

RE-THINKING END OF LIFE AIRCRAFT INTERIORS THROUGH CO-DESIGN AND REPURPOSING

Tully Mahr[1], Lily Whiteman[1], Alex Daley[1], Shenal Hewa Witharange[1], Juliana Prpic[1], Katja Holtta-Otto[1], Madhurima Das[1]

[1]University of Melbourne

Abstract

The global aerospace industry faces a growing challenge in managing the end of life of aircraft, with many components currently disposed of in landfill. Over the coming 20 years, over 20,000 commercial aircraft are expected to be retired [1]. Furthermore, while modern aircraft are designed for a service life of around 50 years, operationally and financially-motivated decisions often lead to their retirement much earlier [2]. This anticipated high volume of potential waste provides an opportunity for innovation, as many subsystems and components may still offer usable value even if they are no longer air-worthy.

The circular economy emphasises extending the lifespan of materials and components by prioritising the higher levels of waste hierarchy, i.e., reusing a metal component instead of melting it down for recycling, thereby retaining the embedded engineered value for as long as possible [3], [4]. In practice, directly reusing aircraft components for their original function can be difficult due to safety concerns, outdated technology, or elevated performance requirements. Repurposing, which is using a discarded component in a new application, offers a practical middle ground between reuse and recycling and allows for still maintaining some of the engineered value of these precision components.

Repurposing can involve changing the function or context of the part to be repurposed [5]. Aircraft contain many high-value, precision-engineered parts, and in this paper we explore pathways where these aircraft components are repurposed in a different non-airplane context. Our past work has identified means to explore repurposing opportunities using a design tool called a Repurposable Attribute Basis (RAB) [6]. This enables a systematic search of potential repurposing options. This framework provides examples of a component's attributes that could be repurposed such as its material properties, structural elements, and geometric features [6]. Additionally, it includes transformer attributes that inspire repurposing by changing an aspect of the component including employing multiple instances of the same product, changing the orientation, or separating a section [6].

This paper explores alternative end of life pathways for decommissioned aircraft components, building on the Repurposable Attribute Basis and focusing on reuse strategies co-designed with an Indigenous Australian community. This community partner, the Centre for Appropriate Technology (CfAT), brings expertise in repurposing and re-engineering waste items to create bush hardy products for local community use (e.g., transforming a discarded oil drum into a bush oven). In partnership with this group, we expand and update the RAB tool for use in community contexts where not everyone involved in the design process has a formal engineering background. Using airline economy passenger seats as a case study, we then investigate multiple repurposing pathways informed by part properties, local constraints, and stakeholder values. A codesign framework is applied with a specific community group in Alice Springs to identify use cases that prioritise social value and functionality alongside sustainability outcomes. The study demonstrates how aerospace components can be recontextualised beyond traditional recycling streams and waste, extending service life and improving value retention while providing local benefit. The findings highlight the potential for community-engaged, value-driven repurposing to complement existing end of life management practices within the aerospace sector.

Keywords: repurposing, circular economy, sustainability, aviation, end of life management

1. Introduction

The sustainability challenges faced by the aviation industry extend beyond aircraft operation and fuel efficiency. As aircraft fleets age and are decommissioned, the aviation industry must also address the growing environmental impacts associated with end-of-life aircraft management. Current end-of-life practices commonly focus on harvesting decommissioned planes for parts, recycling, or disposal [7], [8], [9]. While these approaches are important for reducing waste and recovering high value materials, they don't always capture the full value still embedded within decommissioned aircraft components.

Aircraft interiors present a particular opportunity within this challenge. Interior components such as seats are often removed from aviation service long before their functional or structural value has been exhausted. Although these components may no longer meet the requirements for certified use in the aviation industry, they still retain useful attributes that can be leveraged in engineering design. When managed only through recycling or disposal pathways, this remaining value is often overlooked, and the embodied value of the component is reduced to material value alone.

Circular economy discussions within aerospace have frequently focused on recycling, material recovery, and the reuse of certified aircraft parts [7], [8], [9]. However, repurposing remains an underexplored pathway for extending the useful life of aircraft components. Unlike recycling, which breaks an object down into its constituent materials, repurposing seeks to retain and use the existing function, form, and value of an object in a new application [5]. This approach has the potential to preserve functional value, reduce waste, and generate social value beyond the aviation sector.

This paper investigates how aircraft interior components can be reimagined through co-designed repurposing strategies at the end of their primary operational life. In particular, it explores how technical assessment can be integrated with community defined value and Indigenous Australian expertise in reuse, adaptation and engineering. Indigenous communities in remote and regional contexts have long demonstrated practical knowledge in repairing, adapting and repurposing available materials to create durable, locally useful and context appropriate solutions. The Indigenous-led Centre for Appropriate Technology (CfAT) is a contemporary example of an organisation putting Indigenous knowledges into engineering practice, and their expertise is recognised as central to the design process in this paper.

This paper presents a version of the Repurposable Attribute Basis (RAB) tool adapted for use in community co-design contexts, and applies it as a method to a case study involving Boeing 737 economy seats donated by an airline. Through this case study, the paper demonstrates how community engaged, social value-driven repurposing can expand circular economy practice within aerospace by considering both what materials can be recovered, and explores what future value aircraft components retain.

2. Background and Literature Review

2.1 End-of-life aircraft management

As of June 2025, the global commercial fleet was comprised of approximately "35,550 aircraft, including 30,300 active units and 5,250 held in storage" [10]. It is common for an aircraft to have multiple service lives under different airlines, either through leasing arrangements with multiple operators or through premium carriers selling individual aircraft to budget airlines. However, the operating life of any airframe is fundamentally limited to "the period they are safe to fly before metal fatigue poses a safety threat." [9]. When an airline, leaser or individual decides to retire and decommission an aircraft, they are often sent to an aircraft boneyard/scrapyard to be scrapped for valuable components, systems and materials.

Aircraft decommissioning and recycling are big business in the aviation industry. According to estimates collated by Schellhasse et al. [11] "over the next 20 years, the International Civil Aviation Organization (ICAO) and Airbus estimate that there will be a total of around 12,000 (Airbus, 2022a) to

20,000 (ICAO, 2019) retired aircraft". With annual aircraft retirements expected to reach over 1,000 aircraft per year by 2030 [12], the aircraft decommissioning market is projected to grow from 8.00 billion AUD in 2026 to 10.56 billion AUD in 2030 [13]. Furthermore, Global Market Insights place the aircraft metallic recycling market at $7.3 billion AUD in 2025 [7].

When an aircraft is disassembled at the end of its operational life, many of its components and systems retain their value and airworthiness beyond the life of the airframe. Scrapping aircraft for spare parts is an increasingly profitable venture [9], as is recycling metallic materials that make up the airframe [7]. Up to 92% of a retired aircraft's weight can be recovered to be reused or recycled [14]. The majority of aircraft parts that are refurbished, recertified, and reused are engine parts, which are "typically more valuable than the rest of the aircraft combined" [15]. According to Airbus subsidiary Satair, "engine segments represent 70% of the surplus market, with 20% components and 5% airframe parts" [12]. Landing gears and auxiliary power units are also among the most highly valued components [15].

