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Circular 4.0: Using digital intelligence in automotive parts remanufacture to enable a circular economy

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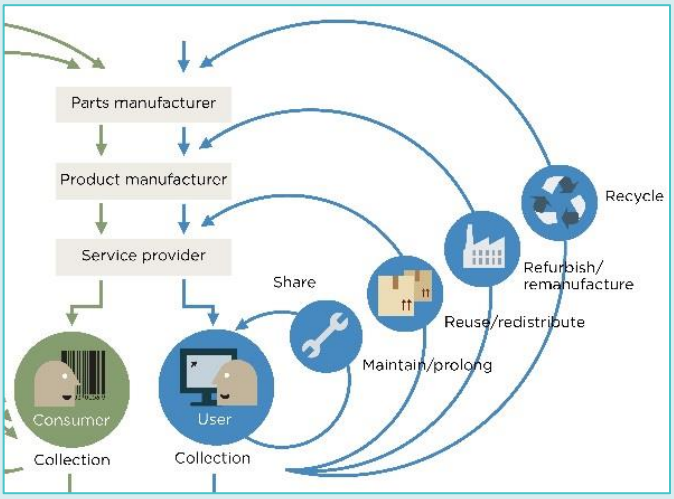
Moving from a linear economy towards a circular economy

Modern industrial societies have developed by taking raw materials to manufacture products which are then used and disposed of by consumers. There is interest in moving away from this linear economic model towards a circular economy in which the full value of materials is realised by keeping products, and their constituent parts, in use for as long as possible. Various strategies can help, such as to reuse, maintain, remanufacture and recycle suitable parts.



The Circular Economy
Source: Ellen MacArthur Foundation

The EPSRC-funded Network Plus *Connected Everything: Industrial Systems in the Digital Age* aims to identify the key challenges we face as digital technologies transform our industrial systems.

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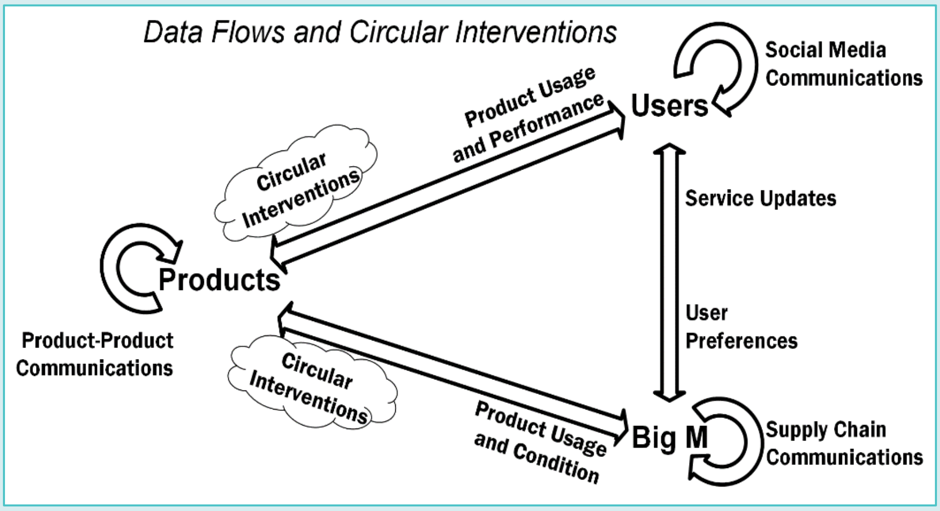
The project is the first to demonstrate how digital data can be used in the development of a decision support system, to facilitate the adoption of circular strategies in the context of the automotive sector.

Remanufacture of automotive parts has already been proven economically viable, as shown by the Renault remanufacture facility at Choisy, France, which now generates revenue of €0.5 billion per year. The high degree of variation in the quality of products returned makes the remanufacture process difficult and this has consequently limited its uptake across the automotive sector. The project exploited recent advances in digital technologies in seeking to overcome this issue; affordable sensors can now be attached to parts, such as the motor, batteries and fuel cells, to provide real-time information about how a part is being used.

Remanufacture processes and the flow of data in the system

We began by identifying how data can be accessed and collected as it flows between users, products and ‘Big M’ manufacturers (Original Equipment Manufacturers, service agents and dealerships) in the system.



This initial project work highlighted, firstly, the vast array of forms of data and highly variable amounts of data available for any given product. A taxonomy of manufacturing data was defined in three categories (structured, semi-structured and unstructured data sources).

The remanufacture processes, at a hypothetical independent remanufacture facility, were mapped and simulated. The Discrete Event Simulation (DES) model that we developed focused on the remanufacture of two major components of an electric motor; a shaft and a rotor.

Key remanufacturing features were identified as: Collection (returned products), Inspection and Sorting, Disassembly, Time spent in disassembly, cleaning and inspection, Inspection and Grading, Fault diagnosis and prognosis, Reconditioning and Repair, Reassembly and Testing.

