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of Glasgow



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circulus
Circular Resource Management



CASE STUDY 1 - PRESERVING VALUE THROUGH CIRCULAR COMPONENT LIFECYCLE MANAGEMENT

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ABSTRACT

Repairability becomes commercially meaningful when the wider value network is organised to recover, repair, recertify and redeploy components before their embodied value is lost through premature disposal.

Dr Carlos Carbajal

Dr Jawad Abbas

Prof Nuran Acur

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How Circulus is converting a replace-and-dispose maintenance system into an expanding value cycle

CASE OVERVIEW

Circulus operates at the intersection of commercial equipment maintenance, component repair, reverse logistics, and electronics recovery. This case focuses on its circular component lifecycle model for a large installed estate of commercial automated beverage equipment, where thousands of machines operate across geographically dispersed customer sites. The service began with a relatively narrow repair problem but has developed into an integrated system that manages the return, diagnosis, repair, recertification, storage, and redistribution of serviceable modules. Over the years, Circulus has also established an information system collecting data on component faults and repair histories, allowing it to identify patterns across the wider equipment estate.

The case is relevant because it challenges a common assumption in service-intensive industries: that replacing a failed component is the most practical and efficient response to equipment failure. Replacement is certainly convenient at the point of service. A field engineer can remove the faulty module, install a working spare, and restore the machine quickly. Yet the conventional model usually treats the removed module as waste or low-value recycling feedstock.

This destroys remaining functional value, triggers avoidable procurement and manufacturing demand, and misses information about why the component failed and how to prevent future disruptions.

Circulus has redesigned this process around systematic component recovery. Failed modules are returned to a centralised, specialist operation, assessed and repaired where technically and commercially viable, tested to an agreed standard, placed into circular stock, and redeployed across the installed estate. The repaired module is not necessarily returned to the machine from which it came. Instead, it becomes part of a managed pool of good stock that supports the whole service network.

This decoupling is important: it allows a component to retain its function within the network even when its individual route changes.

The reported scale indicates that the model has moved beyond a small repair pilot. Circulus described an installed estate of approximately 16,000 machines, around 72 supported component types, with more than 30,000 components processed in recent years, and a network of about 250 field engineers. For the supported component categories, approximately 97 per cent of demand was reportedly met from components processed through the circular system rather than newly purchased stock. A separate assessment of a previous operating year estimated around 747 tonnes of avoided carbon emissions, including the impact of replacement manufacture, transport and Circulus's own processing.

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These figures illustrate the breadth of value that the model is intended to preserve and demonstrate.

FROM A LINEAR FLOW TO A VALUE CYCLE

Most circular-economy models show loops around an otherwise linear product lifecycle. They are valuable for distinguishing repair, reuse, remanufacturing, and recycling, but they do not always reveal the organisational change required to turn a disposal point into a repeatable circular flow.

This “Preserving value through circular component lifecycle management” case suggests a complementary concept: the value cycle.

A **value cycle** is a deliberately created circular flow within a previously predominant linear value network. It tracks the value embodied in the system and its components, then coordinates the activities, information and relationships needed to keep that value productive through repeated cycles. The focus extends beyond the physical recovery of materials. Instead, the value cycle seeks to preserve multiple forms of value simultaneously: the **functional value** of a working component; the **material value** embodied in the energy, labour and resources already invested in it; the **financial value** generated by avoiding unnecessary replacement; the **informational value** captured through data on component performance, failures and repairs; and the **relational value** embedded in the network of partners that enables efficient recovery, repair and redeployment.

Predominant linear replacement flow

In a linear model, component failure usually triggers replacement and disposal, causing much of the embodied value to be lost.

