Intellectual Property Office

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ECONOLYST THE 3D PRINTING & ADDITIVE MANUFACTURING PEOPLE

The Current Status and Impact of 3D Printing Within the Industrial Sector: An Analysis of Six Case Studies

Research commissioned by the Intellectual Property Office, and carried out by:

Phil Reeves and Dinusha Mendis

Study II

March 2015

This is an independent report commissioned by the Intellectual Property Office (IPO). Findings and opinions are those of the researchers, not necessarily the views of the IPO or the Government.

Intellectual Property Office is an operating name of the Patent Office

2015/41

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This is the second of a sequence of three reports on the intellectual property implications of 3D printing commissioned to evaluate policy options in relation to online platforms and selected business sectors.

Study I presents a legal and an empirical analysis of 3D printing online platforms; Study II offers an insight into the current status and impact of 3D printing within selected business sectors by employing a case study approach; the Executive Summary provides a summary of the findings of Studies I and II and provides conclusions and recommendations for Government, Intermediaries (online platforms) and Industry.

The research outputs are the result of the IPO commissioned project (Ref: CT-RES-024) awarded to CIPPM, Bournemouth University and carried out by Dr. Dinusha Mendis, Dr. Davide Secchi and Dr. Phil Reeves.

Acknowledgements: The authors are grateful to Sophie Jones, Belinda Johnson and Loic Le Merlus of Econolyst Ltd for their research assistance.

ISBN: 978-1-908908-86-5
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Published by The Intellectual Property Office
March 2015

1 2 3 4 5 6 7 8 9 10

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This publication is available from our website at www.gov.uk/IPO

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INTRODUCTION

This document presents the second part of a two part study which considers the Intellectual Property implications of 3D printing and scanning. This document considers "the current status and impact of 3D printing within the industrial sector" through an analysis of six case studies. The document accompanies the first part of the study (Study I) *"A Legal and Empirical Study of 3D Printing Online Platforms and an Analysis of User Behaviour"* written by Dr Dinusha Mendis and Dr Davide Secchi from the Centre for Intellectual Property Policy & Management (CIPPM) at Bournemouth University.

Background to 3D Printing

3D Printing is a term used to describe a range of digital manufacturing technologies, which produce component parts layer-by-layer through the additional use of materials. There are many different types of 3D printing processes, which are all controlled using three-dimension digital data. Some processes build parts by extruding molten plastic through a nozzle and depositing this accurately onto a build platform. Other technologies use lasers to melt layers of powdered material, with other processes using ink-jet printing heads to deposit material into the shape of the desired component part.

3D printing technologies can now be bought online and from high street retailers such as *Staples* and *Maplin* for as little as £1,000, effectively turning consumers into 'makers' and democratising manufacturing across supply chains. This shift in manufacturing capability has raised a number of questions relating to intellectual property, as the technology now allows for parts to be copied, modified, replicated, used and sold easily with potentially no recourse for intellectual property owners. The copyright issues that arise in relation to online platforms have been addressed in detail in the first part of this study (Study I) *"A Legal and Empirical Study of 3D Printing Online Platforms and an Analysis of User Behaviour"*. This document presents the second part of the study through a series of case studies and interviews. This document also presents the intellectual property issues arising from the use and access to 3D printing in selected industries.

The Benefits of 3D Printing

As a 'tool-less' and digital approach to production, 3D printing presents companies and consumers with a wide and ever expanding range of technical, economic and social benefits. 3D printing has the potential to change the paradigm for manufacturing, away from mass production in centralised factories constrained by tooling and low-cost labour rates, to a world of mass personalisation and distributed manufacture – where the choice of production location is driven by the demographics of demand, rather than the economics of supply.

Using 3D printing, it is possible to reduce the need for some fixed assets such as tooling, freeing up working capital within the supply chain and reducing business risk in new product innovation. More fundamentally, 3D printing enables manufacturers and 'makers' to cost effectively produce in very low unit volumes – down to batch sizes of one part, with little cost penalty.

The layer-wise nature of 3D printing also enables the manufacture of highly complex shapes with very few geometric limitations compared to traditional manufacturing processes, letting manufacturers produce parts that cannot easily be made by traditional methods, if at all. This complexity is also to some degree dislocated from cost, with complex geometry parts costing less to manufacture than solid ‘bulky’ parts of a similar size – the inverse of established manufacturing methods.

The layer-wise manufacturing approach of 3D printing can also reduce the amount of raw materials used during production, placing a lower burden on commodity purchasing, natural resources and the environment. Moreover, 3D printing has the ability to greatly compress the supply chain and allows concurrent manufacture at multiple locations nearer to the point of consumption, which has clear supply chain benefits to the consumer, the local economy and the environment.

As a digital technology 3D printing is progressively being integrated with the Internet and other digital data sources such as human body scanning, computer gaming and photogrammetry, enabling consumers to engage directly in the product design process and allowing for true consumer product personalisation, rather than just customisation through the selection of pre-defined options.

The Applications of 3D Printing in Industry

Beyond producing industrial prototypes, early adoption of 3D printing as a way of making products has centred on health related devices and consumer products. To-date, acetabula cups used in hip replacement surgery, knee implants, cranial patches and maxiofacial implants used in reconstructive surgery following trauma or disease are all made commercially using 3D printing.

Outside of the medical and healthcare domain, 3D printing is being used in the production of toys, dolls and avatars, gifts, collectables and personalised keepsakes. The technology is also at an early stage of adoption within the automotive and aerospace sectors along with some applications in the consumer electronics sector for the manufacture of cases and covers used on smart phones, tablets and other portable devices.

Making in the Home

Many medical and consumer products made by 3D printing are produced using commercial and professional hardware. However, within the last 4-years there has been a steady growth in the sale of consumer 3D printers, which can be bought as kits for as little as £400, but are typically purchased as working machines for between £900 and £2,000. Consumer 3D printers are now being sold as ‘plug-and-play’ electrical devices, which can be configured and used by the general public with little training or experience.

To-date, over 100,000 consumer machines have been sold. Although limited in their capabilities compared to professional hardware, these machines are finding applications in direct part manufacture, effectively turning home consumer users into manufacturers and home factories.

The Intellectual Property Considerations of Industrial and Home 3D Printing

3D printing is a technology that enables established manufacturers, makers and consumers to produce an almost unlimited range of products. This does then raise the question of ownership and intellectual property, and coupled with other technologies such as 3D scanning it is theoretically possible to reverse engineer existing products and to replicate these using 3D printing. The presentation of case studies in this part, are also complemented by the intellectual property implications of a number of scenarios. These include the manufacture of spare parts for both cars and domestic appliances; what happens when consumers become the designers of the products that they buy; the implications of 3D printing using data generated from scanning; the protection of design files accessible through the Internet; and the links between computer games data and the production of toys and high value small status goods.

Research Methodology

To map the impact that 3D printing technology is having on the UK's economic and legal landscape, six case studies have been prepared which consider the current and future consequence of 3D printing.

The methodology used in this research was to interview leaders within industry to identify existing intellectual property precedence in the UK and EU relating to 3D printing, and the business drivers, constraints and benefits of transitioning to 3D printing rather than more traditional supply chains. Focus groups were held with artists, creatives and technology users to further understand the opportunities and constraints presented by this manufacturing approach with the results of this primary research being analysed using qualitative software tools.

Report Structure

The six case studies are arranged into three key themes: "Replacement Parts", "Customised Goods" and "High Value Small Status Goods".

