Business as Unusual: Designing products with consumers in the loop

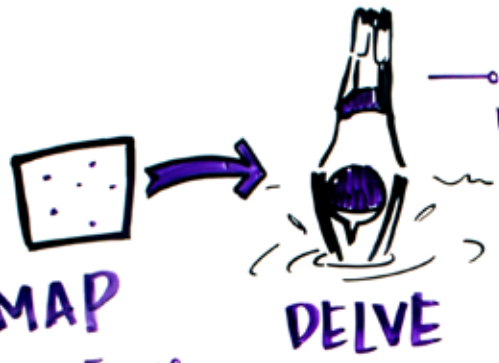
RECODE Network

Cranfield University

RECODE-NETWORK

BUSINESS as UNUSUAL

...CONSUMERS in the LOOP...



MAP
INTERACTIONS

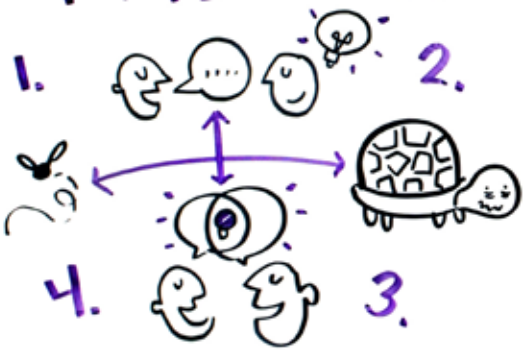
DELVE

IMPORTANT in EARLY STAGES of PRODUCT DEVELOPMENT

ENVISION

FUTURE WAYS to TRANSFORM PRODUCT DESIGN & MANUFACTURING through RDM...

FUTURE SCENARIOS



WHO's DESIGNING?
WHERE is it MADE?
HOW MUCH DATA is USED?
WHAT's the CUSTOMER JOURNEY?
& the PRODUCT LIFE CYCLE?
WHO's in CONTROL?

1 CIRCULAR CONSUMABLES

2 DEMOCRATIC DESIRABLES

3 ENGAGING ENDURABLES

4 TAILORED TEMPORARIES

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About Us

RECODE Network

The EPSRC-ESRC funded Network in Consumer Goods, Big Data and Re-Distributed Manufacturing (RECODE) has been created to develop an active and engaged community to identify, test and evaluate a multi-disciplinary vision and research agenda associated with the application of big data in the transition towards a Re-distributed Manufacturing model for consumer goods.

The exponential growth of available and potentially valuable data, often referred to as big data, is already facilitating transformational change across sectors and holds enormous potential to address many of the key challenges being faced by the manufacturing industry including increased scarcity of resources, diverse global markets and a trend towards mass customisation. The consumer goods industry, has remained largely unchanged and is characterised by mass manufacture through multi-national corporations and globally dispersed supply chains. The role of Re-distributed Manufacturing in this sector is often overlooked, yet there is great potential, when combined with timely advances in big data, to re-define the consumer goods industry by changing the economics and organisation of manufacturing, particularly with regard to location and scale.

The RECODE Network conducted five feasibility studies led by the academic core partners, steering group partners, and new partners who joined through the RECODE Sandpit on 02-03 March 2016. A multidisciplinary team comprised of internationally renowned experts from Cranfield University, Open University, Loughborough University and Imperial College London and practicing industry leaders in the fields of design, manufacture, big data, circular economy and consumer goods, were involved in the delivery of this feasibility study.

RECODE has developed novel methods and undertaken innovative events to engage communities of academics, international experts, user groups, government and industrial organisations to define and scope a shared multi-disciplinary vision and research agenda. To find out more, visit our website: **http://www.recode-network.com**

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Introduction

A significant challenge consumer product manufacturers face is to be able to rapidly identify new market segments and to respond to those segments with products that consumers will actually consume[34]. Re-distributed Manufacturing (RdM) has the potential to disrupt the way we produce and consume products across the lifecycle and to create new models of 'Business as Unusual'. New structures of design and manufacturing can enable large reductions in resource consumption by limiting waste in a supply chain (e.g. reducing transport distances) and through addressing the flows of resources at critical times in the lifecycle of products. It can also enable reduction of R&D waste by enabling a more targeted delivery of custom products to meet specific user needs and demands in different contexts and across extended timespans of the product lifecycle[34].

Specifically, this study has explored how to respond to this major challenge:

How should we engage users in New Product Development in future re-distributed models of sustainable production and consumption?

This involved mapping of the challenges and opportunities for user engaged design and manufacture, and investigating their application to bridge the gap between users, companies and the products they produce. In addition, it will seek to understand how the promotion of resource efficient product lifecycles can be incorporated within future, more localised and responsive structures of manufacturing and product adaptation.

Furthermore, it involved the people-product interactions across the entire lifecycle of a product from front end New Product Development (NPD) through to products' repair and afterlife. We achieved this through addressing both fast moving consumer goods (FMCG) and consumer durable products, such as large and small household appliances. We involved representatives from industry representing the sectors above.

We investigated opportunities for new types of product – people interventions that foster co-creation and co-maintenance of products, both in the initial design of those products and in the co-evolution of the product across its lifecycle. The main focus of the investigation is the interaction between consumers both in the New Product Development (NPD) process and in interventions across product lifespan, to ultimately position the consumer in product development decisions by allowing their influence at key stages in a product's life. This will enable the creation of new structures of design and manufacture in a more localised and distributed context. In addition, two areas of focus were chosen for this exploration, as the product-people relationships are under-explored in lifecycle decision-making. As such, the two perspectives from these relationships will be the short-life cycle products within the FMCG sector and the longer life cycles associated with consumer durable products to create a complete map of those interactions.

We also explored the diverse methods of engagement that are currently available or could potentially be deployed in practice in the future and mapped them to help designers to gather data, understand user needs, and support lifecycle decision-making. Existing approaches range from traditional market research methods such as surveys and focus groups to more ethnographic influenced approaches; and new approaches to NPD such as mass customisation and crowd sourcing, and the analysis of big data obtained through service contracts, smart phone apps, etc. These are the stepping-stones to explore the emerging opportunities for data-rich integrated consumer interaction in the design process.

The ultimate aim of our research in this exciting domain is to map and address the options available for integrating users in the product development decisions of future sustainable products they need. This implies that in the future the customer/end user/consumer is co-creator of the products they wish to consume. It also implies the determination of new and emerging market segments. However, identifying and responding to these market segments will require new forms of organisation and models for design and manufacture and product lifecycle models that support different types of consumption. The drivers for the inevitable transformation to re-distributed and resource efficient systems will be determined and mapped. To this end, this study brought together an interdisciplinary network of academic and industrial partners to investigate the following objectives:

1. To understand where, when, and how, interactions with consumers occur across the various stages of the NPD process and product life cycle.

2. To investigate how those interactions can scale via a data-driven approach to front end NPD

3. To investigate the product lifecycle stage of 'ideation' and 'use', to develop an understanding of how a range of consumer interactions in product use or repair can be expanded and built upon to inform more sustainable models of product development in RDM contexts.

Meeting these objectives meant that we had to *Map* the possible consumer interventions across the lifecycle of products, focusing primarily on consumer products; *Delved* into fast moving consumer goods (FMCG) by exploring crowdsourcing techniques to enable consumer interactions at large scale; *Delved* into durables to explore people-product relationships occurring in the lifecycle of consumer products and finally *Envisioned* models, future work and enablers towards transforming product design and manufacturing through RdM types of organisation. In this report the outcomes of this study are presented.

Map: Consumer interventions across the product lifecycle

Customer journey mapping

Within Customer Relationship Management (CRM), Consumer Touchpoints[1] are a well-established tool for mapping and understanding the interactions between a brand and its customers[2,3,4]. The purpose of a consumer touchpoints diagram is to show all the potential opportunities for a customer to "experience" the brand - typically these include instances such as advertising, point-of-purchase, packaging, after-sales service, etc. These touchpoints may also be further subdivided, such that advertising, for example, may be comprised of print advertising, TV advertising, online advertising, etc. Consumer Touchpoint diagrams have been used in both academia and industry, to understand customer-brand relationships in sectors as diverse as energy supply, mobile phone networks, charities, consumer electronics and food retail. However, CRM typically focuses on consumer-brand interactions which the brand can control, and ignores those which brands are unable to influence. Consumer interventions such as post-purchase modification, repair and re-sale have therefore received little attention.

Within user-experience design[5], and especially service design[6], Customer Journey Maps (CJM's)[7] are employed as a method for documenting the way in which a customer experiences a product-service system. CJM's utilise consumer touchpoints in order to understand how a customer perceives and relates to the brand over a relevant timescale or throughout a relevant process. However in order to understand and manage the chaotic feedback resulting from every customer having their own journey, brands typically employ personas to 'summarise' a subset of its customers[8]. This inevitably focuses attention on a brand's core customers while excluding its outliers; as a result the opinions of customers who are engaging with a brand in new or unexpected ways can be overlooked. In addition, in conventional manufacturing paradigms, the customer appears at the end of the value chain[9], i.e. the value chain is taken to end when a product is sold. Manufacturing within a Re-Distributed paradigm[10], through NPD processes such as Mass Customisation, Crowdsourcing and Open Design, enables the earlier engagement of customers [11], and extends the value chain further. CRM literature has not previously given attention to CJM's within NPD, and has therefore neglected instances where customers engage with the design and production of products and services, rather than just their consumption.

