SUSTAINABLE THROUGH LIFE SUPPORT

Strategy, Concepts & Enablers

TEAM DEFENCE INFORMATION. 02 December 2025

THE TEAM, THE TOPIC

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DEFINING SUSTAINABILITY – MORE THAN JUST "NET ZERO"

One can consider Sustainability as the literally the **"ability to sustain"**.

In a Defence setting, this could be the ability to sustain things like:

- Freedom to modify
- Freedom to operate
- Achieving Operational & Support Advantage
- Access to finance
- Public support

This is coming under threat from:

Increasing Climate Change - extreme weather disruption (across operations/supply chain). **Higher temperatures, stronger storms.**

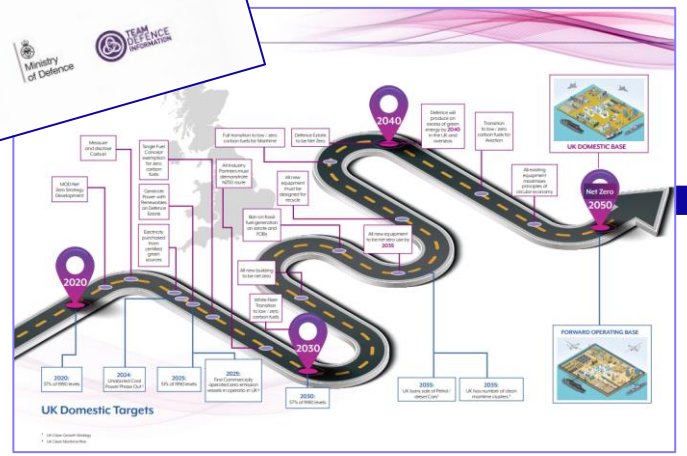
Geopolitical tensions & the "take make waste" culture – consequently **reducing access to critical raw materials**

Affordability – in the form of escalating carbon costs (taxes/offsets) render **fossil fuel rich enterprises unaffordable** over time

Taxpayer/Stakeholder expectations – reduced **access to finance**, falling **employee retention**, compliance and **financial penalties**

Fundamentally, we are talking about risk and resilience.