The first two case studies address issues relating to Replacement Parts and consider how 3D printing will affect the supply of aftermarket parts to the consumer. The *"Automotive Aftermarket – Printing Parts"* case study evaluates the likelihood of automotive manufacturers; third-party manufacturers and consumers producing spare parts for vehicles using 3D printing technologies. The potential scale of the impact on the automotive industry is considered based on the capabilities of commercial technologies today and forecasts for technology development. The case study is based on primary research interviews with automotive manufacturers and suppliers and through secondary desk based research.

The *"Domestic Appliances Aftermarket - Using Home Based 3D Printing"* case study evaluates the implications of consumers and independent repair companies being able to manufacture spare parts for domestic appliances on demand, using consumer 3D printers. The case study also looks at how consumers are using online platforms to share digital models of spare parts and how this is expected to change. The case study is based on primary research interviews with consumer goods manufacturers and parts retailers and through secondary desk based research.

The two case studies within the Customised Goods theme address how 3D printing enables unique products to be manufactured that are tailored to consumers' needs, and the intellectual property challenges that arise from this. The *"Engaging the consumer - When we all become designers"* case study investigates the intellectual property implications when the consumer has an increased role in the design of products. The ownership of intellectual property that has been created through collaborative design processes is considered, as well as the how the resulting data can then be used to enable either commercial or home based 3D printing technologies. The case study is based on primary research interviews with companies developing web based collaborative software tools and through secondary desk based research.

The *"Scanning and Reverse Engineering: Taking the tangible back into the electronic"* case study investigates the extent to which scanning technologies will enable users to replicate and modify existing physical objects using 3D printing and the impact that this could have on the owners of intellectual property rights. This case study, which is based on interviews with scanning technology vendors and desk-based research, considers the technical limitations of the technology today for both consumer-level and professional-level scanners.

The two case studies within the High Value, Small, Status Goods theme look at the impact that 3D printing is having on consumer products that have a low functional purpose, such as collectible figurines or sculptures. The *"Realising the virtual to the physical: Computer Games and Computer-Generated Imagery (CGI) Studios as a Data Source"* case study considers the intellectual property implications of extracting printable data and content from sources of computer-generated imagery (CGI) such as computer games. Industry experts from the CGI and 3D printing industries were interviewed to determine if this is likely to be a widespread issue and if further measures need to be implemented to protect rights owners.

The *"Designers Perspective: How to Protect and Monetise your Digital Assets"* case study looks at how artists and designers are protecting their digital content from intellectual property infringement when manufacture is enabled through commercial and home 3D printing. The case study uses interviews and focus groups with designers to understand if users feel that greater or lesser intellectual property protection is required and how mechanisms such as Creative Commons are currently being used.

Through these case studies, this documents aims to highlight the extent of the adoption and use of 3D printing in the selected industrial sectors whilst, at the same time, outlining the various intellectual property implications for the replacement parts, customised goods and high value, small, status goods industries.

REPLACEMENT PARTS

INTRODUCTION TO REPLACEMENT PARTS

The use of Additive Manufacturing (hereinafter AM) to create spare parts has generated a high degree of interest in recent years[1]. It is a seemingly obvious application for the technology and many people can immediately appreciate the advantage of being able to create spare parts on demand. The idea of low prices for essential parts, a shorter waiting-time for the delivery of critical and specialist parts and being less dependent upon manufacturers to support aging products excites many people and has captured media interest:

"All the major appliance manufacturers publish their instruction manuals online. It is only a small stretch to imagine them publishing software which would allow you, or your tradesman, to print the crucial spare part in a matter of minutes".

Daily Telegraph, 2014[2]

"What if we had a digital catalogue of spare parts for items that you'd bought?"

Daily Mail, 2013[3]

"It surely won't be long before we're all rustling up spare parts for broken electronic items"

The Independent, 2011[4]

In addition to the consumer benefits, AM has the potential to help businesses improve their supply chains and reduce operating costs. For any company engaged in the manufacture, distribution or sale of products, replacement or spare parts represents an on-going business concern. Companies want to maintain customer loyalty and positive brand recognition by providing responsive and cost effective after sales support including replacement parts. These parts may be required when original components malfunction through wear and tear, or break

1 In addition, websites such as *Kazzata* are dedicated to offering 3D printable spare parts for consumers. For further details, see www.kazzata.com

2 Wallop H., 3D Printing: Seven Weird and Wonderful Uses (15th April 2014) *Daily Telegraph* at http://www.telegraph.co.uk/technology/news/10767017/3D-printing-Seven-weird-and-wonderful-uses.html

3 Wilkinson P., Tesco Could Soon Offer 3D Printing so Customers Can Print Out Their Own Toys, Spare Parts and Clothes (25th June 2013), *Daily Mail*, http://www.dailymail.co.uk/sciencetech/article-2348278/Tesco-soon-offer-3D-printing-customers-print-toys-spare-parts-clothes.html *See also* Mendis D., Enters the Fast Lane [2014] *Intellectual Property Magazine*, pp. 39-40.

4 Object lesson: How the World of Decorative Art is Being Revolutionised by 3D Printing, (28th August 2011), *The Independent*, http://www.independent.co.uk/arts-entertainment/art/features/object-lesson-how-the-world-of-decorative-art-is-being-revolutionised-by-3d-printing-2342500.html

through accidental damage. Moreover, within a product's warranty period, companies are obligated to provide customers with after sales support including spare parts[5].

However, companies are reluctant to 'carry' excessive levels of replacement parts. As such, an inventory represents tied-up working capital, has associated storage costs and risks becoming obsolescent, at which point it must be written off and disposed of. In an ideal world, replacement parts would be made-to-order as and when required, but in reality such a solution is rarely economical or practical using production methods such as plastic moulding or metallic machining.

Additive manufacturing in the supply chain or consumer 3D printing in the home could therefore provide a possible solution to these compounded business problems, as in theory spare parts could be manufactured to order using just digital design data. This would mitigate stock holding and the associated risk of stock obsolescence.

This section will consider the practical, technical and intellectual property considerations of two replacement parts case studies, namely the manufacture of replacement parts for the domestic appliance aftermarket and the manufacture of aftermarket automotive components using industrial Additive Manufacturing technologies.

Intellectual Property Implications in the Replacement Parts Market

Irrespective of the use of 3D printing or additive manufacturing technologies, the replacement parts market encompasses a number of different intellectual property considerations, including design rights, copyright, trade marks, passing off and patents. In this first section, this report will address the intellectual property implications and how they relate to the replacement parts market place.

Implications for Design Rights-Registered Design

A "design", under the *Registered Designs Act 1949* (as amended) refers to "the appearance of the whole or a part of a product resulting from the features, in particular, the lines, contours, colours, shape, texture or materials of the product or its ornamentation"[6]. A "complex product" means "a product which is composed of at least two replaceable component parts permitting disassembly and reassembly of the product" and a "product" means "any industrial or handicraft item other than a computer program; and, in particular, includes packaging, get-up, graphic symbols, typographic type-faces and parts intended to be assembled into a complex product"[7].

There has been much debate as to what is meant by the 'appearance' of a product – i.e. does it relate to what can be seen or does it also involve the 'feel' (as well as the 'look') of a product? The European Design Directive clarifies this question and lends support to the view that protection is "conferred by way of registration upon the rights holder for those design features

5 Trading Standards Institute http://www.tradingstandards.gov.uk/advice/problemswithgoods-sum16.cfm

6 Section 1(2) *Registered Designs Act 1949* (*as amended*) (RDA 1949).

7 Section 1(3) RDA 1949.

of a product, in whole or in part, which are shown visibly in an application and made available to the public by way of publication or consultation of the relevant file"[8].

