White Paper

Screw-In, Not Soldered: Advancing Repairable USB-C® Design for Regulatory Readiness

2026/4/7

WP26001-1E

Executive Summary:

Electronic waste (**e-waste**) is one of the world's fastest-growing waste streams, with **53.6 million metric tons of e-waste generated globally in 2019** – a 21% increase in five years – but only about **17% of that was formally recycled** [1]. In response to this mounting crisis, governments are enacting regulations to encourage more **durable, repairable electronics**. Notably, the European Union approved the **Ecodesign for Sustainable Products Regulation (ESPR) in 2024**, which broadens eco-design requirements to cover almost all consumer products and ensure they are **more durable, easier to repair, upgrade, and recycle** [2]. France has likewise implemented a **Repairability Index** (effective 2021) that scores certain devices on a **10-point scale** based on criteria like availability of repair documentation, ease of disassembly, spare parts availability, spare part pricing, and product-specific design factors [3]. These trends reflect a growing consensus: to reduce e-waste, products must be designed for longevity and serviceability.

A small hardware component – the **USB-C® port** – illustrates the challenge and opportunity. Now the de-facto standard for charging and data in smartphones, tablets, and laptops, **USB Type-C® connectors experience constant use and mechanical stress** (frequent plug-unplug cycles, cable yanks, and pressure from attached dongles). When a USB-C port wears out or breaks, **repairs are often impractical** because the port is usually soldered directly to a device's main circuit board. Fixing it requires microsoldering skills or replacing the entire board – a **costly and wasteful outcome** that frequently leads consumers to discard the device instead. This raises the question: **How can designers make such a critical, high-wear component more repairable**?

This white paper argues that **adopting a repair-friendly USB-C connector design can significantly extend device lifespan** and reduce e-waste. In particular, we highlight JAE's **Repairable DX07 USB-C receptacle** as a case study in designing for **solderless, modular I/O connectivity**. The DX07 is a USB-C port module that attaches with screws and **pluggable compression contacts** instead of solder, allowing it to be replaced using just a screwdriver. This design decouples the port from the main board, so a damaged USB-C connector can be swapped out without desoldering or board replacement.

Importantly, the Repairable DX07 sacrifices no performance: it supports the latest **USB4® Version 2.0 (80 Gb/s) data rates and up to 240 W (48 V/5 A) USB Power Delivery** – meeting the highest USB-C specifications – and is rated for **10,000 mating cycles** to withstand years of use [4].

By enabling quick, inexpensive port replacements, the DX07 connector can help manufacturers **improve product repairability scores and comply with emerging regulations**, all while maintaining the full functionality consumers expect. In the following sections, we examine the e-waste problem and repairability trends (Section 1), compare current approaches to USB-C integration (Section 2), introduce the design and benefits of the Repairable DX07 connector (Section 3), and discuss how such innovations can align with manufacturers' business and sustainability goals (Section 4). Section 5 concludes with the broader implications for **extending product lifespans** and supporting a circular electronics economy.

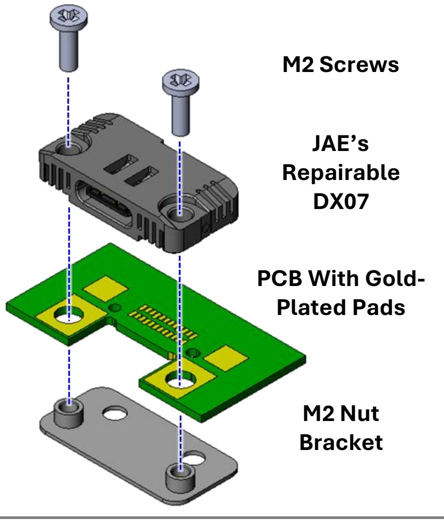


Figure 1 – Reference design of the Repairable DX07 compression-mount USB-C module (M2 screws + JAE's Repairable DX07 + PCB with gold-plated pads + M2 nut bracket)

1. The E-Waste Challenge and Regulatory Response

1.1 The Rising Cost of E-Waste

Modern society's dependence on electronic devices has led to an **alarming rise in electronic waste**. Global e-waste reached **53.6 million metric tons in 2019**, and the trend points to more than 74 million tons per year by 2030 if nothing changes [1]. To make matters worse, only about **17% of 2019's e-waste was formally collected and recycled** [1].

