



# AWK'23

WWW.AWK-AACHEN.DE 11. / 12. MAI 2023

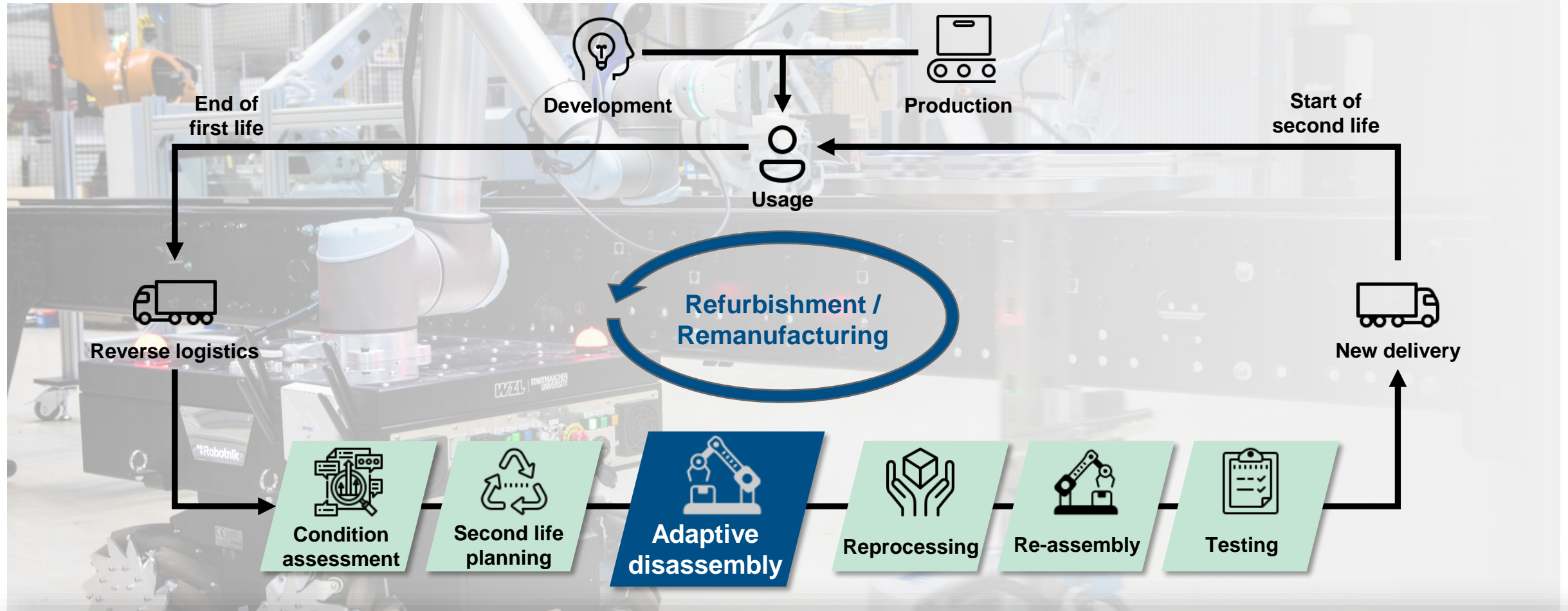
## Closing the Loop with Adaptive Automated Disassembly