Apart from the design features being visible, to qualify for registered design, a design should also show that it is new and has individual character[9]. A design is considered new "if no identical design or no design whose features differ only in immaterial details has been made available to the public"[10]. To have 'individual character' the overall impression of a design on an informed user must differ from designs previously made publicly available[11]. In determining the extent to which a design has individual character, the degree of freedom of the author in creating the design shall be taken into consideration[12].

In the case of the design of parts of complex products, a design shall only be considered to be new and to have individual character if the component part, once it has been incorporated into the complex product, is visible to the user in ordinary use[13]. This does not mean that the design should be visible to the user at all times; what is important is that the design should be capable of being seen. For example, the designs of the interior of chocolate eggs[14] or computer screen icons may only be visible when the chocolate egg is open or the related software is running[15]. However, these designs will not be precluded from registration simply because they are not visible to the user at all times.

However, even if visible, the design should not be solely dictated by the technical function of the product (thereby excluding maintenance and repair), which would preclude it from protection[16]. It must be noted that registration is denied when design is solely dictated by function when it is the only possible design with which the product will be able to perform its function[17].

Over and above the general exclusion of 'technical function', design law provides for a further exclusion known as the 'must fit' exception which was incorporated to ensure that designs do not lead to monopolies in technical replacement products such as exhaust pipes, fan-belts, washers and dishwasher brackets amongst others[18].

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8 See, Recitals 11 and 13 of the Directive 98/71/EC of the European Parliament and of the Council of 13 October 1998 on the Legal Protection of Designs.

9 Section 1B(1) RDA 1949.

10 Section 1B(2) RDA 1949.

11 Section 1B(3) RDA 1949. To be informed, "the user should know the existing design corpus, taking into consideration the nature of the product to which the design is applied or in which it is incorporated, and in particular the industrial sector to which it belongs". See Waelde *et al, Contemporary Intellectual Property: Law and Policy* (Oxford: Oxford University Press; 2014) p. 283.

12 Section 1B(4) RDA 1949.

13 Section 1B(8)(a)-(b) RDA 1949.

14 *Ferrero and CSPA's Application* [1978] RPC 473.

15 *Apple Computer Inc., v. Design Registry* [2002] FSR 38.

16 Section 1C(1) RDA 1949.

17 *P B Cow v. Cannon* [1959] RPC 347. It was decided in this case that the design of a hot water bottle is not dictated solely by function and the design of the hot water bottle in question, was not considered to be the only possible design for a hot water bottle and therefore it was registered.

18 *Amp v. Utilux* [1972] RPC 103. Section 1C(2) of RDA 1949.

The essence of the above criteria is that most products manufactured in the replacement parts industry will not qualify for protection as they are deemed to be hidden in everyday use, and therefore are excluded under the requirement for novelty and individual character in accordance with section 1B(8) of the *Registered Designs Act 1949* (hereinafter RDA 1949). Also, where a replacement part is dictated by the technical function of the product, such a design will not qualify for protection according to section 1(C) RDA 1949. Furthermore, even if visible, such parts will not meet the 'new and individual character' threshold, as most replacement parts will be common designs. Even if a replacement part were eligible for protection, section 7A(5) of RDA 1949 states that a registered design will not be infringed where a "component part ... may be used for the purpose of the repair of a complex product so as to restore its original appearance...".

This will cover the 3D printing of a part such as a car wing panel. Whilst the wing panel satisfies the requirements of visibility and is not wholly constrained in design by its function or fit, it has to be replaced in order to maintain the original appearance of the car.

Where a registered design is copied via a 3D printer this would not be an infringement if it is carried out "privately and for purposes which are not commercial"[19]. It is essential that both criteria are met; it is insufficient that copying is not done for profit. Purely personal use of a 3D printer to make items will thus not infringe a registered design, so long as the purpose for which the item was designed was genuinely non-commercial. However, as discussed below, if these items are then shared on online platforms, even though not for profit, it will infringe design laws.

Implications for Unregistered Design Rights

Unregistered design rights (hereinafter UDR) arise in an 'original'[20] design comprising "the shape or configuration (whether internal or external) of the whole or part of an article[21]". Amongst others, design right does not subsist in a method or principle of construction and surface decoration[22]. In addition, and similar to registered design, UDR also provides for a 'must fit and 'must match' exception. The second element of 'must match' allows for repairs, which in aesthetic terms provides for the same sort of article which the consumer had originally bought[23]. A panel for a car door and the connector linking the dial to a washing machine are typical examples of the 'must match' exception. The exception was also introduced to "prevent monopolies arising in the first place, and to preserve the benefits of competition"[24].

UDR will be infringed only where there has been actual copying – i.e. where there has been reproduction of the design for commercial purposes by either making articles to the design or by making a design document recording the design for the purpose of enabling such articles to be made[25]. Therefore, a person, who without the licence of the design right owner does, or

19 Section 7A(2)(a) RDA 1949.

20 The design must not be "commonplace in the design field in question at the time of its creation". Section 213(4) CDPA 1988. 'Originality' under UDR will be decided on a case-by-case basis.

21 Section 213(2) *Copyright, Designs and Patents Act 1988* (*hereinafter CDPA 1988*). *See also*, section 1(1) *Intellectual Property Act 2014.*

22 Section 213(3) CDPA 1988.

23 *Dyson Ltd., v. Qualtex (UK) Ltd*., [2006] EWCA 166.

24 *Parliamentary Debates*, 29 March 1988, HL, col. 699.

25 Section 226(1) CDPA 1988.

authorises another to do any of the above acts, will infringe design right[26]. In the 3D printing context, this encompasses the Computer-Aided Design (CAD) files (design document) of domestic appliance parts or replacement automotive parts which are reproduced exactly or substantially to an existing design. It does mean that a CAD file / design document, which has been substantially modified, will not infringe UDR.

Similarly from a **copyright** point of view, products, which are purely 'utilitarian' in nature, will not attract protection and will not be copyright protected[27]. This means that copyright protection for a work of artistic craftsmanship is limited to objects created principally for their artistic merit – i.e. the fine arts – and not to automotive parts which might be purely utilitarian in nature.

On the other hand, CAD files, which are shared on online sharing platforms such as *Thingiverse*,[28] could potentially be in breach of the law[29] - even if the designs are being shared for non-commercial purposes. Although section 226 CDPA 1988 permits personal and private use, disseminating a CAD file of a protected item for purposes of 3D printing a domestic appliance part / automotive replacement part via online platforms such as *Thingiverse* will infringe UDR and in particular, section 227 CDPA 1988. This section states that a design right can be infringed by a person who without the licence of the design right owner "sells, lets for hire, or offers or exposes for sale or hire, in the course of a business, an article which is, and which he knows or has reason to believe is, an infringing article"[30].

Implications for Trade Mark Law

Trade mark issues relating to 3D printing of replacement parts arise where a 3D printed product is sold that includes a trade mark embedded into it, which will infringe the existing trade mark in accordance with section 10 of the *Trade Marks Act 1994* (as amended) (hereinafter TMA 1994). As such, commercial use of a trade mark without the consent of its proprietor will infringe the trade mark.