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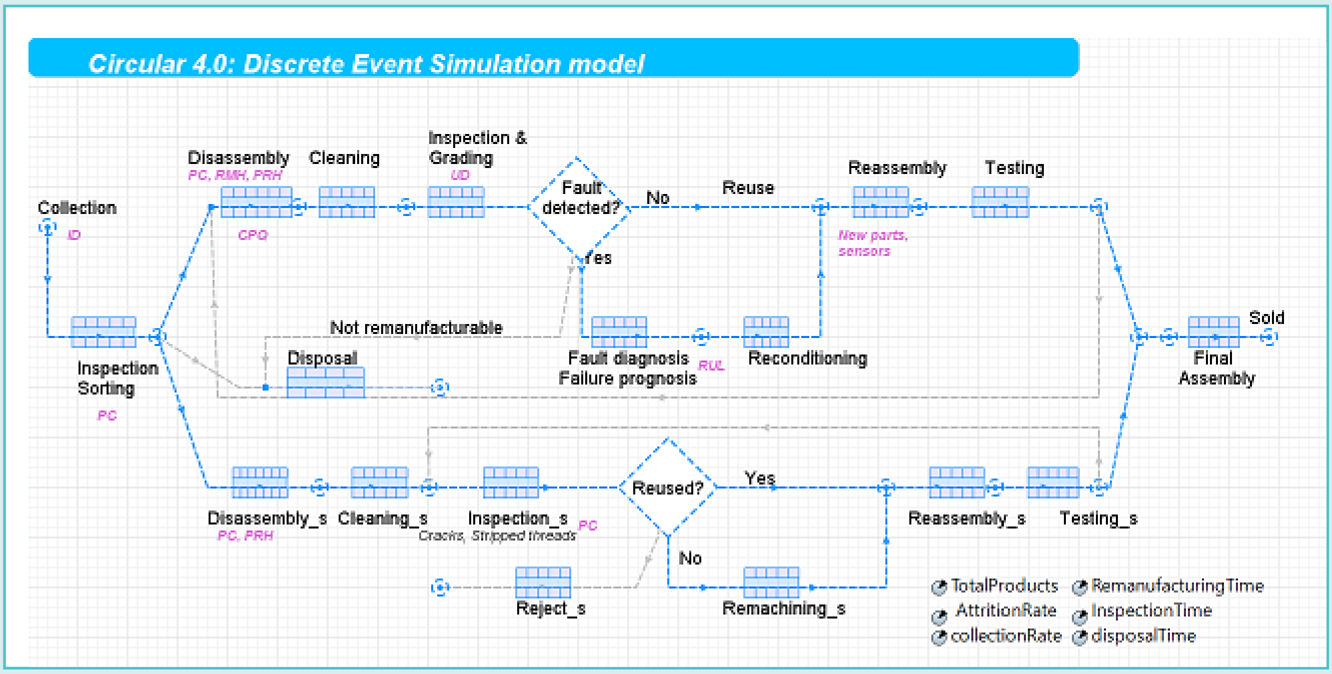

Certainty in Product Quality (CPQ) – a new concept

We propose a new concept of Certainty in Product Quality (CPQ), which expresses the degree of confidence in the quality of a returned product. CPQ is based on the product's condition, remanufacturing history, part-replacement history and data from sensors. A value between 0 and 1 is derived on the basis of the amount of information from these sources which is available for the particular product. Values around 0.8 – 1.0 express confidence/certainty about the quality of the item; values below about 0.5 express lack of confidence.

The usefulness of the CPQ concept was investigated by developing another model, this time for the system dynamics of the remanufacturing process of a fuel cell at RiverSimple. The results were clear as shown by these results for a batch of 100 products:

Time products spent in disassembly, cleaning and inspection

High CPQ of 0.8 to 1 > 75 percent spent between 31 and 35 hours in disassembly, cleaning and inspection.
Low CPQ of 0.1 to 0.3 > 75 percent spent between 46 and 52 hours.

Batches of CPQ rated products await remanufacture in the system

Low CPQ 0.1 > after 10 days only 1 product completed disassembly, cleaning and inspection.
High CPQ 1.0 > after 10 days 3 products completed disassembly, cleaning and inspection.

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Key finding 1

The concept of Certainty of Product Quality (CPQ) can support a more efficient and intelligent remanufacturing process, resulting in substantial cost, material and resource savings.

Key finding 2

The data from embedded sensors are important determinants of the CPQ value, but existing data streams are not designed to inform remanufacturing decisions.

Wider applications

The capture of CPQ rates can predict the time required as well as the number of products that can be remanufactured. Thus it allows a forecast that could be used to plan remanufacture and production processes, particularly by allowing an automated distinction to be drawn between the decision to ‘go’ or ‘no go’ for remanufacture.

In the context of the Circular Economy, this forecasting of the condition of returned goods through the CPQ value, can inform decisions about where and when a part might re-enter the manufacturing process to best effect. CPQ would need to be product specific and in the longer term this ought to be considered when designing a product or component.

The circular data-driven approach developed in this project is also of relevance to other sectors including consumer electronics and high value engineering products.

What next?

A further 3 year project will build on this early pioneering work, addressing the challenges identified by it; as we work towards developing circular economy approaches. We will be identifying how data from products in the automotive and aerospace sectors can further inform decisions surrounding the implementation of Circular Economy strategies within manufacturing. Data streams will be characterised to select the optimal Circular Economy strategies and timing of intervention. Research findings will be applied and tested in use cases at Airbus, Rolls Royce and Riversimple.

Further funding achieved

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