Building on the theory for implementation of CJM's within CRM, in this project we have introduced the concept of consumer intervention mapping, to visualise the opportunities for the consumer to intervene in, and modify, the intended or expected product lifecycle. In line with CJM methodology it takes a user-centric perspective, rather than focussing on the brand or manufacturer, but untypically gives attention to outliers (both brand champions and brand antagonists) as well as core customers. Crucially, it maps the journey throughout the entire product lifecycle as understood within traditional models of production and consumption, from product specification, design and manufacture, through promotion, sale and use, to repair, re-sale and disposal. The purpose of this mapping exercise is to then explore new models of production and consumption which fall into the re-distributed and circular economy paradigm[12].

Systematic review of consumer intervention touchpoints

In order to determine both the scope and detail of information required to construct the Consumer Intervention Map (CIM), an initial literature review was conducted to understand the relevant phases of a customer journey within a circular economy paradigm. In common with existing CJM models, the CIM depicts the customer journey space at increasing levels of detail (Figure 1). At the widest level only three phases were identified[13]: Purchase, pre-purchase and post-purchase. At the intermediary level, the CIM draws on a number of sources[14,3,15] to model six phases encompassing the NPD process through to usage. Finally at the narrowest level of detail, 18 discrete phases were identified from the literature[14,11,13,16].

Following a systematic review of the literature, it was possible to populate the map with the relevant touchpoints (the complete systematic literature review can be found at: https://doi.org/10.17028/rd.lboro.4772275.v1). In this exercise, only those instances in which consumers directly and intentionally intervene to alter the brand's intended, or expected, customer journey model, were deemed relevant. Passive touchpoints (for example magazine advertising or sales staff interactions) that do not involve consumer intervention were excluded.

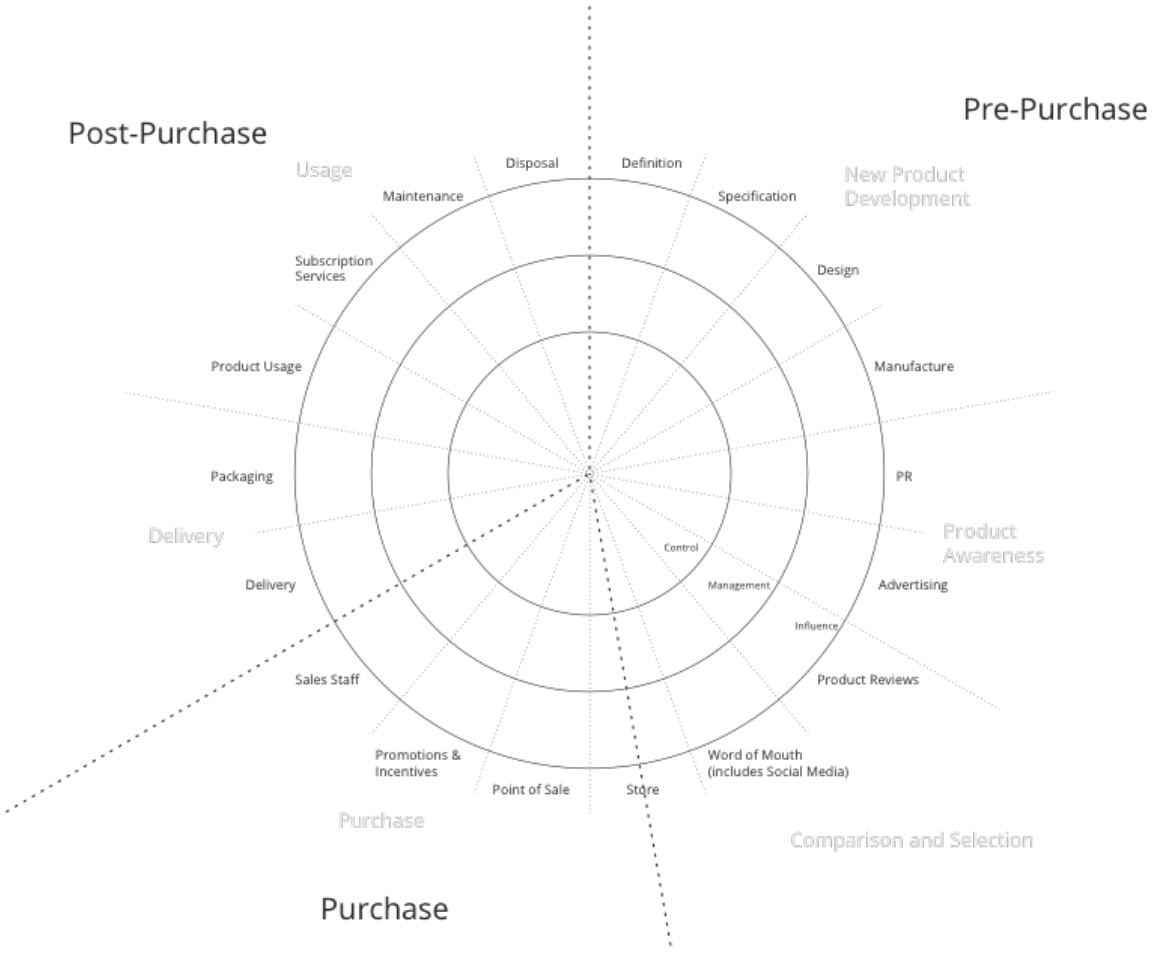

Figure 1 The customer journey space

Finally, the identified touchpoints were mapped to their appropriate phases in the product lifecycle (Figure 2). A system of colour coding was used to identify touchpoints as occurring at different stages in the product lifecycle – manufacturing (orange), communication (pink), supply (blue) and usage (green); these were coloured darker or lighter according to the degree of intentionality a brand or manufacturer has in allowing consumers to intervene at this touchpoint. The consumer intervention mapping will be used to validate findings from the Delve studies, through depicting scenarios of the different product-people interactions across the product lifecycle in customer journey space.

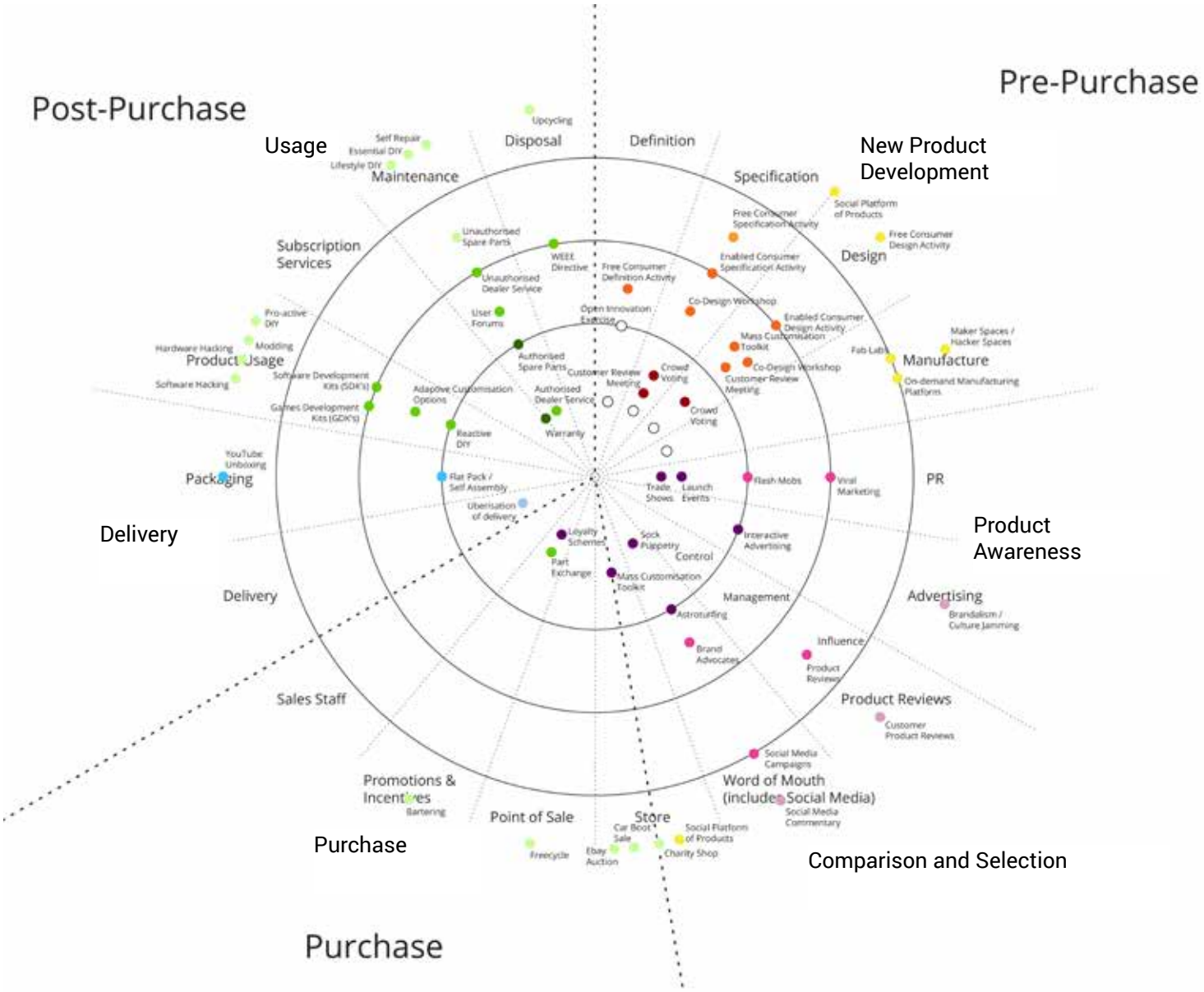

Figure 2 Consumer intervention map fully populated with intervention touchpoints

Delve: Consumer product co-creation for Fast Moving Consumer Goods

Engaging users in new product development using the preference market place

Due to short product life cycles and increasing demand on individualised products, within the fast-moving consumer industry; new product developers and manufacturers need quick and effective consumer engagement. Sometimes response to demands must be near the user. Hence, Re-distributed Manufacturing (RdM) can enable a more targeted delivery of custom products to meet specific user needs and demands in different contexts and across extended timespans of the product lifecycle.

