11th October 2023

Circular Economy Innovation Network Taking action towards circularity in aluminium

www.ktn-uk.org

UKRI Innovate UK KTN

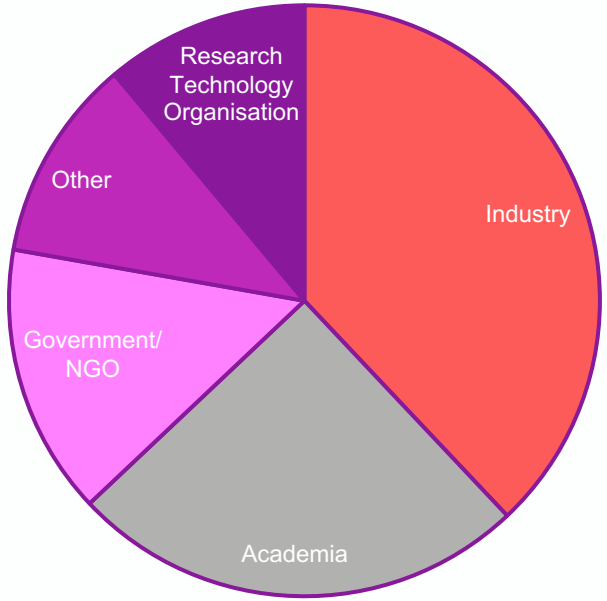
Interaction

- Please use Q&A function to ask questions

- Networking
  - Please add your name, organisation and interest in this area into the chat
  - You can access the attendee list to contact those after the event

- Break out rooms
  - You will be able to select the break out room
  - Break out rooms will not be recorded

Participants



Circular Design	Circular Recovery	Circular Business Models
Ajay Kapadia	Robert Quarshie	Chris Pilgrim
Rachel Wiffen	Graham Hurrell	Ebad Bagherpour

UKRI Innovate UK KTN

Agenda

10:00 Introduction and overview of innovation action plan for aluminium in a circular economy
Chris Pilgrim – Innovate UK KTN

10:15 Circular Design – How Life Cycle Assessments can facilitate circularity
Rachel Wiffen – Innoval

10:30 Circular Recovery – How data can enhance material value and recovery
Graham Hurrell – Hydro Building Systems

10:45 Circular Business Models – How the Metal Health Service will transform business models
Dr Ebad Bagherpour - BCAST

11:00 Break out rooms – Meet the speakers and discuss themes

11:35 Next steps – Funding, Initiatives, Collaborations
Chris Pilgrim – Innovate UK KTN

11:45 Meeting close

UKRI Innovate UK KTN

Circular Economy Innovation Network – Taking action towards circularity in aluminium

Metal Health Service (MHS)

Prof. Zhongyun Fan

Dr Ebad Bagherpour

Dr Alessio Franconi

Brunel Centre for Advanced Solidification Technology

11th October 2023

BCAST

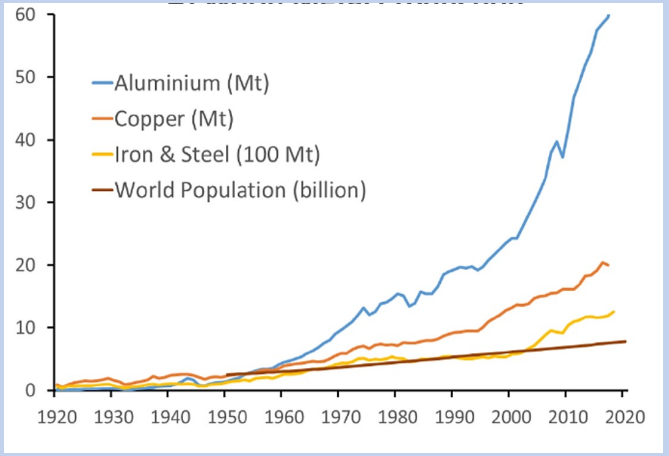
Brunel University London

UKRI Interdisciplinary Centre for Circular Metals

Mining in the 21st century: historical & future demand

UKRI Interdisciplinary Centre for Circular Metals

The demand for metals increased throughout the twentieth century, driven by a growing population, urbanisation, industrialisation, and increased per capita income.