On the other hand, the "use of a trade mark where it is necessary to indicate the intended purpose of a product or service (in particular, as accessories or spare parts)"[31] will not be an infringement of the registered trade mark provided it is carried out "in accordance with honest practice in industrial or commercial matters"[32]. Case law has interpreted "honest practice" to mean that which "constitutes a duty to act fairly in relation to the legitimate interest of the trade mark owner"[33]. For example, in *Gillette Company* v. LA-Laboratories Ltd., Oy, the Court held that the duty to act fairly in the legitimate interests of the trade mark owner test would fail when:

1. "Use of the trade mark will not comply with honest practices in industrial or commercial matters where, first, it is done in such a manner that it may give the impression that there is a commercial connection between the reseller and the trade mark proprietor[34].

26 Section 226(3) CDPA 1988.

27 *Lucasfilm Ltd. & Others v. Ainsworth and Another* [2011] 3 WLR 487.

28 http://www.thingiverse.com *See also*, Study I of this two-part Study: Mendis D., & Secchi D., '*A Legal and an Empirical Study of 3D Printing Online Platforms and an Analysis of User Behaviour*'.

29 Section 227 CDPA 1988.

30 Section 227(1)(c) CDPA 1988.

31 Trade Mark Act 1994, s 11(2).

32 Trade Mark Act 1994, s 11(2)(c).

33 Case C-100/02 *Gerolteiner Brunnen GmbH & Co v. Putsch GmbH* [2004] RPC 39.

34 *The Gillette Company v. LA-Laboratories Ltd*., Oy Case C-228/03 [2005] All ER (EC) 940 at para. 42.

2. The use would affect the value of the trade mark by taking unfair advantage of its distinctive character or repute[35].

3. If the use discredits or denigrates that mark[36].

4. The third party presents its product as an imitation or replica of the product bearing the trade mark of which it is not the owner"[37].

The meaning and significance of "honest practices" has also been considered in cases such as *DataCard Corporation v. Eagle Technologies Limited*[38] and *Bayerische Motoren Werke* (BMW) *AG v. Round & Metal Ltd*[39]. In *DataCard,* Justice Arnold encapsulates the trade mark position of common-place parts as follows:

> As for the requirement to act in accordance with honest practices in industrial or commercial matters, the ECJ has repeatedly held that this "constitutes in substance the expression of a duty to act fairly in relation to the legitimate interests of the trade mark proprietor …Members may provide limited exceptions to the rights conferred by a trade mark, such as fair use of descriptive terms, provided that such exceptions take account of the legitimate interests of the owner of the trade mark and of third parties"[40].

The duty for third parties to respect the legitimate interests of the trade mark owner, also expands to other areas of intellectual property laws. For example, the cases of *DataCard*[41] and *Bayerische Motoren Werke* (BMW)[42] also raised claims relating to patents and registered designs respectively. In *Dyson Ltd v. Qualtex* (UK) Ltd[43] *Dyson* claimed infringement of numerous unregistered design rights in parts for its vacuum cleaners following *Qualtex* (UK)'s selling of "pattern spares", i.e. spare parts designed to fit and also look like the originals[44].

35 *The Gillette Company v. LA-Laboratories Ltd*., Oy Case C-228/03 [2005] All ER (EC) 940 at para. 43.

36 *The Gillette Company v. LA-Laboratories Ltd*., Oy Case C-228/03 [2005] All ER (EC) 940 at para. 44.

37 *The Gillette Company v. LA-Laboratories Ltd*., Oy Case C-228/03 [2005] All ER (EC) 940 at para. 45.

38 [2011] EWHC 244 (Pat).

39 [2012] EWHC 2099 (Pat).

40 *DataCard Corporation v. Eagle Technologies Limited* [2011] EWHC 244 (Pat) Arnold J., at p. 297.

41 *DataCard* claimed that the defendant, *Eagle Technologies Ltd*., infringed their RFID Patent by sales of various Plus-Ribbon products that are compatible with DataCard printers. Eagle denied that its products fell within the claims of the RFID Patent. Eagle Technologies was held to have infringed the patent of DataCard. *DataCard Corporation v. Eagle Technologies Limited* [2011] EWHC 244 (Pat) Arnold J at para. 39.

42 *Bayerische Motoren Werke AG v. Round & Metal Ltd* [2012] EWHC 2099 (Pat). BMW alleged infringement of four Community Registered Designs.

43 [2006] EWCA 166.

44 Michaels A., The end of the road for "pattern spare" parts? Dyson Ltd., v. Qualtex (UK) Ltd [2006] 28(7), *European Intellectual Property Review*, pp. 396-398, at p. 396.

Implications for Passing Off

As far as manufacturers and trade mark owners are concerned, the widespread use of 3D printing could lead to an increased supply of counterfeit or mislabelled products and replacement parts. On the other hand the common law of passing off could act as a remedy for manufacturers where one trader sells goods or services in the guise of another trader's goods or services[45]. For a manufacturer to be successful in a passing off action, it will be necessary to show goodwill (attached to the goods or services which he supplies); misrepresentation (leading or likely to lead the public to believe that goods or services offered by him are the goods or services of the plaintiff); and damage (caused by the defendant's misrepresentation)[46] known as the 'classic trinity'. The action of passing off will probably be most useful where other intellectual property rights such as copyright of industrially reproduced artwork have expired and where goods are being sold or 'shared' to appropriate the goodwill of the original rights holder. Furthermore, passing off certainly has the benefit of not being time-restricted unlike other IP rights, with a manufacturer simply needing to show goodwill, misrepresentation and damage to their goods. However, whether it will be an effective remedy within the 3D printing industry is difficult to establish at present.

45 Lord Langdale MR provided the following definition in 1842 in the case of *Perry v. Truefitt* (1842) 6 Beav 66 at 73: "A man is not to sell his own goods under the pretence that they are the goods of another man; he cannot be permitted to practise such a deception, not to use the means which contribute to that end. He cannot therefore be allowed to use names, marks, letters or other indicia, by which he may induce purchasers to believe that the goods he is selling are the manufacture of another person".

46 The modern definition encompassing the 'classic trinity' of passing off was given in the House of Lords by Lord Oliver in the '*Jif Lemon*' case – *Reckitt & Coleman Products v. Borden Inc* [1990] RPC 341. However a decision in 1979 delivered in the 'Advocaat' case – *Erven Warnink v. Townend* [1979] AC 731 by Lord Diplock is still regarded as the most important decision on the extended version of passing off.

Case Study I:

The Automotive Aftermarket: 3D Printing Parts

In this case study, the use of AM technology to support the automotive aftermarket is considered. The rationale for selecting the automotive aftermarket is two fold: (1) the extent and size of the automotive aftermarket in comparison to other smaller industries; and (2) the potential opportunities for AM integration into its well-established supply chains.

What is the Automotive Aftermarket?

The automotive aftermarket is a broad term used to describe the manufacture, supply and fitting of spare and service parts needed after the initial sale of a vehicle. The aftermarket also includes the restoration of classic cars and the customisation of vehicles.

It should be noted that spare parts and service parts are somewhat different[47]. Within the context of this case study, reference is made to the combined space of service parts, spare parts, historic parts and customisation parts as the 'aftermarket', as they all present opportunities for AM.

The Scale of the Automotive Aftermarket

Over 60-million cars are produced globally each[48] year with a typical vehicle lasting some 11.4-years[49]. In 2011, it was estimated for the first time that more than 1-billion vehicles were being used globally[50]. Within this market, the typical manufacturer's warranty lasts for only 3 to 5 years, with vehicle owners covering the total cost of any service parts, spare parts or repairs needed beyond this period. Apart from some classical restoration projects, the market is driven largely through the need to keep cars both operational and legal.