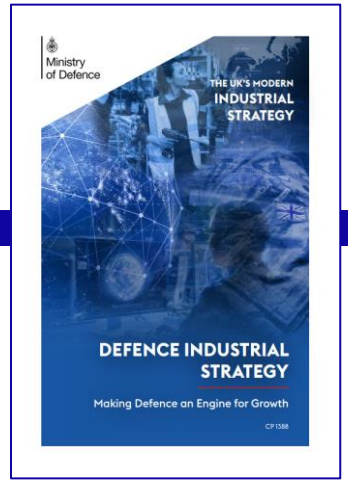
OUR JOURNEY, STRATEGY & THINKING



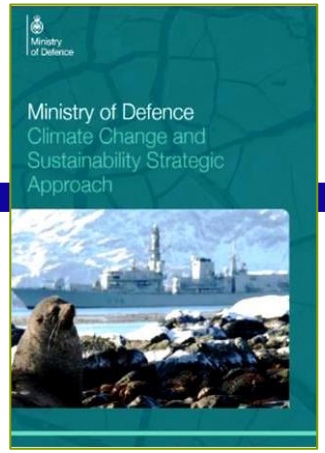
2020

2035. All new equipment entering service with UK MOD will be net-zero operation & support.

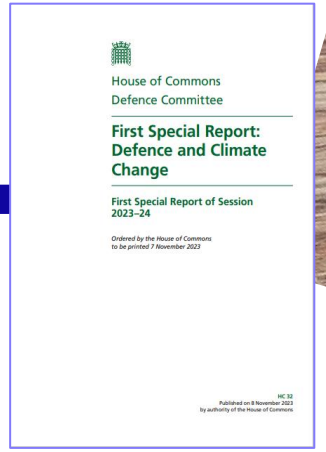
2025



2021



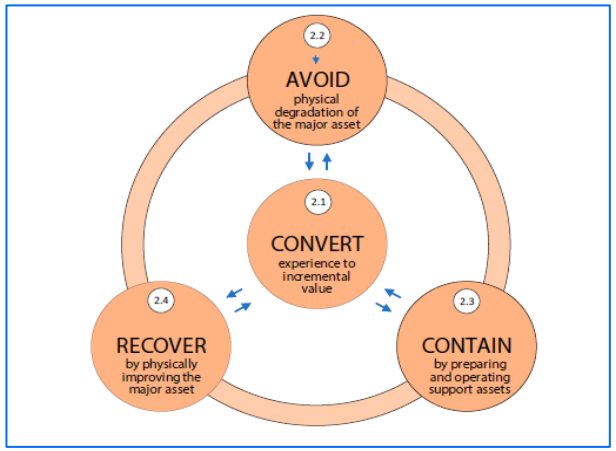
2022



2023

PRODUCT, SUPPORT & SUSTAINABILITY

Our approach to *Sustainable Through Life Support*, builds on the core principles of PAS280 **THROUGH ENGINEERING SERVICES (TES).** Utilise *Avoid, Contain, Recover & Convert* methodologies to 'Realise Customer Value'.



Product Support Challenge: Make best use of asset (life) and best use of asset (materials), through life. Know when to retire an asset before it is so degraded, its material value is reduced or lost?

Route to Value: Circular Economics needs new digital capabilities and lots of data!

Effective management of 'Material in the Loop' will depend on access to (more) data and (new) digital capabilities to realise value from all points of the Circular Economy model, through life.

OBJECTIVES: RESILIENCE, SUPPORT ADVANTAGE AND AFFORDABILITY.

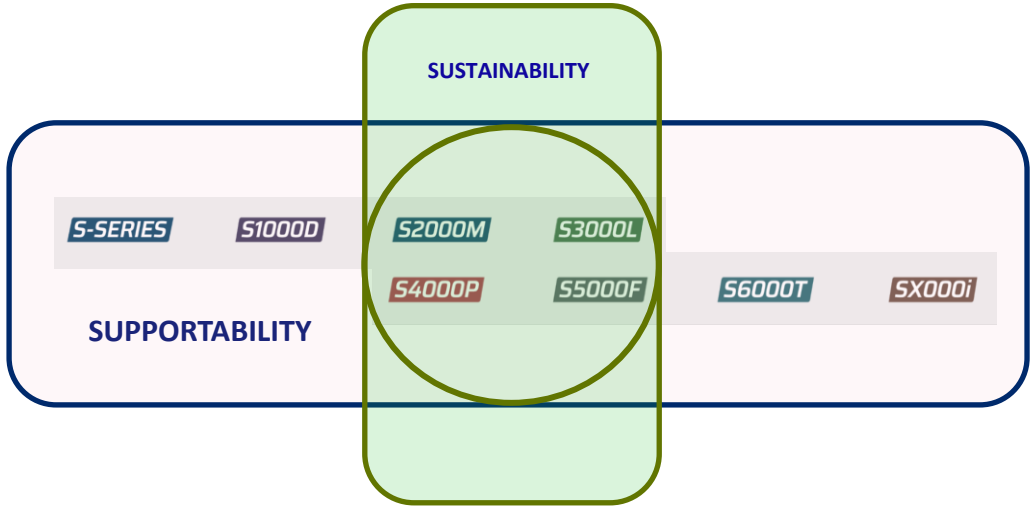
INTEGRATED PRODUCT SUPPORT (S-SERIES)

A sustainable product, starts its life in Design (life, reliability, mass, material selection, performance).

Sustainable support, is enabled through the International S-Series (specifications) for Integrated Product Support.

S3000L (Supportability Analysis): includes Obsolescence Management, Configuration Management, Maintenance, Storage, Supply & Logistics, Waste & Hazardous Materials, Termination & Disposal.

GCAP Industry partners, Military Users & Governments (UK, Italy, Japan) are planning for the environmental and economic challenges the product will face through life, particularly those related to access to material and Critical Rare Earth mineral risk.