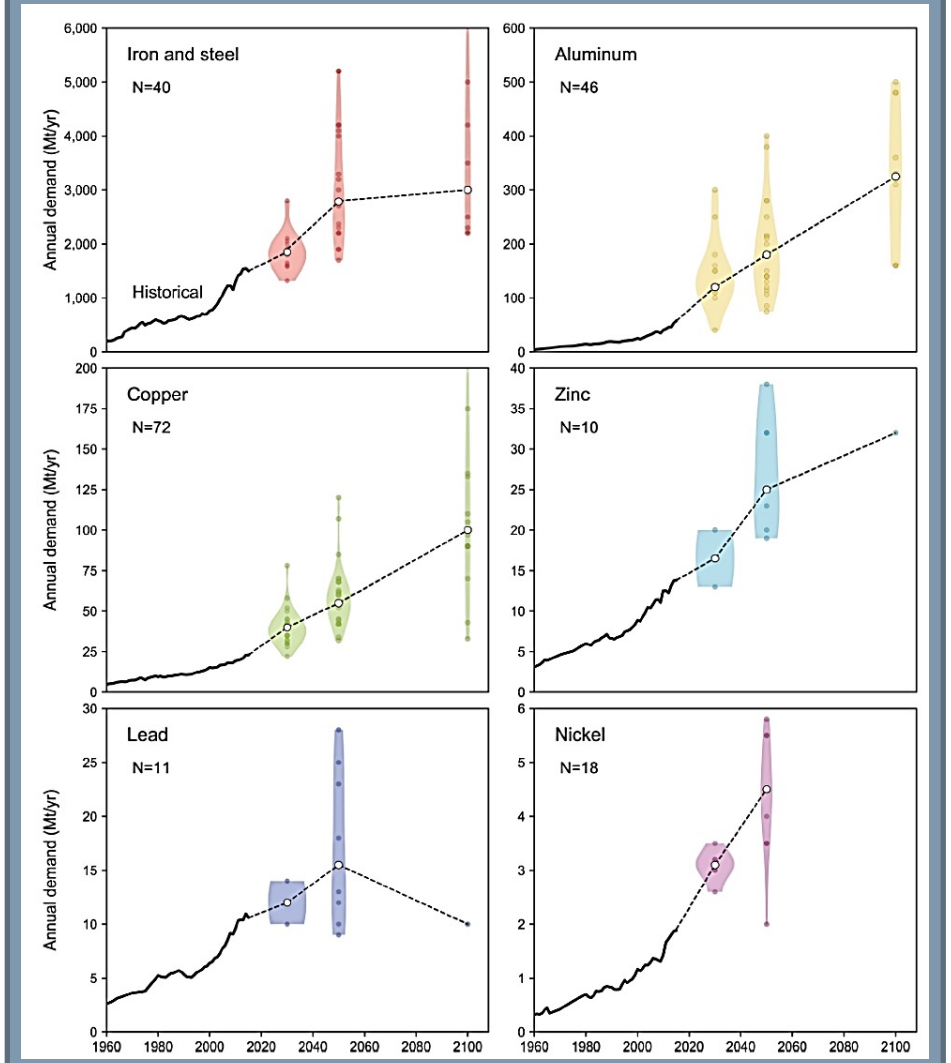
Global metal production

Demand growth rate by 2050:

Aluminium: 215%
Copper: 140%

Demand growth rate by 2100:

Aluminium: 470%
Copper: 330%



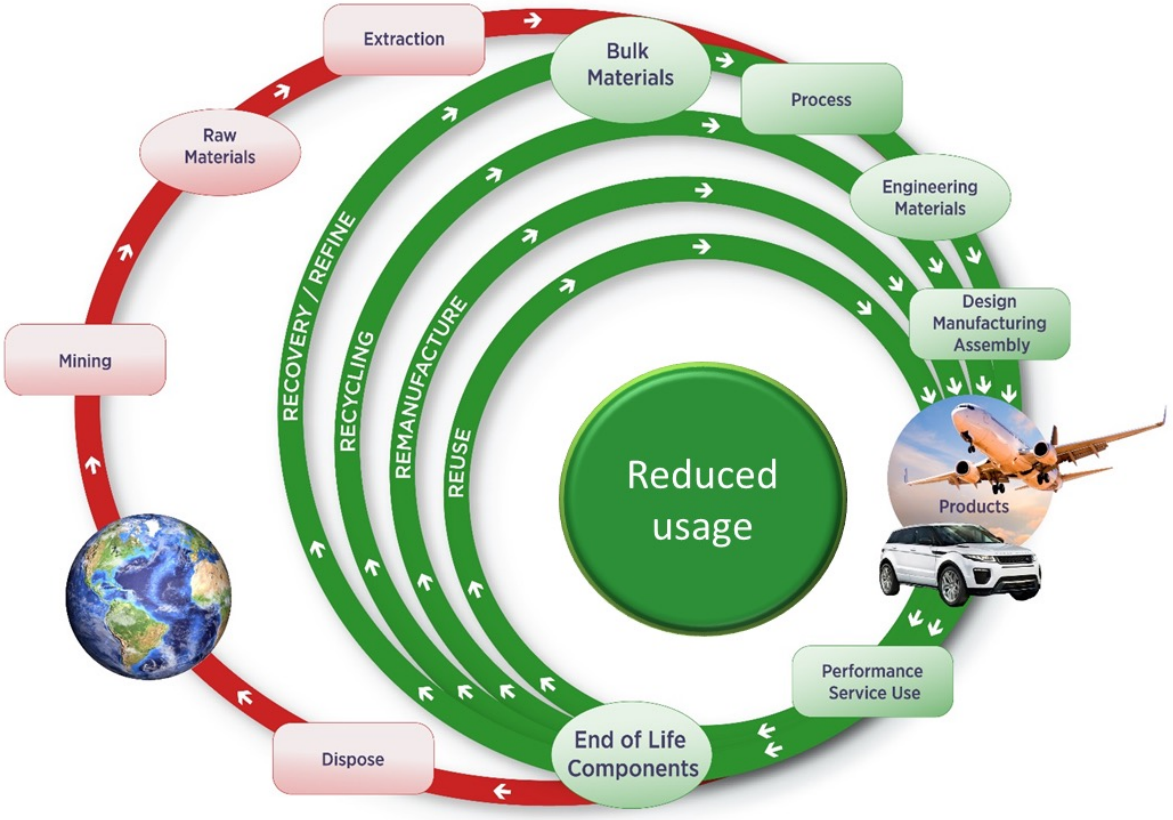
The demand outlook for major metals through 2030, 2050, and 2100

1. Danial smith, Jonathan Wentworth.UK parliament Research briefing: Mining and the sustainability of metals. 20 January 2022
2. Watari, T., Nansai, K., & Nakajima, K. (2021). Resources, Conservation and Recycling, 164, 105107.

BCAST long-term vision: Full Metal Circulation

UKRI Interdisciplinary Centre for Circular Metals

- **Closing the loop** – **designing out waste and pollution**: eliminating extraction; use of existing metals
- **Slowing down the loop – keeping metals in use:** designing for durability, reuse, remanufacture.
- **Narrowing the loop – using less for more:** use less; serve longer; higher performance; encouraging sufficiency …