The rest – containing valuable materials like gold, copper, and rare earth elements, as well as hazardous substances like lead and mercury – often ends up in landfills or is informally recycled, causing environmental damage and health risks. This linear **“take-make-dispose”** model of electronics consumption is clearly unsustainable. Increasing device longevity and repairability has therefore become a central strategy to curb e-waste. By enabling consumers to use products longer and fix them when they break, we can delay end-of-life disposal and reduce the demand for manufacturing new devices (and the associated resource extraction and emissions). In short, improving **product repairability and lifespan is critical for cutting down e-waste**.

1.2 Regulations Favoring Repairable Design

Recognizing this, policymakers are instituting new rules to make **longer-lasting, repairable products the norm**. A landmark example is the European Union’s **Ecodesign for Sustainable Products Regulation (ESPR)**, which was formally adopted in 2024. The ESPR extends the EU’s eco-design framework beyond energy efficiency, allowing officials to set product design requirements aimed at **durability, repairability, and recyclability** for nearly all product categories [2]. In other words, to be sold in the EU, future electronics may need to meet standards for things like **availability of spare parts, ease of disassembly, and software support**, in addition to existing requirements on energy consumption. The exact requirements will be defined in coming years for each product group, but the direction is clear: **manufacturers must design products to last longer and be easier to fix**.

France has already implemented a pioneering policy: its **Repairability Index**, active since January 2021, compels manufacturers and retailers to **display a repairability score (out of 10)** for smartphones, laptops, and several other electronics at the point of sale [3]. This index is calculated based on **five criteria** that cover key aspects of serviceability: availability of technical **documentation**, **ease of disassembly** (including whether special tools are needed), **availability of spare parts**, **price of spare parts**, and certain **product-specific factors** (for example, software resets that could hinder repair) [3].

If a laptop's USB-C port is soldered and hard to remove, or if replacement ports are unavailable or too expensive, those criteria would yield a low repairability score. By contrast, designs that feature modular, easily removable components score higher. The intent is to give consumers upfront insight into how repair-friendly a product is, and to spur manufacturers to compete on designing **more serviceable, upgradable devices**.

These regulatory developments in Europe are part of a broader **"Right to Repair" movement** that is gaining momentum globally. Manufacturers that stay ahead of these trends – by making products easier to repair and supporting the availability of spare parts – will not only comply with new laws but can also appeal to environmentally conscious consumers. In the next section, we focus on one specific design decision with large implications for repairability: how the **USB-C port** is integrated into devices.

1.3 USB-C Ports: Small Connector, Big Impact on Longevity

The **USB Type-C port** is now ubiquitous in modern electronics, from phones and laptops to peripherals, as the common standard for charging and data connectivity. Its popularity is due to broad support (power, video, data in one connector) and user-friendly reversible plug design. However, this tiny part is also a common **longevity bottleneck** for devices. With typical use involving hundreds of mating cycles per year, plus the strain of cables getting tugged or twisted, USB-C receptacles are prone to **wear and tear**. The connector's internal pins can deform, and the solder joints that attach it to the circuit board can crack under mechanical stress. When a USB-C port fails, what happens next depends on how it is built into the product – and here is where design for repairability (or the lack thereof) dictates the outcome.

In many thin electronics, the **USB-C port is soldered directly onto the main logic board** for space and cost efficiency (as we will discuss in Section 2.1). In those devices, a broken charging/USB port can be extremely difficult to fix. Repair technicians must desolder and replace a fine-pitched 24-pin connector on a densely populated board, a procedure requiring skill, specialized tools, and careful process control to avoid damaging pads, traces, or nearby components. For most users – and even for many repair shops – this kind of microsoldering is impractical or uneconomical.