The worldwide automotive aftermarket accounted for £135-billion of revenue in 2010 (based on the purchase of components alone), with the average driver within developed Western

47 The term "service part" typically describes a component used to replace another component that was from the outset expected to be replaced. For example within the automotive sector, car tyres, oil filters, windshield wipers, light bulbs and brake pads are all known service items.
The term "spare part" however typically describes a component that is needed to replace a part that has either failed unexpectedly or failed through accidental damage. Within the automotive sector a spare part could be a body panel damaged in an accident or an engine component that has failed through fatigue.
The term "historic part" describes parts used in car restoration or the up-keep and repair of cars no longer in mass production, but where there is an emotional or economic benefit in maintaining a working vehicle, such as it rarity value.
"Customisation" refers to the personal modification of a cars aesthetic and performance, inherently using non-authentic parts. This can cover anything from minor interior alterations to entire overhauls.

48 OICA Production Statistics (2013) at http://www.oica.net/category/production-statistics/

49 National Automobile Dealer Association (NADA) Used vehicle price report (2013): Age-level analysis at http://www.nada.com/b2b/Portals/0/assets/pdf/Q3%20Whitepaper%20Age-level%20Analysis%20and%20Forecast.pdf

50 Plunkett Research, Automobile Industry Introduction (2013) Available at http://www.plunkettresearch.com/statistics/automobiles-trucks-market-research/

economies spending some £230 each year buying parts for their vehicles[51].

The customisation market accounts for only a small fraction of the global aftermarket; it is estimated that the US customisation market was worth £2.9-billion in 2012, with a large part of this driven by demand for premium electronic systems such as sound systems, satellite navigation systems and Bluetooth connectivity[52].

The US Federal Trade Commission estimated that in 2009 counterfeit automotive repair parts costs the automotive industry approximately £7.9 billion a year in lost revenue[53], albeit that it represents less than 6% of the total market value worldwide[54]. However with such a high value aftermarket, and lower prices becoming the main battleground to win customers, there is an increased risk of resellers, garages and consumers sourcing counterfeit parts, either inadvertently or intentionally.

The Dynamics of the Automotive Aftermarket

Many aftermarket automotive components are generic and readily available, such as tyres, oil filters, windscreen wipers, fan belts and brake pads. The supply of model specific parts to vehicle owners is also guaranteed for at least the period of time during which a vehicle is under warranty[55], but often for longer (assuming the vehicle maker remains in business).

Historically, car makers enjoyed a virtual monopoly in the new car aftermarket due to owners running the risk of nullifying their warranty if they had their car serviced or repaired by any garage other than one belonging to the vehicle manufacturer (or a certified dealer). However in 2003, the European Commission brought in new legislation known as the "European Block Exemption Regulation"[56]. The new Regulation's aim was to force competition into the market and disassemble the monopoly held by the automotive manufacturers by allowing car owners to have service and repairs done at any workshop of their choosing. This Regulation was however further revised in 2011[57] requiring automotive manufacturers to register all replacement parts required on new vehicles, further stimulating market competition by third party manufacturers.

51 Plunkett Research, Automobile Industry Introduction (2013) Available at http://www.plunkettresearch.com/statistics/automobiles-trucks-market-research/

52 IBIS World, Auto Paint Customisation Shops in the US: Market Research Report (2014) at http://www.ibisworld.com/industry/auto-paint-customization-shops.html

53 US Automotive Parts Industry Annual Assessment – Department of Commerce (2009) at http://trade.gov/mas/manufacturing/OAAI/build/groups/public/@tg_oaai/documents/webcontent/tg_oaai_003759.pdf

54 Plunkett Research, Automobile Industry Introduction (2013) Available at http://www.plunkettresearch.com/statistics/automobiles-trucks-market-research/

55 Trading Standards Institute http://www.tradingstandards.gov.uk/advice/problemswithgoods-sum16.cfm

56 Commission Regulation (EC) No. 1400/2002 of 31 July 2002 on the application of Article 81(3) of the Treaty to categories of vertical agreements and concerted practices in the motor vehicle sector at http://europa.eu/legislation_summaries/other/l26098_en.htm

57 Commission Regulation (EU) No 330/2010 of 20 April 2010 on the application of Article 101(3) of the Treaty on the Functioning of the European Union to categories of vertical agreements and concerted practices (Text with EEA relevance) in the motor vehicle sector at http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32010R0461

The aftermarket also benefits from the progressive move by carmakers towards shared vehicle platforms and modular systems', where common components are used across many different vehicles[58]. The result being that one aftermarket part will fit a variety of models and in some cases a variety of makes, keeping manufacturing costs and sales prices down. However, as vehicles age the availability of both vendor and third party spare parts also decreases, increasing waiting times and cost, and in some cases preventing vehicle repair altogether.

Drivers to Additive Manufacturing Adoption in the Automotive Aftermarket

The projected business case for AM adoption within the automotive sector is compelling. AM could be used to make component parts for the automotive industry directly from digital design files, rather than high cost fixed assets such as injection moulding, rotational moulding and die casting tooling. These parts may be designed specifically for AM production, or they could be 'reverse engineered' and used to replace parts originally made using more traditional manufacturing processes. This approach could reduce the need for car companies and third party suppliers to over produce and stock spare parts, which they currently do for many years after the sale of a vehicle. It would also allow parts to be produced to order within the car dealership, repair centre or parts retailer, speeding up the supply of rare or specialist parts to the customer by compressing the supply chain. Such localised production could also be coupled with personalised design, allowing people to modify and personalise individual vehicle parts prior to manufacture.

For the vehicle manufacturer, AM could be used to reduce the need to hold stock at the end of a vehicle's life. This would eliminate the need to cover manufacture parts or order short run production batches using historical tooling. It would also eliminate the need for part storage and eliminate the need to ethically dispose of any excess stock at the end of the vehicles supported life cycle.

For third party manufacturers, AM could reduce the need to invest in fixed assets such as bespoke tooling, which could then reduce manufacture cost and risk. It could also allow more third party suppliers to operate in lower volume 'niche' vehicle sectors with higher margins such as specialist commercial vehicles, or classic cars.

For the vehicle owner, AM could enable the third party manufacture of more cost effective non-branded component parts, which may be desirable outside of the vehicle warranty period. It could also ensure the more timely availability of replacement parts irrespective of the customer's location or the age of the vehicle being repaired. 3D printed part manufacture could also be undertaken locally within the automotive aftermarket super store, the preferred garage, or online for home delivery.

At present however, beyond a small number of exceptional cases where AM is being used in the manufacture of luxury vehicle components, AM has made very little impact on the overall automotive market.

58 Doran H., Hill A., Hwang K-S., & Jacob G., Supply Chain Modularisation: Cases from the French Automobile Industry (2007) 106(1) *International Journal of Production* pp. 2-11.

Use Cases of Additive Manufacturing Within the Automotive Sector

To date, only the Swedish *Hypercar* manufacturer *Koenigsegg* has openly demonstrated adoption of AM in the manufacture of production vehicles, which are only available in very low production runs and at a market price averaging £1.5 million per car[59].

Unveiled at the Geneva Motor Show in March 2014, the *Koenigsegg* One has been claimed to be the world's first production car incorporating a number of functional AM components. The most significant of these components is the printed Titanium Exhaust, the world's largest AM titanium component. Each part took approximately three days to print and was produced by AM technology vendor *Arcam AB of Sweden using an Arcam Q20 Electron Beam Melting 3D printer*[60]. Typically producing components in this fashion would prove uneconomical. However, due to the small production run of just six cars, AM methods makes economic sense compared to other production routes. Moreover, the price of AM components is largely negated by the very high price of the vehicle, presenting a very unusual use case within the automotive sector.

