Sustainable Circular Economics (CE) for Defence – A Concept Note

Introduction

Climate Change is considered a non-traditional threat multiplier that can "exacerbate problems such as government instability, the spread of disease, conflicts over water supplies, the strengthening of terrorism, and widespread migration".[1] In fact, it contributes to accelerating countries' instability and exacerbates other insecurity drivers that – at the same time – will affect other areas of society[2]. Although some experts affirm that Climate Change won't directly act as triggers for major conflicts, its impact will increase existing triggers' risks; "as security threats go, climate change is not the wolf at the door, threatening to blow the house down. Rather, it is thousands of termites whose individual impacts are small and hard to see, but whose collective impact is potentially just as catastrophic. Because of the complex nature of these threats, climate change does not fit neatly into conventional security paradigms for risk mitigation or neutralization. This implies the traditional toolkit for addressing security threats will need to be augmented by a more inclusive approach to conceptualizing national security threats and the agencies tasked with addressing them."[3]

For the above reasons, a Circular Economics' (CE) approach should be analysed and considered for implementation in Defence as it would provide resilient solutions for future risks linked – directly and/or indirectly – to Climate Change.

What is the vision for the future?

The Sustainable Support Strategy (SSS)[4] published in November 2022 has defined the theoretical framework in which Defence Support should focus to "meet the challenges of the Integrated Operating Concept through addressing the urgent issues of Climate Change and sustainability"[5]. The main goals are "improving the effectiveness and efficiency of operational support; increasing our military capability; reducing our vulnerability to environmental threats; and mitigating our activity's impact on the environment."[6] This Concept Note is aligned to the six strategic initiatives[7] identified by the SSS, and its purpose is to offer a model to deliver the actions needed to meet the Strategic objectives by introducing CE across the initiatives, with the purpose of enabling effective actions to implement sustainable transition to CE in Defence. It is important to note that any CE solution to the military challenge must account for several additional factors.

- The complexity of the environment and possible Climate Change future scenarios.
- Interactions with adaptive adversaries and the persistence of enduring competitions.
- Transregional challenges and risk of disruptions.
- Emerging patterns of hybrid competition.
- Challenge of integrating military activities within the FLCs and aligning those activities with partners and allies.

Currently there is no established and formally recognised systemic approach to practically embedding circularity within a business, with studies on CE targets mainly focusing on existing targets that have already been adopted by governments and organisations; specific solutions such as targets around the recovery of materials, geographical areas or regions, and sectors or industries such as energy or waste management[8]. Whilst the concept is circulated widely as an ideal way of running a sustainable business,

[1] Causevic A., 2017
[2] *Ibid.*
[3] Hendrix, C, 2020
[4] Sustainable_Support_Strategy_2022.pdf (publishing.service.gov.uk)
[5] *Ibid.*
[6] *Ibid.*
[7] SSS Strategic Initiatives: Sustainable delivery of Platform Availability; Maintaining Operational Energy through the energy transition; Building Resilience Across the Global strategic Base; increasing self-sustainment of Operations; Decarbonising the Impact of Defence Materiel; Reducing the Impact of Deployed Food.
[8] Morseletto, 2019

the practical implementation of the theory is limited[9]. To identify routes of successful implementation it is important to focus on analysing current product lifecycle flows within Defence, and applying targeted CE actions to current processes. This will ensure successful implementation of CE within Defence, resulting in greater resilience and agility within the supply, delivering sustainable and self-sufficient operations whenever possible, optimising efficiency, and increasing Force self-reliance whilst also incorporating environmental sustainability to maintain Support Advantage.

Timeline

The activity is broken down into 3 epochs; Epoch 1 (out to 2025), Epoch 2 (2025 - 2035) and Epoch 3 (2035 – 2050) with the work happening now being used to inform activity to take place in the subsequent epochs. By the end of Epoch 1 the SSS aims to:

- Position Defence Support at the forefront of sustainability by having evolved "engineering and equipment support to maintain platform availability as the environment deteriorates"
- Put Defence "on a clear path through the energy transition"
- Fully understand "how to deliver increased self-sufficiency of deployed operations"
- Identify and plan "mitigation for the environmental threats to the Global Strategic Base"
- Position Defence Support to be "ready to negotiate a low-carbon, low-cost next generation commodities and logistics contract having assessed how to reduce the environmental impact of deployed food and examined the potential, for increasing the circularity."[10]

This Concept Note fully reflects the above timeline and is a first step towards implementation of the Strategy.