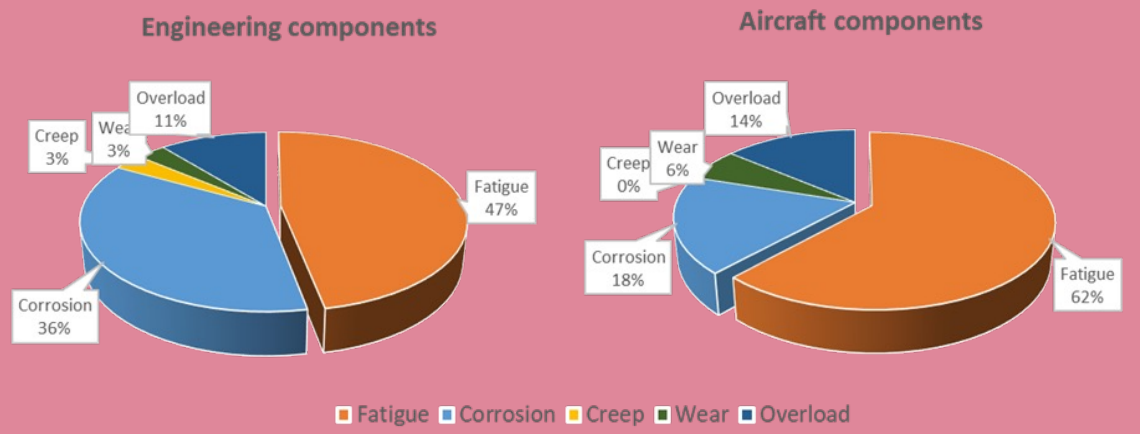


[https://www.brunel.ac.uk/research/Centres/BCAST/About-us]

Failure Modes of Metals

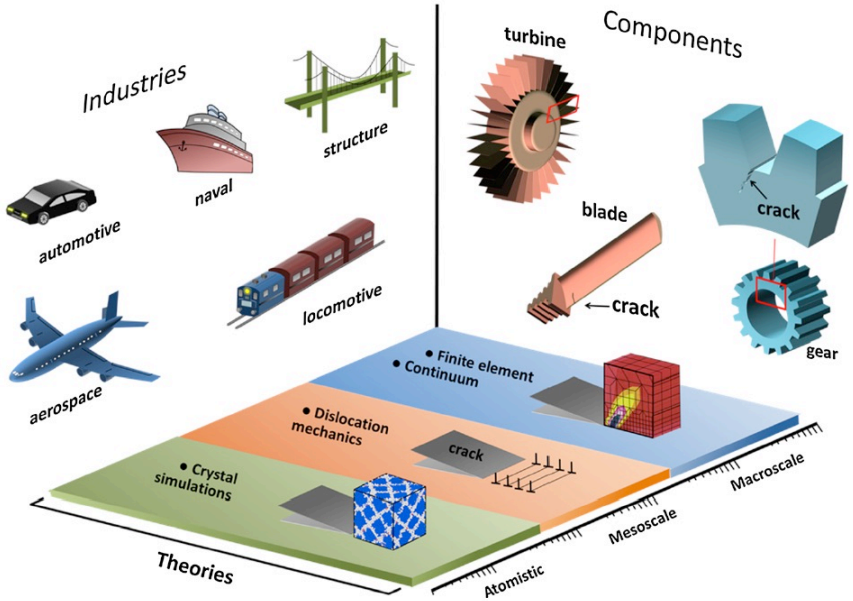
UKRI Interdisciplinary Centre for Circular Metals

1. Overload
2. Impact
3. Creep
4. Wear
5. Corrosion, stress corrosion cracking
6. **Fatigue**



- The total economic costs of fatigue fracture-related events to the economies of advanced countries are **4% of the GDP** (2005). In the UK this is equivalent to twice the amount spent on defence (defence 2% GDP) and comparable to what is spent on education or health (education 5.2% GDP).

- It is estimated that more than 80% of metallic components at the end of their service have perfect physical dimensions but reduced mechanical performance due to the existence of flaws, which all originate from fatigue during the operation.



1. Chowdhury, P., and H. Sehitoglu. Fatigue & Fracture of Engineering Materials & Structures 39.6 (2016): 652-6742.
2. Tavares, S. M. O., and P. M. S. T. De Castro. Fatigue & Fracture of Engineering Materials & Structures 40.10 (2017): 1510-1529.

