# Towards Sustainable Management of IoT Cargo Devices

Guidance Document

# Contents

# 1. Executive summary

The airfreight industry is witnessing a significant increase in the use of Internet of Things (IoT) devices, driven by the exponential growth in e-commerce and the need for real-time tracking of specialized cargo. These IoT devices, including data loggers, temperature control devices, and GPS trackers, provide comprehensive visibility and instant updates about shipments, fulfilling the demands of online retailers, consumers, and producers of perishable goods and pharmaceuticals.

Adopting these devices has led to more transparent and efficient operations, particularly in minimizing the loss of perishable and pharmaceutical goods. This aligns with the UN Sustainable Development Goals 12.3, which aims to reduce food waste, and 3.8 and 3.b, which aim to provide access to safe, adequate, quality, and affordable vaccines and medication.

However, the rapid proliferation of these devices presents an environmental challenge, especially during their end-of-life stage if not appropriately managed. In 2022, the world generated 62 million tonnes of e-waste, a figure projected to reach 82 million tonnes annually by 2030[1]. Small IT and telecommunication equipment, the category under which IoT devices are used for cargo interactivity, contributes an estimated 4.6 billion kg per year to this total, or 7.4%. Only 22% of this e-waste is formally collected and recycled.

This guidance document addresses this pressing issue by providing manufacturers and stakeholders in the air cargo industry with comprehensive information on the proper end-of-life management of these devices. It also offers a clear set of recommendations to ensure environmentally responsible practices in the industry. In particular, this document includes recommendations for:

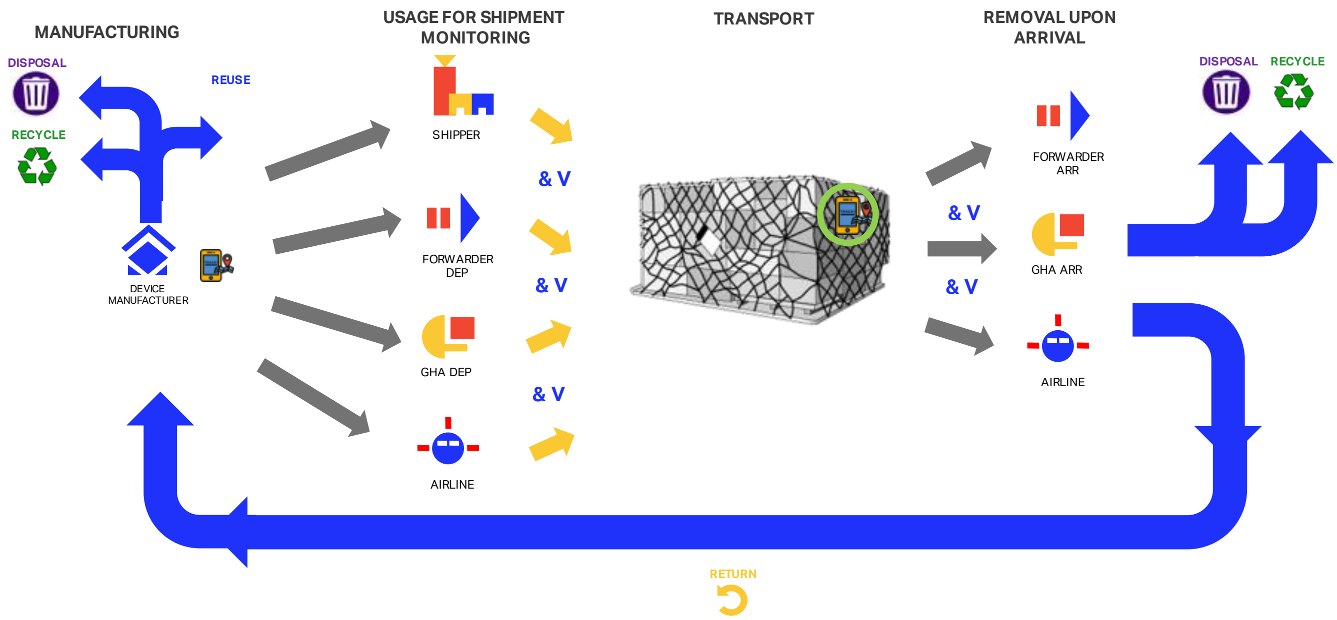
- Reducing waste at source
- Commission LCAs for decision-making
- Efficient returns for device refurbishment and recycling
- Accelerating the transition to circular models
- Enhancing awareness about device recycling processes
- Adequate disposal of spare parts and batteries
- Collaborative approaches for device recycling

[1] **Global e-Waste Monitor 2024**

## 2. Scope and framework

This guidance aims to assist air cargo industry stakeholders in establishing more sustainable processes for Internet of Things (IoT) devices used in air cargo and their parts by fostering reutilization, recycling, and adequate disposal of these devices. It covers the entire life cycle of the device, focusing on its end-of-life.