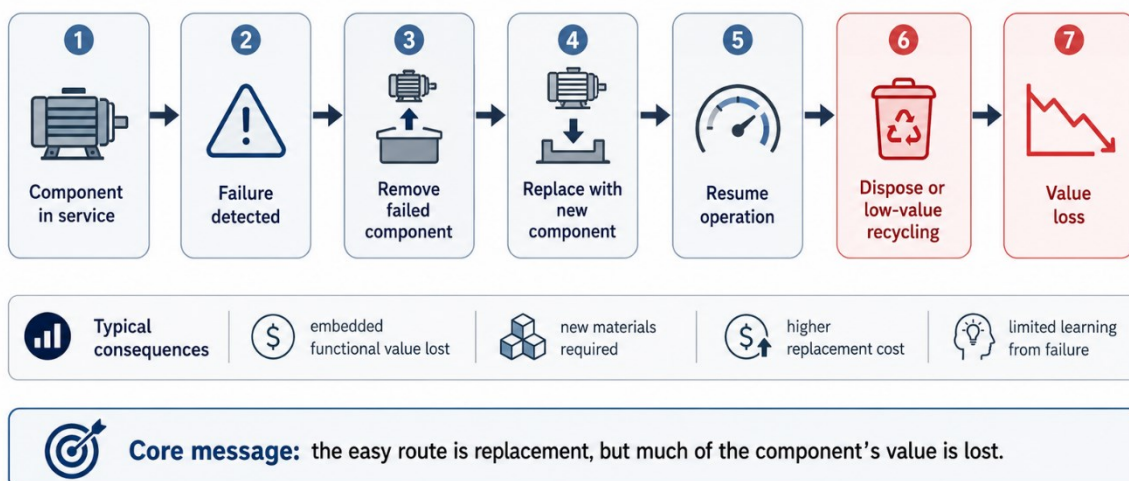


Figure 1 Existing linear replacement flow.

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Component value cycle

A deliberately created circular flow that transforms a linear replacement process into a value-preserving cycle.

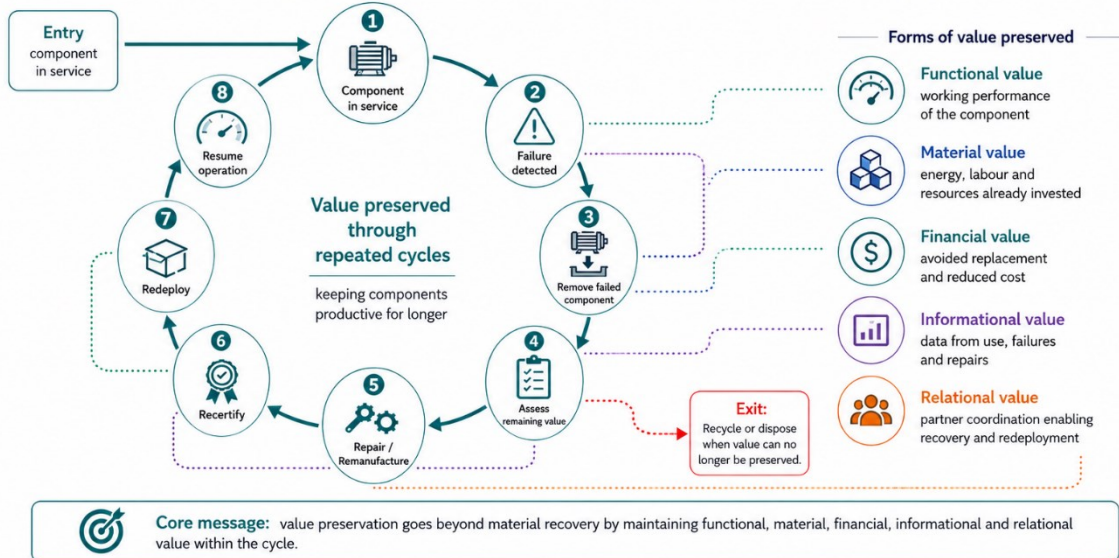


Figure 2 Value cycle focused on preserving the embodied value.

This introduces **value preservation** as a distinct activity alongside four established value activities. **Value creation** introduces new value through products, services, capabilities or knowledge. **Value delivery** makes value available to users and other stakeholders. **Value capture** converts a share of value into revenue or another organisational return. **Value demonstration** provides credible evidence that the value exists and that claimed outcomes have occurred. **Value preservation** acts earlier: it prevents value already embodied in a product, component, or relationship from being unnecessarily degraded, removed, or destroyed.

