suspension system, safety sensors)
- Nickel-cadmium batteries
- Nitrogen cylinders
- Organic solvent
- Oxygen cylinders
- Oxygen masks
- Rain repellent fluid system
- Escape slide and raft
- Squib
- Tires
- Underwater locator beacon (ULB)
- Wastewater

<table>
<thead>
<tr>
<th>Fuel oil and diesel</th>
<th>130701*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brake fluids</td>
<td>160113*</td>
</tr>
<tr>
<td>Antifreeze fluids</td>
<td>160114*/15</td>
</tr>
<tr>
<td>Oil filters</td>
<td>160107*</td>
</tr>
<tr>
<td>Synthetic hydraulic oils</td>
<td>130111*</td>
</tr>
<tr>
<td>Mineral-based non-chlorinated engine, gear and lubricating oils</td>
<td>130205*</td>
</tr>
<tr>
<td>Petrol</td>
<td>130702*</td>
</tr>
<tr>
<td>Aqueous liquid wastes (feces)</td>
<td>161002*</td>
</tr>
</tbody>
</table>

Table B-1: Hazardous fluids contained in an aircraft and their European waste codes

(*: record of waste disposal required in the EU)
<table>
<thead>
<tr>
<th>Hazardous Non-liquids</th>
<th>European Waste Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explosive components (fire extinguisher bottles, escape slide bottles)</td>
<td>160110*</td>
</tr>
<tr>
<td>Components containing PCB (capacitors, sealants)</td>
<td>160109*</td>
</tr>
<tr>
<td>Brake pads containing asbestos</td>
<td>160111*/12</td>
</tr>
<tr>
<td>Components containing mercury (fluorescent lamps)</td>
<td>160108*</td>
</tr>
<tr>
<td>Insulation materials containing hazardous substances (mineral/glass fiber produced until about 1995)</td>
<td>170603*</td>
</tr>
<tr>
<td>Chlorofluorocarbons (CFC), Hydrochlorofluorocarbons (HCFC), Hydrofluorocarbons (HFC)</td>
<td>140601*</td>
</tr>
<tr>
<td>Oxygen generators</td>
<td>160507*</td>
</tr>
<tr>
<td>Lead batteries</td>
<td>160601*</td>
</tr>
<tr>
<td>Ni-Cd batteries</td>
<td>160602*</td>
</tr>
<tr>
<td>Gases in pressure containers (halon, fire extinguishers)</td>
<td>160504*</td>
</tr>
<tr>
<td>Absorbents, filter material (cabin air filters)</td>
<td>150202*</td>
</tr>
<tr>
<td>Smoke detectors</td>
<td>Atomic Energy Acts of individual States</td>
</tr>
<tr>
<td>Fluorescent signs</td>
<td>Atomic Energy Acts of individual States</td>
</tr>
<tr>
<td>Depleted uranium ballast weights</td>
<td>Atomic Energy Acts of individual States</td>
</tr>
<tr>
<td>(aircraft manufactured until the early 1980s)</td>
<td></td>
</tr>
</tbody>
</table>

Table B-2: Hazardous non-liquids in an aircraft and their European waste codes
(*: record of waste disposal required in the EU)
Appendix C – Framework for managing hazardous waste materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Estimated quantity for the aircraft model</th>
<th>Location on the aircraft</th>
<th>Storage equipment (metal barrels, plastic barrels, tanks, etc.)</th>
<th>Storage location once the HAZMAT is removed from the aircraft</th>
<th>Method of disposal</th>
</tr>
</thead>
</table>
## Appendix D – ICAO Member States that may have aircraft age restrictions for importation of aircraft

<table>
<thead>
<tr>
<th>State</th>
<th>Type of Restriction</th>
<th>Age Restriction [years]</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bolivia</td>
<td>Importation</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Congo</td>
<td>Importation</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Ecuador</td>
<td>Importation</td>
<td>manufactured after 1990</td>
<td></td>
</tr>
<tr>
<td>Egypt</td>
<td>Importation</td>
<td>17*</td>
<td>20* 10 years for passenger aircraft with a MTOW below 5700 kg</td>
</tr>
<tr>
<td>Ethiopia</td>
<td>Importation</td>
<td>22</td>
<td>25</td>
</tr>
<tr>
<td>India</td>
<td>Importation</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Indonesia</td>
<td>Importation</td>
<td>15</td>
<td>30 20 years for other than transport category passenger aircraft and all category helicopters</td>
</tr>
<tr>
<td></td>
<td>Operation</td>
<td>35</td>
<td>45 45 years for other than transport and category passenger aircraft and all category helicopters</td>
</tr>
<tr>
<td>Jordan</td>
<td>Importation</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>Kyrgyzstan (Kyrgyz Republic)</td>
<td>Importation</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operation</td>
<td>40</td>
<td>except aircraft Yak-40, register No. EX-00007</td>
</tr>
<tr>
<td>Lebanon</td>
<td>Importation</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Mongolia</td>
<td>Importation</td>
<td>15</td>
<td>for passenger aircraft in service must be no older than 20 years after 2020</td>
</tr>
<tr>
<td>Turkey</td>
<td>Importation</td>
<td>15</td>
<td>25</td>
</tr>
<tr>
<td>United Arab Emirates</td>
<td>Importation</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>

The following States and Territories confirm having no age-related import restrictions:

- Kingdom of Bahrain
- Macao, China
- Japan
- Brazil
- Colombia
- Mauritania
- China
- Côte d’Ivoire
- Mexico
- Hong Kong, China
- Ghana
- Uruguay

Source: Replies to ICAO State letter AN 3/3.1- IND/17/15, sent to 43 States
Acknowledgements

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