What is CE and why is it an opportunity for military support?

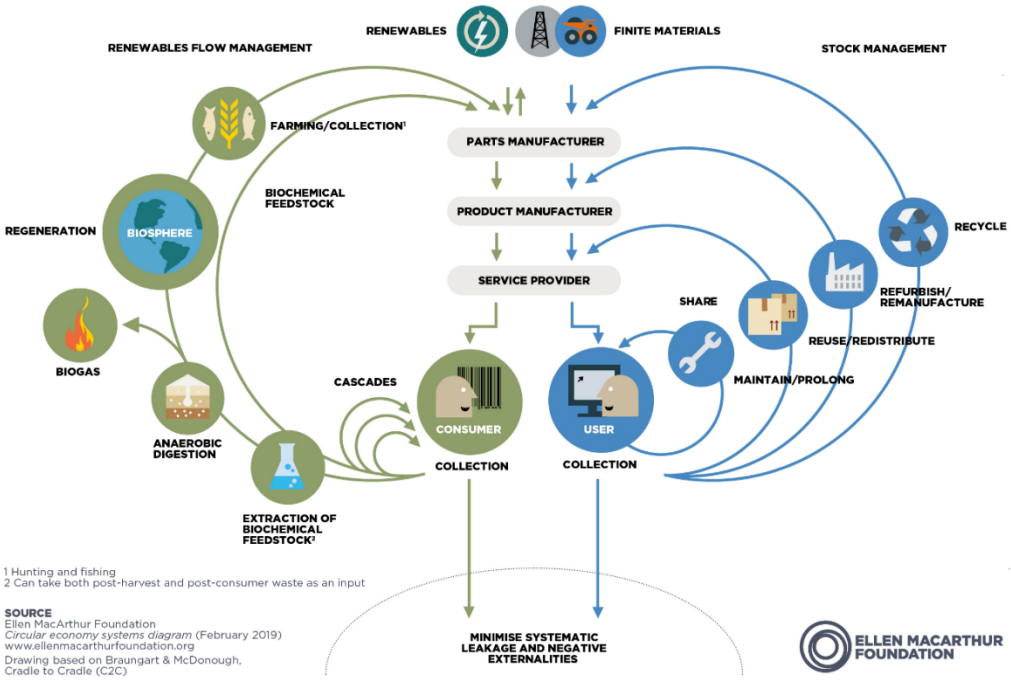
CE is a theoretical concept promoted by several governments and businesses that uses the argument of creating a cyclical model for currently linear product flows. It is "based on fragmented ideas derived from some scientific fields including emerging fields and semi-scientific concepts"[11]. Despite being academically unclear in its theoretical models, CE is an important step to develop the current system into something that better meets Defence's needs, with potential benefits including improvements in the resilience and agility of the supply chain, and longer product life cycles resulting in long term cost-savings, despite an initial transitionary increase in upfront costs. If correctly applied, CE could reduce resource intensity and logistical footprint, improve standardisation (plug and play) and interoperability, improve self-sufficiency of operations, and increase technology sophistication. Any CE solution challenges faced by Defence must account for several additional factors such as:

- Complexity of the environment and possible climate change future scenarios
- Interactions with adaptive adversaries
- Persistence of enduring competitors
- Transregional challenges and risk of supply chain disruption
- Emerging patterns of hybrid competition
- Challenge of integrating military activities within the FLCs and aligning those activities with partners and allies (interoperability).