Value activities and value preservation

Five distinct activities in a circular value system

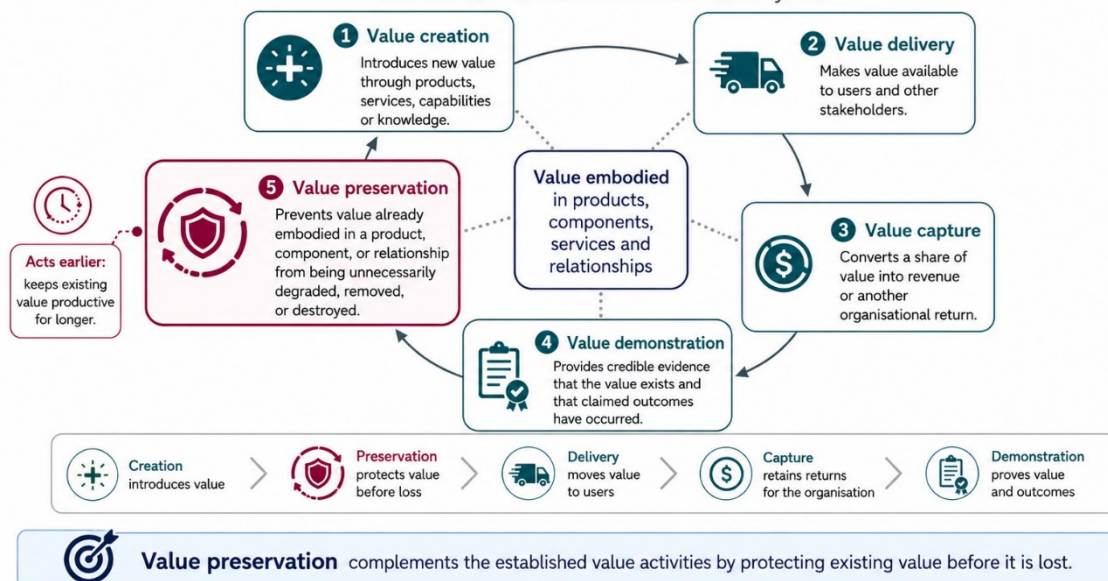


Figure 3 Value activities around embodied value.

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Value preservation is therefore not passive conservation. It comprises purposeful activities such as identifying recoverable components, retaining access to them, diagnosing remaining useful potential, repairing or remanufacturing them, assuring their quality, returning them to service, and maintaining information across successive cycles. It also requires decisions about when preservation is no longer appropriate. Components should eventually move to material recovery when they are unsafe, obsolete, uneconomic to repair, or no longer compatible with the operating estate. The principle is not to preserve everything forever, but to preserve value at the highest viable level before moving down the hierarchy.

The Circulus value cycle illustrates this shift clearly. In the linear flow (see Figure 1), a component travels from manufacture to installation, use, failure, replacement and disposal. In the value cycle (see Figure 2), failure becomes an intervention point rather than an endpoint. The module moves from use to recovery, assessment, repair, recertification, circular stock and redeployment. Information from each return is fed into maintenance decisions, engineer training, customer planning and, where possible, manufacturer design improvement. The result is not one forever-lasting, closed circle, but a flexible cycle that retains different forms of value for different periods of time.

HOW THE COMPONENT VALUE CYCLE OPERATES

The **value cycle** begins in the field. Engineers servicing the installed equipment carry or obtain working replacement modules so that a faulty unit can be exchanged quickly. This preserves the operational priority of restoring the machine without asking the field engineer to undertake complex component-level repair on site. The removed module is returned to Circulus with a job reference and information about the reported fault or maintenance event.

At Circulus, the module enters a controlled triage and quality process. The reported fault is checked against diagnostic testing, and the team determines whether additional issues are present. Where the module is suitable for recovery, it is disassembled and cleaned. Necessary lower-level parts are replaced, the module is rebuilt, and it is fully retested in a working system. Once it meets the agreed performance standard, it is recertified, packaged, and placed back into the circulation stock. Modules that cannot be preserved at component level move to appropriate recovery or recycling routes.

The technical repair is only one part of the model. Circulus has progressively centralised the surrounding logistics and inventory activity. It receives returned modules, holds circular stock, and redistributes components directly to engineers. Engineers are replenished regularly, while higher-value or less frequently used modules can be held in regional forward-storage locations. Where a required component is not already available in a van or local store, Circulus described rapid fulfilment arrangements designed to limit repeat visits and equipment downtime. The value cycle therefore replaces a slow, specialist repair-in-situ process with a fast service-exchange process. Circularity does not delay the customer's operation because the repaired stock is already circulating ahead of the next failure.