Expert presentation – Session 1  
Guido Nilgen & Dr. Thilo Greshake

## Empower Green Production

# Circular strategies enable the transformation from cradle-to-grave approaches toward disassembly and re-utilization

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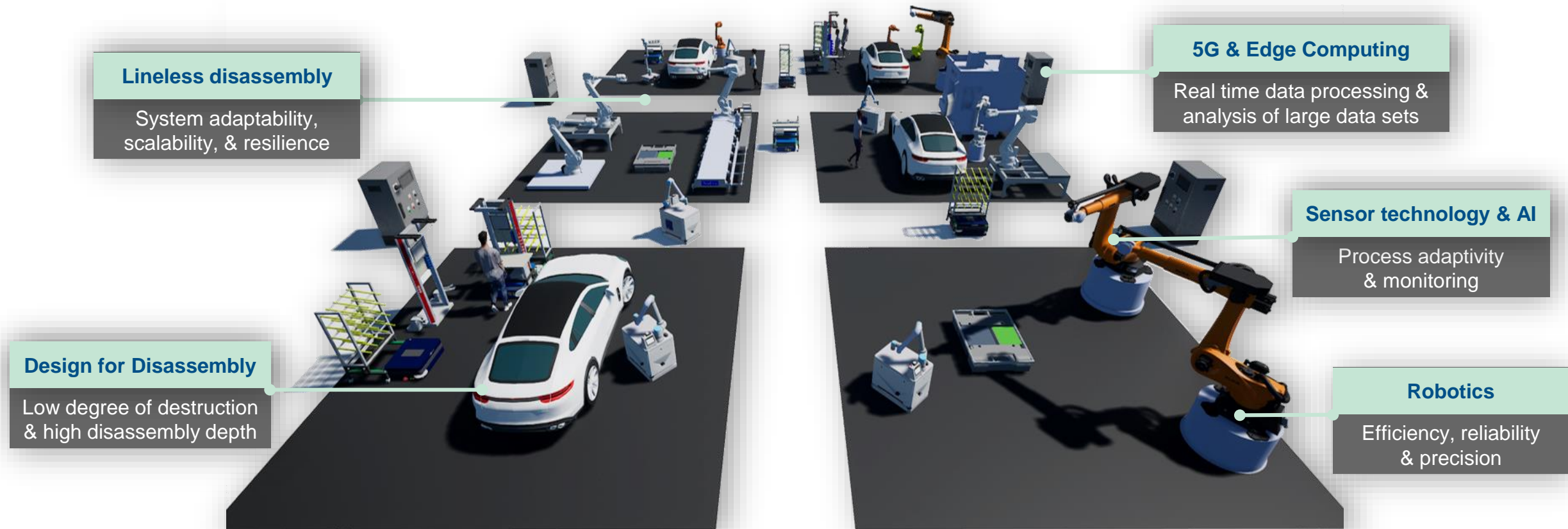


**Adaptive disassembly is a key technology for extending product life cycles**

Sources: [1] Potting (2017), [2] Sauer (2011)

# Adaptive disassembly systems use technologies to increase short-term flexibility and long-term transformability

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**Product, process, and system technologies are the enablers of adaptive automated disassembly systems**

Sources: [3] Günthner (2017), [4] Kneer (2023), [5] Soh (2014), [6] Hering (2012), [7] Schmitt (2017)



# The design of disassembly systems depends on product properties and reprocessing strategies

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**Miele**

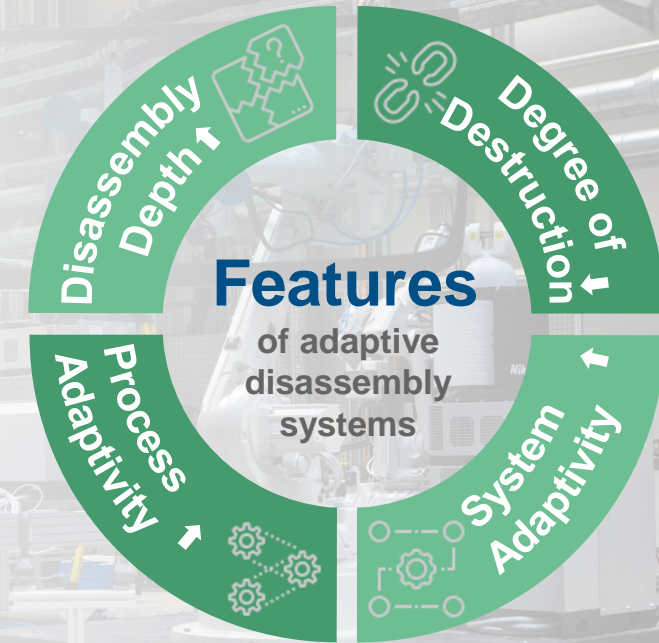
**Refurbishment of  
washing machines**



**Disassembly of  
car battery boxes**



**PCH  
/INNOVATIONS  
Disassembly of  
leisure shoes**



Sources: [3] Günthner (2017), [4] Kneer (2023), [8] Feldmann (1999)

# Refurbishment increases the total product lifetime and enables Miele to offer second life washing machines

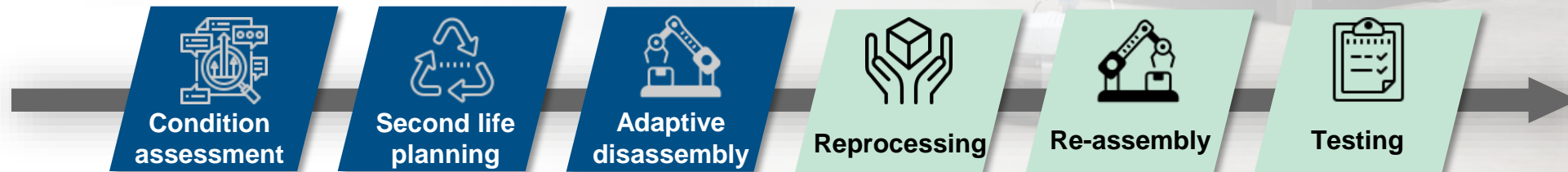
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## Software-supported disassembly planning

