

**SUSTAINABILITY**

# Enabling Circular Solutions: How Specialized SMEs Can Help Incumbent Companies by Using Modularity

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## *Enabling circular solutions through modularity*

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The principles of modularity hold out the great promise of improving circularity through product design in incumbent companies.<sup>1</sup> If products could be made from modular, upgradable parts – components that can be repaired, replaced, or repurposed

independently – resource efficiency could be greatly improved. In theory, such an approach has the power to minimize waste, conserve resources, and extend product lifecycles, thus allowing the value of products and components to be maintained at its highest possible value.<sup>2</sup> Although modularity could revolutionize product design and improve circularity significantly, many companies are falling short. In particular, many incumbent companies have deficient capabilities in modularity<sup>3</sup> and fail to bridge this deficiency by collaborating with partners. Therefore, the potential of modular design remains an untapped resource.<sup>2</sup>

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For companies interested in shrinking their environmental footprints, modularity is more than a design choice – it is a strategic advantage. Modularity is a design approach that breaks down products into independent, interchangeable components, allowing individual parts to be repaired, replaced, or upgraded without disrupting the entire system.<sup>4</sup> Effective modularity relies on several core design principles. These design principles can create adaptable, long-lasting systems by prioritizing independent, core components that integrate seamlessly (*decoupling interface*) using versatile, multi-functional modules (*reusability*).<sup>5</sup> *Scalability* enables the system to grow by integrating data from multiple sensors, allowing it to handle larger tasks without overloading, while *customization* adjusts the modules to meet specific customer needs.<sup>6</sup> *Flexibility* ensures that parts are easily replaceable or upgradeable, while *maintainability* extends total system life through updates rather than replacements.<sup>7</sup> Together, these principles foster circular, efficient solutions, minimizing waste and environmental impact.<sup>7</sup>

However, not all incumbent companies have the capabilities to thoroughly execute these modularity principles. Against this background, some small, specialized companies can help bridge this gap by co-creating modular solutions that align with circular economy principles and help industries, such as manufacturing, energy, and construction, to achieve sustainability goals.<sup>8</sup> These smaller, innovative companies also design adaptable components that larger companies can integrate into incumbent systems and platforms, thereby making it possible to update systems rather than replacing them.<sup>9</sup>

## Helping Large Companies Go Circular: Illustrative Case Examples

In this short article we report on insights from a larger research program into how SMEs help incumbents with modularity to drive circularity. We interviewed founders, CEOs, CTOs and other key decision-makers from Swedish SMEs and incumbent companies, all of whom actively integrated modularity into their offerings to help large companies transition to more sustainable, circular business practices. These interviews provided valuable insights into how modular solutions were reducing the environmental impact while simultaneously contributing to business goals. We believe this provides ideas for other companies (SMEs and incumbents) from other countries can progress toward using modularity as a tool to drive circularity. A couple of representative case examples may help contextualize the ideas.

First, Exeger is a Swedish SME specializing in customizable solar cells called Powerfoyle. These solar cells can turn any kind of light into electricity. Exeger has teamed up with 3M, a global diversified manufacturing company. Together, they are working on adding these solar cells to some of 3M's safety equipment. The idea is to create products that can power themselves, thereby becoming more eco-friendly along with improving safety for workers. In addition, it will save money in the long run because the equipment will need fewer battery changes or recharges.<sup>10</sup>

Similarly, Enviro, another Swedish SME, has developed a modular recycling technology for tires. It has partnered with Volvo Group in the design, manufacturing, and distribution of commercial vehicles and construction equipment to create a more sustainable tire

recycling process. Enviro's technology recovers valuable materials, such as carbon black and oil from used tires, which can be reprocessed in the production of new tires or other rubber products, thereby enhancing circularity and sustainability.<sup>11</sup>

Finally, Flasheye specialize in 3D LiDAR technology. This company offers modular 3D perception systems that enhance spatial awareness with real-time data. Flasheye collaborates with large companies in industries such as mining, manufacturing, and security to help incumbents reduce resource consumption, optimize efficiency, and extend the lifespan of equipment. By enabling targeted upgrades rather than full system replacements, Flasheye promotes circularity, reduces waste, and minimizes environmental impact. A specific example of this is in the mining sector, where the solution enhances the navigation and obstacle detection capabilities of trucks, helping them operate more efficiently by cutting fuel consumption and reducing wear and tear on equipment.<sup>12</sup>

In sum, by offering scalable, adaptable, and upgradeable technologies, the SMEs we studied enabled businesses across various industries—including mining, manufacturing, agriculture, transportation, and security—to improve circular practices via modularity.

## What exactly is it that the SMEs are helping the incumbents with?

SMEs are helping incumbents by deploying the core principles of modularity, such as decoupling interfaces, reusability, scalability, and flexibility. These allow incumbents to reduce waste, optimize resource use, and extend the lifecycle of their products and systems. Specifically, this means:

1. **Decoupling Interface:** Modular systems have the ability to decouple components so that they can function independently. This enables businesses to add or replace individual components without overhauling the entire system. For example, one of our case companies in the security sector required a solution to enhance its surveillance capabilities to better monitor and manage high-traffic areas. To solve this challenge, the company partnered with an SME specializing in modular sensor

systems. This SME provided new sensor modules that could seamlessly integrate into the company's existing infrastructure, enabling them to upgrade their surveillance system without needing to replace the entire setup. This modular solution not only helped reduce waste but also minimized material use by utilizing the existing infrastructure, contributing to a more sustainable and cost-effective approach. Similarly, another incumbent from the mining industry needed to expand its operations to include additional capabilities, such as air quality monitoring, to improve workplace safety and efficiency. To address this need, the mining company collaborated with a specialized SME who offers modular environmental monitoring solutions. Through a flexible, modular system that could easily be added to the existing setup, enabling the mining company to enhance its monitoring capabilities without disrupting ongoing operations. This approach allowed for minimal disruption and significant resource efficiency, supporting the company's broader sustainability goals.