A proprietary information system supports this operation. Modules are tracked by serial number, including previous returns, repair interventions, components replaced and time between recorded visits. Job information from the customer's field-service system can be linked to the returned part, helping Circulus compare the reported symptom with the result of workshop testing. This data has practical uses. It can reveal recurring failure modes, highlight possible

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training needs, and identify distinct modules returned from the same locations, showing when engineers are replacing the same component without resolving the underlying problem.

The central position of Circulus creates an additional network advantage. A single engineer may encounter a particular fault only occasionally, while Circulus sees returns from hundreds of engineers across the installed estate. A small local signal can become a clear system-level pattern once aggregated. Circulus can investigate the root cause, advise the customer and, in some cases, feed findings to the equipment manufacturer or component supplier.

Circulus described an instance in which recurring display failures were analysed and communicated upstream, contributing to a design or production change and supporting a warranty response. Downstream repair activity thus becomes a source of upstream product intelligence.

This operating model changes the role of Circulus. It is not simply a repair subcontractor and not merely an electronics recycler. It acts as an orchestrator of component flows, quality, stock, and information across the service ecosystem. Its capabilities sit between the equipment operator, field engineers, manufacturers, logistics providers and end-of-life recovery partners.

The value cycle works because these activities are coordinated rather than left as disconnected transactions.

FINDINGS THROUGH THE FIVE-VALUE LENS

Value preservation: retaining what is already embodied

The primary finding is that the model preserves value at component level before attempting to recover value at material level. A faulty module still contains engineered assemblies, high-value materials, embedded energy, previous manufacturing effort and a body of performance information. Repair and recertification allow this bundle of value to remain productive.

The reported 97 per cent circular-stock contribution is especially significant because it indicates the degree to which supported demand can be met without introducing new modules into the system.

Preservation also occurs at network level. The model retains specialist knowledge in a central team, maintains a pool of available components and protects relationships that enable technical information and feedback to move between organisations. These less visible forms of value are essential. A component may be physically repairable, but without return logistics, trusted testing, compatible stock systems, and a customer willing to use recertified modules, its remaining value will still be lost.

Value creation: building the capability to preserve

Although preservation is the organising purpose, the cycle depends on newly created capabilities. Circulus has developed diagnostic routines, test equipment, repair knowledge, quality standards, stock-management processes and a serial-level information system. It has also created relational capability: the ability to interpret field information, work with the customer, engage manufacturers and translate technical findings into operational

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recommendations. This clarifies the relationship between creation and preservation. New capability is created so that existing product value can be preserved.

The business does not eliminate value creation; it redirects it away from repeatedly manufacturing replacement modules and towards creating the infrastructure, knowledge, and trust needed to keep existing modules in use.

Value delivery: making the preserved value operationally useful

A repaired component has limited value if it cannot reach the right engineer in time or if the customer does not trust its quality. Value delivery in this case includes collection of failed modules, controlled handling, testing and recertification, stock availability, regular engineer replenishment, regional storage, and rapid distribution.

These mechanisms allow the circular route to match the operational convenience of new replacement stock.

The model also delivers information. Customers receive visibility of returns, fault patterns, and engineer activity through reporting and portal access. Manufacturers may receive evidence about systemic faults or design weaknesses. Engineers benefit from access to tested modules and from a service model that separates rapid field exchange from specialist workshop repair.

Value capture: converting preservation into a viable service

Circulus captures value by providing repair, component management, stock, and logistics services. The customer captures a substantial share through avoided purchase of new modules, reduced inventory complexity, lower downtime, delegated warranty management, and improved reliability. Manufacturers can capture value through fault intelligence, reduced repeat defects, and better warranty management.

The model contains a productive tension. Better repair and failure prevention can reduce the volume of future faults, apparently shrinking the work available to the service provider. Circulus addresses this not by preserving failure, but by expanding the scope of the relationship: supporting additional components, taking responsibility for more of the logistics and information chain, improving the customer's operation and transferring the model to other equipment estates.

The unit of value capture therefore shifts from an individual repair transaction towards long-term management of the value cycle.

Value demonstration: proving that preservation matters

One of the case's most important lessons is that preserved value can remain invisible. A repair invoice appears as a direct cost in one departmental budget, while avoided replacement purchases, reduced downtime, and sustainability benefits may appear elsewhere or may never be recorded. Early in the relationship, this fragmentation made it difficult to articulate the total financial case. Circulus and its customer have progressively developed data and reporting that connect service activity with avoided expenditure and operational outcomes.