- Device-specific condition assessment
- Automated, quality-assuring second life planning
- Adapted disassembly concept





# Battery modules are assigned to a suitable second life based on their condition assessment

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## Second life applications

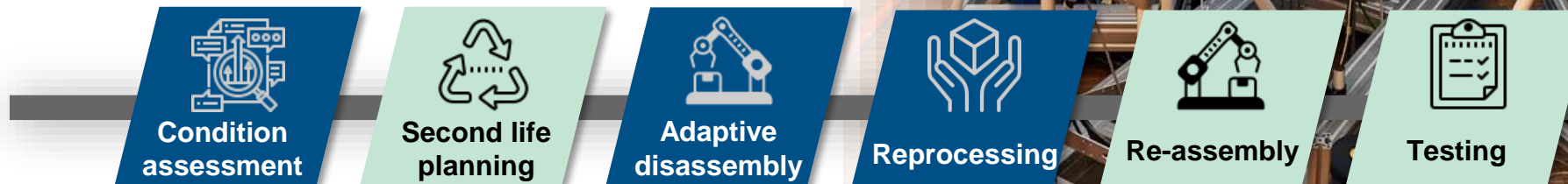
- Remanufactured for used cars
- Repurposed as stationary energy storage
- Recycled components for further use



## PCH /INNOVATIONS

### Disassembly strategies of versatile products

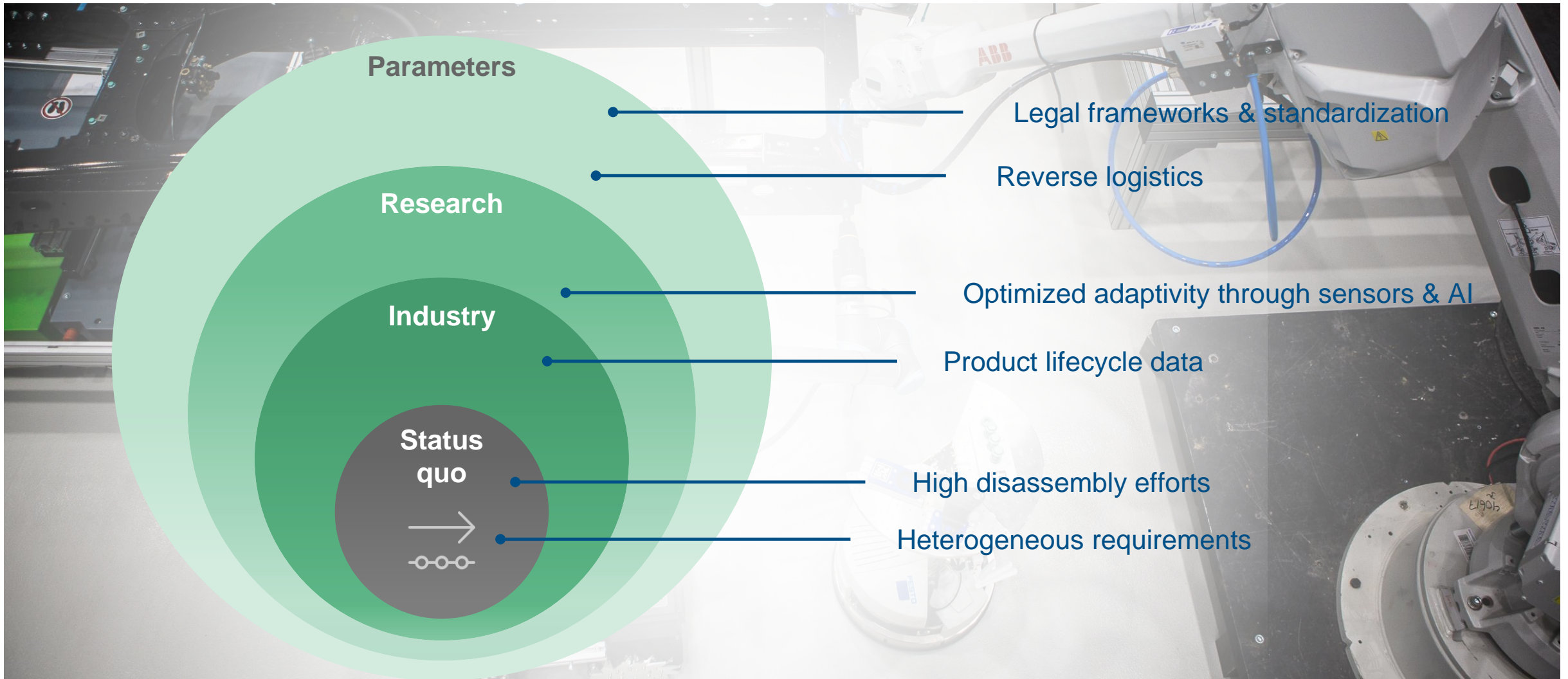
- Component recognition and assessment
- Robust work-holding and tooling
- Adaptive tool path generation