Metal health service (MHS): Our vision (inspired by NHS)

BCAST

UKRI Interdisciplinary Centre for Circular Metals

Regular performance monitoring: *NDI*

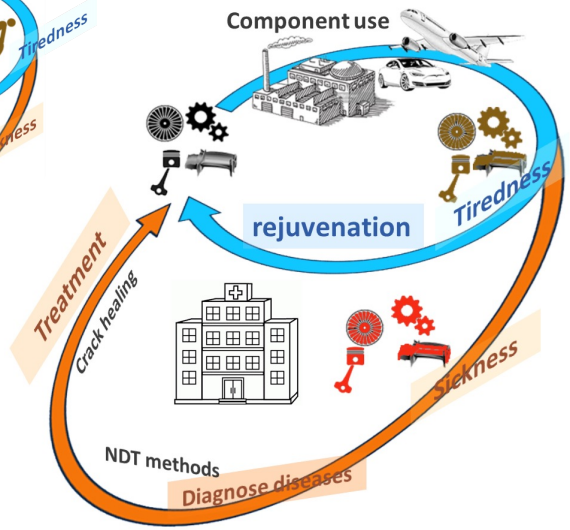
EAT DRINK SLEEP REPEAT

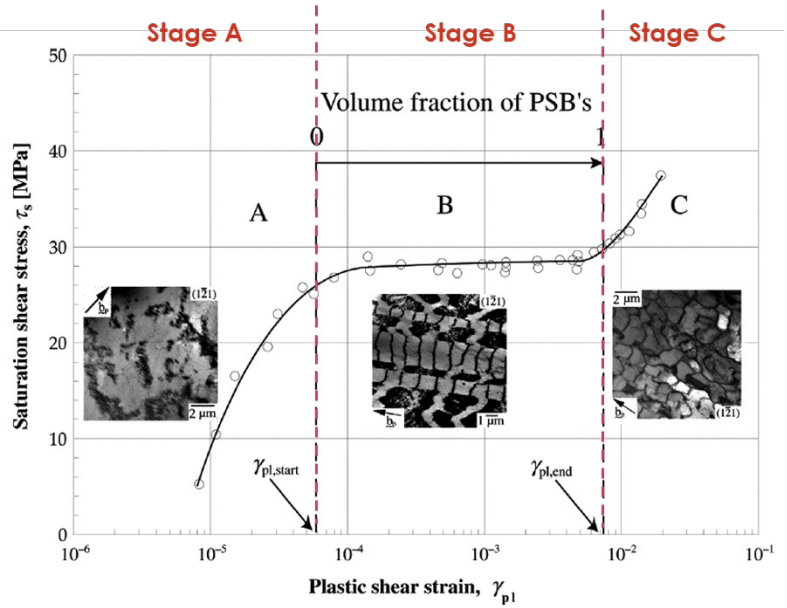
Regular Rejuvenation Treatment: *Tired* components (***Stage A***)- Analogous to the Eat-Drink- Sleep for Human beings

Metal clinic for minor damages: *Sick* components (***Stage B***)- Analogous to a GP surgery where medication and outpatient treatments are available

Metal hospitals for severe damages: *Damaged* components (***Stage C***)-
Analogous to a hospital where advanced therapies and inpatient treatments are available

Digital health record: All the health records of a metal component will be saved in a digital passport





METAL REJUVENATION SERVICES

BCAST

UKRI Interdisciplinary Centre for Circular Metals

BUSINESS MODEL ASPECTS

WHY DOES THE METAL ECONOMY NEED THIS BUSINESS MODEL?

- This model relates to the inherent change in microstructure and the occurrence of micro-cracks and defects on the metallic components throughout their manufacturing and operational lifespan.
- The presence of these defects negatively impacts the mechanical properties of the materials.
- Preventive rejuvenation, recovery and healing procedures are applied prior to or during the initial stages of fatigue, aiming to mitigate the formation of micro-cracks.
- The implementation of a proactive approach successfully extends the durability of the material, thereby reducing the necessity for intrusive interventions or replacement, resulting in cost savings.