Figure 1 - Simplified IoT Device Lifecycle



# 3. Types of devices

## 3.1. Single-use device

A tracking or monitoring device or data logger with a non-rechargeable battery intended to be used once. The device/data logger user needs to turn on the device/data logger using the power button. Battery life can differ significantly between devices, depending on battery type and use case. Following use, the devices can be disposed of or returned to the manufacturer for renewal or proper disposal, following manufacturer instructions.

## 3.2. Multi-use device

A tracking or monitoring device or data logger with a rechargeable or non-rechargeable battery is intended to be used multiple times. The user can reuse the device/data logger several times. Battery life can differ significantly between devices, depending on battery type and use case. Following the last use, the devices shall be returned to the manufacturer for renewal or proper disposal, following manufacturer instructions.

**MORE THAN 50% OF DEVICES MANUFACTURED ARE DESIGNED FOR MULTIPLE USE**

**Box 1: Benefits and drawbacks of the different device types**

| | Single-use device | Multi-use device |
|---|---|---|
| **Benefits** | ▪ Limited device management<br>▪ No reverse logistics that can incur additional costs<br>▪ Does not require charging | ▪ Usually rechargeable battery<br>▪ Easy to reuse and reallocate<br>▪ Lower e-waste generated by recycling<br>▪ Pricing models may make them financially beneficial |
| **Drawbacks** | ▪ No rechargeable battery<br>▪ Non-reusable<br>▪ Generate non-recyclable e-waste | ▪ Difficulty of reverse logistics due to high costs and customs procedures |

The above table emphasizes the differences between single-use and multi-use devices. Similar characteristics, such as multiple sensors enabling monitoring of several aspects of the shipment or ease of use, are not listed among the benefits.

# 4. Regulatory landscape

A variety of international, regional, national, and local legislation covers the end-of-life of electrical and electronic equipment. These regulations affect e-waste, used electronics destined for refurbishment, reuse, resale, or recycling through material recovery or disposal.

## 4.1. International and Regional Agreements

A broad set of international agreements affect the management and control of e-waste, including the chemicals, ozone-depleting substances, persistent organic pollutants, mercury, and other hazardous wastes that may be contained in these devices or generated during their manufacturing, use, and end-of-life.

### THE BASEL CONVENTION

The Conference of Plenipotentiaries in Basel adopted the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal on 22 March 1989. The overarching objective of the Basel Convention is to protect human health and the environment against the adverse effects of hazardous wastes. Its scope of application covers a wide range of wastes defined as "hazardous wastes" based on their origin and/or composition and their characteristics, as well as two types of wastes defined as "other wastes" - household waste and incinerator ash.

The provisions of the Convention focus on the following principal aims:

- the reduction of hazardous waste generation and the promotion of environmentally sound management of hazardous wastes, wherever the place of disposal;
- the restriction of transboundary movements of hazardous wastes except where it is perceived to be in accordance with the principles of environmentally sound management; and
- a regulatory system applying to cases where transboundary movements are permissible.

In addition to the Basel Convention, regional conventions also exist, such as the Bamako Convention and the Waigani Convention. These regional conventions have arisen in response to the Basel Convention and aim to further restrict the movement of hazardous wastes, including e-waste, in African and South Pacific countries, respectively.

Figure 2 - e-Waste Regulations Global Map 2024[2]

## EUROPEAN UNION

The European Union has specific objectives to prevent the creation of Waste from Electrical and Electronic Equipment (WEEE), contributing to the efficient use of resources and the retrieval of secondary raw materials through re-use, recycling, and other forms of recovery, and improving the environmental performance of everyone involved in the equipment's life cycle.

Two EU directives, one on WEEE (2012) and one on restricting the use of certain hazardous substances in electrical and electronic equipment (ROHS, 2011), are the primary laws regulating this topic at the European level. The European Commission is currently reviewing the WEEE Directive to ensure it is fit for purpose.

The objective of the **WEEE Directive** is to promote re-use, recycling and other forms of recovery of waste electrical and electronic equipment to reduce the quantity of such waste to be disposed of and improve the environmental performance of the economic operators involved in the treatment of WEEE. The WEEE Directive sets criteria for collecting, treating, and recovering electrical and electronic equipment waste. The WEEE Directive established a target of a 65% minimum collection rate for electronic waste from 2019.

Figure 3 - EU WEEE mandatory label

In March 2020, the European Commission presented a new **Circular Economy Action Plan** that prioritizes reducing electronic and electrical waste. The proposal specifically outlined immediate goals like creating the right to repair and improving reusability, introducing a common charger, and establishing a rewards system to encourage recycling electronics. In March 2023, the Commission presented a new proposal to promote repairing and reusing goods.