As a result, a **simple port failure can render a device essentially non-viable**: service centers often replace the entire motherboard (an expensive part) rather than attempt such a difficult port repair, and out-of-warranty consumers faced with a costly board replacement often choose to replace the device instead of repairing it. This outcome is a textbook example of preventable e-waste and is driving interest in approaches that make high-wear interfaces like USB-C **modular and easily replaceable**.

2. Design Pathways for USB-C Integration

When engineering a device, designers have a few options for how to integrate a USB-C receptacle. These design choices dramatically affect how serviceable that port will be. In this section, we compare three main approaches – (1) directly soldering the port to the main board, (2) using a small **I/O daughterboard**, and (3) adopting a **compression-mount (screw-in) connector** – examining how each impacts **repairability**.

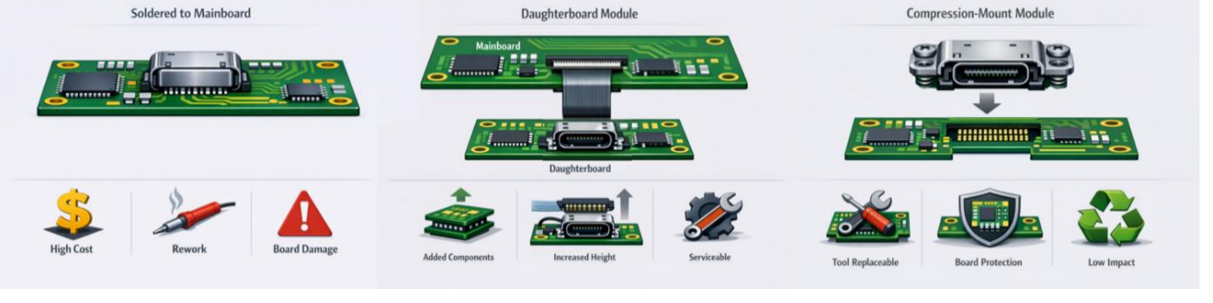


Figure 2 – Side-by-side comparison of USB-C integration approaches (soldered mainboard vs. daughterboard vs. compression-mount)

2.1 Soldered Ports on the Mainboard

In many consumer devices, especially slim laptops and tablets, the USB-C connector is **soldered directly onto the primary logic board** (PCB). This approach minimizes the number of parts and maximizes space efficiency – the port takes up only the footprint of the connector itself on the motherboard, with no extra cables or boards required. From a manufacturing standpoint, it is convenient and cost-effective: the USB-C port and other components can be soldered in one go during the standard board assembly (reflow soldering) process.

The downside, as mentioned earlier, is that **repairability is very low**. Replacing a bad port means having to desolder it from the multi-layer PCB, which is a complex operation. Techniques such as hot-air rework or microsoldering must be used to avoid lifting PCB pads or damaging nearby components with heat. For non-experts, this procedure is typically **inaccessible**. Even authorized repair centers often find it inefficient: if a device is under warranty, it is usually cheaper in terms of labor time and reliability to swap in a new board rather than have a technician spend an hour trying to microsolder a new connector. Consequently, a **soldered-on USB-C port is considered "non-serviceable" by design**, and a failure often triggers a full motherboard replacement. This not only means higher repair costs (the motherboard is one of the most expensive parts in the device) but also generates significantly more electronic waste – the entire board (and all components on it) become scrap over a single connector fault.