However, some components and structures may be challenging to recertify as airworthy due to economic, regulatory, and safety constraints. Recommissioning components to be sold as spare parts is a capital and labor-intensive process, involving inspection, removal, testing, assessment for airworthiness, recertification where required, and documentation [15] regulated by the Civil Aviation Safety Authority (CASA) in Australia in alignment with ICAO's Standards and Recommended Practices (SARPs). Instead, components and structures may be removed from the aircraft and recycled to recover their constituent materials, following a longer end-of-life pathway. For example, the aluminum and titanium alloy components and structures that make up the airframe are typically recycled [7].

Aircraft parts and structures that are too challenging to reuse or recycle are usually disposed of or incinerated. In particular, interior furnishings and composite structures are often disposed of at the end of their service life as they are challenging to recycle or reuse [8], [16]. An aircraft's interior components have engineered value that is lost when they are disposed of. They are typically strong, lightweight, and durable components, but they also possess functional value through their ability to effectively serve a specific purpose. Hence there is significant opportunity in identifying appropriate repurposing pathways.

2.2 Circular Economy and Reuse Hierarchy

In most contexts, modern consumerism operates within a linear economic model. The model involves the thought process and societal behaviour of "take-make-dispose" [17] or use-remove-discard. It is inherently a model that creates waste, depletes natural resources, limits innovation and increases social inequity [17]. It is the linear process of taking materials from our ecosystems, making them into products and at end of life throwing these products away as waste [3].

A circular economy, on the other hand, replaces 'end-of-life' (decommissioning) with reducing, reusing, recycling and recovering materials [18]. It is an economy that "promotes the continual use, recycling, and regeneration of materials and products" [17] with emphasis on reducing extractive behaviour and consumption [17]. There are three key goals that drive a circular economy, to "eliminate waste and pollution", "circulate products and materials" and "regenerate nature" [3].

Regenerative design is an emerging concept in western academia used to describe efforts to increase circularity. Regenerative design is a process of co-evolution whereby all involved "engage in continuous and healthy relationship" [19]. It goes beyond sustainable design and works to recreate connection to and restore place through interrelated wholeness [19].

Simultaneously, circularity is integral to Indigenous Australian culture with similar messages echoed through concepts such as reciprocity and interconnectedness with the living world. Examples of circularity in practice within an Indigenous Australian context range from the kinship system to multipurpose tools, such as a coolamon. In an Aboriginal worldview, circularity places key importance on maintaining reciprocal relationships between people, Country, culture and future generations, and

emphasises honour and respect in caring for Country [20].

There are several strategies growing in practice that can be used to promote circularity, with Reike et al. [21] categorising the most common perspectives on "resource value retention options" as a 10R typology. They span from short term to long term practices and consist of Refuse, Reduce, Resell/Reuse Repair, Refurbish, Remanufacture, Repurpose, Recycle Re-mine and Energy Recovery.

This project focuses on repurposing - an end-of-life practice that aims to preserve partial value of used products by using them in new contexts, prolonging the life of the high valued product as long as possible [22]. It is a beneficial strategy as it delays the inevitable disposal or material recycling and works to maintain the functional value of the original product [5].

This paper outlines the process of ideating and evaluating ideas for repurposing from different worldviews. Our community partners at the Centre for Appropriate Technology (CfAT) demonstrate their repurposing expertise through their "bush hardy" products – delivering "appropriate fit-for-purpose technology" [23] to remote Aboriginal communities around Alice Springs from discarded products such as 44-gallon drums. Examples of their bush hardy products include bush ovens, hot water heaters, campfire guards and "bush hardy beds" [24]. These products are designed specifically to be appropriate for remote Aboriginal communities, in line with CfAT's core mission of enabling "Aboriginal communities to use technology to maintain their connection to country, live and thrive sustainably on country" [23]. Repurposing from this lens treats a repurposing concept or product as valuable when it supports people to remain on Country, return to Country, protect Country or secure economic self-determination from Country [23].

This highlights the difference in repurposing approaches from a Western academic setting, as an Aboriginal worldview places a larger emphasis on repurposing where need, context and appropriateness drive the design.

2.3 Identifying Repurposing Opportunities

Given the growing interest of repurposing as an end-of-life pathway, Witharanange et al. [5] identified the need for a support structure to aid in the identification of repurposing opportunities and to strengthen the impact of such options. The Repurposable Attribute Basis (RAB) was developed by examining repurposing cases studies in academic literature to catagorise the typical attributes that can result in a repurposed application [6]. Using the RAB to think about a product's current or possible future attributes allows the user to think of possible repurposing opportunities that may have otherwise been overlooked.

The RAB in its current form is an engineering tool intended to inspire ideation in individuals for repurposing [6]. The language is engineering focused and requires a formal background in engineering and the concepts/processes involved. As such, the format of the RAB was adapted into a simpler format that inherently includes the foundations of the framework while conveying the integral message in a way that is accessible for general public audiences.

This paper explores opportunities for repurposing aircraft interiors by working in collaboration with CfAT in a co-design process using this adapted RAB.

3. Methodology – Indigenous Research Paradigm & Co-design

Co-design is a collaborative process that encourages end users and stakeholders to be active contributors of knowledge and ideas to the design process and design content [25], and was central to this work. Co-design brought a "depth of knowledge, resources and lived experience to the design process that otherwise would not be possible" [26].

This co-design work sits between Indigenous research paradigms and engineering design practice. It

required a methodology that could support technical design outcomes while also remaining accountable to relational, ethical and community informed processes.

Rather than treating Indigenous research and engineering design as separate or competing approaches, this project brings them together through yarning: a process of shared dialogue, reflection and decision making through which the project's priorities, tools, ideas and outcomes were shaped.

There were four different types of yarning practices used in this work, based off the framework proposed by Dawn Bessarab and Bridget Ng'andu [27] and Petah Atkinson [28].

The first is the social yarn, which is the yarn that takes place before the research begins where trust is developed and a relationship is built [27]. Our collaboration with CfAT is built from a 7+ year relationship between the community and Juliana Prpic and various student capstone groups from the University of Melbourne. Social yarns were used in the first engagements between the University of Melbourne research team and the Aboriginal workforce at CfAT to establish trust and connection.

The cross-cultural yarn involves participants (both Aboriginal and non-Aboriginal) adjusting their behaviour to operate within the protocols of the other's culture [29]. We used cross-cultural yarning to share practices, processes and knowledge for research within our respective worldviews, and to develop tools that can be shared across cultures.

The research topic yarn is used to collaboratively gather information relating to the research question of circularity and repurposing.