International case studies have shown valuable applications, although different models have been used. For example, "in China CE is promoted as a top-down national political objective while in other areas and countries such as the European Union, Japan and USA it is a tool to design bottom-up environmental and waste management policies"[12]. In the UK, actions mostly focus on the last

[9] Corvellec, 2021
[10] *Ibid.*
[11] Korhonen et al., 2018
[12] Ghisellini et al., 2016

stage of recycling, not on other CE areas like reuse, remanufacture or repurpose. There are several pilot and innovation projects being run by UK industries, however it is important to analyse these on a case-by-case basis to understand if they are applying consistent actions to limit the risk of CE being embedded only for reputational purposes which could lead to *greenwashing* that could then lead in being considered reputationally disruptive and consequentially undermine any sustainability/environmental work being undertaken.



Assumptions

For military purposes and due to the complexity of Defence operations, applying a mixed and flexible top-down and bottom-up model is the suggested approach, where top-down refers to policy making and bottom-up refers to innovation. For Defence to best respond to current and expected impacts of Climate Change - such as global security threats - CE should be considered a priority enabler in improving resilience and agility and should be integrated across the business. Although CE could be applied without including sustainability measures and without involving renewable energies, it is important to merge the different areas to maximise the benefits of sustainable circularity and converge with the ultimate goal of sustainable operational self-sufficiency. In terms of actions, bottom-up innovation - as either a fast follower and/or first innovator - can initiate discussions required to achieve the desired impact by implementing circular, sustainable and adaptable pathways of resilience, in order to be able to operate at full potential in an increasingly challenging environment.

Supporting Benefits Hypotheses

Although CE's first challenge requires a change in conventional thinking, which is rooted in the current linear model, there would be several benefits for Defence operations, especially considering the opportunities offered by transformative technologies that could reduce supply chain demands and vulnerabilities. Although implementing CE would require a change to requirement setting (that should be scrutinised and designed with the full end to end lifecycle), scrutiny and design of key equipment in the future – and consequentially a reshape of the relationship between MoD and industries – CE offers several benefits that would increase adaptation equipment, people, and operating procedures. The main benefits are captured below.

- Cost Reduction due to reduced acquisition and longer product life spans
- Greater self-sufficiency on operations leading to potential military advantage

- Reduced distribution due to sustainable choices that include micro-circularity (at single firm level)[13]
- Reduced use of raw materials and reliance on a single country for resources – especially from competitors and adversaries (i.e., China)
- Innovative routes to market (i.e., raw materials) and regeneration projects
- Innovative enablement of repair, reuse, remanufacturing and recycling of components and materials
- Creation and implementation of proximity in the supply chain and reduced import dependency (especially from adversaries)
- Improved maintenance and care leading to higher quality or more reliable products

In the table below some examples on how embedding CE principles will benefit the delivery of each of the 6 Strategic Initiatives within the SSS.

No	Initiative	Example description	CE implementation benefits
1	Sustainable delivery of platform availability	Additive manufacturing and 3d printing	Increased platform availability increases resilience by reducing supply chain needs (and consequential time constraints) and by providing agility in platform availability using 3d printing technologies of spare parts using raw material that has come from redundant spares of the same composition, minimising the risk of inoperability.
2	Operational energy through the global transition	modular microgrids embedding renewable energies, hydrogen, nuclear	To navigate the global energy transition whilst reducing the environmental impact and maintaining/increasing energy capability, associated reduction in distribution and transport, mitigating increased costs and risks; reducing the risk of uncertain supply and disruptions in the transport system.
3	Increasing self-sustainment of operations	predictive maintenance, upskilling, AI, and digital twins	Integrating digital twins (with active learning process), AI and long-distance support, whilst applying predictive maintenance for an extended variety of industrial and commercial components also using imaging-based sensors, AI and machine learning analytics to increase self-sustainment and self-sufficiency also reducing the need of high skilled specialist workers, whilst upskilling a minor number of deployed maintenance personnel.
4	Building resilience in UK & Overseas Strategic Bases	wastewater and closed-circle reuse	Wastewater system that treats organic waste transforming it to water and hydrogen. Resultant water can be collected, treated, and then pumped back for secondary use (sanitary water) whilst hydrogen can be used as fuel. Integrating

[13] micro-level (i.e., single firms), meso level (i.e., eco-industrial parks) macro level (i.e., city, province, region, nation), Franco, 2017

			a wastewater system would reduce the need for major infrastructure.
5	Reducing the impact of defence commodities	Uniform (clothing) circularity	Applying CE in the uniform process would reduce supply chain (especially related to adversaries and competitors), reduce the long-term cost, and improve efficiency
6	Cutting the environmental impact of deployed food	vertical farming, 3d printed food, protein from air	Maximising food production in limited areas by using vertical farming in conjunction with soil-less systems like hydroponic and aeroponic. This option would reduce distribution and increase self-sufficiency. 3D printed food and protein from air would provide nutritional elements and would reduce supply of finished products and packaging.