[2] **The Global e-Waste Statistics Partnership, 2024:** https://globalewaste.org/map/

In line with the circularity ambitions of the European Green Deal, the new **Batteries Regulation** (July 2023) ensures that, in the future, batteries have a low carbon footprint, use minimal harmful substances, need less raw materials from non-EU countries, and are collected, reused and recycled to a high degree in Europe. Targets for recycling efficiency, material recovery and recycled content will be introduced gradually from 2025 onwards. All collected waste batteries will have to be recycled, and high recovery levels will have to be achieved, particularly critical raw materials such as cobalt, lithium, and nickel. Starting in 2027, consumers can remove and replace the portable batteries in their electronic products at any time of the life cycle. This will extend the life of these products before their final disposal, encourage reuse, and reduce post-consumer waste.

## 4.2. National Legislation

### UNITED STATES

The United States has no official federal e-waste regulation system, yet certain states have implemented state regulatory systems. The National Strategy for Electronic Stewardship, co-founded by the Environmental Protection Agency (EPA), the Council on Environmental Quality (CEQ), and the General Services Administration (GSA), was introduced in 2011 to focus on federal action to establish electronic stewardship in the United States.

So far, 25 states and the District of Columbia[3] have enacted legislation to regulate e-waste, which means 65% of the population must uphold their state's e-waste recycling policies. Every state with e-waste regulation laws, except Utah and California, uses the Producer Responsibility approach to hold manufacturers accountable by making them fund e-waste recycling[4].

### CHINA

Effective 1 February 2000, the Ministry of Environmental Protection (MEP) passed a regulation entitled Notification on Importation of the Seventh Category of Wastes. This regulation prohibits e-waste from being imported under the seventh waste category approved by the MEP. On July 1, 2004, Measures on the Administration of Business Certificate on Hazardous Materials required businesses to acquire a license to collect, store, or dispose of e-waste legally. Additionally, previous legislation was revised in 2005 to firmly disallow solid waste imports from entering China for dumping.

In 2008, the MEP passed Administrative Measures for the Prevention and Control of Environmental Pollution by Electronic Waste, a set of administrative rules requiring all e-waste treatment enterprises to adopt pollution control techniques and register with local government agencies. Under this act, violators are subject to heavy fines of up to ¥500,000 ($73,000).

In 2011, the Collection and Treatment Decree on Wastes of Electric and Electronic Equipment strengthened national standards for the e-waste treatment sector, setting minimum annual treatment capacities for formal e-waste treatment enterprises. These new laws also required treatment plants to adopt pollution prevention principles during the entire disposal process to minimize adverse environmental impacts.

In 2012, China adopted the extended producer responsibility (EPR) system from the EU, which held manufacturers responsible for collecting and recycling electronics. Otherwise known as “Producer Takeback,” the EPR management system requires manufacturers to carry out environmentally safe management of their products even after they are discarded. The Measure on Tax Levy and Use for E-waste Recycling was implemented on manufacturers to enact the EPR system officially.

---

[3] **Electronics Recycling Coordination Clearinghouse -** https://www.ecycleclearinghouse.org/contentpage.aspx?pageid=10
[4] **National Conference of State Legislatures:** https://www.ncsl.org/environment-and-natural-resources/electronic-waste-recycling

### INDIA

The Ministry of Environment, Forests, and Climate Change (MoEFCC) is primarily responsible for regulations regarding electronic waste. Additionally, the Central Pollution Control Board (CPCB) and State Pollution Control Board (SPCB) produce implementation procedures to ensure proper management of rules set forth by the MoEFCC.

In October 2016, the E-Waste (Management) Rules replaced the E-Waste (Management and Handling) Rules from 2011. This set of rules clarifies the duties of responsible parties, enacts more stringent regulations on e-waste production, and clarifies the general definition of e-waste. Electronic product producers must implement Extended Producer Responsibility (EPR) schemes to ensure their electronic waste is delivered to authorized recyclers or dismantlers. These rules establish and place specific responsibilities for each party involved in producing, disposing, and managing electronic waste. These rules also stated target goals for particular industries to reduce electronic waste.

### OTHER COUNTRIES

E-waste management and disposal regulations vary significantly across different countries and regions worldwide. Each nation often implements unique rules, guidelines, and protocols governing electronic waste handling, recycling, and disposal.

Therefore, it's crucial for all stakeholders operating within these areas to be well-informed about the specific local and national legislation concerning e-waste. By staying updated and adhering to these regulations, one can ensure proper and responsible electronic waste management, contributing to environmental sustainability and reducing hazardous impacts on ecosystems and human health.