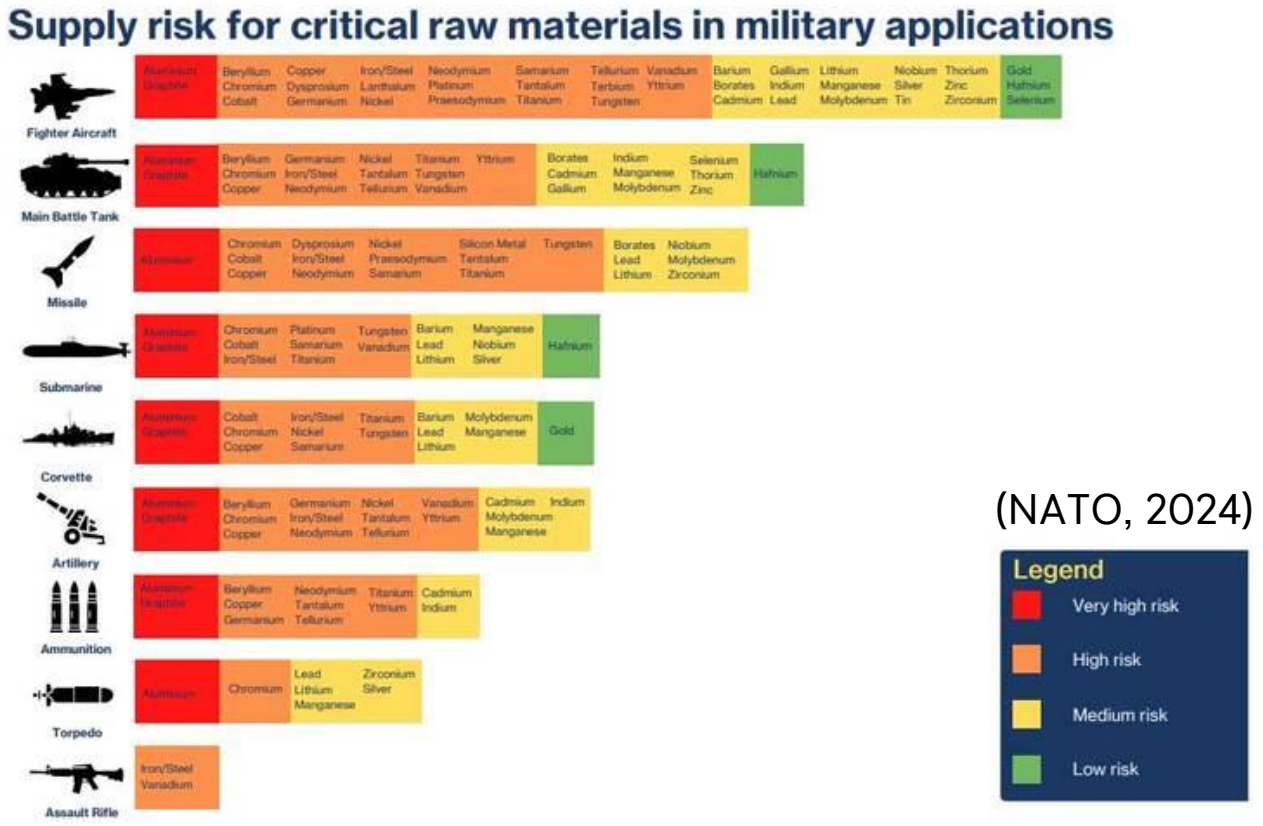
ASD AeroSpace and Defence Industries Association of Europe

MATERIALS & TECHNOLOGIES

The **Global Combat Air Programme (GCAP)** 'future fighter' must address Critical Mineral and Raw Material supply risk (through life).

We're working to manage this risk by:

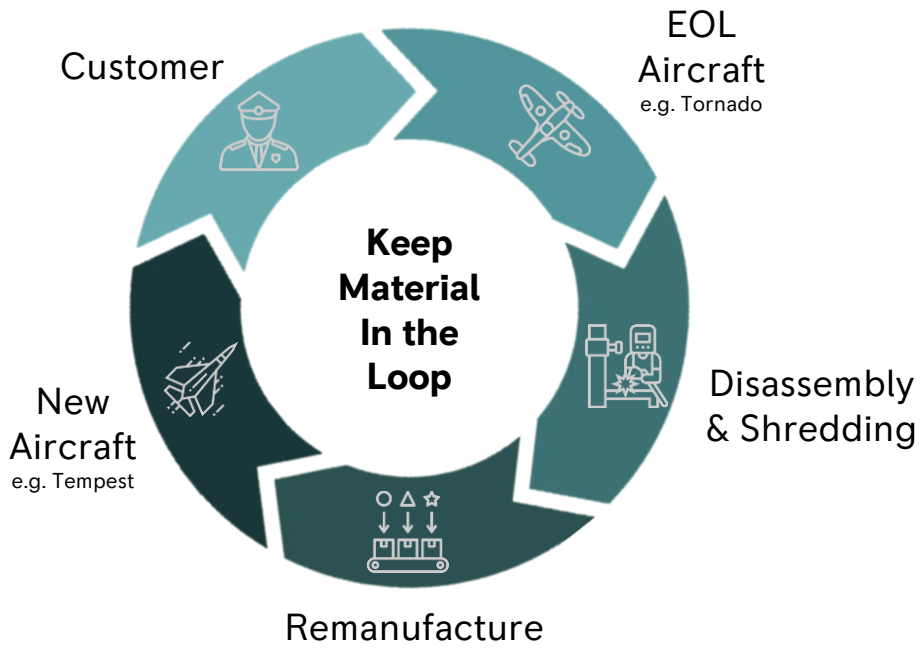
- Identifying data & developing Digital Tools to manage these risks, through life.
- Learning and aligning with existing activities within the Rolls-Royce (such as REVERT, our closed-loop recycling programme).
- Launching new pilot projects to demonstrate circular economy principles and new closed loop material opportunities.



(NATO, 2024)

TORNADO TO TEMPEST

A CIRCULAR ECONOMY PILOT & DIGITAL DEMONSTRATOR



- Titanium compressor blades from an RB199 engine were selected as End of Life
- They were cleaned, atomised and recycled into a new component (nose cone) via Additive Manufacturing process.
- The nose cone was fitted to an Orpheus test engine and run, passing suitability and safety checks, demonstrating the technique's potential and application on future products.
- Orpheus is Rolls-Royce's small engine concept that is part of the MOD's Future Combat Air System (FCAS) programme, for Tempest.
- The team also demonstrated a Digital Product Passport (DPP) by capturing and recording material provenance and lifecycle data.
- DPP's can potentially enable more informed decisions around material allocation and protect against the use of counterfeit materials.

ADDITIVE MANUFACTURING CLOSED LOOP SUPPORT

A large risk to delivery of products is **supply chain shortages and lead time**

RR **must** develop the capabilities to ensure **resilient manufacturing and supply chains** regardless of global outlook

In 2022, based on Project TAMPA, and FLC unit, MoD support for **AM adoption became large scale**.

Ukraine has stated **"speed of repair"** just as important as "speed of delivery" especially for **hard-to-source items** and replacements for **obsolescent parts**.

Our ultimate aim is **reduced lead times, obsolescence, and improved sustainability** to ensure delivery of products

1 – Modular **factory-in-a box** (e.g. SPEE3D).

2 – Imagine **deployable** 40-ft high cube **cargo container** with mission critical equipment.

3 – Container variability with equipment inside dependant on mission aim (**different container types**).

4 – Push for **AM adoption** due to lead time reduction, improved sustainability, inventory reduction.

5 – Containers capable of **manufacture, repair, maintenance, inspection, post-processing.**

6 – Provides **benefits now** and in times of crisis

FACTORY IN A BOX USP

A certified, cyber-secure, drop-in micro-factory that **reduces lead time to either repair or deliver components and tooling.**

End-to-end service that equipment providers cannot match. RR designs, manufactures, certifies, deploys, and maintains our products.

Turn-Around-Time (TAT) reduction from transportability and pre-qualified repair routes. **Save days/weeks on parts** waiting for casting or long-haul shipping.

Digital inventory to convert spares, safety stock and shortages.

Obsolescence and end-of-life support by keeping legacy fleets serviceable with on-demand spares after tooling is obsolete.