Collaborative yarning was used to identify project priorities and to discuss and analyse data, providing opportunities to explore and explain concepts in collaboration with CfAT, resulting in new understandings about the research topic [27]. This paper navigates two over-arching methodologies, one from a deeply rooted academic background and one informed by the oldest continuous living culture in the world.

4. Case study: repurposing Boeing 737 economy seats

A set of Boeing 737 economy triple seats (Figure 1) donated by an airline, contain precision engineered components designed to meet the high standard posed by regulatory requirements in aviation. They were used as a case study to investigate repurposing opportunities for a community context in Alice Springs. This work involved an ideation process to generate many potential applications of the seats and its components; evaluation to refine and select ideas to further analyse; and feasibility analysis to determine the technical, environmental, and economic feasibility of the selected ideas.



Figure 1 - Airline economy triple seat used for case study. Photo taken by Centre for Appropriate Technology.

4.1 Idea Generation

4.1.1 Methods

Through yarning and co-design practices with CfAT, an adapted Repurposable Attribute Basis (Figure 2) was developed to make the RAB more accessible for the general public, and more grounded in local context in Alice Springs. A key adaptation from the original RAB [6] included visually restructuring it into concentric circles, with the common attributes encircled by the transformer attributes (see Figure 2). Physically rotating the inner and outer circles encourages the user to combine the attributes and engage in nonlinear thinking. Additionally, similar attributes are grouped, and the language is simplified. Supplementary cards contain prompting questions for each attribute are also included (an example can be seen in Figure 3). This was an iterative process that involved collaborative and cross-cultural yarning, alongside informal working sessions and brainstorming.

Idea generation was conducted using the adapted RAB wheel and associated prompting questions as a structured ideation tool. The process followed a divergent-convergent approach, where the first stage prioritised generating a broad range of ideas before later refinement and evaluation. This approach aligns with creativity research, which suggests that novel and useful ideas often emerge through repeated cycles of idea generation, exploration, and refinement [30].

The adapted RAB was applied to three focus areas of the aircraft economy triple seat: the whole triple seat assembly, the seatbelts, and the reclining mechanism to explore a variety of types of parts and at a few levels of granularity. For each focus area, the team first used the prompting questions to build a shared understanding of the part, including its purpose, location, material properties, forces, shape and parts.

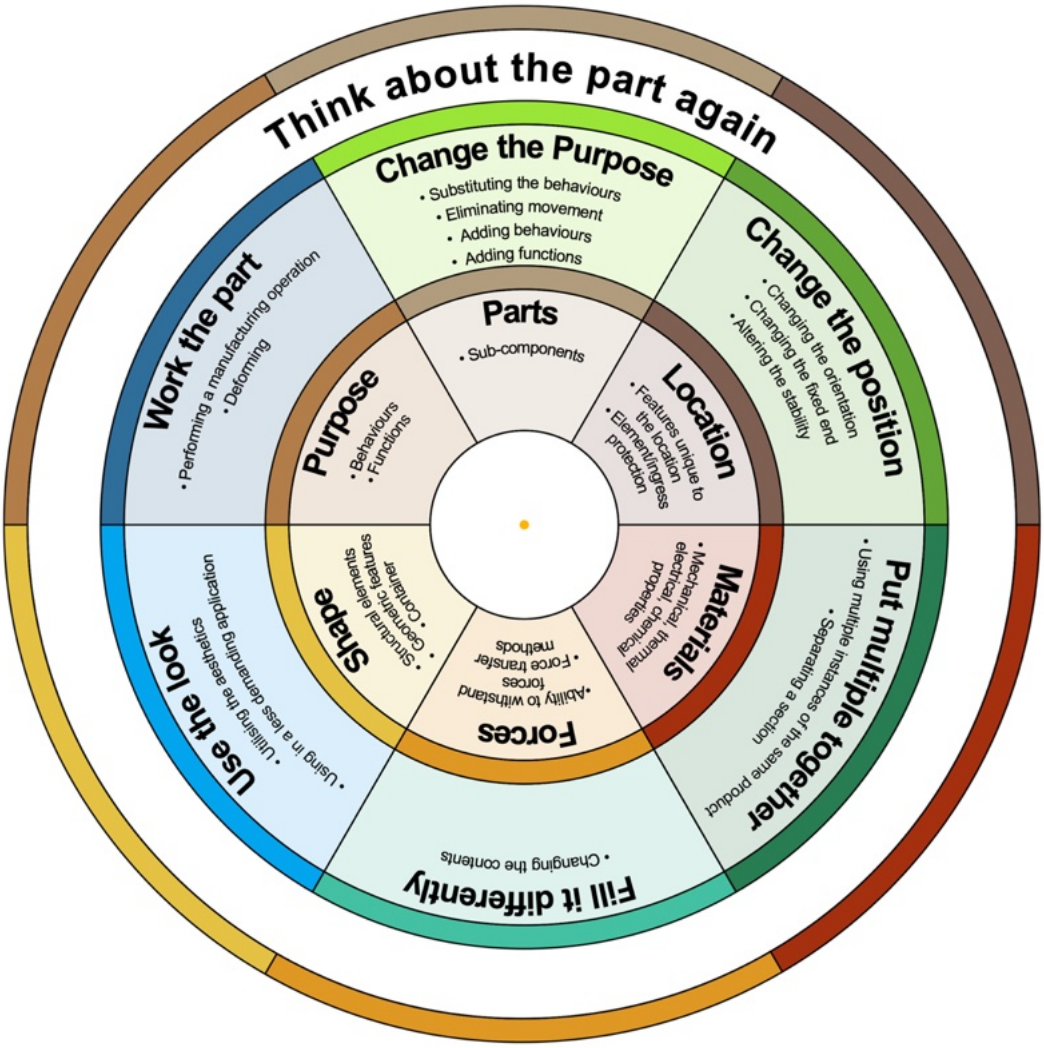


Figure 2 – Final iteration of the adapted RAB.