2.2 USB-C on a Modular I/O Daughterboard

To mitigate the repair difficulty of soldered ports, some manufacturers use a **dedicated I/O board** (often called a daughterboard) for USB-C and other connectors. In this design, the USB-C receptacle is mounted on a small separate circuit board, which attaches to the mainboard via a ribbon cable or board-to-board connector. The primary advantage is **repair segmentation**: if the port breaks, only the small I/O board needs replacement, leaving the mainboard untouched. This simplifies the repair process – typically, a technician or experienced user can open the device's case, unscrew the faulty daughterboard, disconnect a cable, and swap in a new board using standard tools (no soldering required). The repair is faster and cheaper than a full motherboard replacement since the daughterboard is a less expensive component. Many laptops and game consoles have adopted this approach, striking a balance between compactness and serviceability. The trade-offs are modest: a daughterboard adds a bit of material cost (for the extra PCB and connector) and takes up some additional space inside the device to accommodate the board and its connecting cable. There is also an extra assembly step in manufacturing.

Nonetheless, for several product categories, these costs are justified by the service benefits. By localizing the impact of port failures, a modular I/O board design can prevent a broken connector from "totaling" the device.

2.3 Compression-Mount (Screw-In) Connectors

As a step beyond the daughterboard, the most serviceable option is a **compression-mount USB-C connector** – a **solderless, removable port module**. In this design, the USB-C receptacle is not permanently affixed by solder. Instead, it features spring-loaded or compliant pins that make an **electrical connection by pressing onto matching pads on the PCB** (much like a pressure contact or "pogo pin" interface), and the connector is **secured mechanically with small screws** that attach it to the chassis or board. This decouples the port's mechanical attachment from its electrical connection. If the port is stressed or damaged, the screws (and the robust metal shell of the connector) absorb the strain, protecting the PCB. To replace the port, a technician (or even an end user) simply unscrews the module, lifts it off the board, and installs a new one – no desoldering required. **All that has needed is a screwdriver**, and the swap can be completed in minutes. This approach virtually eliminates the technical barriers to port repair: it requires **no special equipment or expertise**, and it avoids exposing the board to heat altogether during service. In the context of repair-friendly design, a compression-mounted USB-C fits all the criteria: it is *non-destructive, easy to remove, and simple to reinstall*.

This concept has lately moved from theory to reality. As shown in Figure 1, in early 2026 JAE introduced the **Repairable DX07**, a USB-C compression-mount connector that embodies this screw-in, solder-free approach [4]. We will examine the DX07 in detail in Section 3. But broadly, the potential advantages of such a design include unparalleled field serviceability and **standardized replacements** (a single port module can be stocked and used for many device models). The downsides are limited but include a higher unit cost for the connector and a slightly larger physical footprint to accommodate the screws and housing.

These are real considerations – the module's metal shell and mechanical hardware can be bulkier than a standard port, which **product engineers must factor into tight designs**. In many cases, however, devices already use internal metal brackets or reinforcements around ports for durability, meaning a compression-mount connector can often utilize similar space and mounting points. In return for a small trade-off in packaging, manufacturers gain a **massive improvement in repairability**: a broken port can be isolated and changed without costly side effects for the rest of the system. The table below summarizes how the three USB-C integration approaches compare:

Table 1 – USB-C Integration Strategies vs. Repairability

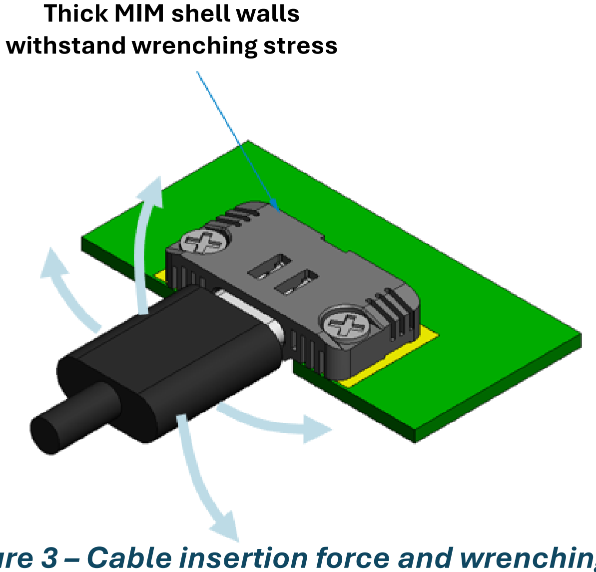
Integration Approach	Ease of Port Replacement	Tools Required	Cost Impact	Space/Design Impact
Soldered to Mainboard	**Very Low:** Port replacement is difficult; often requires entire logic board swap or microsoldering of the port itself.	**Advanced:** Specialized tools (soldering station, hot-air rework) and expertise needed – beyond reach of typical consumers.	**High repair cost:** Mainboard is a costly part, so replacing it (or performing labor-intensive micro-soldering) is expensive. Low unit cost during manufacturing.	**Minimal:** No extra boards or cables; port directly on main PCB (ideal for thin designs).
Daughterboard Module	**Moderate:** Port is part of a small I/O board; replacement means swapping that board. Easier than mainboard repair.	**Basic:** Standard screwdrivers to open device and detach the module; no soldering required for replacement.	**Moderate repair cost:** Cost of a small I/O board (much cheaper than a full mainboard). Slight increase in BOM cost for extra PCB and connector during manufacturing.	**Medium:** Requires space for the daughterboard and flex connectors. Adds a minor amount of bulk and an extra assembly step.
Compression-Mount Module	**Very High:** Port can be unscrewed and lifted out in minutes. Field-replaceable without desoldering.	**Basic:** Only a small screwdriver needed; no special tools or skills required.	**Low repair cost:** Only the connector module is replaced (inexpensive as a part). **Higher unit cost** than a soldered port (due to a more complex, robust design).	**Medium:** Connector module is larger and uses screws or bracket but often overlaps with space already used for port reinforcement in the chassis.

As shown, a **compression-mounted USB-C** offers a major leap in serviceability. We next explore a real-world example of this approach: JAE's Repairable DX07 USB-C connector.

3. The Repairable DX07 USB-C Receptacle

3.1 Design and Performance Features

The [Repairable DX07] USB Type-C receptacle (developed by Japan Aviation Electronics in 2026) is a prime example of a compression-mount, screw-in connector designed for maximum repairability. In terms of form and function, the DX07 looks and acts like a standard USB-C port, but with critical internal differences. It uses a **solderless "compression coupled" interface**: instead of solder tails, the connector's 24 pins are implemented as spring contacts that press firmly onto corresponding **gold-plated pads on the PCB**. When the connector's two small mounting screws are tightened, the contacts are compressed, creating solid electrical connections just as reliable as solder joints. The DX07's metal housing is a high-strength **MIM (metal injection molded) stainless steel shell**, which provides structural support and protects the contacts from physical damage. Thanks to this robust design, the DX07 meets all of the standard's requirements for durability and throughput: it is **fully compliant with USB Type-C Specification 2.4 and USB4 Version 2.0 (supporting 2× 40 Gb/s lanes for a total of 80 Gb/s data bandwidth), and supports USB Power Delivery up to 48 V/5 A (240 W)** – the maximum "Extended Power Range" in the USB PD 3.1 standard. The connector is also rated for **10,000 mating cycles**, matching the endurance of conventional high-quality USB-C ports. In short, devices using the Repairable DX07 do not sacrifice any I/O performance or longevity compared to soldered ports.