Risks

Risks of not applying CE in Defence have already started to be identified. For example, when analysing the uniform disposal management process, it was identified that reusing or repairing uniform is rarely considered even in the case of unused uniforms that are instead disposed of through 'recycling' in the wholesale market with Defence accruing minimal financial benefit when the clothing is sold.

There are also risks related to rising costs of products or materials due to international and global supply chain challenges, as evidenced by rising costs of energy following Russia's invasion of Ukraine. These risks can be mitigated through the implementation of CE by reducing Defence's reliance on manufacturing or production provided by areas of the globe that are at greater risk of disruption as highlighted above. CE also reduces reputational and interoperability risks when collaboration with allies, by adopting more sustainable solutions to operational challenges also due to the risk of operational misalignment.

Applying CE principles in a practical way requires complex policy changes and as there is currently a lack of evidence of successful implementation of CE within a governmental organisation; the transition between the current linear model and a CE model holds risk that will need to be managed. These risks could be mitigated through clarity of processes, data analysis, industry partnerships and innovative technologies to ensure successful implementation of CE within Defence. This would place UK Defence at the forefront of delivering sustainable operational self-sufficiency and allow for the sharing of best practice with allies, partners, and other Government departments.

Integrated Approach - a Model for Defence

While there is great potential in CE concepts, an integrated approach must be adopted. In the past efforts were made to implement Social Values (ESG) in the Defence procurement system, including partial CE, such as recycling. However, it is not clear "how the concept of the Circular Economy will lead to greater social equality, in terms of inter- and intra-generational equity, gender, racial and religious equality and other diversity, financial equality, or in terms of equality of social opportunity. These are important moral and ethical issues which are missing from the construct"[14], that could lead to tensions and limitations, including "an absence of the social dimension inherent in sustainable development that limits its ethical dimensions, and some unintended consequences"[15]. Whilst CE could be included in the social value element of the procurement process during the transition from a linear approach to a circular approach, a new approach in addition to the social value element needs to be included in Defence's procurement process to encourage suppliers to actively adopt a CE approach As CE does

[14] Murray et al, 2017
[15] Murray et al, 2017

not fully fit in the social values - even if it may have a positive environmental impact - it should be considered as a separate addition from current Social Value procurement system, as it could bring high level value with different and wider perspectives towards an integrated approach.
Possible benefits to Defence delivered through circularity values could be:

- Driving transparency within Defence's end to end (E2E) supply chain
- Acting as a thought leader when it comes to CE, influencing industry to adopt a CE approach more rapidly
- Cost effectiveness by rethinking design and supply chain innovation
- Improving quality and duration of products by analysing through life vs up front cost of a product during the procurement process
- Delivering Operational self-sufficiency by minimising disruption of supply chains resulting in competitive advantage over our adversaries and reducing competition for scarce resources with our allies.

A new circular approach in Defence should focus on a long-term transition involving all stakeholders and key enablers to implement a successful and sustainable circular strategy, with simultaneous changes at the operational and tactical level[16]. This is extremely important, as a circular approach may not be necessarily better than a linear system depending on the context; inefficient circular systems can cause social, economic, and environmental damage.[17]. For example, initial efforts to implement CE within Europe were characterized by an absence of stakeholder engagement with a fragmented and siloed vision and governance which prevented systematic implementation. This combined with uncertainty around system boundary limits, the unpredictability of the waste sector, and ambiguous governance contribute to difficulties in measuring, assessing, and improving circularity within the economy.[18]. With this purpose, it is important to create a model for materiel classification; for example, Van Buren at al. recognise 9 different CE options called the 9Rs (an evolution of the "3R framework" - reduce, reuse, and recycle) that could be a starting point for the classification of materiel (and parts) for implementation in the manufacturers' requirements to measure the circularity of each product. It is worth noting that in academia "all R-lists resemble each other and differ mainly in the number of circularity strategies they put forward. They typically present a range of strategies ordered from high circularity (low R-number) to low circularity (high R number). R0 and R1 strategies decrease the consumption of natural resources and materials applied in a product chain by less product being needed to deliver the same function. Therefore, R0 and R1 are generally also considered circularity strategies, even though they do not necessarily involve increasing the reuse of products and components, or reapplication of recycled materials."[19]