In 2009 Germany luxury carmaker BMW took part in a three-year collaborative research project to evaluate the use of AM technologies for the production of spare parts[61]. After a significant period of investigating suitable parts to study, the head-lighting assembly for a classic vehicle was identified as a viable candidate part for AM production. Using the original design data, replica parts were produced using the best-in-class AM Processes identified by BMW. In this case the technology used was the Selective Laser Sintering (SLS) process, which produces parts by consolidating powdered nylon plastic using a laser beam. Although the parts were of the correct dimensions, they did not conform structurally to the original design and were not fit-for-purpose. Moreover, the AM parts were found to cost almost 5-times as much as available classic car spares. From this, BMW concluded that additive manufacturing is not yet a viable technology to support the aftermarket.

59 *Koenigsegg*, Swedish *Hypercar* manufacturer at http://www.koenigsegg.com/

60 Information extracted from email correspondence with Koenigsegg.

61 EU Direct Spare Project, A European Initiative Towards Innovative Manufacturing of Spare Parts (2011) at http://www.rapidnews.com/TCT-presentations-2012/Olaf%20Rehme.pdf

The Limitations of Using AM to Support the Vehicle Aftermarket

Although some of the very earliest installations of commercial layer manufacturing machines were within the automotive sectors, and the sector currently uses many thousands of machines to make models and prototypes[62], there are very few cases of the technology actually being applied to make production items. There are even fewer cases surrounding spare parts.

From an engineering perspective this is understandable, as the technology has significant limitations when compared to more established production processes. To understand why this is the case, it is necessary to look in detail at the automotive industry and the aftermarket, and then consider the applicability of AM processes.

Within the £130-billion automotive aftermarket, the 30 most common components represent some £121-billion or 90% of all expenditure, with tyres, brake linings and batteries alone accounting for over £66-billion[63]. However, by no means can all these parts be manufactured using AM. When assessing the potential impact of AM it is critical to consider the technical and economic limitations and capabilities of the technology. In summary:

1. *Are there suitable AM processes by which a comparably engineered part can be made?*

2. *Will the resulting AM part have the same mechanical or thermal properties, strength and longevity to the original?*

3. *Will the AM parts be cost effective to produce and available to the consumer at a comparable price point relative to the benefits that may be experienced by increased speed of delivery?*

Table 1 (below) highlights the 30 most common automotive aftermarket parts purchased within the US automotive aftermarket in 2010, which have then been extrapolated by sales value globally[64]. Each part has then been evaluated for both technical feasibility as an AM component and also economic viability as an AM component.

62 Wohlers Associates Report 2014 at http://wohlersassociates.com/2014report.htm

63 US Automotive parts industry annual assessment http://www.trade.gov/static/2011Parts.pdf

64 Industrial Marketing Research Inc., Des Rosiers Automotive Consultants & Experian http://www.desrosiers.ca/aftermarketanalysisgroup.html

Component	Percentage expenditure	Global expenditure[65] ($-million)	Technically possible to 3D print	Economically viable using 3D printing
Radiators	3.1%	£3,804	YES	NO
Water Pumps	2.9%	£3,477	YES	NO
Exhaust Pipes	0.8%	£960	YES	NO
Silencer boxes	0.8%	£954	YES	NO
CV Joints	0.7%	£794	YES	Possibly
Wheel Bearings	0.5%	£574	YES	NO
Rack and Pinion	0.2%	£267	YES	Possibly
Distributor Caps	0.1%	£85	YES	YES
Brake Callipers	10.4%	£12,565	YES	NO
	19.4%	£23,482		
Brake disks	2.4%	£2,948	Possible	Possibly
Shock Absorbers	2.2%	£2,673	Possible	Possibly
Fuel Pumps	2.1%	£2,542	Possible	Possibly
Catalytic Converters	1.3%	£1,537	Possible	Possibly
	8.0%	£9,702		
Tyres	36.5%	£44,244	NO	N/A
Brake pads	11.0%	£13,323	NO	N/A
Batteries	7.4%	£8,917	NO	N/A
Oil Filters	2.5%	£3,026	NO	N/A
Air Filters	2.5%	£2,998	NO	N/A
Fuel Filters	2.4%	£2,847	NO	N/A
Wiper Blades	1.5%	£1,810	NO	N/A
Alternators	1.5%	£1,757	NO	N/A
A/C Compressors	1.3%	£1,569	NO	N/A
Starters motors	1.2%	£1,491	NO	N/A
Clutches	1.1%	£1,361	NO	N/A
A/C Condensers	1.1%	£1,333	NO	N/A
Radiator Hoses	0.9%	£1,041	NO	N/A
Thermostats	0.6%	£761	NO	N/A
Air conditioning	0.6%	£680	NO	N/A
Headlamps	0.4%	£482	NO	N/A
Ignition Wire Sets	0.3%	£310	NO	N/A
	72.6%	£87,954		

[Table 1: most commonly purchased aftermarket parts globally extrapolated in 2010].

65 The global figures have been extrapolated using statistical data derived in footnotes 68 and 69.

As it can be seen in Table 1, of the £121-billion of automotive aftermarket component parts purchased worldwide each year, £88-billion are not suited to AM production. Moreover, it is unlikely that these parts will ever be suited to AM given the complexity of the parts required and the limited number of materials that can be processed using AM.

On analysis, less than £24-billion of the automotive aftermarket parts sold worldwide per annum (19%) are suited to AM production in terms of size and scale, and to a lesser degree, material compatibility. However, the economics of AM production make the vast majority of these parts cost prohibitive to produce; with AM parts costing up to 100-times more than existing spare parts produced using conventional processes.

A significant example of this scenario arises from the brake calliper (£13-billion of sales in 2010). The average price for a brake calliper is £77, with some 75.5-million being sold each year in the USA alone[66]. Considering the size and scale of a typical aluminium die-cast calliper for a family car and using cost modelling and simulation tools for AM, it is estimated that it would cost approximately £6,500 to make such a part using Selective Laser Melting (SLM) metallic AM technology. This amounts to 87-times the price of the current product, and is considerably more expensive than the piece-part price for the current casting. It is forecast that metallic AM processes will reduce in cost by as much as 90% over the next 10-years[67]; even so, it would still make the technology 10-times more expensive for the production of automotive parts like callipers.

A similar economic picture is seen for other automotive components such as water pumps, exhaust pipes, silencers and radiators. All these parts could conceptually be made using AM, but the production costs would be of a greater magnitude than the current aftermarket value, thereby restricting the value proposition of the AM printed aftermarket to only a small number of very high value vehicles.

Based on the top 30 parts by sales revenue, the only aftermarket parts that are close to being economically or technically viable at present include the production of distributor caps, Constant-Velocity (CV) joints and rack and pinions. To this end it is suggested that the vast majority of automotive aftermarket demand will be serviced using parts manufactured through conventional manufacturing processes, with AM being used only for rare and classic cars and hard-to-find parts, where the cost of the part is of secondary importance.

Assuming that 10% of car owners struggle to source traditionally manufactured parts, AM could be the solution for the production of £84-million of the automotive aftermarket. Given that the top 30 selling replacement parts account for some £121-billion, this represents just 0.07% of aftermarket expenditure. Albeit, many of these parts would no doubt present inferior mechanical properties to the current production components, and may be called into question by both customers and regulators.