## 4.3. Regulations on Recycling and Disposal Responsibilities

### EUROPEAN UNION

Users of devices must dispose of electronic devices, including tracker devices, at designated collection points or authorized recycling centers. The WEEE directive encourages users to return their e-waste to registered recycling facilities. Users should erase company data from devices before disposal.

> Manufacturers must comply with the WEEE directive by taking responsibility for the collection, recycling, and environmentally friendly disposal of devices. They should implement eco-design principles to facilitate easier recycling and reduce the environmental impact of products.

### UNITED STATES

Users of devices shall utilize certified e-waste recycling facilities or take advantage of manufacturer or retailer take-back programs. They must ensure that company data is wiped from devices before disposal, following guidelines such as those from the National Institute of Standards and Technology (NIST).

> Manufacturers must adhere to state-specific e-waste regulations (e.g., California's Electronic Waste Recycling Act) and support recycling efforts by establishing collection programs and implementing product design strategies that facilitate disassembly and recycling.

### CHINA

Device users shall utilize government-approved recycling channels or collection points for e-waste disposal. Before handing over devices for recycling, it's essential to delete company information and data.

> Manufacturers must comply with China's e-waste regulations by setting up collection and recycling systems. They must also design products focusing on resource efficiency and recyclability, aligning with

the Circular Economy Promotion Law. The extended producer responsibility (EPR) system holds manufacturers responsible for collecting and recycling electronics.

**INDIA**

Users of these devices shall dispose of them at authorized collection centers or through registered recyclers. Company data should be erased securely before handing over devices for recycling, following guidelines provided by the Ministry of Electronics and Information Technology (MeitY).

Manufacturers must adhere to the E-Waste (Management) Rules, which require manufacturers to collect a certain percentage of the e-waste generated by their products, implement Extended Producer Responsibility (EPR) schemes, and support recycling initiatives.

## 4.4. Customs declarations and international transport

When electronic IoT devices are transported across different countries, customs clearance poses numerous challenges. The complicated customs procedures and requirements for these devices often lead to unnecessary delays and shipment damage.

Customs practices regarding the need to declare IoT devices attached to or included in the shipment on departure or arrival and for device reverse logistics are highly fragmented globally. Hence, the industry must also understand local regulations regarding customs declarations and applicable taxes. Currently, there are no global guidelines on handling these declarations for IoT devices and how to do so when devices need to be returned or recycled in another country.

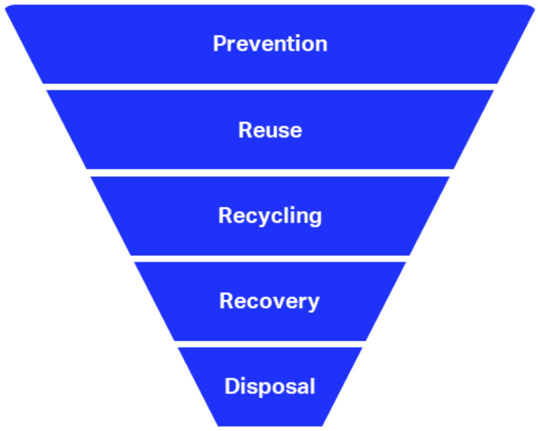
In 2022, a study[5] highlighted some challenges in international shipping with cargo IoT devices, namely the fact that Other Government Agencies' approval is needed before devices can be imported in some countries due to the control of telecommunication equipment and/or the regulation of the transport of lithium batteries, the duty and tax levied upon the importation of the device, and the challenges in filling the customs declaration.

[5] Navigating the complexity of border clearance with a cargo tracking device. (n.d.). GEODIS. Retrieved May 21, 2024, from https://geodis.com/se/en/blog/customs/navigating-complexity-border-clearance-cargo-tracking-device

# 5. Waste management and circularity approach

## 5.1. Waste management

Figure 4. Waste Reduction Hierarchy




Waste management is intended to reduce the adverse effects of waste on human health, the environment, planetary resources, and aesthetics. A waste management hierarchy[6] is a tool that indicates an order of preference for actions to eliminate waste at source, reduce waste through reuse models, recover waste by recycling, and dispose of different types of waste from least to most harmful. Usually presented as a pyramid, the hierarchy captures the progression of a material or product through successive stages of waste management and represents the latter part of each product's life cycle.

For tracking devices, the hierarchy emphasizes preventing e-waste generation by taking action before the product has become waste, such as creating solutions to prolong the product's lifecycle or re-designing it with a waste reduction approach. The waste management hierarchy guides responsible and informed decision-making by keeping disposal as the last resort.