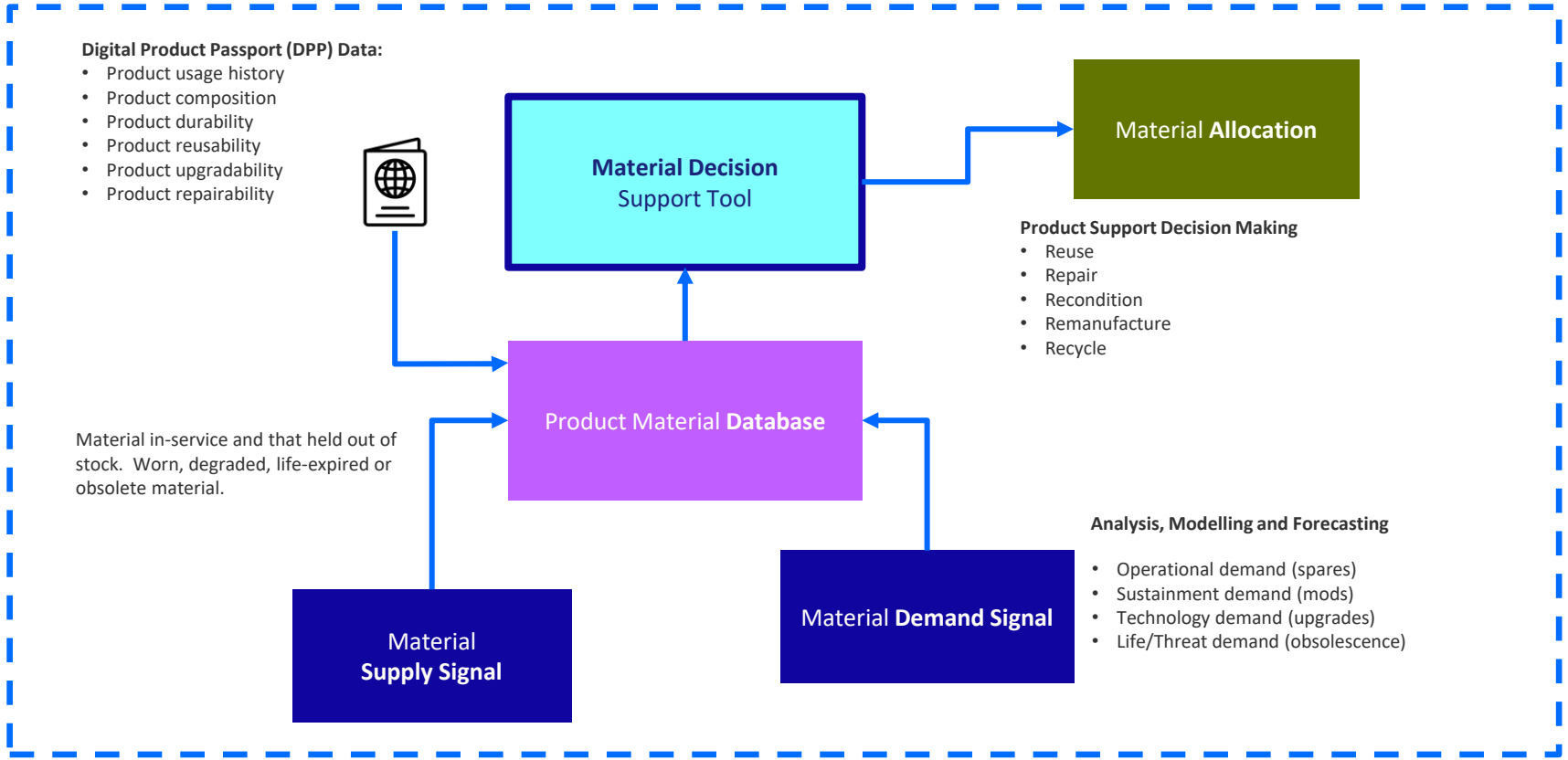
Resilience **mitigates geo-political and logistics** shocks. Also, containers can be deployed at bases, major MRO hubs, airports.

First-mover advantage where SPEE3D is the main market competitor but in CSAM.

IN-SERVICE DECISION SUPPORT

A Circular Approach to Product Support will require precise Asset Management and meticulous Material Control, through life.

In addition to deterioration, damage (limits) and life remaining at an asset level, future Product Support will consider material composition, availability (scarcity, lead time and cost) and recovery options beyond those of today (reuse, repair, recondition) – recycle, remanufacture.