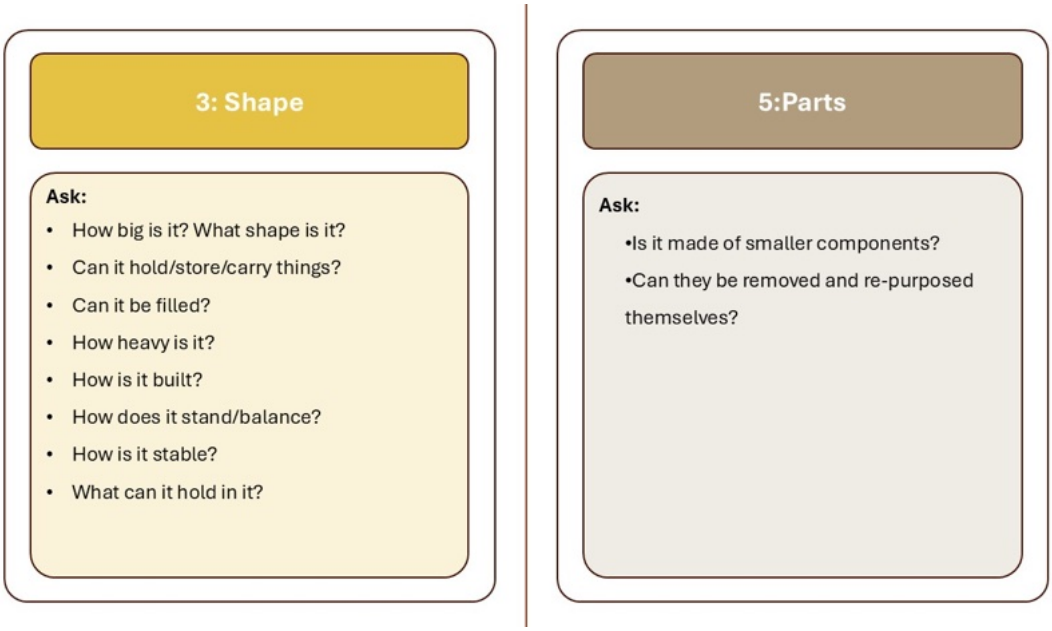


Figure 3 – Example of the prompting cards that support the adapted RAB wheel.

After discussing the prompts to an attribute as a group, a timed individual ideation activity was completed. For each selected attribute, a 5 minute timer was set and team members independently generated as many repurposing ideas as possible that were relevant to that attribute [31]. Table 1 shows the typical ideation process for various parts. During this stage, quantity was prioritised over quality to encourage creative thinking and reduce self-censorship, allowing both practical and unconventional ideas to emerge [30], [32], [33]. The ideas were then collected for later consolidation and evaluation. While there were many informal ideation sessions with CfAT, and those ideas were included in the final evaluation, this formalised process was conducted solely within the student team as a proof of concept, and it is expected that future work will employ this process with the CfAT crew in future engagements.

Table 1 – Process for idea generation using the adapted RAB and prompting questions.

Part	Attribute	Prompting Question Example	Team Answer Example	Resulting Idea Example
Whole seat assembly, see Figure 1	Purpose	How does it achieve its purpose?	It is strong and lightweight; it adheres to aircraft safety regulations; it is rigidly attached at the base to the aircraft and restrains passengers using a seatbelt.	Retrofit the seats to trucks to transport passengers through a guided On-Country tour.
Pneumatic Actuator in Reclining Mechanism 	Forces	In what ways is it strong / weak?	Strong in the axial direction when the spring is locked; the piston bears the primary load not the spring; has multiple failure modes.	Use mechanism as a mass spring damper to act as a shock absorber in motorbikes.
Tray table 	Location	Where is it and what is its purpose there?	Attached to the seat in front, positioned in front of the user, used to create a surface to eat on.	Combined with change the position, the table can be fixed to a harness and attached to a person to create a portable table.
Seatbelt 	Material, put multiple together	What does this material mean?	Fire resistant, durable, strong, lightweight.	Daisy chained, can become fire resistant straps for firefighters to use in emergencies.
Armrest 	Fill it differently	What else can it hold?	Grain, animal feed.	Turn the armrest into a slow-release animal feeder (e.g., for chickens).

4.2 Results

The idea generation process produced a large collection of potential repurposing pathways for the aircraft triple seat assembly, ranging from concepts that required minimal modification to the original component, to ones that involved a more significant transformation. Ideas were generated across both whole-seat repurposing and component level repurposing, including seatbelts, cushions, tray tables, aluminium frame, and reclining mechanism.

The final ideas were grouped according to the degree of functional transition from the original aircraft seat assembly (Table 2). The first category identified the ideas as retaining the same function, but applied in a new setting, such as seating for events. The second category involved ideas that have a direct substitution, where components replaced existing products with minimal modification, such as seatbelts as garden ties. The third group contains ideas that utilised a specific engineered property of the part, such as strength or adjustability, into a new structural or mechanical use. The final group involved more transformative repurposing uses, where components were reimagined into significantly different products.

Table 2 – Final idea categorisation.

Category	Description	Idea Examples
Same function, new setting	The part maintains its primary function from its use in aircraft, but the environment / context is changed.	• Turn seats into wheelchairs • Use as seating in a cinema • Cushions into couch cushions
Direct substitution	The part replaces an existing object with little change.	• Seatbelt as tie down straps • Seatbelts as garden ties • Cushions as pet beds
Property based use	The part no longer performs the same task but still uses one of its engineered properties.	• Using the reclining mechanism in a farm gate • Using the reclining mechanism as a shock absorber in a motorbike • Seatbelt as a tow strap
Transformed use / new identity	The part is reimagined as a new object, with the original function being secondary.	• Seatbelt into a dog toy • Seatbelt into bag straps

Several patterns emerged across the categories. Seatbelt ideas commonly drew on strength, adjustability and fastening, while whole seat ideas often remained connected to seating or human support. The reclining mechanism generated more property-based ideas, particularly around adjustability, locking and controlled movement. Cushion and fabric-based ideas were generally linked to comfort, padding, insulation or soft material use. These patterns suggest that ideas were strongest when there was a clear relationship between the original function or property of the part and its proposed new use, with the additional factor that the team of engineers discovered more detailed ideas for the mechanism, highlighting the benefit of including many different perspectives into the ideation process.

Some ideas required little modification and appeared more immediately feasible (e.g., seatbelt as a tie down strap), while others required greater redesign (e.g., reclining mechanism as a spring-loaded seed planter). Higher transformation ideas often offer more novelty or social value but require

significantly more testing and development.

The CfAT crew also generated ideas that connected directly to local community needs and priorities, reinforcing the relationship between need and value. This supported the idea that useful repurposing is about identifying applications that connect with the realities and priorities of the communities the project seeks to support.

Although the project did not conduct a direct comparison between the original RAB and the adapted RAB, the adapted tool appeared to support the idea generation process. By translating the original RAB into more accessible prompts and grouped categories, the adapted version helped participants engage with the parts without needing to rely on technical terminology alone. The tool also helped to shift the focus from identifying the parts of the aircraft seat to recognising and discussing the transferable value of those parts. For example, components were not only considered as seatbelts, cushions, mechanisms etc, but instead focused on its attributes such as strength, comfort, adjustability or lightweight.

The prompting questions were particularly useful as a starting point. They encouraged participants to first understand the part itself, including its properties, attributes, materials, mechanisms, and original function, before proposing new uses. This grounded the ideation process in what the part could realistically do and helped ensure that ideas were connected to the component's existing value. In this way, the adapted RAB acted as a scaffold for broadening discussion, supporting both technical understanding and creative brainstorming.

4.3 Idea Evaluation

4.3.1 Method

300+ ideas were generated through the formalised initial ideation process, with additional ideas resulting from informal yarns with CfAT being included. Similar repurposing concepts were consolidated together, and all the ideas were combined into a list to be assessed using a staged evaluation process. The first stage was a quick filter, where ideas were reviewed based on our intuition and judgement as engineers, screening them for technical feasibility and project relevance. Ideas that were clearly infeasible within the project scope were discarded (i.e. if the concept was too technically challenging or prohibitively expensive within the scope of the project). Ideas that appeared promising but required further clarification or iteration were flagged and re-discussed by the team to determine whether they could be refined into feasible concepts, or if they should be removed. 99 ideas remained for evaluation after this initial filter was applied.