## 5.2. Circularity approach

The global economy can be characterized as "linear" as it is mainly based on extraction, production, use and disposal. This linear economy leads to resource depletion, biodiversity losses, waste and pollution, causing serious damage to the capacity of our planet to continue to provide for the needs of future generations. In contraposition, a circular economy, based on a circular flow of resources, is restorative and regenerative by design. It aims to keep products, components, and materials at their highest utility and value at all times, distinguishing between technical and biological cycles. Ultimately, this economic model seeks to decouple global economic development from finite resource consumption.

A series of international standards recognizes the principles of "circular economy." The broadly used ISO 14000:2015 already covers some basic circular economy principles, such as waste reduction, and promotes actions to reduce risks regarding the organization's impact on the environment. The ISO 59000 series of standards harmonizes the understanding of the circular economy and supports its implementation and measurement.

### CIRCULARITY FOR IOT DEVICES

In 2022, 62 million tonnes of e-waste were generated globally[7], and forecasted to reach 82 million tonnes per year in 2030. Only 22% of e-waste is documented to be appropriately collected and recycled under appropriate conditions. The remaining 78% is thrown into the residual waste stream, dumped, traded, or treated in substandard conditions. Small IT and telecommunication equipment e-waste is estimated at 4.6 billion kg per year, of which only 22% is formally collected and recycled.

The consequences of this linear electronics system pose environmental and health impacts both at the production and disposal ends. Vast amounts of energy and hazardous substances are required in the mining and

---

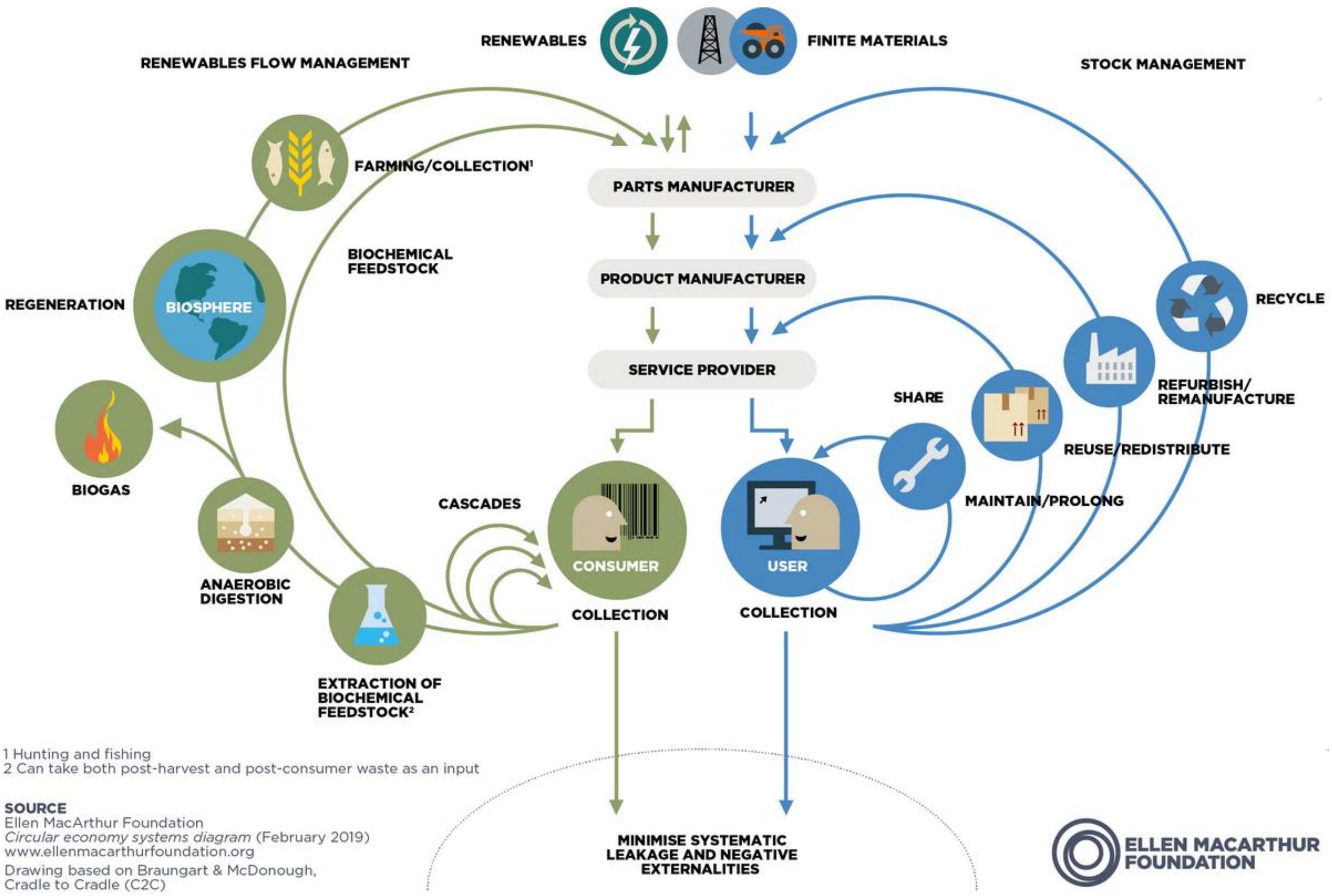
[6] **EU Waste Framework Directive (2008/98/EC)**