- **R0 - Refuse:** preventing the use of raw materials/non-CE products and/or changing the product with a new one
- **R1 – Rethink:** Review the product design or use a multi-functional product
- **R2 - Reduce:** reducing the use of raw materials, increase efficiency of products in use, and reduce the number of products used if operationally sustainable and advantageous
- **R3 - Reuse:** product reuse (second-hand, sharing of products and loans)
- **R4 - Repair:** maintenance and repair of defective products
- **R5 - Refurbish:** refurbishing a product
- **R6 - Remanufacture:** creating new products from (parts of) old products
- **R7 - Repurpose:** use discarded product for a different purpose
- **R8 - Recycle:** processing products to obtain the same level of quality
- **R9 - Recover energy:** incineration of residual flows (product's end of life)

[16] Van Buren et al., 2016
[17] *Ibid.*
[18] Corvellec, 2021
[19] Potting et al., 2017

In applying CE, it is important to consider the range of options from R0 to R7, however often when discussing of CE, the focus is on recycling (R8). Although R8 is usually considered the optimised way for implementing CE, it should be remembered that it is the last possible stage. The integration of a CE Process with the DE&S Climate Change & Sustainability Acquisition Team would act as a key enabler for Defence to embed CE as an option within the acquisition process and would encourage contractors and industries to update and innovate towards a circular process, whilst also sharing the responsibility across the supply chain. Applying the R-List to Defence platforms could improve operational effectiveness without compromising capability whilst delivering sustainable solutions across Defence ensuring competitive advantage.

Extended Producer Responsibility (EPR) as an over-arching policy principle

As explained above, CE should be shared between the stakeholders involved in the materiel life cycle, this could be enacted using Extended Producer Responsibility (EPR) as a policy principle. EPR is an "over-arching policy principle that could be enacted with many combinations of instruments"[20], not only in relation to the products' end of life, but also throughout the life cycle. The instruments that can be used are agreements, traceability, technical/official standards from product design to recycling techniques. By enabling EPR, Defence would then share the responsibility for sustainable products and processes, whilst encouraging innovation.

Moreover, applying EPR in conjunction with a stakeholder map and with the R list would help to identify weak points in the product's life cycle, allowing targeted actions to improve the circular process and the sustainability of each stage of the life cycle, identifying responsibilities and further actions that may be required, and increasing resilience and weakness traceability in the supply chain.

Applying an EPR model would allow the identification of priority areas, and to explore possible innovation technologies and processes to aid in the improvement of operational effectiveness. For example, identifying products categorised only as R8 and R9 would allow focused research and innovation to enhance the application of R1-R7, whilst also identifying where responsibilities sit, and which department/stakeholder should take actions to improve the sustainable efficiency of a product.

CE Innovation

Businesses are increasingly persuaded to invest in innovation that applies CE. It is important to note that there isn't a branch of innovation specifically for CE, instead each business looks to their own cycle and products and applies new technologies and models that best fit their purposes. Despite this appearing dispersive, it provides an opportunity to implement a CE approach in different areas simultaneously if cohered correctly, with innovation focusing on the innovative operational models based on sustainable CE. Firstly, Defence needs to continue focusing on recyclability of R9 products (including those subjected to ACTO) whilst at the same time investing in alternative solutions that may allow R1-R7 processes when possible. Innovations may be focused on alternative materials, components - including novel innovation offering significant opportunity for transformative technologies - and product circularity, whilst also designing innovation for modularity of sustainable and resilient applications.