The company also commissioned an assessment comparing the carbon impact of refurbishment with the manufacture and transport of replacement modules. The reported result of

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approximately 747 tonnes of avoided emissions for one operating year was independently verified and has attracted interest from the customer's sustainability function. Demonstration therefore performs two roles: it validates the environmental claim and helps the customer recognise that circularity is an operating and financial benefit rather than only a waste-management activity.

TRANSFERABLE BEST PRACTICES

The case provides a set of practices that other organisations can adapt. They are most relevant where there is a sizeable installed equipment estate, repeat component failures, field-service operations and a meaningful difference between the cost of a new module and the cost of controlled recovery.

Start with components where preservation has a strong business case. Circulus did not attempt to redesign the whole equipment system at once. The model developed around recurring component problems for which repair could be technically proven and financially justified.

Organisations should prioritise modules that are high-value, recoverable, sufficiently common and expensive to replace. Early successes create the evidence and confidence needed to widen the cycle.

Separate rapid service restoration from specialist repair. Field engineers need to return equipment to operation quickly, while component repair benefits from controlled conditions, diagnostic equipment and concentrated expertise. A circular-stock exchange allows both objectives to coexist. Engineers replace a module rapidly; a central team repairs it properly; the recovered component later returns to the estate.

Design the reverse flow with the same care as the forward supply chain. Repairability is often discussed as a physical property of a product, but the Circulus case shows it is also a network capability. Failed parts need identifiers, collection routes, accompanying job information, triage rules, stock controls, and reliable redistribution. Without these mechanisms, technically repairable components will still be discarded.

Build quality and trust before scale. Repaired modules must meet an agreed standard and perform reliably in the field. Circulus uses controlled testing, recertification, and managed stock to make the recovered component operationally equivalent to an acceptable spare. The customer's confidence was built over time, module by module, rather than assumed at the outset.

Treat lifecycle information as a shared asset. The return stream can reveal patterns that no single stakeholder can see. Serial histories, fault reports, test results, and location or usage data can support root-cause analysis, engineer training, warranty claims, product redesign and maintenance planning.

Value increases when data flows back upstream rather than remaining trapped in separate organisational systems.

Demonstrate value in the language of each stakeholder. Operations teams may value availability and first-time repair; procurement may value avoided new-buy; finance may value total cost; sustainability teams may value carbon and material retention; manufacturers may

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value fault intelligence. A convincing circular proposition links these perspectives rather than relying on environmental benefit alone.

Scale through modular replication. The process can be packaged as a repeatable sequence of component selection, technical validation, quality assurance, reverse logistics, circular stock and data requirements. This enables expansion to new component families, customers, and service-intensive sectors without reproducing every detail of the original equipment system.

EXTENDING AND SIMPLIFYING THE VALUE CYCLE

The current model is mature enough to demonstrate substantial value, but it is not presented as complete. Circulus is continuing to expand and simplify the cycle. This development pathway creates clear opportunities for customers, manufacturers, technology providers, logistics organisations, researchers, and policymakers to participate.

First, Circulus is seeking closer collaboration with manufacturers to rationalise component ranges. Greater commonality across equipment models would reduce the number of distinct parts required in circular stock, simplify repair capability and improve the utilisation of recovered components.

*The goal is not necessarily fewer functions, but fewer unnecessary variants
and better compatibility across product generations.*

Second, the company is continuing to remove friction from reverse logistics. Each avoidable handover, storage point or transport leg adds cost and delays the component's return to service. Centralising receipt, repair, stock, and distribution has already shortened the route; further optimisation could simplify customer onboarding and make the model easier to replicate.

Third, the next stage depends on interoperability between information systems. Circulus can track modules while they are part of the repair cycle, but it has incomplete visibility during their working life in the field. Linking the component identifier with machine use, location, duty cycles, and maintenance activity would show how operating conditions affect performance and when particular failures are likely to occur. The immediate requirement is not a single universal database, but agreed identifiers, data requirements, and interfaces that allow relevant information to be exchanged securely between the customer, engineers, Circulus, and manufacturers.