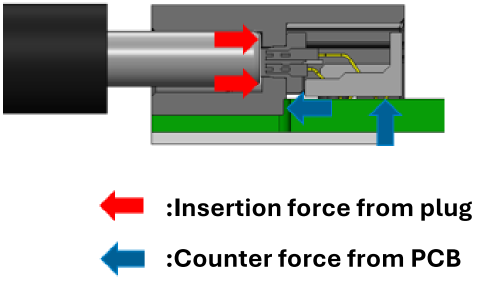


Figure 3 – Cable insertion force and wrenching demonstrated: the mechanical load path going into the module, PCB and screws/bracket rather than solder joints

The DX07 is available in both **single-port and dual-port modules**, enabling it to be used for one or two USB-C sockets side by side (a common layout in laptops). In a dual-port configuration, a single module can host two USB-C connectors, each with its own set of compression contacts, simplifying the design of devices that require multiple ports in proximity. From the user's perspective, a device with a DX07 connector is indistinguishable from one with a traditional port – the USB-C jacks function the same for charging and data, and only a subtle pair of screw heads flanking the port give away the difference. But if that port ever breaks or wears out, the repair difference is dramatic. **Replacing the DX07 module involves removing the device's cover, unscrewing the connector, and lifting it off the board – then reversing the steps with a new module**. There is no need for any soldering or glue. A routine port replacement can be done **on-site in minutes**, whether by an electronics repair technician or an experienced end user. This stands in stark contrast to the hours-long, high-skill process of re-soldering a damaged port (or the even costlier alternative of replacing an entire motherboard). By simplifying port replacement, the DX07 connector can significantly cut **repair turnaround times and costs** – for instance, a manufacturer's support service could mail a small replacement USB-C module to a customer or local repair shop, instead of having to ship and stock whole motherboards or require the device to be sent to a central depot. It also reduces the likelihood of additional damage: since no heat or complex disassembly is needed for port fixes, there's minimal risk to other components during repairs. In effect, the DX07 transforms a once-troublesome repair into a quick, **routine maintenance task**.

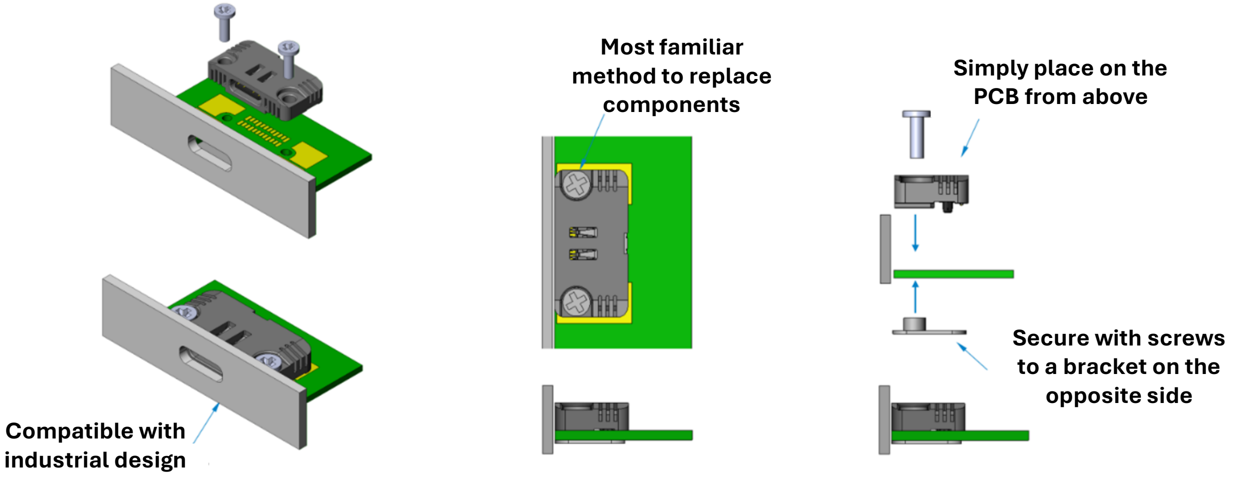


Figure 4 – Demonstration of Repairable DX07 system integration and easy repairability