Understanding consumer demands is still a vital challenge for the market. However, gamification could be a potential solution to accelerate new food and beverage product development, and reduce waste on research and development processes due to proximity of these activities to the end user. This delve study presents the preference marketplace, a platform that offers participants to influence creation of new products using game mechanics. Preference marketplace is inspired by a combination of financial market and prediction markets[17]. These are virtual markets that enables participants' trade contracts which are linked to the future outcome of unknown events. Market pricing mechanism is the most effective tool to reveal aggregated information of heterogonous individuals by converting their preferences into one single value which is share price[18]. Participants can buy and sell product shares multiple times depending on their preferences or they might be influenced by others by following the price trends. Pricing mechanism has been successfully used to identify customer preferences in the development of a new cell phone[1]. Here we develop a novel digital crowdsourcing tool to engage with consumers by playing a game.

How does the preference market place crowdsourcing tool work?

Participants receive 1000 Bitcoins (virtual currency to invest in the preference marketplace), once they create their own profiles. They can invest their initial profit among different markets according to their preferences. They can buy/sell up to 50 shares each transaction. The limit to 50 shares maximum for each transaction, was selected to prevent any potential manipulation by buying or selling large number of shares. Preference marketplace features are shown in Figure 3.

To test the performance of the proposed crowdsourcing tool to engage with different consumer groups, we conducted two case studies focused on a beverage product development (i.e orange flavoured beverage case study), and a food product development (i.e. noodle case study).

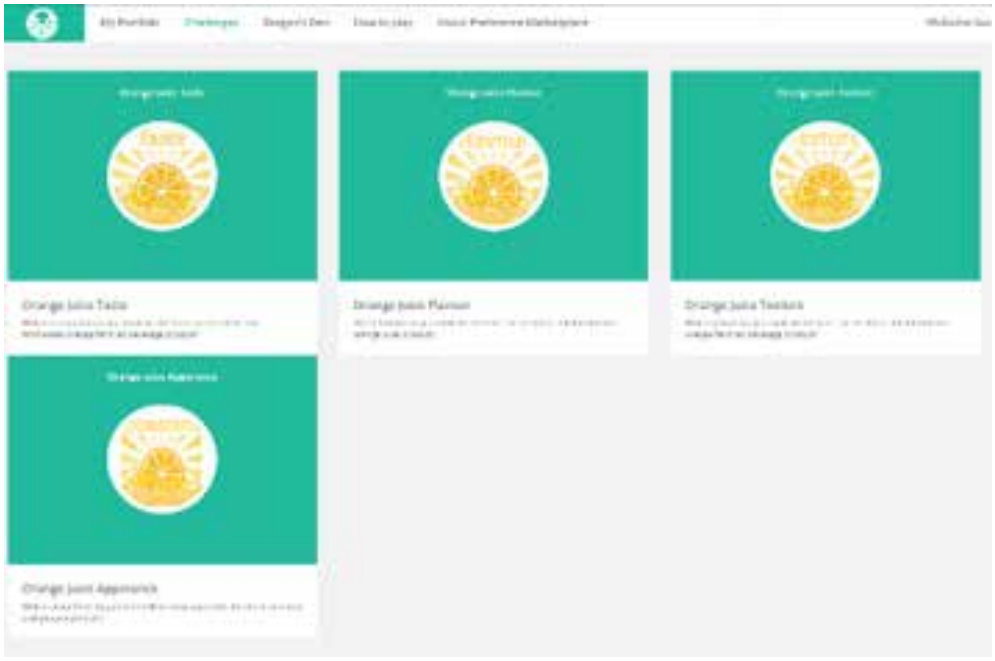

Figure 3 Preference marketplace features (leader board page)

Beverage product development – Orange flavoured beverage case study

Fruit/vegetable flavoured beverages are a prominent model of emulsions in the soft drinks industry as a concentrated or diluted product. As consumer lifestyles become more personalised and demand has surged for a greater variety of beverage options, the industry has considerably evolved with product formulations becoming particularly targeted to the user needs.

In this case study, we identified the most required sensory attributes of orange juices by playing the consumer market preference game with consumers. Compared to other techniques, such as surveys and opinion pools; the preference marketplace allows to discover more detailed information on sensory attributes such as taste, flavour, texture and appearance. For this case study, the challenges were set up including the same sensory attributes of orange flavour beverage products (i.e. appearance, flavour, taste, texture) as shown in Figure 4. Detailed product features including price trend, features image, description and title can be seen in Figure 5. 10 MSc Students from Cranfield University participated over a gaming period of a week. However, 96 respondents were obtained for all markets set as challenges.
The final price of each sensory attribute defined the preference of each corresponded sensory attribute as a percentage. The target values for the sensory attribute formulation are the product prices that the participants have decided during the preference marketplace.

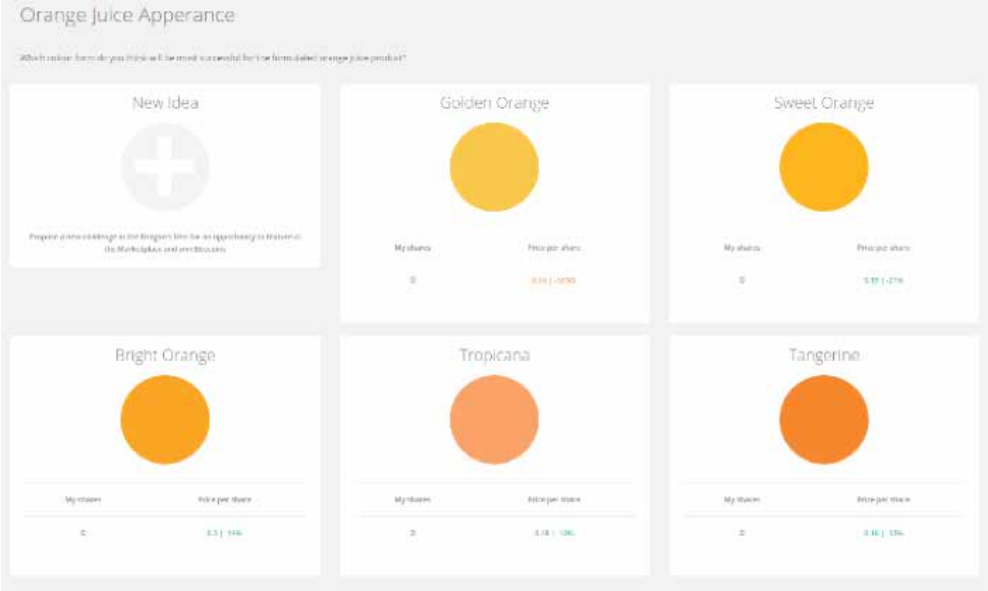

Figure 4 Sensory attributes of orange flavoured beverage product – Example of appearance

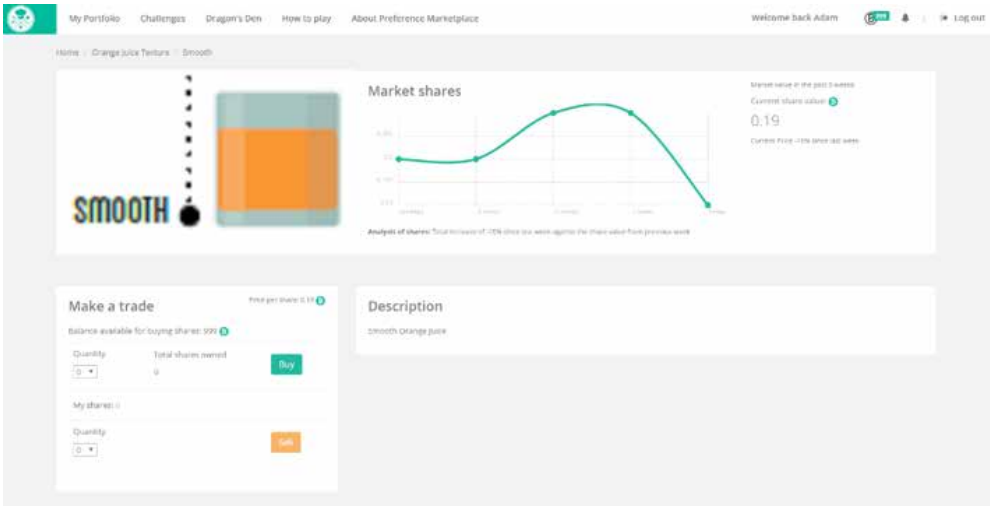

Figure 5 Detailed information of each product feature

Taste attribute results

The taste attribute results of the consumer market preference game are shown in Figure 6. It is seen that people's preference was inclined for sweet beverages. The prices of the sweet attribute were 45 bitcoins that means 45% of the participants preferred a sweet beverage product. With this result, a sweet orange flavoured beverage was produced using novel flow formulation system and through a consumer panel session with the same participants, they were asked to evaluate if their preferences were delivered or not. After the consumer panel, participants were invited to play the consumer market preference game again. The prices changed considerably after the consumer panel. The price of the citrus increased to 38 bitcoins (38% of participants) where sweet and bitter prices decreased to 32 bitcoins (32% of participants). This means that people change their preference from sweet orange flavour beverages to a citrus orange flavour.