[7] Baldé, C. P., Kuehr, R., Yamamoto, T., McDonald, R., D'Angelo, E., Althaf, S., … Wagner, M. (2024). The Global E-waste Monitor 2024. International Telecommunication Union (ITU) and United Nations Institute for Training and Research (UNITAR).

manufacturing products, and the demand for resources has been linked to dangerous working conditions. Disposal and recycling of electronics can expose people and the environment to toxic chemicals when used products are not treated in formal recycling centers. (Ellen MacArthur Foundation, 2018)

A circular model for electronics will 'close the loop' through actions across the value chain, including designing for product lifetime extension, promoting repair and refurbishment, and improving recycling.

Figure 5 - The Butterfly Diagram: Visualizing the Circular Economy - Ellen MacArthur Foundation




When it comes to keeping entire products in use for a longer time, there are two main strategies currently being taken by companies:

- Repair and system upgrade by users
- Repair/refurbishment by technicians

Companies can adopt intermediate strategies, allowing users with the necessary knowledge and tools to repair parts of the product or specific components. Whether done by users or professional technicians, both approaches can potentially promote a more circular use of resources. This is because the overall longevity of the product can be extended under the right conditions.

Some air cargo IoT device manufacturers have implemented remote troubleshooting, software updates, and repair solutions to reduce returns and improve the prolonged existence of their products. These solutions enable the manufacturer's technical support team to diagnose and resolve issues remotely without physical intervention. By providing these services, manufacturers can increase customer satisfaction and reduce costs associated with returns and repairs.

## 5.3. Component and material recovery strategies

### Reutilization of components for IoT devices

Reusing basic components, such as screens, batteries, sensors, hard drives, and chips, from higher performance applications to lower ones could help to displace the consumption of new primary resources and keep those components in use for longer. An important note regarding reused parts for IoT devices is that modified device characteristics (battery, charging port, connectivity, etc.) always require device reapproval from operators. Hence, there is no difference in the certification process from an operator's point of between a device manufactured from new or reused material.  This is a hindering factor for device circularity.

### Material recovery

The design of products and components must allow for the identification and separation of materials, which is challenging if different materials are fused, for example. Strict collection standards must be maintained to keep different material streams separate. When combined with deliberate design for recycling, increasing yields and quality of materials strengthen the economic case for recovering consumer electronics after use.

# 6. Recommendations for stakeholders

Regarding IoT device sustainability, various stakeholders in the supply chain have specific responsibilities to ensure their effective use and reduce waste. Following the waste reduction hierarchy and circularity principles, stakeholders must prioritize eliminating waste at its source and focus on reuse, repair, and recycling.

The items listed below provide a general overview of the areas where manufacturers and air cargo stakeholders may take action.

## 6.1. Reducing waste at source

The priority of waste reduction is analyzing how it can be prevented at the source. Improving product design to facilitate recycling and product longevity and focusing on improvements in energy efficiency, material sourcing, and manufacturing processes is an important component for IoT device manufacturers. When possible, it is particularly important to avoid materials that can harm the environment and human health (lead, mercury, cadmium, selected flame retardants, and such).

Air cargo stakeholders should analyze their business needs and operating standards from a waste reduction perspective, identify opportunities to avoid e-waste generation in their processes, and incorporate end-of-life/waste disposal into their procurement decisions.

### MAINTENANCE AND REPAIR OF REUSABLE DEVICES

Adequate maintenance and repairs between uses can extend the useful lifecycle of reusable devices. However, the complexity of the air cargo supply chain may make returning the devices to the manufacturer or authorized technician difficult. For this reason, most modern IoT devices are designed with remote troubleshooting capabilities. These features allow technicians or support teams to diagnose and resolve issues without physically accessing the device.

In addition to these remote solutions, other practices, such as enabling the end user or authorized third parties to perform small repairs, may contribute to lowering the costs associated with maintenance and repair and extending the lifecycle of reusable devices.

## 6.2. Commission LCAs for decision-making

A Life Cycle Assessment or Analysis (LCA) is an established methodology framework to estimate the environmental impacts of a product or service, taking into account all stages in its life, in a transparent, replicable, and comparable manner. An LCA analyzes where in the product's life cycle their impacts on the environment are greatest and lowest.