The remaining ideas were then evaluated in two stages using the project's value framework (Table 3). The adapted evaluation framework was developed by extending Brown's Feasibility-Desirability-Viability model [34] to better align with the project's community centered aims so that ideas weren't assessed through economic or technical value alone. Drawing on sustainable worldview and the concept of responsibility [35], [36], the framework reframed desirability around community priority and social value ("assumed social value"), expanded feasibility to include responsible environmental outcomes ("assumed environmental sustainability"), and added appropriateness to local context as a key measure of whether an idea could realistically support CfAT's mission and remote community needs ("assumed CfAT viability").

Table 3 – Evaluation criteria

Criteria	0	1	2
Assumed Social Value	Doesn't meet an identified local community need.	Meets a niche/smaller identified local community need **or** addresses a general population need.	Strongly addresses an identified local community need.
Assumed environmental sustainability	Lack of future focus **or** relational continuity, harmful/destructive **or** creates waste.	Considers the current generation **and** no harm is caused.	Actively sustainable in creating interconnectedness **and** providing opportunities to live on and maintain connection to Country.
Assumed CfAT viability	Unscalable concept **and** no capacity building **and** no aid in CfAT operations.	Capacity building opportunities **or** may be adapted to be scalable **or** assistive to operations.	Highly relevant for CfAT **and** scalable **and** provides capacity building.
Project technical feasibility	Too much effort **and** tools unavailable **and** skills can't be learnt.	Acceptable effort **and** tools and skills available (for purchase, already in possession, can be taught).	Minimal effort **and** tools available **and** skills possessed.

In the first stage, ideas were assessed against environmental sustainability and assumed social value, centering these criteria as a priority for our project. Each criterion was scored from 0 to 2, and a normalized score was calculated using:

(criteria 1 score + criteria 2 score)/4

Ideas with a normalized score above 50% progressed to the next stage, leaving 28 ideas.

In the second stage, these ideas were assessed against project feasibility and assumed CfAT viability, using the same 0-2 scoring approach and normalised total, allowing selection for our project's specific co-design requirements.

12 ideas scored above 50% in this final stage and were selected for further development through diagrams, design considerations and identification of potential constraints.

4.3.2 Result

The staged evaluation process helped narrow the initial idea set into a smaller group of concepts that were more aligned with the project's aims, constraints and value framework. For example, using the seats as seats in a rollercoaster or a mechanical bull ride were removed by the quick filter since they would be prohibitively expensive, or involve significant technical and regulatory challenges to realise as repurposed products. Ideas that looked promising but required further iteration or clarification before progressing through the quick filter included concepts such as a clip-on heat pack made from stitched seatbelts, or seatback pockets used for storing fruits and vegetables. These ideas were revisited as a team before either being refined or removed. For example, further research on the heat-pack concept uncovered that the most common material used for airplane seatbelts is not appropriate for the microwave, hence the idea was removed.

The first formal evaluation stage demonstrated how the inclusion of assumed environmental sustainability and assumed social value shaped the decision-making process. Several ideas that may have been technically feasible did not progress beyond the first formal screening as they did not strongly align with these criteria. For example, technically feasible ideas such as commemorative coins made from seatbelt buckles, a camera rig stabilizer made using the reclining mechanism, or an adjustable monitor stand were removed at this stage as they did not address an identified social need of Aboriginal communities in remote Central Australia and/ or didn't meet the sustainability criteria. Concepts such as using the seatbelt strap as a dog chew toy or using seat cushions as sponges/rags scored a 0 on environmental sustainability as they are reused as disposable products. They lack relational continuity / future focus and actively create waste, despite scoring highly on project feasibility. This highlights an important outcome of the evaluation process. When social value and sustainability are prioritised, the most technically possible ideas are not necessarily the ideas that best align with the project's purpose and community context.

The final evaluation stage further narrowed the concepts based on project feasibility and assumed CfAT viability. Some ideas scored strongly in terms of social or environmental value but were not feasible within the project timeframe or technical capacity. For example, reforming the seat frame tubing into irrigation piping was considered valuable from a Community and sustainability perspective (scoring 2/2 for both), as providing access to water is an identified priority for Communities in remote Central Australia. However, the concept would require substantial technical development beyond the scope of this project, including preventing the pipe from calcifying from the hard water and ensuring it met the relevant standards and regulations, and therefore scored 0 for project feasibility. This suggests that some removed ideas may still have future value and could be revisited by later project teams.

The 12 ideas that progressed reflected a stronger alignment between community usefulness, practical feasibility, and the retained value of the aircraft seat components. These ideas were then developed further through diagrams and design considerations. Two concepts were then selected for further feasibility analysis and as a proof of concept, and are explored in this paper.

Spring loaded farm gate

The first final concept was the use of the aircraft seat pneumatic actuator as a spring-loaded locking support for a farm gate (see Figure 4). This idea transfers the original function of the actuator (controlled movement, locking and position adjustment) into a new context. The concept was scored highly in assumed social value (2/2) as it directly addressed a need articulated by CfAT of keeping stray animals out of areas. A simple mechanism that can hold a gate open or closed in a fixed position could respond to practical needs around property access, livestock management and everyday maintenance, particularly in remote settings.



Figure 4 - CAD model of the spring-loaded farm gate concept, using the repurposed reclining

The idea scored highly for project feasibility (2/2) because it could be prototyped at a manageable scale and iterated using available workshop tools – an identified need of our co-design process. It also aligned well with CfAT viability (2/2) as it could plausibly be fabricated, repaired, adapted, or installed through local technical capability. The environmental sustainability score was strong where aircraft parts could replace newly manufactured components for the hinge component. Overall, this idea demonstrated how a relatively simple concept could score highly because of its practicality, maintainability and alignment with local need and use.

Solar Panel Mount

The second final concept was the use of the reclining mechanism and seat back support as an articulating arm for a solar panel (Figure 5), allowing the panel position to be manually adjusted. This idea was selected as it connects the mechanical properties of the seat component to a locally relevant infrastructure need. Solar panel infrastructure is already important in many remote contexts, and therefore this concept had a strong assumed social value (2/2) because it could support energy access, maintenance and usability. It is also well aligned with the sustainability criterion (2/2) as it provides renewable energy and allows Aboriginal communities to continue living on Country.

The idea was considered feasible for the project scope (2/2) as it could be explored through design and load analysis. The concept scored strongly for assumed CfAT viability (2/2) as it connects to remote infrastructure, maintenance and potential capacity building work.