Flavour attribute results

A second market challenge was set up to identify the most required flavour for the formulation and manufacturing. Five most common orange juice flavour attributes (citrus, fruity, grapefruit, tangerine and tropical) were included. Participants were asked to prioritize these flavours in the preference marketplace. Results showed that there was not a strong agreement on the participants for a flavour. All flavour stock prices were very close during one week trading period as shown in Figure 7. However, citrus was a bit higher than other flavours. Before the consumer panel, the price of the citrus was 24.67 bitcoins, the second most popular flavours were grapefruit and tangerine with same price being 20.2 bitcoins. According to these market results citrus flavoured orange juice was formulated and manufactured for the consumer panel session. After the consumer panel evaluation, citrus product prices increased to 31.5 bitcoins, while other product prices decreased below 20 bitcoins.

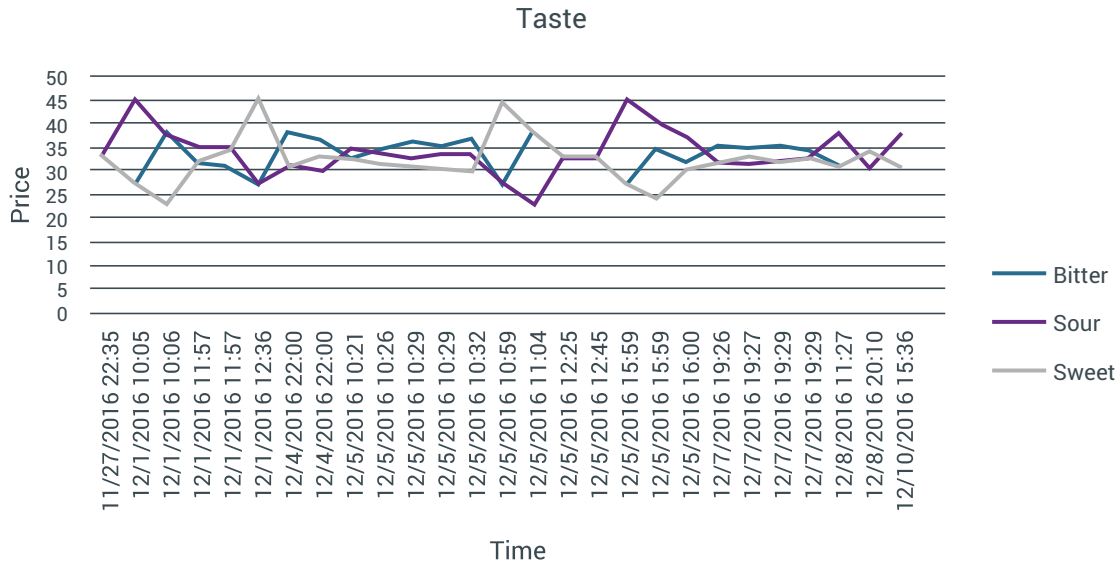

Figure 6 Preference marketplace - Orange beverage taste results

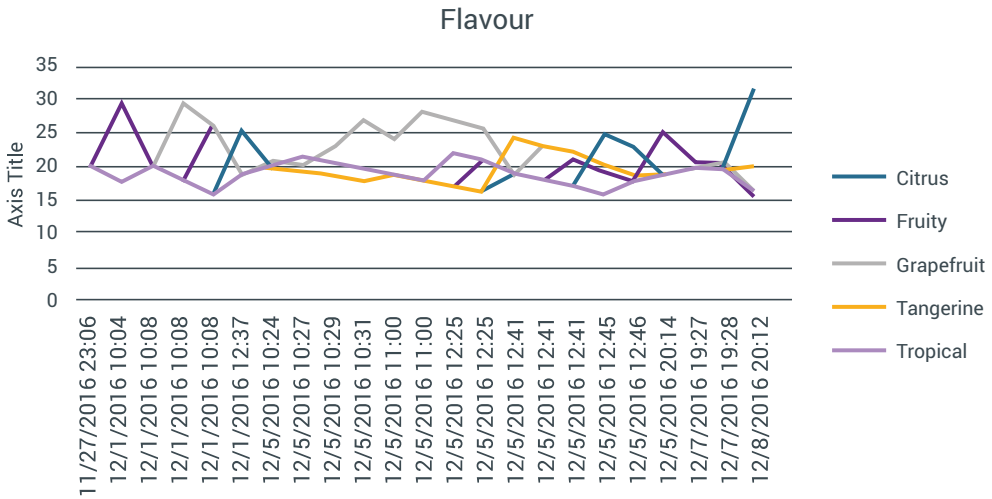

Figure 7 Preference markeplace - Orange beverage flavour results

Texture attribute results

Texture is another very important parameter to influence people for the purchasing of their preferred beverage product. Five different texture attributes (e.g. thin, smooth, with a few particles, pulpy and thick) were proposed to participants. At the end of the game, all prices were very similar as shown in Figure 8. The results from playing have shown that participants' preference was inclined for the thick beverage product with 40.50 market price and based on this market price, high viscous orange juice was formulated and manufactured for the consumer panel evaluation. In the consumer panel study, this preference remained.

Appearance attribute results

Five different shades of orange colour (from dark to light) were presented to participants so they can invest in their preferred beverage colour. Bright orange colour was the most required orange colour shade with 40.40 bitcoins market price before the consumer panel session, as shown in Figure 9. The required colour option was formulated with natural food colouring ingredients (e.g. beta-carotene), and given to the participants to try it in the consumer panel evaluation. The bright orange price was decreased to 29.9 bitecoins once they played the game again after the consumer panel evaluation, but it was still the most preferred shade of orange flavoured beverage colour.