2. **Reusability:** Modular systems are designed to be multi-functional, meaning a single module can perform multiple tasks. This is a key advantage for companies that need to optimize their resources while minimizing the number of components in use. One SME company we studied, specializing in modular monitoring solutions, reported that they helped a large company in the safety and surveillance industry, which lacked the ability to streamline its operations. The SME provided a solution by offering multi-functional sensor modules that track personnel, monitor baggage handling, and manage access control—all within the same system. This modular approach allowed the company to integrate several functions into one unified system, eliminating the need for multiple separate systems. In ports and harbors this modular solution helps to monitor cargo, oversee docking activities, and manage traffic, all using a single set of modules. This reusability not only helped the company reduce equipment redundancy but also supported the “reuse” principle of circularity, minimizing the environmental footprint and optimizing resource use.
3. **Scalability:** Modular systems provide businesses with the flexibility to expand as their needs grow, a key feature of scalability. As industries scale operations, the need for monitoring or tracking more variables increases. For example, in manufacturing industry, as production demands increase, one of our case SMEs provided modular perception software that enabled incumbent companies to monitor products or

processes. This approach boosts operational efficiency by enabling easy scalability, without the need for major new infrastructure investments. It allowed businesses to expand their operations smoothly and cost-effectively, ensuring that growth is achieved while maintaining control over expenses. This scalability allows businesses to grow more efficiently, in line with the “reduce” principle, by avoiding the need for new purchases or full system replacements.

4. **Customization:** The modular nature of systems also allows for high levels of customization. Each industry may have its unique requirements here. For example, a large incumbent in the agriculture sector for sustainable farming connected with one of our case SMEs, specialized in modular automation solutions, to enhance their operational efficiency through process modularity. The SME helped the incumbent company by providing customized sensor solutions that allowed them to monitor soil moisture, track crop health, and assess equipment location in real-time. These customized modular systems were designed to integrate seamlessly into the company’s existing operations, enabling them to easily adjust for seasonal changes and specific growing conditions. By using modular automation, the company was able to add or replace individual sensor modules as needed, without overhauling their entire system. For example, as the growing seasons changed, the company could add additional sensors to monitor specific crops or adjust irrigation levels based on real-time data. This customization and adaptability helped the company optimize resource usage, improve crop yields, and maintain efficiency throughout the year, all while reducing the environmental footprint. This approach supports the “reuse” principle of circularity, enabling companies to adapt their systems over time without the need for a complete infrastructure overhaul.

5. **Flexibility:** Modular solutions are inherently flexible, allowing for easy upgrades or replacements of individual components. This feature is especially useful for industries like robotics or automated guided vehicles (AGVs), where technology evolves rapidly. One of our case SMEs, specializing in modular vehicle components, reported that they helped a large firm in the automotive industry through their modular product solutions. The SME in this case provided customizable and upgradable components for the company’s fleet of automated vehicles, allowing them to easily integrate the latest technology as it became available. This modular approach enabled the company to keep its systems up to date without needing to

replace entire vehicles or overhauling the whole infrastructure, thus reducing costs and enhancing operational efficiency over time. This approach supports the “reuse” principle of circularity, enabling companies to adapt their systems over time without the need for a complete infrastructure overhaul. It also aligns with the “reduce” and “recycle” principles of circularity, making upgrades less wasteful and extending the life of existing systems.

6. **Maintainability:** One of the most powerful aspects of modular solutions is their ability to extend the lifecycle of products and systems through regular upgrades and proactive maintenance. This reduces the need for full system replacements, helping companies maximize the value of their existing resources. For example, one of our previously mentioned case SMEs, with its advanced sensing and perception technologies, collaborated with a large technology provider in the security sector. The SME assisted the company in maintaining and optimizing its existing surveillance systems by integrating modular, customizable sensor modules that could be easily updated as new technologies emerged. This solution allowed the company to regularly maintain and upgrade its monitoring capabilities without requiring a complete infrastructure overhaul, thereby reducing long-term costs and extending the system’s operational lifespan.

## Conclusions

The modular capabilities provided by specialized SMEs holds immense potential for driving circularity in incumbents across various industries. By integrating adaptable, upgradable, and flexible components into existing systems, incumbent companies can extend product lifecycles, reduce waste, and optimize resource use. The examples from industries, such as mining, ports and harbors, manufacturing, robotics, agriculture, and security, demonstrate how modular design principles enable businesses to improve circularity. Such solutions enable targeted upgrades rather than entire system replacements, and they can, by extension, help incumbent companies incorporate greater circularity into their operations and value creation processes.<sup>13</sup>

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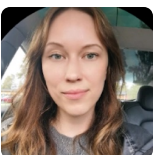
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