3.2 Design Trade-offs and Considerations

Implementing the Repairable DX07 (or similar compression-mount connectors) in a device does require some planning. Manufacturers must allocate a bit of extra space for the connector's slightly larger housing and the insertion of two small screws or a bracket. The metal module's **footprint can be larger than that of many soldered USB-C sockets**, so extremely thin devices might find it challenging to accommodate. However, many products already incorporate internal brackets or reinforcements for their ports, meaning the DX07 module can often occupy the same volume (serving the dual purpose of a connector and a reinforcement). In terms of cost, the DX07's advanced design does entail a higher unit cost than bare-bones soldered connectors. The use of a MIM metal shell and additional hardware (screws and standoffs) makes it a more expensive component – on the order of a few times the cost of a standard port, depending on purchase volume. Nonetheless, this impact on the **bill of materials (BOM)** can be offset by savings elsewhere: preventing even a small fraction of mainboard replacements under warranty can save an OEM significant money, not to mention the less tangible benefits of improved sustainability metrics and customer satisfaction. The DX07's introduction comes at a time when such calculations are shifting. As companies face requirements to stock spare parts and facilitate repairs (per regulations like ESPR) [2], designing a product around a readily replaceable connector may reduce future compliance costs and logistics complexity.

On the technical side, engineers integrating the DX07 will want to ensure that the **PCB landing pads** for the compression contacts are properly designed to maintain signal integrity and power delivery, just as they would for a standard USB4 port. The good news is that JAE's design has been validated to meet USB-IF standards, meaning it passed the same electrical and protocol compliance tests as other certified USB-C connectors. Concerns about the long-term reliability of the spring-contact interface have been addressed through engineering and testing: the compressed contacts maintain constant pressure and have low contact resistance, and the device is specified for 10,000+ insertions as noted earlier.

Manufacturers do need to manage the assembly process (adding an extra step to screw the module in place during production) and plan for spare part supply, but these are in line with general moves toward modular design. Overall, the **trade-offs for using a repairable connector are modest and manageable** – especially when weighed against the substantial benefits in serviceability and sustainability.

4. Strategic Implications for OEMs

4.1 Compliance and Competitive Advantage

Designing products with highly repairable components like the DX07 USB-C port can help companies navigate the evolving landscape of **sustainability regulations**. While a single component does not make a device automatically compliant, it can significantly contribute to meeting repairability criteria. For example, under France's repairability scoring system, easy-to-replace connectors would earn points for **"disassembly with common tools"** and **"availability of spare parts"** [3]. Similarly, as the EU's ESPR enables requirements on reparability, a laptop or tablet that uses a screw-in USB-C module could fulfill potential rules on having key interfaces be replaceable without specialized equipment. Early adoption of such features can therefore set manufacturers ahead of regulatory curves and avoid costly redesigns down the line.

Beyond legal compliance, there is a growing **market differentiation opportunity** in producing repairable, longer-lasting devices. Consumers are increasingly aware of and frustrated by products that fail prematurely or are impossible to fix. High-profile examples of **repairable design** – such as modular smartphones and laptops that prioritize user-serviceable parts – have garnered positive media attention and a loyal customer base. By integrating visible, user-focused repairability improvements like a replaceable USB-C port, companies can **signal their commitment to durability and customer empowerment**. This can enhance brand reputation and appeal to sustainability-minded buyers, potentially allowing a premium to be charged for products that are built to last. Enterprises and institutional buyers (schools, corporations) also value devices that can be easily serviced, as this reduces the total cost of ownership. In these segments, features like field-replaceable ports can be a selling point, minimizing device downtime and maintenance expenses.

Another consideration is the impact on **warranty and support costs**. If a common failure mode (like port damage) can be remedied with a low-cost part and a short repair, manufacturers could see reduced warranty claim expenditures. Devices designed for quick fixes might also enable new service models – for instance, manufacturers could train and certify local repair providers or even end-users to perform certain repairs, reducing shipping and labor costs. In the case of the DX07, because the replacement part is small and self-contained, it can be economically shipped to customers or repair depots and swapped without special equipment. This not only cuts the cost and time of repairs but also aligns with the **circular economy** principles many companies have publicly embraced (by keeping products and components in use longer).