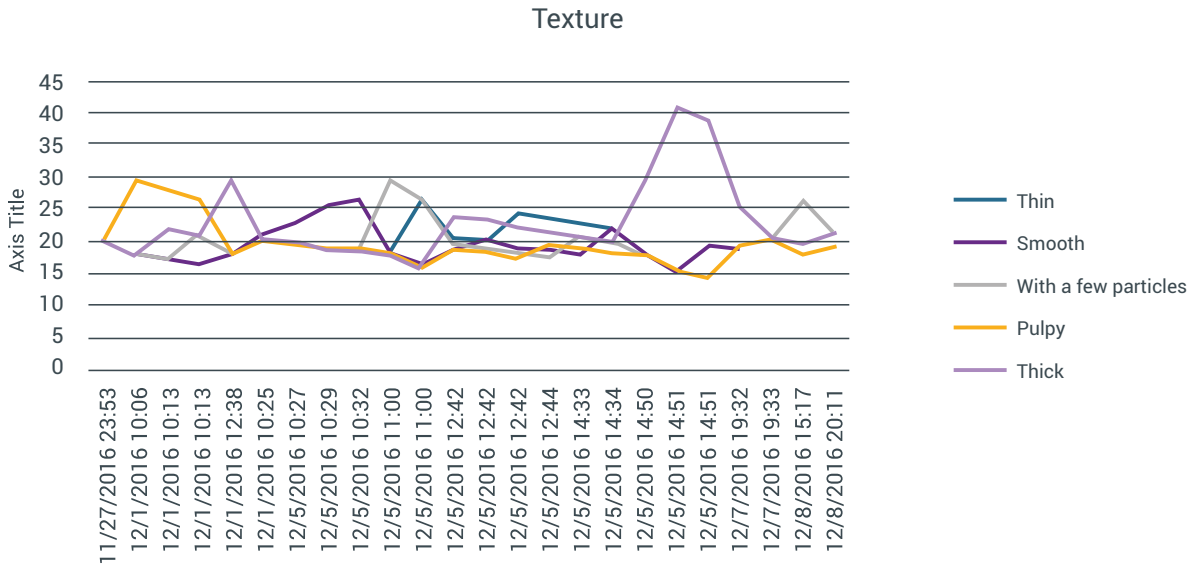

Figure 8 Preference Marketplace - Orange beverage texture results

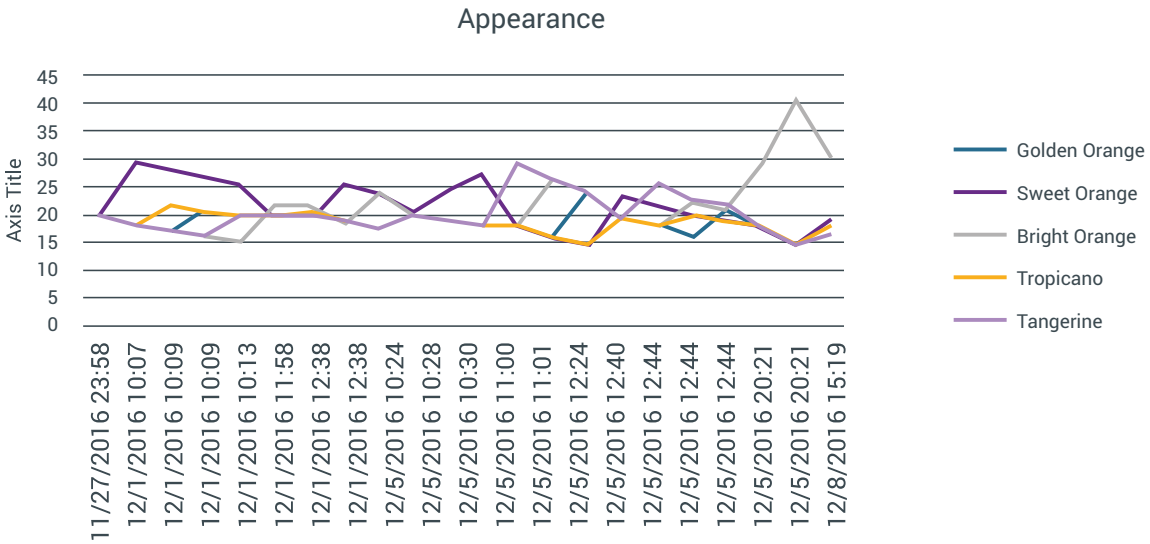

Figure 9 Preference marketplace - Orange beverage appearance results

Food product development – Noodle case study

The preference marketplace was developed to test large preferences for large numbers of new product features and concepts as seen in the orange flavoured beverage case study. The platform also allows to participants to provide new ideas, and evaluate those ideas by rating them.

In this case study, two workshops were designed to identify the most required noodle product features in three concepts; meal scenarios, noodle types and noodle kit components as shown in Table 1. The first workshop was to evaluate six different meal scenarios and each meal scenario started with the same market price 0.18 bitcoins. Identifying a meal scenario is very important to start developing a new food product. Different meal occasions such as lunch, dinner, weekend and weekdays require different combination of food ingredients. 27 participants (14 male/13 female) were recruited. These were MSc students from the Water and Design programme at Cranfield University. The workshop started by explaining to participants how to use the preference marketplace and noodle product development case study. After, participants played the game using the market preference tool for an hour. During this time, participants attempted to increase their initial profit by buying and selling different meal scenarios. In addition, twelve new ideas were collected from the crowd and over 600 trading activities were observed in 1 hour trading period. Quick weekday lunch for one was selected as a winning meal scenario by the crowd with the final price of 0.57 Bitcoins.

Once a meal scenario was identified as quick weekday lunch for one, we conducted the second workshop to identify the most required noodle type and noodle kit components according to the selected meal scenario. 21 MSc (19 male/2 female) students mostly from the manufacturing department were recruited. A different engagement approach was followed in this workshop. We only provided the link of the software and description of the workshop and case study to the participants with a 10-min presentation. Then we asked participants to access the game remotely. Two short videos are embedded into the platform to explain how the game works. This can be accessed remotely using an Internet connection. This study employed the same user interface as the first workshop. Participants goal was the same, they had to increase their initial profit to win the game. After one week trading period, the markets were closed. Thin egg noodle was selected as winning noodle type with the final price of 0.25 Bitcoins and Value Price – Noodles + sauce + spice/garnish was defined as winning noodle kit combination with final price of 0.17 Bitcoins.

New noodle product development		
Meal scenarios	Noodle types	Noodle kit components
Quick weekday lunch for one	Thin egg noodle	Value price – noodles + sauce
Refuel after a long working day	Medium egg noodle	Value price – noodles + sauce and own extras
It's weekend time to treat yourself for dinner	Thick egg noodle	Value price – noodles + sauce + spice/garnish
Working lunch – sharing with colleagues	Thin rice noodle	Value price – noodles + sauce + spice/garnish and own extras
With friends for dinner	Medium rice noodle	Quality price – noodles + sauce
Friends for the weekend	Thick rice noodle	Quality price – noodles + sauce and own extras
		Quality price – noodles + sauce + spice/garnish
		Quality price – noodles + sauce + spice/garnish and own extras

Table 1 Noodle product features and concepts

Study conclusion

Through this study, it is acknowledged the need to drive consumer demands in the most successful close-loop NPD process at large scales, with a quick and flexible manner. Thus, the preference marketplace tool can be then used for identifying different consumer segments, and at the same time respond to consumer demands in a rapid manner, especially if the NPD process is in proximity to the user. Hence, ultimately, we can envisage a distributed manufacturing system, using a new advanced production method that is not just characterised by its rapid response, but also could enable a smaller footprint due to its possible low energy requirements within the NPD and manufacturing systems.

For RdM, the implementation of gaming techniques such as the preference marketplace could enable further customisation, a key characteristic for RdM to succeed. This means that producers will be making exactly what people want, at the time it is needed, and as such could help to reduce material/resource throughput as well as less waste by producing a surplus of unwanted items. This enhanced customisation of products, could also enable new markets, in which products can be made and tested on demand, allowing a more effective NPD.

Delve: A narrative of slowing loop repair landscape

Engaging users in the role of repair

In response to issues of global resource scarcity and increasing levels of product consumption there is a perceived need to encourage systems of longer product cycles - slowing resources through the loop - and nurturing a new product literacy. According to the Energy Saving Trust in Great Britain, the number of electrical appliances and devices in households has increased steadily over the past 40 years; tripling from the 1970s to 2002[19]. Research also indicates that people are more likely to replace products with high technological innovation at a faster rate even when those products are still functioning[20]. A linear flow of products through the make-use-dispose cycle ultimately results in large amounts of valuable resources being lost to landfill, and large amounts of energy wasted in production, collection and disposal. Initiatives that intervene in linear resource flows are increasingly in evident; for example the Swedish government has recently proposed to support a repair economy through introducing tax breaks on all repair activities[21]. A circular economy aims to reverse this trend through a more sustainable model of consumption employing different initiatives and strategies to move towards a resource efficient model[22], where quality, durability, recyclability, locality and reparability are valued[23].

This section of the report explores how different flows (slower, circular) of materials, components and products can be enabled through a focus on repair as an opportunity to understand the stories of why products break, and the context of local and dispersed re-making beyond the formal agreements that the product warranty provides. This delve study calls attention to the possibilities of extending product life horizons and the ways people can actively engage in product lifetimes. Slowing the trajectory of product consumption is one of many business strategies that support the creation of circular economies[24]. The outcomes from this part of the project contribute to the different business as unusual scenarios the envision section of this report, two of which refer to extending product life and slowing resource loops.

Exploring the repair landscape

Exploring 'repair' provided a means to illustrate peoples' interactions with their products long after the usual new product development consumer based interactions had occurred. This part of the study comprised of a series of conversations with people who brought products to be repaired and with the people involved in those repair activities -the repairers - exploring their observations of repairing and their views on the motivations of people bringing things in to be repaired.

This study, included a small number of semi-structured interviews[a] that were carried out between May and July 2016. A survey of relevant literature was also completed prior to interviews to establish key interview themes and to help populate the customer journey space. A key purpose of the interviews was to understand what constitutes brokenness and repair and to find out how people engage in the repair process and to further understand the role of more localised product interventions (e.g. maintenance and making) in slowing resource loops. In total 41 interviews were completed: 10 were visitors to the Farnham Repair Cafe[b] and the Guildford Repair Cafe[c] bringing their products to be repaired; 16 were volunteers at those Repair Cafes or members of other Makerspaces (The Restart Project in London and Men in Sheds[d] in Milton Keynes); and 15 were members of the general public local to Cranfield University and Milton Keynes. The data from interviews were coded and it was found that people were generally happy to discuss their products and stories of repair.

One criticism of this approach is that the people attending these events are already, by default, pro-repair. This bias is recognised but does not influence the findings as the aim of the research was to undercover motivations for repair and the types of activities that constitute repair and not to seek a general representation of the value of repair. Although most interviews do involve participants at repair cafes or similar settings, a proportion of interviews were undertaken with the general public to understand wider perceptions of product brokenness and attitudes to repair.