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66 Source, Industrial Marketing Research Inc., Des Rosiers Automotive Consultants & Experian http://www.desrosiers.ca/aftermarketanalysisgroup.html

67 Internal cost modelling software tools developed and deployed by *Econolyst Ltd*.

Of course the scale of the market discussed is based solely on the top 30 parts by sales revenue. In addition to the £121-billion of revenue generated by the top 30 parts there may be as much as £14-billion of revenue from other service and spare parts used within the automotive aftermarket[68]. Analysis would suggest that these parts are largely external body components such as bumpers, light housings and body panels, which need to be replaced following accidental damage.

It is unrealistic to ever assume that AM processes will be used to make components such as metallic body panels, as these parts gain their structural integrity and aesthetic value by sheet metal stamping. It is possible that parts such as bumpers may one day be produced, in whole or in part using AM technologies, but given the critical nature of bumpers and the safety of both passengers and pedestrians this is not expected to happen for at least 15-years due to the technical limitations of AM technology and the anticipated rate of development[69]. It is however conceivable that component parts for systems such as exterior headlight housings could be made using current or near future AM technologies.

Data Considerations Constraining AM Adoption Within the Aftermarket

One of the biggest limitations to the production of AM spare parts will undoubtedly be the lack of credible and authorised design data from which to print. It is assumed that parts can simply be scanned and reverse engineered, with the resulting date then being stored to the cloud for downstream printing. However, this would require access to a brand new undamaged component with absolutely no wear and tear. It would also require access to the original design data to understand issues such as tolerances, loading conditions and materials requirements. Alternatively, it could be assumed that if the part was originally designed on CAD then the data must be available. Unfortunately, the vast majority of automotive parts are made using traditional manufacturing processes and established supply chains. Within this system, the original part design data is used to manufacture tooling, which is then used to make components. Because of this dislocation between 3D design and part production, there may not be suitable design data to drive AM technologies.

The Industry Viewpoint

To further understand the potential for AM within the automotive aftermarket, leaders within two major automotive manufacturing companies were interviewed. The aim was to understand the opportunities and barriers that are presented by the technology[70 71]. Both companies have well-established additive manufacturing departments and use the technology extensively for prototyping purposes; neither company uses the technology for the production of end-use components for vehicles.

68 US Automotive parts industry annual assessment http://www.trade.gov/static/2011Parts.pdf

69 Interview with automotive manufacturer BMW (June 2014).

70 See *supra* n. 69.

71 Interview with automotive manufacturer Jaguar-Land Rover (June 2014).

Neither company believes the impact of AM in the next ten years will be significant, especially for the aftermarket sector; it was said that the automotive industry will first need to adopt AM into the manufacturing process of production vehicles, before it can be used to produce spare parts for the aftermarket sector. As demonstrated by BMW, the technology is not capable of producing acceptable parts that are fit-for-purpose from designs that were originally intended to be manufactured using conventional process such as injection moulding. The parts are not fit-for-purpose, as they do not meet the quality and safety standards necessary within the automotive industry. Consequently, parts manufactured via AM will only be acceptable if they were originally designed to be manufactured using AM processes; this means that spare parts are only likely to be manufactured via AM if they are to replace original AM parts. As neither company expect AM to become part of their production process for the next ten years due to economic and quality issues with the technology, there will be no opportunity for aftermarket parts until after this time.

The manufacturers of original spare parts - Original Equipment Manufacturer (OEMs) - have a very low level of concern about the control of data and subsequent intellectual property should AM of spare parts become widespread. It was noted that the adoption of AM for producing aftermarket parts will be driven primarily by OEMs, not by consumers or by supply chain-led initiatives; consequently, the production data will be generated by the OEM and this can be controlled in the same way that it is at present, thus protecting their intellectual property. The OEMs already have secure data transfer networks in place to protect their assets and the infrastructure has already been used to stream engine diagnostics data to local service centres securely. The service centres will either pay a service fee to have access to this data from which they can manufacture the parts themselves, or they will purchase parts from authorised manufacturers. Hence, there will be no immediate or real threat to the OEM's valuable data.

Another reason given for the lack of concern about protecting the aftermarket was that the dealers will always fit OEM-manufactured parts which they have sourced from reputable vendors, otherwise they risk losing their dealership. This is not expected to change simply because the parts are manufactured using AM processes; therefore the potential impact of 3D printing on aftermarket sales is considered to be negligible. The exception to this is for legacy products where the OEM has minimal on-going involvement, such as the classic car and restoration market, where consumers often have difficulty sourcing parts for very old vehicles, and where safety may be a secondary consideration if the vehicle is being restored for show purposes. It was stated, however, that this would not likely be a source of concern for the OEM due to the very small size and nature of this market, which exhibits very small revenue opportunities.

There was some opportunity seen in the customised market; but this was not expected to affect OEMs soon but it was felt that, once consumers have an awareness of the capabilities of OEMs to create customised parts, they would want to engage with this process. It was envisaged that this would be carried out in collaboration with the dealers, as the customer is not necessarily a designer, and would therefore require assistance. This was seen as a potentially lucrative opportunity, but that is a long-term opportunity.

Of the two companies that were interviewed for this case study, one stated that they were engaged in continually evaluating the use of AM within their supply chain with a focus on the adoption of the technology for production parts, designed to be made using AM. The other company stated that they did not believe the automotive industry was actively looking at applying AM to mainstream production purposes and did not see a shift away from using the technology primarily for prototyping; the only potential application that they could envisage beyond prototyping was for very low-volume, high-value vehicles.

Based on the discussions with thought-leaders within the automotive industry and expert knowledge of the rate of development within the AM industry, it is believed that it will be at least ten years before the automotive industry is affected by AM technology. After this period, there may be some opportunities in the aftermarket, but these will represent a fraction of the global market.

Conclusions and Recommendations

In summary, there is little evidence to suggest that there will be any short-term business opportunities for the production of automotive spare parts using AM within a ten-year horizon. Current AM technologies largely do not produce parts that are of a suitable quality to replicate traditionally manufactured automotive components. Where the technology is technically acceptable, the economics of AM production outweigh the accepted price point of current spare parts. Given the speed of AM technology development it is very unlikely for there to be significant revenue opportunities in this sector for at least the next 15-years.

Although the timeframe for widespread adoption of AM within the automotive spare parts market is significant and the companies that were interviewed did not express concerns about the impact that AM will have on their business in the near future, it is recommended that consideration is given to the traceability of spare parts.

When it becomes possible to manufacture automotive spare parts using AM processes, the paramount concern will be that the parts perform correctly and are safe to use. Manufacturers will therefore be required to show that the data that is used to produce a part is from an approved source and that it will give them a safe and useable part, as well as provide a method of determining liability in the event of failure. It is, therefore, recommended that the UK establish a method of certifying the origin of printable files for the automotive spare parts sector. This could be implemented by either the public or private sector. Commercial digital signature software to verify the authenticity of a document has existed for over thirty years[72] and as discussed in the final case study presented in this report - “Designers Perspective: How to Protect and Monetise your Digital Assets” - there are already AM-specific Technological Protection Measure tools available such as *Authentise*[73] that aim to protect a designer’s intellectual property rights[74]. It is envisaged that it would be possible for similar commercial software to be developed that could verify the origin of printable files.

72 The first digital signature method – the RSA algorithm - was proposed in 1978. For further details, see, Rivest R., Shamir A., & Adleman L., “A Method for Obtaining Digital Signatures and Public-Key Cryptosystems” (1978) 21(2) *Communications of the ACM*, pp. 120–126.

73 *See infra n*. 245.