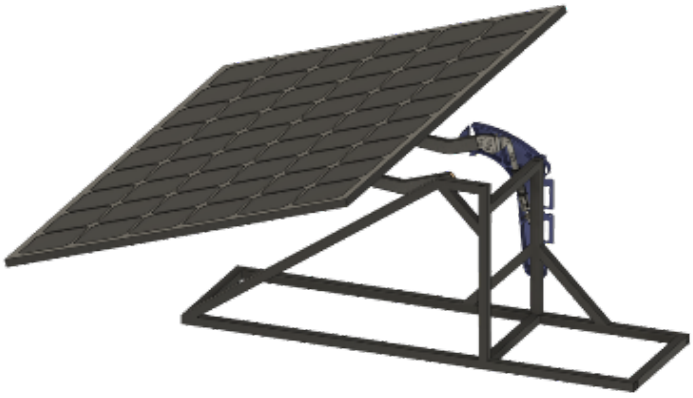


Figure 5 - CAD model of the solar panel mount using the repurposed reclining mechanism and the seat back support structure.

This concept would allow end-users to easily adjust the position of a solar panel to face the sun throughout the day, increasing solar exposure and improving energy generation. The design leverages the durability of the reclining assembly and the seat back support structure to withstand the conditions in remote Central Australia. The concept is manufactured from readily available materials, and contains no electromechanical components that might make it difficult to maintain, making it appropriate as maintainable infrastructure suitable for remote energy systems. As such, the concept aligns with CfAT's mission to deliver reliable and maintainable power supply to Aboriginal and Torres Strait Islander communities to thrive on Country. However, the concept requires further design iteration prior to feasibility analysis, so is left as a recommendation for future work.

4.4 Technical Feasibility Analysis – Locking Spring-Loaded gate

Following the selection of the spring-loaded locking gate, rudimentary calculations were completed to check whether it was technically and environmentally feasible. These calculations were treated as a screening of the idea to demonstrate its basic viability and to provide an early indication of whether the concept was worth developing further, including additional engineering analysis.

The selected idea repurposes the reclining mechanism from the aircraft seat, shown in Figure 6. This mechanism is driven by a locking spring-loaded actuator, where engaging /opening an internal valve allows fluid to be displaced within the damped cylinder, enabling the spring piston to be

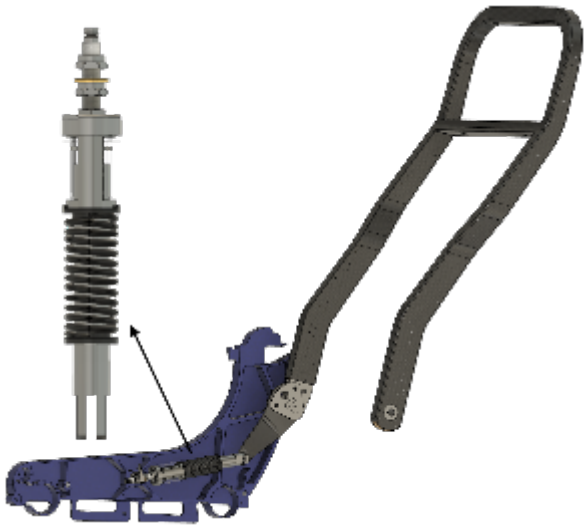


Figure 6 - Reclining mechanism and actuator removed from a Boeing 737 triple chair.

compressed or extended. When the valve is released/closed, the fluid flow is restricted, locking the actuator in place and holding the seat in position. Manufacturing company Crane Aerospace & Electronics [37] suggests that a similar recliner has a compression and tensile load of 3000 lbf (13334 N). However, according to ITT Enidine Inc [38], more recent versions of the UltraLOC actuator suggest a maximum compressive/tensile rating of 10230N – 22241N. This recliner has a maximum displacement of 21mm.

The preliminary technical feasibility assessment of the lockable spring-loaded gate concept considered the concept to be technically feasible if it could be configured such that the existing actuator displacement could produce a 90° gate swing, it can be opened and closed manually in the unlocked state with a force not exceeding 20N (in accordance with AS 1428.1:2021 General Requirements for Access), and can withstand the local wind loading conditions when locked.

The design requires a linkage mechanism to convert the linear displacement of the actuator from the reclining mechanism into a 90° gate swing. To achieve this motion within a small footprint, a lever-actuated 4-bar parallelogram linkage was designed (see Figure 7).

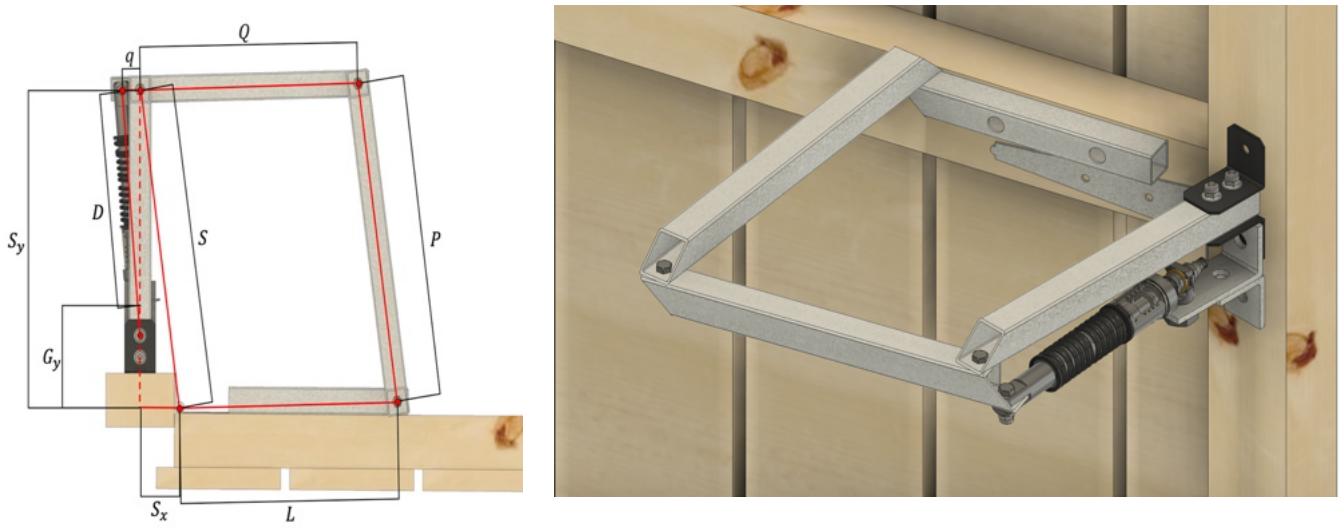


Figure 7 – a) Geometry of the 4-bar parallelogram linkage. b) Close-up view of the CAD model for the lockable spring-loaded gate.