To identify possible innovation for Defence, it is important to consider the impact in including it in BaU. For this purpose, Potting et Al. (2017) have developed a list of diagnostic questions useful for considering a product's measurability and effect within a CE transition[21], that can be used as a guideline for creating a Defence Specific question set.

[20] Massarutto, 2014

[21] Potting et al, 2017 (colours changed)

	Diagnostic questions
Means	**Mobilisation of means** - Are all relevant product chain partners actively involved in realising CE solutions? - Is there sufficient funding for realising CE solutions? - Are there specific physical means limiting the realisation of CE solutions?
	Knowledge development - Does the available knowledge suffice to develop CE solutions (with regard to technology, patents, consumer and chain actor behaviour)?
Activities	**Knowledge exchange** - Is the level of knowledge exchange on CE solutions high enough in the product chain?
	Experimenting by entrepreneurs - Are entrepreneurs experimenting sufficiently with CE solutions and revenue models? - Is upscaling of CE solutions already taking place?
	Giving direction to search (vision, expectations of governments and core-actors, regulations) - Is there a clear vision among product chain partners of the pursued circularity strategy? - Do product chain partners broadly share this circularity strategy? - Does this circularity strategy structure the activities of the product chain partners?
	Opening markets - Are product chain partners active in creating consumer awareness of CE solutions? - Are companies investing sufficiently? - Does the government have supplementary policies, and do they help in opening markets?
	Overcoming resistance - Is there resistance against CE solutions (among product chain partners, or in the form of regulatory barriers)? - Is sufficient action being taken to overcome resistance against CE solutions?
Achievements	**CE design** - What is the present lifespan of a product and has it increased compared to its original lifespan? - Have products become easier to disassemble? - Does the design foresee the use of recycled materials? - Are the components designed for high-grade recycling (without increasing environmental pressure)?
	Production - Is the overall (primary and secondary) consumption of materials by companies decreasing? - Do companies use fewer substances which are hazardous to human health and ecosystems? - Is production moving towards lower levels of waste generation? - Are companies moving to CE revenue models with increased reuse of products and components, or models based on providing a service rather than offering a product?
	Consumption - Is the consumption of CE products increasing (compared to conventional products)? - Do CE products have a longer lifespan or are they used more intensively? - Is reuse of products leading to less waste?
	Waste - Is the volume of landfill decreasing in favour of incineration? - To what extent is high grade-recycling applied? - To what degree is recycling effective with regards to costs and environment?
Effects	**Circularity (resource efficiency)** - Is primary material consumption decreasing (in kg per functional product unit)? - Is primary material consumption decreasing for the whole sector (in kg)?
	Environment For all product groups (over the whole life cycle of a product): - Is cumulative energy consumption decreasing per functional product unit? - Is cumulative energy consumption decreasing for the whole sector? Environmental pressure caused by specific product groups (over the whole life cycle of a product): - Is cumulative environmental pressure decreasing per functional product unit? - Is cumulative environmental pressure decreasing for the whole sector?
	Economy - Is the added value of products and product services increasing? - Are employment levels in the product chain increasing?

Although the above diagnostic questions are meant for a business audience, it is important for Defence to diagnose innovation at an early stage to encourage innovation where it's happening - and kick-start it where it isn't - with the purpose of understanding the sustainable potential of new products/processes to include in BaU. This can be delivered by incorporating sustainable considerations in all projects/programmes.

Conclusions

This concept note adheres to the SSS and focuses on the possible application of CE in Defence, initially focusing on the SSS Initiatives. The main actions identified show a real potential and the opportunity of a coherent innovation and future implementation plan in the BaU of R&E. There are clear benefits and identified risks that can be mitigated through implementing CE and including EPR in the products' life cycle. The R list provide a useful instrument for prioritisation and traceability and can be adopted in cooperation with internal and external stakeholders aiding in the development and understanding of priorities across the Defence Enterprise. The Diagnostic questions offer an opportunity to understand innovation potential in Defence applications and can be tailored to the area of interest. In conclusion, CE is a theoretical concept that has several different applications that offers a model that Defence can utilise to reduce supply chain vulnerabilities, increase resilience, and enhance operational effectiveness.

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