An LCA allows one to see differences in disposal procedures, enables comparison between different processes or products, and covers a wide range of environmental impacts. LCAs are internationally recognized with broadly accepted standards such as ISO 14040 and 14044.

**Box 2. LCA commissioning guidance for the airline sector [8]**

The starting point of any e-waste reduction program must be focused on preventing and minimizing waste at the source. When comparing different solutions is required, an LCA can help.

**Guidance**

- Undertake a cradle-to-grave study, including all the life cycle stages, to make comparisons between studies more straightforward.
- Be extremely clear on what is included in the scope, such as functional units, environmental impact categories and systems boundaries (see definitions below).
- Be aware that environmental impact categories are chosen at the discretion of the researchers and their commissioners, so the same topics might not be included in all assessments.
- It is essential that the emissions from jet fuel consumption are included in the scope, but it should not be the only focus. Including other impact categories will enable an airline to make more informed decisions.
- An LCA should include the results of different end-of-life scenarios, including landfill and incineration, and not solely focus on one.
- Remember that the consequences on biodiversity and the environment are not fully understood, nor is there a consensus on how to measure them, so LCAs are not likely to be able to consider these issues.

**Definitions and scope**

- A **functional unit** is the reference unit for the study, covering the service being provided (what), the extent to which it is provided (how much), its quality (how well), and its duration (how long). For airlines, this means, for example, comparing the same number of single-use items with the number of uses for the reusable alternative (e.g., 100 single-use IoT devices versus 100 uses of a reusable device).
  An example of a functional unit could be "the quality provision of shipment visibility through an IoT device for 100 shipments over one year."
  In this example, "quality" refers to ***how well***, "provision of shipment visibility" is ***what***, the number of devices refers to ***how much*** and the time period covers ***how long***.

- **Environmental impact categories can range from global warming potential (the potential for a product or process to contribute to climate change by quantifying GHG emissions) to** ecotoxicity **(the potential for damage to freshwater ecosystems and species within them through the release of toxic materials)**, resource use **(the use of non-renewable natural resources and is measured through abiotic resource depletion)**
  and soil acidification (by emitting harmful substances that contribute to acid rain). The choice of environmental impact categories is at the discretion of the researchers and/or their commissioners/clients, and not all will be included in the assessment.

- **System boundaries** define the beginning and end points of the life cycle being assessed. Using electronic products as an example, this might start with raw material extraction of metals and end with end-of-life disposal, such as landfill. The many processes and activities between these two points can also be at the discretion of researchers, commissioners, and/or clients.

Some examples of the different stages of the life cycle that may be considered during an LCA for IoT devices:

- **Raw materials extraction** (per component)
- **Transport of raw materials**
- **Manufacturing** (energy consumption, generated waste, emissions, others)
- **Distribution (f**rom manufacturing to the distribution centers and the customers, considering location and means of transportation)
- **Usage** (Energy power use over a lifetime, data upload, emissions during the use phase)
- **Disposal / Recycling**

[8] Extract adapted from: Reassessing Single-Use Plastic Products in the Airline Sector (2024). IATA. https://www.iata.org/contentassets/821b593dd8cd4f4aa33b63ab9e35368b/reassessing-supp-in-the-airline-sector_260324_rm-2.pdf

## 6.3. Efficient returns for device refurbishment and recycling

Extending the lifecycle of multi-use devices and recovering single-use ones for recycling and/or recovering their useful parts. Numerous initiatives already exist within the supply chain to support device returns, including:

- Device takeback programs: Manufacturers may establish device takeback programs with a global reach and promote the return of data collection devices for renewal and reuse regardless of whether the device is single or multi-use.

- Incentives for device return: Manufacturers and regulators can create additional incentives to motivate consumers to participate actively in recycling programs. Those incentives can take the form of financial measures such as discounts, vouchers, or monetary rewards.

- Convenient postal returns: Regulators can contribute by increasing the use of postal services to return used and waste electronic devices, for example, by providing pre-paid envelopes or labels to consumers to return their devices.

**LESS THAN 1% OF IoT DEVICES ARE RETURNED FOR REPAIR.**

## 6.4. Accelerate the transition to circularity models

A circular economy is a sustainable model in which products and materials are designed in such a way that they can be reused, remanufactured, or recovered and thus maintained in the economy for as long as possible.[9] The Ellen MacArthur Foundation outlines industry actions to accelerate the transition to a circular economy for electronic devices[10], several of which may be of relevance for manufacturers and air cargo stakeholders:

- Design for circularity: Select a circular design strategy that fits the business model and the wider system in which the device operates. These strategies can range from "designing for durability" to "designing for adaptability and repairability," but they will focus on preserving value in both the inner and outer loops of the technical materials cycle, such as increasing the ease of partial disassembly and only including materials fit for a circular economy.