4.2 Balancing Innovation with Sustainability

Integrating a repairable USB-C connector is a clear step toward sustainability, but it also requires thoughtful product development and system-level thinking. Companies must ensure that other components likewise support longevity – a repairable port has more value in a device that also has a replaceable battery or modular display, for instance. This means R&D teams may need to revisit some established design practices (like soldering or gluing everything for minimal cost) and find creative ways to maintain sleek form factors while improving repair access. The good news is that numerous emerging technologies and design techniques can help: from **non-destructive adhesives and clips**, to software tools that guide repairs, to new business models for selling spare parts and refurbishment services.

There may be an initial learning curve and slight cost increase in adopting features like the DX07. However, these investments can pay off. Under the ESPR and similar regulations, companies that ignore repairability could face exclusion from key markets or be scored poorly by consumer labels, which in turn could hurt sales. Conversely, those that lead on repair-friendly design have a chance to shape industry standards and win early adopter customers. This form of innovation – making products that are **not only high-performing but also high-lasting** – can be a source of pride for engineering teams and a cornerstone of corporate social responsibility efforts.

5. Conclusion

The push for repairable electronics is no longer confined to niche hobbyists or environmental activists – it is moving into the mainstream of policy and product strategy. As we have discussed, something as small as a USB-C port can determine whether a device lives a full lifespan or heads to the scrap heap prematurely. With regulators worldwide signaling that **repairability and sustainability are becoming requirements**, manufacturers have a clear mandate to rethink design practices that lead to unnecessary e-waste. **JAE's** **Repairable DX07 USB-C connector** demonstrates that solutions are within reach: it tackles a well-known failure point in consumer electronics (damaged charging and data ports) by introducing a simple, effective mechanism for field replacement. This kind of connector can prevent countless devices from being junked over minor issues, yielding benefits up and down the value chain – from cost savings on warranty service, to better scores on repairability indexes, to reduced environmental impact.

We encourage OEMs to consider the broader implications of integrating repair-friendly components like the DX07. Doing so is not just about meeting new rules – it is about **adapting to a market where customers value sustainability and longevity**. In a competitive landscape, offering products that can be repaired and last longer can become a selling point and brand differentiator. Furthermore, the shift toward modular, repairable design paves the way for more circular business models (like device trade-in programs and refurbishments) that can create new revenue streams while demonstrating environmental stewardship.

In conclusion, the case of the USB-C port underlines a general principle: by reimagining product design with an eye toward the full lifecycle, manufacturers can achieve a triple win – extending product life, **saving costs and resources**, and meeting the demands of regulators and consumers for a more sustainable tech ecosystem. The technology and components to enable this exist today; it is now up to industry to embrace them and drive the **transition from a throwaway culture to a circular economy**.

Note: USB Type-C®, USB-C®, and USB4® are registered trademarks of USB Implementers Forum.

References:

[1] United Nations University (UNU), *"Global E-Waste Surging: Up 21% in 5 Years."* Press release, 2 July 2020. Available: https://unu.edu/press-release/global-e-waste-surging-21-5-years

[2] European Commission, DG Environment, *"Sustainable products to become norm for consumers as new law enters into force."* News article, 19 July 2024. Available: https://environment.ec.europa.eu/news/sustainable-products-be-norm-consumers-new-regulation-2024-07-19_en

[3] Right to Repair Europe (iFixit EU), *"The French repair index: challenges and opportunities."* Blog post, 3 February 2021. Available: https://repair.eu/news/the-french-repair-index-challenges-and-opportunities/

[4] Japan Aviation Electronics (JAE), *"DX07 Series: USB Type-C® Compression Mount Connectors with Enhanced Repairability and Robustness."* Product announcement, 7 January 2026. Available: https://products.jae.com/gl/en/connectors/category/io/dx07-receptacle/

Japan Aviation Electronics
Industry, Limited

Technology to Inspire Innovation

JAE