[a] Masters of Design (MDes) Thesis, Narratives of Repair, by Lourdes Saca, 2016, School of Energy, Environment and Agrifood, Design Strategy and Leadership, Cranfield University.
[b] Farnham Repair Cafe - https://www.facebook.com/FarnhamRepairCafe
[c] Guildford Repair Cafe - https://www.guildford.gov.uk/repaircafe
[d] Men in Sheds - was launched in March 2012 with the support of Age UK Milton Keynes. The organisation provides an opportunity for older men to meet together and engage in different activities (e.g. woodworking, metal work and model making) and exchange skills.

Findings – Understanding the role of users in repair

A summary of repair cafe respondents' motivations and barriers to repair is presented in Table 2.

Motivations and barriers to product repair			
When is a product considered to be broken?	What makes something worth repairing?	Why don't you repair it yourself?	What are the main barriers for repair?
- When it doesn't work as it used to - When it no longer can do what it was bought for - When the main function doesn't work anymore - When it is no longer convenient to use - When it stops working or doesn't work well - When the quality and performance decreases	- A product with emotional attachment that you want to keep - A familiarity with the product and technology - Better to repair than replace with a product you don't understand. - Cheaper to repair than replace - Cheap products are not worth paying repair for	- Lack of knowledge - Lack of time - The inconvenience of repair - The ease of buying a new product - Not owning the right tools - Concerns about voiding the warranty - Concerns that product won't work anymore - Lack of creativity to do repair - Lack of skill	- Lack of access to spare parts - Obsolete components - Lack of knowledge about the spare parts required - Products are not designed for longevity or repair -Products designed for manufacture, not disassembly - Difficult to open products to repair them - Products not looked after, are seen as disposable

Table 2 Repair cafe participants' views on product repair

Perceptions of brokenness varied but most respondents referred to a loss of function or a decline in the performance of the product that no longer meets the expectations of the user. Poor product performance was similarly highlighted in a study undertaken by Nottingham University[25]. This study looked at why vacuum cleaners were replaced, and found that it was often also due to a decline in the performance of the product, and specifically the reduced power of the vacuum suction: a problem that can be easily remedied by cleaning or replacing the filters. Instead, many owners chose to dispose of the product and purchase a new one. Comments made by repair cafe interviewees highlighted issues of product care and maintenance and include:

- People don't treat things well as they don't expect them to last long
- People don't take things apart anymore. They don't give the proper maintenance to their products. They don't even know how.
- Glue also makes it difficult to take components apart. It is sloppy work but cheap to produce. Some products also use proprietary screws that make it impossible to disassemble. That is why they don't give you warranties.
- Products are not built to last. People bring things to get repaired when they don't work how they're supposed to.
- Products fail usually because of lack of maintenance, wear and tear.
- When people have made, or repaired a product they take more care of it.

Heiskanen[26] discusses that people replace products because of technical failure, dissatisfaction or a change in their needs. Similarly Granberg[27] argues there are two types of obsolescence: absolute obsolescence (technical failure) and relative obsolescence where user expectations change with the availability of new product options. However, he also acknowledges that behind this simple classification of obsolescence is a complex set of relationships between owners and their products, technological trends, and the economic and cultural contexts; these complex reasons for product disposal are also evident in the responses from interviewees. They reported a decline in product performance as a primary factor to dispose of a product. A lack of maintenance and general care across product-life are also key reasons why product functionality decreases below acceptable levels and people seek alternative solutions. It was reported that a lack of product knowledge and lack of technical information about the product and its spare parts can also play an important role in this decision-making process.

Another strong theme from the interviews was the relationships people have with their product. Sometimes it's an emotional connection[28] - a gift from someone special; a product passed down through the family; a comfortable chair; a favourite dress. Other times the attachment is more pragmatic. One elderly lady explained how she much preferred trying to fix her products (she'd brought a number to the cafe already) because she was familiar with how the product worked - what all the buttons do (or the ones she needed to know about), and she didn't want to consider having to think about all that again with a new product using new technology.

Community based repair initiatives alongside on-line IFixit instructions and Makerspaces have provided a new type of platform for people to seek out information to help them make decisions about extending their product's life. Not only do such repair initiatives contribute to waste reduction and product longevity, but they also provide places for people to socialize, share and learn new skills[29,30] as illustrated by some of the points raised by interviewees at repair cafes:

"I am not creative or knowledgeable enough to do repair." [a repair cafe visitor] The same person explained that she'd had lots of positive experiences at the repair cafe and trusted them to do a good job. She wants to bring a bicycle in the future and to keep mending products because it's cheaper than having to buy new ones.

"The volunteers all share their skills" [a repair cafe volunteer]. Once another volunteer was fixing a sewing machine and needed her input as she knew exactly how it should work. She feels it is better if there is another volunteer on your table (different expertise per table e.g. sewing, bike repair, mechanical products, electronics) with you looking at repair problems as you can work together to think what the best solution would be.

"The original manufacturer put a faulty switch to a kettle. I went online to get the replacement and there were so many options ... sometimes it happens that people just don't know which the correct spare part to buy is. They don't repair because they lack the knowledge. That's why they come here. Stuff isn't built to be repaired. Older products are easier to get into. Newer products are hard to take apart" [a repair cafe volunteer].

A further 15 interviews were conducted with members of the general public outside the context of repair venues. Interviewees were asked to tell a story of a product that had broken and discuss whether they replaced or repaired it. They selected a range of products, from small kitchen goods such as a toaster, food processor and a grill to more complex products like laptops, phones and a play-station. Nine respondents had bought a replacement product when theirs failed, and, in general, their common response to product failure leaned towards product replacement. Two respondents had had their products fixed under warranty; one of these then failed again outside the warranty period and at this point the respondent asked her father to fix it which he did. Two respondents successfully repaired their products, one using an expert, the other by himself using on-line 'how to' guides to provide information. Two other respondents had products repaired but they subsequently failed. Both were done by self-repair: one ended up purchasing a new bike component; the second resulted in a subsequent component failure after a couple of weeks of successfully fixing the first. At this point the respondent bought a new razor frustrated that he had wasted his time and money on the first repair.

Study conclusions

Different product-people interactions in the product use phase of the lifecycle can help shape new modes of consumption. Longer-lasting products for example, explore ways in which different types of product intervention can recalibrate peoples' views of resource use, product adaptability and their value. The research points to several opportunities to slow resource flows in product life, as well as opportunities for re-distributed models of production and consumption. These are:

- Systems of Local/Social (re)manufacturing
- Creating a remaking and repair economy
- New networks of resource supply and demand
- Promoting Repair services
- Open Innovation [hacking /adaptation]
- Re-skilling for DIY product care and repair
- Addressing 'performance obsolescence' as key driver for product disposal
- Increasing peoples' product knowledge and increasing access to new skills
- Challenging perceptions of brokenness
- Diversity in product maintenance contracts and warranties
- Infrastructures for component capture and refurbishment
- Networks of collaboration between original equipment manufacturer (OEM) and parts supply
- Authorised repair and spare parts
- Developing expert communities of repair
- Encouraging communities of upcycling, hacking and modding

Reframing ideas of disposability and linear product flow is critical in current contexts where efficiency-oriented drivers have proved ineffectual in creating sustainable outcomes. Addressing product obsolescence (linear flows of resource) requires greater emphasis on creating scenarios of sufficiency alongside those already addressing efficiency. Organisations need to make products more resilient: design 'repairable' products, and engage users more effectively in the design of these products. This exploratory research suggests that developing a better understanding of the opportunities and challenges posed by long-life products, alongside the potential of different people-product interactions in product life, will support evolving cultures of sufficiency and the creation of new business scenarios for sustainable production and consumption. This increased sustainability would not be possible if accessibility to repair/maintenance spaces wasn't available. Hence, opportunities for the re-distribution of these facilities would be key to become mainstream. In addition, for these spaces to thrive, the concept of RdM could help to set up the capacity for new collaborations between OEMs and suppliers of parts as well as upskilling programmes.

Envision: Building future scenarios for Business as Unusual

The findings from the two delve phases of this research, begin to build a picture of how people-product interactions can transform product design and manufacture towards RdM. The studies have explored the impacts of different length life cycles, and the different types of interactions that can occur between consumers and companies. This enables us to envision potential futures for Business-As-Unusual (BAU), and explore what new products, business models and customer interactions could be realised by these new systems of production and consumption.

Scenario planning is a methodology widely used by industry as a strategic planning tool which "aims to rediscover the original entrepreneurial power of foresight in contexts of change, complexity, and uncertainty. It is precisely in these contexts – not in stable times – that the real opportunities lie to gain competitive advantage through strategy"[31] (Wack, 1985). In this way, envisioning future scenarios enables companies to understand how the future might look based on the critical uncertainties facing them. The most common approach is the 'two axes method' in which these uncertainties are mapped onto two axes, allowing four contrasting scenarios to be generated[32]. These visions of the future can then be used for targeting shifts in business mind-set, strategy and activity. In this feasibility study, scenario planning is used to visualise the potential of BAU. The futures produced can then be used to identify opportunities and build stories about the products or services that could be enabled by RdM.