Digital Product Passport applications may provide part of this architecture. In this case, the passport is valuable less as a static compliance record and more as a way to connect distributed, interoperable lifecycle information to a common component identity. Circulus has piloted a remanufacturing-focused passport and is seeking customer engagement to close the information gap between dispatch and return.

Richer in-service data would support the movement from reactive and time-based maintenance towards more precise predictive maintenance. Instead of knowing only that a module typically returns after several months, the network could relate failure to actual usage, such as operating cycles or production volume. This could allow maintenance to be planned before breakdown, reduce downtime, and improve stock preparation. Circulus would remain central because it combines the aggregate repair history with patterns from across the full estate.

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The company is also continuing to strengthen value demonstration. Financial savings, operational performance, avoided carbon, material retention, and local social value need consistent definitions and credible evidence. Better measurement would help existing customers understand the total return, help new customers compare the circular option with replacement, and help policymakers recognise component-level value retention rather than measuring success only through waste tonnage or recycling rates.

Finally, Circulus aims to transfer the approach beyond the current equipment estate. The model is potentially relevant to vending, medical, industrial, retail, energy and other service-intensive systems where engineers replace modular parts across a distributed installed base. Transfer will require adaptation to different safety standards, failure patterns, asset ownership, and commercial arrangements, but the underlying capability is repeatable: recover the part, preserve its value, return it to operation, and use the resulting intelligence to improve the system.

IMPLICATIONS FOR PRACTITIONERS, PARTNERS AND POLICYMAKERS

For equipment owners, the first step is to identify where replacement has become an unquestioned default. Useful questions include: Which modules are replaced frequently? Which are costly or slow to procure? Which can be removed without disrupting the whole product? What proportion of returned modules retain repairable value? Could a circular stock pool protect service availability while reducing new purchases?

A pilot should begin with a bounded component family and measure quality, turnaround, cost, downtime, and retained value.

For manufacturers and component suppliers, collaboration with repair and lifecycle partners can improve product performance as well as circularity. Useful contributions include technical documentation, test criteria, access to subcomponents, shared fault coding, warranty protocols and design feedback. Designing common modules across product ranges can extend the viable market for recovered parts and reduce the risk of good stock becoming obsolete when one model is withdrawn.

For logistics, software and technical-service providers, the value cycle contains multiple points of entry. Partners can support collection and regional stock, system integration, shared identifiers, data governance, test automation, carbon assessment or specialist repair. The opportunity is not limited to competing with Circulus for the whole service.

Organisations can supply capabilities that make the existing cycle more efficient, connected, and scalable.

For policymakers and ecosystem organisations, the case suggests that circularity support should move beyond recycling infrastructure. Procurement and reporting frameworks should recognise repaired and remanufactured components, avoided replacement, and product-life extension. Innovation funding can help firms develop test rigs, reverse-logistics pilots, interoperable data requirements, and early evidence where benefits emerge across several organisations. Standards and guidance should enable appropriate sharing of lifecycle data while protecting commercially sensitive information and intellectual property.

The case also supports a different policy metric. Tonnes collected or diverted from landfill are important, but they do not show whether value was retained at its highest level. Component

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reuse rates, percentage of demand met by circular stock, operating life added, new purchases avoided, and verified carbon savings would give a more complete picture. These indicators make value preservation visible and encourage interventions before products become waste.

CASE CONCLUSION

Circulus demonstrates that the repairability of commercial electronic components is not determined by design alone. It is produced by a coordinated value network that retrieves failed modules, concentrates specialist knowledge, assures quality, manages circular stock, distributes parts at operational speed, and connects evidence across repeated cycles.

The conceptual contribution is the value cycle: a circular flow created within a previously linear system that keeps track of the value embodied in products and components. Within that cycle, value preservation is a distinct activity. It prevents useful function, material, financial, information, and relational value from being lost before replacement or recycling becomes necessary. Creation, delivery, capture, and demonstration remain essential, but they are reorganised around maintaining what the system already possesses: preservation.

For industry, the message is practical. Do not begin by trying to make the entire value chain perfectly circular. Identify a disposal point where recoverable value is being lost, create a controlled loop around it and build the capabilities and relationships required to repeat the cycle reliably.

Organisations can adopt this approach internally, provide capabilities that strengthen it or partner with Circulus to extend it into new components and sectors. The result is a form of circularity that is not an abstract environmental aspiration but a functioning operating model: preserving value before it becomes waste.