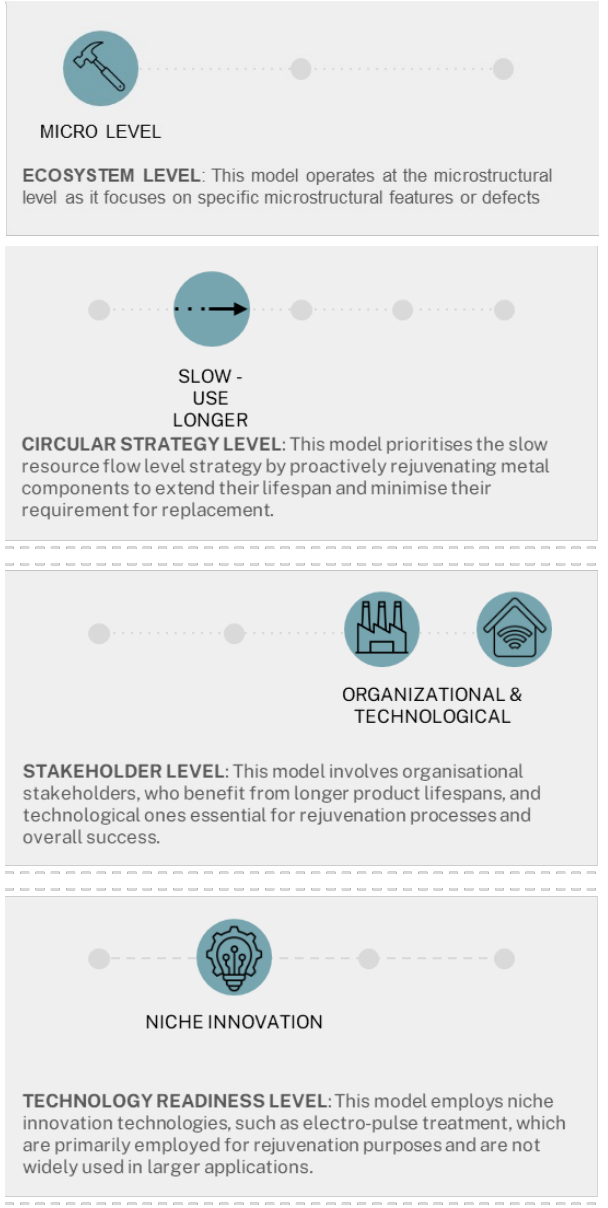
Value is captured through various means:

- Revenue generated from one-time rejuvenation services
- Revenue generated from ongoing or recurring rejuvenation services, such as an annual fee.
- Another potential situation involves the collection of revenue through a rejuvenation service that is integrated into a broader offering, such as a service incorporated within an access or performance/results business model.

POTENTIALLY RELEVANT TO

Solution providers: Solution providers are the entities that offer rejuvenation treatments. These could be companies or research institutions that have developed technologies for the rejuvenation of metallic materials.

Customers/users: The customers are industries that manufacture and use metallic components. These could include sectors such as aerospace, automotive, construction, and any other industry that relies heavily on the use of metallic materials and components.



REPAIR MICRO-ENTERPRISES

BUSINESS MODEL ASPECTS

WHY DOES THE METAL ECONOMY NEED THIS BUSINESS MODEL? This model has the potential to reduce metal consumption by prolonging the lifespan of products within a specific and localised context:

- Local economy centred around repair rather than consumption.
- One of the main barriers for this model is the lack of customer demand for environmental behavior. This lack of demand means that there is little incentive for firms to comply with environmental regulations unless they are strictly enforced or required by insurance companies.
- Another barrier is the high cost of environmental compliance, which SMEs often find difficult to bear. These costs are not easily transferable to customers and provide few benefits without a competitive advantage.