Setting the context for Business as Unusual

In line with the aims of the RECODE network, and of this feasibility study, the future vision of BAU is based on three key assertions – that manufacturing is localised, people are involved in the design of their products, and overall resource use is low. Based on these three founding concepts, two critical uncertainties (or in this case, opportunities) were identified:

- *Product longevity:* The length of the lifecycle of different types of products can vary greatly, from durables to disposables. Short life cycle products can include items such as food, personal care, and often fashion. Long life cycle products can include items such as electronic goods, furniture and homewares.
- *Consumer design drivers:* The type of consumer engagement in the process can vary greatly, depending on the types of user data and mechanisms of interaction available. Consumer inspired design would occur when large amounts of anonymised trend data is available to help direct design. Consumer led design would occur when individual users are able to be more hands on in driving design.

These two uncertainties were used to create two axes, and identify four quadrants for the scenario planning. To provide detail to help interpret these scenarios for easy application, they were then developed in detail using the findings of the studies conducted. This was informed by learning that with different mechanisms of consumer interaction, the location of design can move from being within the company, or beyond its control. Because of this, companies of different sizes need to employ different approaches to consumer engagement. In addition, it was observed that technology is a key enabler of different contexts, and it is important to consider where technological development and data availability will impact the products and services available. Therefore, each scenario describes the future of BAU based on four core factors:

- *Design:* Is it carried out by consumers, or by experts?
- *Technology:* Are important developments needed to support the supply chains, production, or consumer engagement?
- *Data:* Is the most available and appropriate data used for consumer engagement big or small?
- *Companies:* Are they large multinationals or smaller local companies?

Future Scenarios of Business as Unusual

The four BAU scenarios developed are shown in Figure 10, and describe low resource use, consumer engaged, RdM in four different ways as follows:

1. **Circular consumables** (short life cycle + customer inspired design)

   In this scenario circular products with short life cycles are produced, consumed, and recycled in a localised system. They are designed by gathering crowd sourced data to understand the needs of many. Technology development is focussed in the realisation of flexible and comprehensive recycling processes, and online systems that enable the collection and interpretation of these consumer preferences. Large multinational corporations use these big data feedback mechanisms to dictate the products to be manufactured in localised flexible production systems.

2. **Democratic desirables** (long life cycle + customer inspired design)

   In this scenario connected products with extended life cycles are produced, maintained and exchanged in a localised system. They are designed by monitoring life cycle data collected from embedded sensors. Technology development is focussed in realising flexible systems of supply and assembly, and in mechanisms that encourage simple maintenance and upgrade. Large companies gather big data in real time to understand trends and behaviours, and translate these into targeted offerings a localised branches and assembly centres.

3. **Tailored temporaries** (short life cycle + customer led design)

   In this scenario circular products with short life cycles are personalised, used, and recycled in a localised system. They are designed by individual consumers who tailor their products through dedicated online portals. Technology development is focussed in the realisation of flexible production, recovery and recycling processes that facilitate these new consumer centric business models. Businesses of various scales work with end users in both online and physical portals to enable customisation and production of their products locally.

4. **Engaging endurables** (long life cycle + customer led design)

   In this scenario durable products with very long life cycles are crafted and exchanged in localised systems. They are designed by individual customers who work with the makers to customise their purchases. Technology development is focussed in platforms to facilitate consumer engagement and co-design, and build local networks of makers, maintainers and exchangers. Local businesses work with end users through apps, service provision, and physical purchase and repair points.

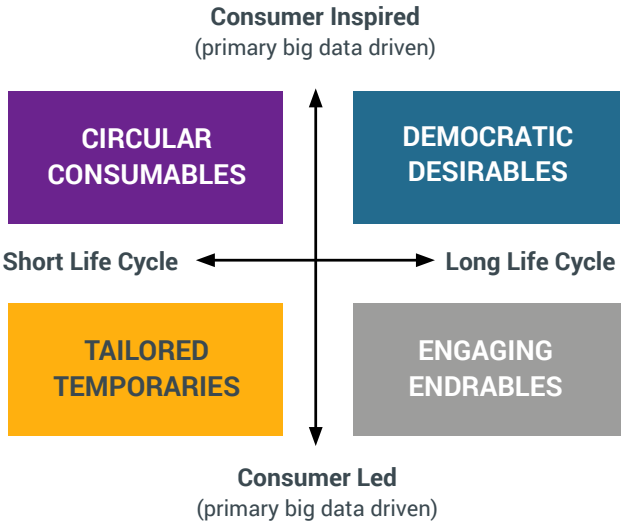

Figure 10 Business as Unusual scenarios

Business as Unusual Storytelling

Each scenario puts forward a different vision of the future for different types of product and company. When developing the scenarios, the investigators could infer potential products and services in each of the four scenarios based on their work. However, to test their applicability for imagining completely novel systems, we held a workshop in which these basic outlines were used to develop new product concepts. We invited a range of industrial practitioners, academics, and post-graduate students who each came from different disciplines and viewpoints, with no prior knowledge of the work. We divided them into groups, one for each scenario, and asked them to develop a product story that crossed the whole life cycle. Their outputs are shown in Table 3.

This exercise generated many unexpected results and interesting insights. For example, the scenarios were not used to describe the product sectors the investigators had in mind, and each group interpreted the scope of consideration differently. From this, compelling stories of BAU products are laid out, identifying novel business models that may emerge as a result of local manufacturing with a low throughput of resources. These example BAU products are taken forwards into the following section of the report where they were used to develop consumer journeys.

	Circular consumables	Democratic desirables	Engaging endurables	Tailored temporaries
Which product?	Personalised party game bundles rental	Smart kettle service	Personalised jumpers	Servitised fashion
What happens during the design phase?	Trend scanning for the company (with consumer as an observer)	Data collected locally from smart kettles is used by companies who share the insights	Prosumer designed across the lifecycle by consensus, with the designer as a facilitator	A general data base holds information about customer body scans, special flexible materials and manufacturing processes
What happens during the purchase phase?	Online marketplace for brokering and customising deal	Tier pricing is used as an incentive, based on the data shared with the companies	There is a perception of individuality at initial purchase, with multiple avenues for swapping and repurchasing second hand	Freemium model where customers can customise their garments online through a facilitated portal, or in person in experiential stores
What happens during the use phase?	During the special event the product is used and retained	Data is gathered to allow local maintenance to be scheduled as needed, and trust is built. Findings shared with legislative bodies	Different cycles of use with consumers engaged in re-design of a second life where needed	Real time customisation via app which allows them to be checked for signs of wear, repaired and even cleaned
What happens during the disposal phase?	Collected by company for re-use and recycling where applicable	Data from use phase enables prediction of best end of life management options	Swap, resell, or unprint/reprint to make something new	Taken back for recycling and upcycling

Table 3 BaU scenarios workshop product concepts

Ideal journeys of people-product interactions for RdM

Envisioning future scenarios gave several alternative models of how BAU might look in the future for different products. To understand which novel touchpoints, interactions and services might be needed to support these new business models, a second workshop exercise was conducted. In this, the participants were asked to create a map of an ideal customer journey for their proposed product lifecycle.

Customer interaction cards

To help participants generate visions of their customer journeys, a set of Customer Interaction Cards were developed (https://doi.org/10.6084/m9.figshare.4749727.v2). Method cards such as these are used widely in design practice as a tool for enabling collaborative ideas exchange, and allowing participants to visualise and converge on concepts together[33]. In this case, each individual card designed contained details of a touchpoint identified in the 'map' phase of this project, as shown in Figure 11.

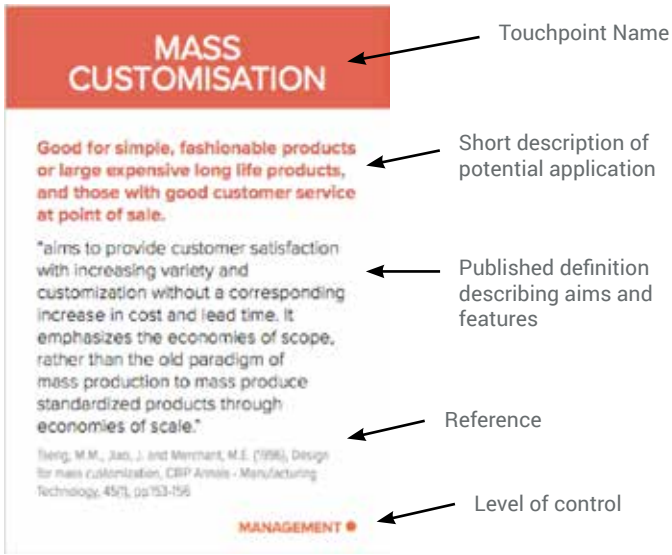

Figure 11 Layout of example customer interaction card

A full set of cards was produced containing each touchpoint, and these were then paired with a populated Consumer Intervention Map to help users locate the touchpoints in their suggested location of use, as shown in Figure 12. A number of blank cards were also created to encourage participants to invent completely new interactions, if they were unable to find what they wanted in the card deck already.