# Product lifecycle data and technology enablers must be combined to achieve adaptive disassembly

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# Wrap Up: Adaptive automated disassembly as a key enabler of circular economy

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Refurbishment and remanufacturing promote green production as circular economy strategies.



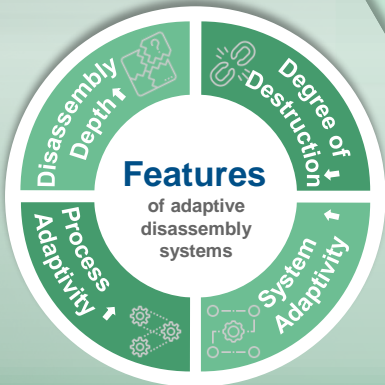
By purchasing high-quality second life products, customers can not only save costs and protect the environment, but also benefit from a possible increase in value.



The variety of product properties and states requires adaptive processes. Adaptive systems are necessary to increase adaptability to external conditions.



The combination of different strategies, technologies and frameworks enables the successful implementation of adaptive disassembly systems.



- [1] J. Potting, M. Hekkert, E. Worrell and A. Hanemaaijer. „Circular Economy: Measuring Innovation in the Product Chain.“ Policy Report. <https://www.pbl.nl/sites/default/files/downloads/pbl-2016-circular-economy-measuring-innovation-in-product-chains-2544.pdf> (Accessed: 24th February 2023).
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- [3] W. Günthner, E. Klenk and P. Tenerowicz-Wirth, „Adaptive Logistiksysteme als Wegbereiter der Industrie 4.0,“ in *Handbuch Industrie 4.0: Bd. 4*, B. Vogel-Heuser, T. Bauernhansl und M. ten Hompel, Ed., 2nd edition. Berlin, Heidelberg: Springer Reference Technik; Springer Vieweg, 2017, pp. 99–125.
- [4] F. Kneer, E. Kamsties and K. Schmid. „Environment Modeling for Adaptive Systems: A Systematic Literature Review.” <https://arxiv.org/abs/2011.07892> (Accessed: 24th February 2023).
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- [6] E. Hering and G. Schönfelder, *Sensoren in Wissenschaft und Technik: Funktionsweise und Einsatzgebiete*. Wiesbaden: Vieweg+Teubner Verlag, 2012.



- [7] R. Schmitt *et al.*, „Frei verkettete wandlungsfähige Montage,“ in *29. Aachener Werkzeugmaschinen-Kolloquium 2017: Internet of Production für agile Unternehmen, 18th to 19th Mai*, C. Brecher, F. Klocke, R. Schmitt and G. Schuh, Ed., 2017, pp. 339–368.
- [8] K. Feldmann, S. Trautner and O. Meedt, „Innovative disassembly strategies based on flexible partial destructive tools,“ *Annual Reviews in Control*, No. 23, pp. 159–164, 1999, doi: 10.1016/S1367-5788(99)90079-2.

## Figure References

### Slide 2:

Background

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### Slide 3:

Disassembly system

Own illustration by the WZL

### Slide 4:

Washing machine

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Ford automobile

© Ford Motor Company (<https://www.ford.de/cars/mustang-mach-e>)

Leisure shoes

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Background

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### Slide 5:

Washing machine

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Background

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### Slide 6:

Ford automobile

© Ford Motor Company (<https://www.ford.de/cars/mustang-mach-e>)

Background

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### Slide 7:

Shoe reprocessing cell

© PCH Innovations, Photo by Jan Schoelzel

### Slide 8:

Background

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### Slide 9:

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### Slide 13 and 14:

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# Thank you for your attention!

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