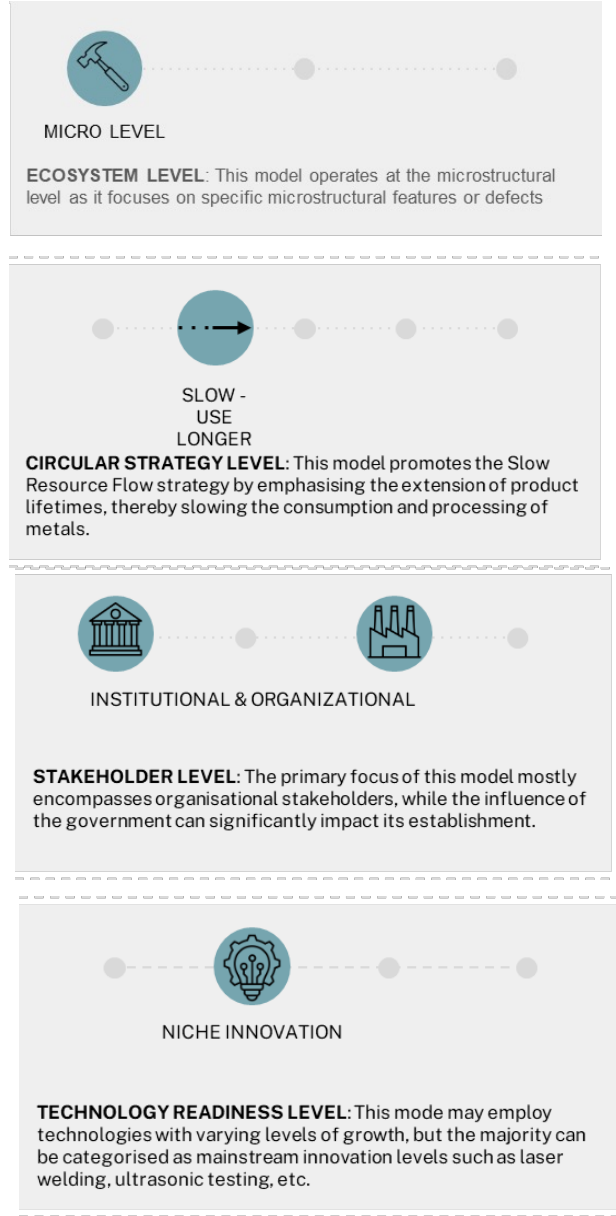
Value is captured through delivering a low-cost, convenient, and reliable service to clients and working with other companies to repair their customers' products. Original Brand Manufacturers (OBMs) and Original Equipment Manufacturers (OEMs) may partner with local enterprises to offer repair services for their own products. This allows them to comply with environmental regulations and gives them a competitive advantage when consumers demand environmental compliance.

POTENTIALLY RELEVANT TO

Solution providers:

- Internally, an individual may assume the role of a sole repair professional who establishes and operates her own local repair enterprise.
- Externally, various entities such as franchisees, dealerships, and trade organisations play a significant role in advocating for environmental and professional standards.

Customers/users: individual product owners in need of repair and maintenance services.



MHS SELF-HEALING METALS

BCAST

UKRI Interdisciplinary Centre for Circular Metals

BUSINESS MODEL ASPECTS

WHY DOES THE METAL ECONOMY NEED THIS BUSINESS MODEL? This approach offers innovative solutions for asset management and utilisation in the metal industries through the integration of advanced self-healing technologies with a service-oriented approach. It encourages the use of self-healing materials in the design and production of products, which reduces the frequency of expensive repairs.:

- By adopting a strategic shift in their business approach, companies can enhance customer loyalty and operational efficiency by transitioning from a product-centric sales model to a service-oriented provision model, facilitated by the implementation of performance-based contracts.
- Strategic alliances play a crucial role in surmounting various challenges, such as securing financial resources for initial research and development (R&D) endeavours, as well as facilitating the integration of digital technologies.

Value is captured through the collection of premium prices for high-end products, or by minimising the expenses associated with product maintenance in the case of products provided as part of a product-service solution

POTENTIALLY RELEVANT TO

Solution providers:

- researchers and organisations engaged in the development of such materials, as well as companies involved in the production and sale of these metals or related products.
- Externally, there may be entities that offer servitisation of self-healing metals. These organisations are engaged in the scientific investigation and advancement of self-repairing metallic materials.

Customers/users: The customer of this model primarily consists of industrial entities that incorporate metals into their operational processes. These sectors encompass areas such as energy, transportation, healthcare, safety, and infrastructure.

Metal health service (MHS)