Material Decision Support Tool:

- Analyse priority of demand, current stock levels, forecast of availability of spare components.
- Analyse geo-political constraints, contract arrangements and value (Commercial, Military and Sovereign).
- Analyse material composition, life and condition. Identifies optimum course of action (Material Allocation).

CIRCULAR ECONOMY (CE)

Planet

Whilst we can acknowledge the importance of adopting a circular economy, its important we understand the impact of this transition

- **Energy Intensity** - Breaking down complex products, separating materials, refining them to usable purity, and remanufacturing components all consume energy
- **Diminishing Returns** - Each recycling cycle can degrade material quality. Metals may accumulate impurities requiring increasingly energy-intensive purification.
- **Transport Emissions** - Collecting used products, transporting them to refurbishment facilities, moving recovered materials to reprocessing sites, then shipping remanufactured goods back to market - all this movement generates emissions

For CE's to make an impact, we need to first conduct Life Cycle Assessment's for each material and process to understand where improvements can be made. We also need to understand that the circular economy isn't truly circular but rather a "spiral" toward eventual disposal and plan for this.

Programme

Our supply chains rely heavily on materials where supply is geographically concentrated in ways that create geopolitical risk.

A circular economy dramatically reduces this geopolitical exposure by creating domestic urban mines - the installed base of engines becomes a strategic material reserve that doesn't depend on potentially hostile nations.

'Industrial Sovereignty' and 'Security of Supply'. The ability to remanufacture and recover materials domestically means:

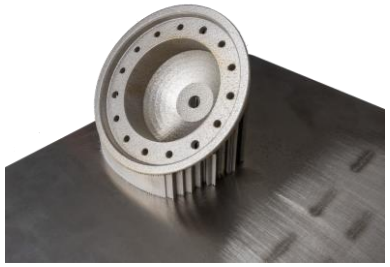
- Less vulnerability to export controls, embargoes, or supply disruptions
- Maintaining military readiness even if external supplies are cut off
- Preserving technological sovereignty without depending on geopolitical rivals for critical inputs

TORNADO 2 TEMPEST.

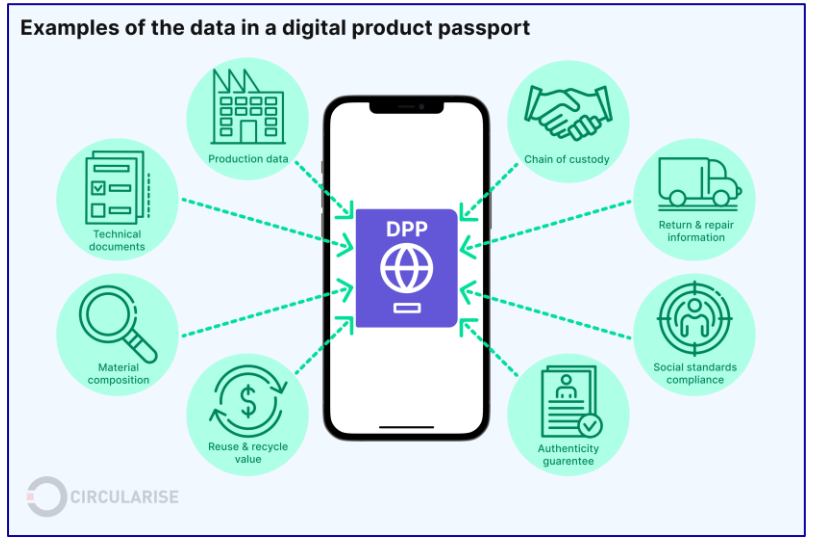
THE DIGITAL JOURNEY. Digital Product Passport

DPP Data:

- Material composition data
- Material processing data
- Packaging, handling, storage and logistics data
- Manufacturing data
- Energy consumption and emissions data



Digital Product Passport



SUSTAINABLE THROUGH LIFE SUPPORT

Circular Approach to Product Support

- Traditional Product Support decisions centre on ‘Reuse, Refurbish, Repair, Refuse’ (…to scrap) material.
- Advances in Technology, Material, Chemical and Digital Science enables a broader approach to Asset Management and Material Control.
- Access to material data (beyond Life, Condition) such as that in a DPP will enable Product Support decisions to be made (at pace) and realise value from each part of the Circular Economy model.