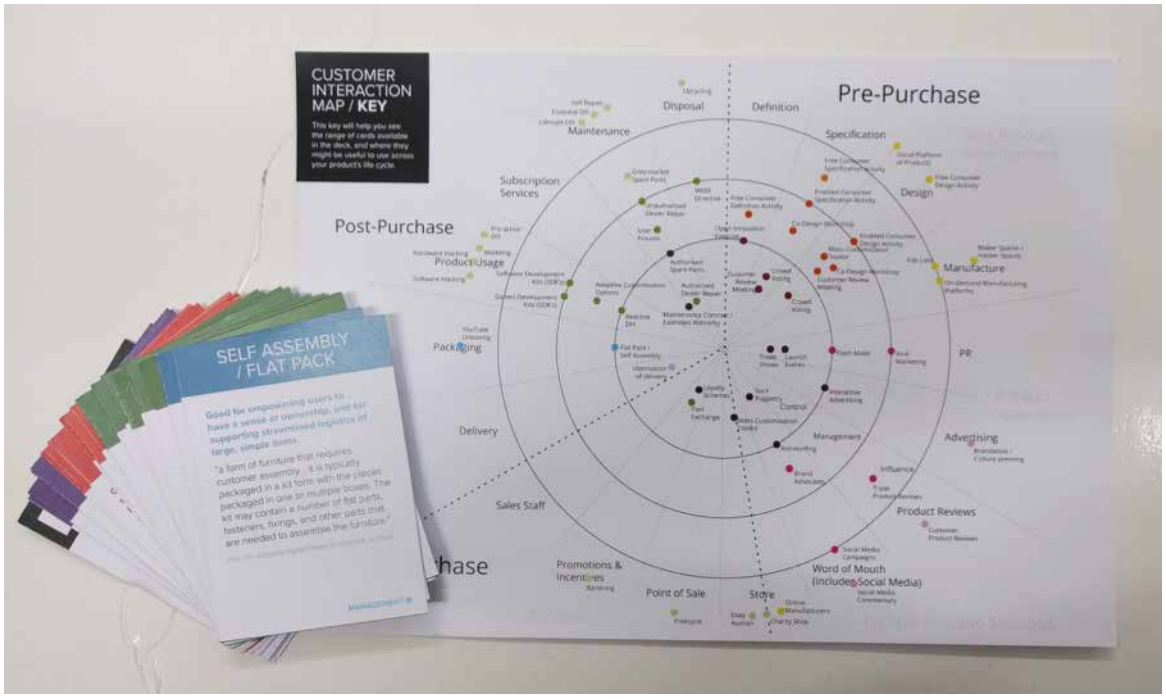

Figure 12 Customer interaction cards and map

Business as Unusual Customer Journeys

In the workshop, each group was given a full set of Customer Interaction Cards, and a large blank Customer Journey Space on which to map their own idealised customer journey based on their product concept (outlined in Table 3). The groups then placed their cards onto the journey spaces, and drew lines across to show ideal customer journeys and touchpoints across the product lifecycle. The results of this mapping exercise are shown in Figure 13, where a black circle shows where the groups created a custom touchpoint not contained within the card deck. In each case, the groups typically lay a large number of cards across the journey space, and then selected only a few when drawing their journey paths. To distil this mapping activity to these core results, only the touchpoints lying on the final paths are shown in Figure 13.

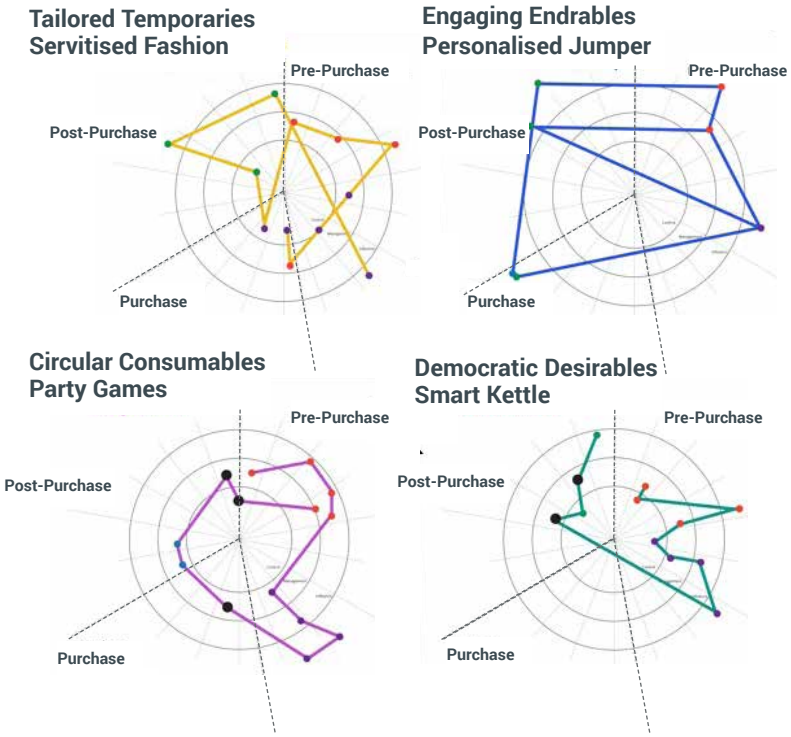

Figure 13 Business as Unusual scenarios workshop ideal journeys

Trends and novel touchpoints

The ideal journeys developed in the workshop show a number of observable trends:

- *Life cycle stages:* Most consumer engagement activity is concentrated around the right-hand side of the journey space (design and manufacture). The bottom left hand quadrant of the journey space remained relatively unpopulated (purchase and delivery). Many of the new custom touchpoints created by the groups were in the post-purchase phase (use and disposal).

- *Company control:* Only a few points of interaction have been placed close to the centre (and therefore under complete control of the company). Many cards were laid around the outside of the journey space initially (under complete control of the customer), but when it came to selecting the ideal journey paths (shown in Figure 15), these outlying touchpoints were used less frequently. Most of the consumer interaction within these four ideal journeys therefore takes place in the central ring (under the management of the company).

These findings show a slow growth of touchpoints moving outwards, beyond total company control, and towards involving the customer. To realise more radical models of BAU, improved mechanisms for consumer interaction are therefore needed across the breadth of the life cycle. These will be particularly useful in the latter stages of the product lifecycle to facilitate better maintenance and recovery, thus promoting longer cycles of use and increased recycling. More compelling opportunities are also needed that place the control closer to the customer in order to promote improved collaboration between companies and people. By creating more opportunities for engagement outside of these traditional bounds, radically new business models of RdM could be enabled.

Impacting design and value creation

Novel touchpoints on the fringes of the journey space, and in the latter stages of the product lifecycle could have far reaching implications on the way new products are designed:

- *Collaboration:* By giving more control to the customer during the development of products, better communication can be facilitated. This could lead to stronger relationships between companies and people that last the full duration of the product lifecycle.

- *Responsiveness:* Closer relationships can also build trust and feedback loops between companies and customers. This enables more flexibility, and an ability to respond and adapt to user needs and other uncertainties.

- *Business models:* More responsive modes of operation could unlock new business opportunities in RdM, enabled by new manufacturing technologies and customer engagement.

Potential impact and future research

This feasibility study was one of five feasibility studies on re-distributed manufacture, consumer goods and big data. The study looked mainly into: How could we engage users in NPD in future re-distributed models of sustainable production and consumption? To answer this question, the study *mapped* the different product-people interactions to identify the challenges and opportunities for user engagement in design and manufacture, to further investigate their application in order to bridge the gap between users, companies and the products that they produce. To further analyse these opportunities, two different product-people interactions were delved into, to understand how new forms of engaging people across the life cycle can achieve a more localised and responsive structures of manufacturing and product adoption. The results of these investigations helped to envision four contrasting scenarios of BaU, and generate conceptual business models and touchpoints to support these novel systems of consumption and production. Within all phases of this feasibility study, several specific opportunities for RdM could be identified that can be used to facilitate the realisation of these more collaborative, responsive business models:

- **Gaming portals and algorithms** for interpreting data could be utilised to actively involve people in the NPD process from the earliest stages of development, and support the production of products that are tailored for local requirements in real time. This can reduce the waste of generating unwanted products, and promote an open dialogue with end users in specific areas.

- **Modes of product maintenance and recovery** should be encouraged and developed to build relationships between companies and customers in the latter stages of the product lifecycles (beyond purchase). An example of this is encouraging the hacking and adaptation of products, thus handing control to the customer and enabling them to build enduring personal relationships with products. This could include both designing products to enable hacking, and encouraging adaptation through service provision and communication.

- **Service models** should be expanded and employed to not only support maintenance and recovery, but also facilitate new points of collaboration with users in the early phases of design and manufacture. These should focus on enabling the customer to have more control and influence on the design, and development of their products. In this way, new models of service could be enabled by new ways of collecting data from products, new ways of providing the designer as a facilitator, and new portals for collaboration and exchange.

Through this, it can be seen that in many cases technological developments could be used to unlock new business opportunities for RdM, though which enhanced people-product interactions can create stronger relationships between companies and people. This will enable the realisation of models of production and consumption that are more responsive; allowing flexibility to respond and adapt to users' needs and uncertainties.

Alongside these observable opportunities, the importance of building relationships with customers, and the opportunities and challenges involved have been highlighted. Future research should therefore focus on setting up mechanisms that could inform which data is meaningful to be able to respond effectively to the intertwined desires, motivations, and needs of people within this envisioned RdM landscape. As such, further research is needed to delve into other possible people-product interactions, and map out other plausible futures that could enable a more productive, responsive, and ultimately sustainable future.

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