The effort required by the user to open the gate from the point where linkage P contacts the gate is given by equation (1).

$$F_{effort} = \frac{1}{MA} F_{spring} \frac{S}{\sqrt{D^2 - 2S\sin(\theta)q}} \cos(\theta) \tag{1}$$

When the gate is unlocked, this effort is then given by equation (2) (results shown in Figure 8).

$$F_{effort} = \frac{1}{MA} kS \left(\frac{D}{\sqrt{D^2 - 2S\sin(\theta)q}} - 1 \right) \cos(\theta) \tag{2}$$

For $k \approx 14120N/m$, $D = 200mm, S = 199mm, q = 20.5mm$, where θ represents the angle of the gate.

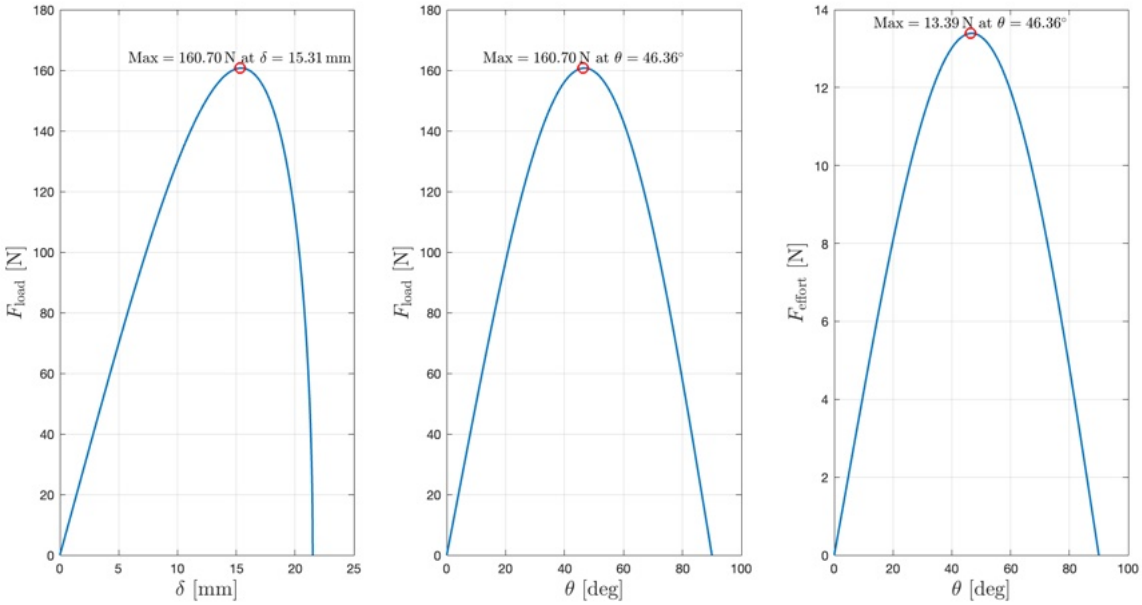


Figure 8 – Force required from the user to open the gate $\boldsymbol{F_{effort}}$ and the corresponding force applied by the spring $\boldsymbol{F_{load}}$ to linkage $\boldsymbol{Q}$ as a function of the actuator's displacement $\boldsymbol{\delta}$ and the gate angle $\boldsymbol{\theta}$. Assumes a mechanical advantage $\boldsymbol{MA = 12}$.

As per Figure 8, for the linkage designed with $MA = 12$, it is estimated that the maximum effort required to open the gate when it is half open (at an angle of approximately $46.36°$) is approximately 13.39 N of force, not exceeding the aforementioned accessible opening force.

Additionally, resistance to wind loading was identified as a potential limiting factor for the design, given that the design must remained locked in its set position in all weather conditions. This work is heavily grounded in local context, so the designs must be suitable for the environmental conditions in Alice Springs. For example, the structural wind loading calculations were calculated based on conditions in Alice Springs. Following the procedure outlined by the AS/NZS 1170.0:2021 & 1170.2:2021 standards, the wind load that the design must withstand is given by (3) & (4).

$$p = (0.5 * \rho_{air})\left(V_{des,\theta}\right)^2 C_{shp} C_{dyn} \tag{3}$$

$$F = \sum \mathrm{pA} \tag{4}$$

Where p is the design wind pressure, A is the area, ρ_{air} was taken as $1.2\ \frac{kg}{m^3}$, $V_{des,\theta} = 39.15\frac{m}{s}$, C_{dyn} taken as 1, and C_{shp} is the aerodynamic shape factor.

To withstand the wind loading, the orthogonal wind force at the closed gate was calculated to estimate how much force the actuator must withstand. When closed ($\theta = 0$), the actuator mechanism is oriented such that the actuator must withstand the full levered wind load.

For the design wind pressure and associated force, the gate's aerodynamic shape factor, C_{shp} was calculated as 1.3 using dimensions of $700mm$ width, $900mm$ height, and $50mm$ off the ground. The gate was modelled as a solid wall to provide a conservative estimate for the orthogonal direction of the wind force. The wind force was calculated as $F_{wind} = 744$N, assumed as acting in the center of the gate. The linkage must provide a force sufficient to resist the moment induced by the wind load. Taking a moment balance, (assuming a frictionless hinge), the force provided by the linkage at point P (see Figure 7) must be $F_p = \frac{.35}{L} F_{wind} = 1021.1N$ where $L = 255mm$. Equation (1) was used to obtain the force transmitted to the locked actuator, which was determined to 12314.8N. Depending

on the direction of the wind, this force acts on the actuator as either a compressive or tensile force. In either case, the force transmitted to the locked actuator was calculated to be slightly less than the maximum compressive/tensile load rating 13334N noted above but sits comfortably under the 22241N suggested by other sources.

In addition to these calculations, to validate that the linkage operates as expected and can be physically realised, the gate was modelled, and a physical prototype was constructed. The development of a physical prototype was also important for engagement with the CfAT team, having been identified as important for design communication during the co-design process while adapting the RAB.

The gate therefore passed the initial screening for technical feasibility, as it was analytically estimated to withstand large wind loads, and was both analytically and physically validated as capable of producing a 90° swing from the full displacement of the spring. It is recommended that further design improvements include testing on a wire gate to reduce the wind loading effect and improve its locking ability, we well as reducing its weight. Additional analysis should be completed on the gate's ability to withstand larger orthogonal forces such as those imposed by a stray animal pushing on the gate

4.5 Environmental Impact Analysis – Locking Spring-Loaded gate

The environmental impact was calculated with the understanding that the recliner mechanism's environmental impact was accounted for in its first life and by repurposing the part it stops the processing of new materials. It was assumed that the repurposed parts are available and would be disposed of in landfill if not repurposed. The environmental analysis of the design therefore lies in the added components to prototype the concept. For the gate, this was the linkage mechanism. The environmental impact of the proposed design was compared, through embodied carbon values, to an existing product, highlighting the benefit in environmental impact of repurposing over producing a new part.