- Give added purpose to cloud migration: With more cloud computing, hardware capabilities become less important than connectivity. Combined with longer operating system stability, this can potentially reduce the pace of hardware obsolescence. However, as tracking and monitoring devices rely on global cellular networks, country regulations to discontinue those (for example, discontinuing 2/3G networks) may accelerate device obsolescence.

- Devices match changing needs: Development of devices that are circulated between users with different and changing needs, aided by real-time product performance communication, which notifies and guides the user when components or products need to be changed. Big data and advanced analytics can vastly increase the effectiveness of this matching exercise and help predict reverse logistics demands.

- Increase automation in disassembly and refurbishment processes: Improved automated processes can increase the number of products that can be treated and reduce the time required. Increased quantity and better quality of material yields will strengthen the economic case for recycling.

---

[9] Turning off the Tap: How the world can end plastic pollution and create a circular economy. (n.d.). UNEP - UN Environment Programme. https://www.unep.org/resources/turning-off-tap-end-plastic-pollution-create-circular-economy

[10] Ellen MacArthur Foundation, Circular Consumer Electronics: An initial exploration (2018): https://www.ellenmacarthurfoundation.org/circular-consumer-electronics-an-initial-exploration

## 6.5. Enhance awareness about device recycling processes

Air cargo stakeholders, manufacturers, and regulators can reduce e-waste generation by providing additional information and education on why and how devices are recycled.

- Include global recycling markings as part of the device labeling: These markings typically refer to standardized symbols or indicators that convey information about the product's recyclability and guide consumers on proper disposal practices. Adhering to global recycling markings ensures that consumers, regardless of location, can easily understand how to dispose of the device in an environmentally friendly manner, promoting consistency and clarity in recycling practices on a global scale.

- Staff training: Air cargo stakeholders should prioritize comprehensive staff training to enhance waste segregation, recycling and disposal processes. This includes education on the importance of recycling, device return procedures, and other relevant information.

- Improved segregation: Facilitate e-waste segregation, if not already doing so, by implementing new operating procedures and guidance.

- User education and awareness: IoT device users should be aware of their responsibilities in the recycling process. In addition, additional information and transparency should be provided to eliminate any concerns about the product refurbishing process if the company chooses this strategy.

- Collection points visibility: Regulators can create awareness by improving the convenience and visibility of collection points where people can return small electronics. Information about the nearest take-back points can be added to user-friendly maps, search tools, and applications. At the take-back points, people should also be made aware that all personal data stored in their devices is properly managed and deleted correctly.

## 6.6. Appropriate disposal of spare parts and batteries

Proper disposal of spare parts and batteries is crucial to minimize environmental impact. Spare parts and batteries contain hazardous materials that can harm the ecosystem if handled incorrectly.

Spare parts and batteries must be recycled using designated recycling centers or collection points whenever possible. Different spare parts and batteries require specific recycling processes; therefore, they shall be separated accordingly to ensure proper disposal. It is also the manufacturer’s responsibility to establish clear communication when disposing of spare parts and batteries.

## 6.7. Collaborative approach for device recycling

All supply chain stakeholders shall be committed to facilitating the recycling process and follow a collaborative approach. This implies a dedication to ensuring the devices are properly recycled/disposed of and do not contribute to environmental harm.

- Effective communication: communication involving awareness about recycling initiatives, clear instructions for stakeholder participation, and an open line for queries. Establishing communication channels between end-users, retailers, manufacturers, and other parties ensures a collaborative, efficient recycling process, promoting environmental sustainability.
- Research & development: support initiatives on R&D to identify and promote alternative sustainable materials and products.
- Collaborative approach: coordinated efforts to improve and develop recycling infrastructure and reverse logistics processes using economies of scale.

### CONSIDER DATA-SHARING FROM A SUSTAINABILITY PERSPECTIVE

To avoid using multiple devices to monitor shipment attributes, supply chain stakeholders shall cooperate with other parties involved in transporting the same shipment and share data on shipment conditions rather than using multiple devices for shipment tracking. IATA is committed to supporting cargo interactivity by providing relevant standards and guidance for streamlined device approval and use through the IATA Interactive Cargo program.

ONE Record is a standard for data sharing and creates a single record view of the shipment. The ONE Record standard defines a common data model for the data shared via standardized and secured web API (Application Programming Interface). The vision for ONE Record is to establish an end-to-end digital logistics and transport supply chain where data is easily and transparently exchanged in a digital ecosystem of air cargo stakeholders, communities, and data platforms.