It is assumed both the current product and the proposed design will have gate materials such as posts, hinges, structure and hence the environmental impact for the spring-loaded gate design comes from the difference between the two. The linkage mechanism is the key change and was designed with 1.53 kg of galvanized steel. The ICE database [39] has hot-dip galvanized steel embodied carbon as $2.62\ \frac{kgCO_2}{kg}$, resulting in the embodied carbon of the linkage design of $4\ kgCO_2$.

There are a diverse range of comparable products, however, none meet the same requirements of this design. For example, a comparable product is an ASSA ABLOY SW100 Swing Door Operator [40], an electric system used primarily on doors to automatically open and close the door with the possibility to hold it in the open position too. This is used as a comparable product because it is a motor, control and linkage system that is similar to those that would be used on a gate automated opening system. The key difference is our gate design is mechanical in nature, and this product is electric, which has a disproportionate effect on the environmental impact as evidenced by the embodied carbon for this product, is product stage A1-A3 and Operational Energy/use B6 being $523\ kgCO_2$ [40].

Alternatively, the product of a 360mm Galvanised Heavy Duty Coil Gate Spring manufactured by Pinnacle [41] could be used for a comparison. This product can be attached to an existing gate to achieve the self-closing action but lacks the ability to lock at any given angle. It is produced from Galvanised Steel and weighs $0.76kg$. Hence using the ICE database [39] value for hot-dip galvanized steel embodied carbon as 2.62 $\frac{kgCO_2}{kg}$ has an embodied carbon $2\ kgCO_2$.

5. Discussion

5.1 Repurposing as an end-of-life practice in aviation

Existing circular economy discussions in aviation commonly emphasise dismantling, reuse of certified parts, and recycling, however, aircraft interiors contain assemblies whose value is additionally functional, structural, mechanical and ergonomic [15]. This case study demonstrates that repurposing can extend the life of aircraft components by retaining functional value that may be lost when their value is only assessed for reuse or recycling. This is particularly relevant for interior components such as seats, seatbelts, cushions, tray tables and reclining mechanisms, which are designed for durability, safety, compactness and repeated use.

The airline economy seat case study shows how an aircraft interior component can be screened for repurposing potential before disposal. The idea generation process identified repurposing pathways ranging from same function reuse, such as seating in a new context, to attribute based transfer such as using the reclining mechanism for locking or adjustment. This supports the premise of the Repurposable Attribute Basis, which uses shared attributes between products and actions to identify opportunities for decommissioned products beyond their original use [6]. In this paper, the most promising concepts were not necessarily the most novel, instead the strongest concepts were those where an existing attribute (e.g., strength or adjustability) matched a practical community need.

The selected concept for the case study illustrates this point. The spring-loaded farm gate retains the mechanical value of the pneumatic actuator while transferring it into remote infrastructure contexts. The feasibility analysis indicates that, while not yet a final design, the concept is a technically plausible and suitable for further iteration.

The solar panel mount is an interesting additional case study that requires design modifications prior to feasibility screening, as the initial proposed design fails under wind loading conditions. However, additional design iterations were out of scope of this paper but are recommended for future work.

The application of the case study suggests a potential industry implication, where aircraft interiors could be assessed for repurposing potential before being directed to recycling streams. Additionally, airlines or manufacturers could partner with community organisations to identify context specific repurposing pathways as early as during the design phase.

5.2 Co-design with CfAT prompting new ideas

The co-design process shifted this work from designing for community to designing with community. The distinction significantly changed both the process of idea generation and evaluation, with the case study process positioning value as something defined through local need, usefulness, maintainability, and potential community benefit. This aligns with Indigenous research methodologies with yarning as a relational research method, where knowledge is developed through trust, conversation and shared meaning making rather than extracted through one way consultation [27].

The adapted RAB tool supported this process by making the technical language of repurposing more accessible and relational. The tool used prompts about what a part does, where it is located, what forces it carries, what materials it contains, and what else those attributes could support. This provided a bridge between repurposing practices in an academic setting to the lived experience of our co-design partners. While addressing a need or problem is a key part of engineering design, for repurposing work, the repurposing of a component itself is considered the need. However, when working with CfAT, community need itself was an important methodological shift where ideas that responded to priorities identified through our engagement with CfAT were highly preferenced and informed the ideation process.

This also changed the outcomes of the evaluation process. Several technically feasible ideas were removed because they did not align strongly with assumed social value or environmental sustainability criteria, while other ideas progressed because they connected more clearly with remote infrastructure, access, maintenance, or everyday community use. The farm gate concept is an example of this shift, having emerged from recognizing the transferable engineering properties of the pneumatic actuator, and prioritised because those properties could be directed towards locally relevant needs. As such, collaboration with CfAT highlighted Indigenous expertise in repurposing and the ability to assess

whether an object is useful in a contextual and relational way.

5.3 Limitations and future work

This paper is exploratory and is based on a single case study involving components from a commercial aircraft interior. The findings therefore cannot be generalized to all aircraft components, airlines or end of life pathways. The adapted RAB tool is also at an early stage of development and was not directly compared against the original RAB or other ideation methods. As a result, this paper can only claim that the adapted tool supported this project's context, rather than providing broader effectiveness.

The co-design process was also limited by time, engagements and an evolving relationship with CfAT. While early outcomes suggest that the approach helped identify more contextually relevant ideas, further community involvement in evaluation and selection would strengthen the legitimacy of future design decisions. Long term social impact cannot yet be assessed as the selected concepts remain conceptual and require further analysis.

There are additional limitations around supply and scalability. The project relied on access to an economy triple seat assembly, and future access to similar aircraft components is uncertain. This affects whether the concepts could become repeatable products or remain as one off demonstrations. Finally, conventional engineering evaluation frameworks can struggle to account for the relational, cultural and community-defined forms of value explored in this project. Future work should therefore focus on iterative prototyping of the selected concepts, particularly for the identified solar panel adjustable mount as the idea aligns with CfAT's mission and community priorities. Future work should also center broader community led evaluation, and further development of the adapted RAB tool as a method for generating repurposing ideas with broader communities.

6. Conclusion

This paper has explored how end-of-life aircraft interior components can be reimagined through co-designed repurposing strategies that extend value beyond conventional recycling and material recovery pathways. Through a case study of retired aircraft seating, the project demonstrated that components no longer suitable for aviation use may still retain functional and social value when assessed through a Community centered lens. The adapted repurposing framework supported a process of idea generation and evaluation that considered local need, maintainability, sustainability and alignment with the priorities of the Centre for Appropriate Technology and remote community needs.

The outcomes suggest that repurposing can complement existing aircraft end of life management practices by preserving embodied value while creating opportunities for place-based innovation. The final concept of the spring-loaded locking farm gate demonstrates how aircraft seat mechanisms may be redirected towards applications that respond to real community needs. While further prototyping and design iterations are required, this work highlights the potential for co-design to broaden the circular economy conversation in aerospace. In doing so, it positions repurposing as a pathway for more socially grounded and contextually appropriate approaches to aircraft end of life management.

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9. Contact Author Email Address

mailto: rima.das@unimelb.edu.au

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