74 For further details of Technological Protection Measures in relation to AM, see “*The Designers Perspective: How to Protect and Monetise your Digital Assets”*, page 60.

An alternative approach would be for standard setting organisations such as ISO or the British Standards Institution to consider developing a standardised method of storing information about the origin and history of a printable file into the code of that file. It is envisaged that this would be a AM-specific equivalent to the guidelines covering the presentation of technical drawings, that allow the history of the design to be recorded[75].

75 ISO 7200:2004 "Technical product documentation: Data fields in title blocks and document headers" specifies the data that should be included in a technical engineering drawing to facilitate the exchange of documents for both manual and computer-based design work.

Case Study II:

The Domestic Appliances Aftermarket: Using Home Based 3D Printing

This case study explores the impact that home based 3D printing could have on the domestic appliance aftermarket in the UK. This case study was selected, as it is the second largest aftermarket in the UK, behind the automotive industry.

What is the Domestic Appliance Aftermarket?

The aftermarket for domestic appliances is a large and complex system in which it is accepted that Original Equipment Manufacturers (OEMs) have a duty of care to provide replacement parts for their products for a reasonable period. The UK's *Association of Manufacturers of Electrical Domestic Appliances* states that members "will endeavour to provide functional components so that appliances may be serviced throughout a products expected life"[76]. This duty of care requirement, combined with the rapid rate at which new products are brought to market, means that OEMs must either stock a large number of spare parts or work with a third party such as *Domestic & Genera*l to manage their aftermarket service. The costs associated with storing quantities of products that may never be required are then passed on to the consumer through increased component prices and service costs.

It should be noted that appliance manufacturers do not have a statutory obligation to provide spare parts[77] and if a suitable replacement part is no longer available, it can often result in the entire appliance being replaced. This is an undesirable situation, from both an economic and environmental point of view. However, the inability to source spare parts is also often the catalyst for consumers to replace appliances.

Unlike certain parts of the automotive aftermarket, where vintage cars maintain and appreciate in value[78], domestic appliance value decreases rapidly over time. To this end, the cost of domestic appliance parts as a proportion of asset value is much higher than automotive spare parts. As such, many consumers will forego the cost of replacement parts and associated service labour costs and purchase new appliances rather than repair old ones[79].

76 Association of Manufacturers of Electrical Domestic Appliances, *Guide on Customer Care, Code of Practice*, (January 2012) at http://www.amdea.org.uk/wp-content/uploads/2014/03/CoP_Customer-_Care_4_January_2012.pdf

77 White Goods Trade Association at http://www.whitegoodstradeassociation.org/index.php/for-public-mainmenu-43/spare-parts-mainmenu-54

78 Millward D., Classic Cars Shrewdest Investment (10th September 2013) *Daily Telegrap*h at http://www.telegraph.co.uk/motoring/news/10292039/Classic-cars-shrewdest-investment.html

79 European Commission, Brief on Policy Affecting Purchasing of White Goods (2009) at http://ec.europa.eu/environment/enveco/pdf/RealWorld_Briefing5WhiteGoods.pdf

The Scale of the Domestic Appliance Aftermarket

The domestic appliance aftermarket is a highly fragmented and complex system with OEMs and third party providers selling through multiple channels. The market for repair and servicing of Domestic Electrical Goods (DEGs) had a value of £600 million in 2009, while the market for extended warranties on brown and white DEGs had an estimated value of £941 million in the same period[80].

The largest spare parts distributor in Europe is ASWO Group[81] (hereinafter ASWO) who supplies parts through 24 subsidiaries to repair organisations across Europe. ASWO stocks 13 million spare parts and distributes 10,000 parts a day to customers. They are able to supply 94% of all parts requested by their customers, suggesting there is little demand for unavailable domestic spares within the current aftermarket model. ASWO source their stock from both the Original Equipment Manufacturers and from third party manufactures[82].

Within the UK, *Domestic & General* is the largest warranty service provider, with 21 million appliances protected and 3,000 repair contractors operating on behalf of the company[83]. Companies such as *Domestic & General* are the typical customers of ASWO. ASWO also sells to over 2,000 online websites[84], who then sell directly to consumers throughout Europe, who then repair their own appliances or use a local experienced repair technician.

Drivers to 3D Printing Adoption

As discussed previously, the use of 3D printing to manufacture spare parts at home has generated a high degree of interest in recent years[85]. There is obvious appeal for consumers to be able to repair costly domestic appliances[86] in order to extend the life of the appliance without having to be dependent upon manufacturers and distributors to hold stock of spare parts. The advantage of using home-based 3D printing to manufacture spare parts is that it enables consumers to manufacture a one-off product at a very low volume with no cost penalty, unlike with traditional manufacturing methods.

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80 Office of Fair Trading, *Market Review of White and Brown Domestic Electrical Goods: Invitation to Comment* (November 2010). In the present context, brown goods refer to light weight, small and portable electrical appliances such as electric kettles, coffee makers, toasters and microwaves whilst white goods is used to describe major appliances such as refrigerators, washing machines and freezers.

81 ASWO Group at http://www.aswo.com/index.php?id=2&L=1

82 Interview with Managing Partner of ASWO Group (June 2014).

83 *Domestic & General*, http://www.domgen.com/about-us.html

84 Interview with Managing Partner of ASWO Group (June 2014).

85 See *supra* n.1

86 The average market price for a domestic washing machine in the UK for the period 2008-2009 was £356. European Commission, Market research for Electronic and Electrical Goods Study (2012) at http://ec.europa.eu/consumers/archive/consumer_research/market_studies/docs/category_washing_machines_en.pdf

Use Cases of 3D Printing in the Domestic Aftermarket

To date, there has only been low-level activity relating to the manufacture of replacement parts for domestic appliances via 3D printing. This has been driven by 3D printing enthusiasts and hobbyists publishing files online that they have created to enable others to print out spare parts if wanted. So far there has been no engagement from OEMs in the 3D printed spare part market[87].

Shapeways – the largest online service bureau for purchasing 3D printed products – hosts a shop called the "Bugaboo Repair Guy". This shop aims to provide consumers with low cost Do-It-Yourself (DIY) solutions for the repair of high-end *Bugaboo* pushchairs. There are currently 32 parts listed in the store and instruction manuals for how to complete the repairs[88]. Similarly, *Shapeways* also features an *Ikea Shop* where spare fixings for *Ikea* products can be bought[89]. It should be noted that there are no specific web shops on *Shapeways* at the time of writing dedicated to domestic appliance spare parts.

However, *Thingiverse*[90] a popular and free online repository of 3D part files hosts a wealth of replacement parts for a wide range of applications and brands including domestic appliances. To-date, files on *Thingiverse* that are free to download include parts such as an Indesit washing machine dial, *Frigidaire* water dispenser levers, *Bosch* dishwasher brackets and a *Zanussi* freezer handle[91].

Although these parts are clearly being positioned as functional and may in fact operate, they often lack the aesthetics of the original components. Whilst this is not an issue for internal components, such as a door latch, it is noticeable for external components such as a dial or handle, which then brings into question the value proposition of using 3D printing for such repairs.

The Limitations of 3D Printing in the Domestic Appliance Aftermarket

Although the idea of printing spare parts at home for domestic appliances appears to hold much promise, and to a small extent is already taking place today, it is believed that it will be a substantial period of time before this becomes a widespread practice[92].

The consumers who are designing and printing their own replacement parts at home are part of the early adopters' wave of 3D printing users. Given that 44% of 3D printing users identify themselves as "*3D Printing Enthusiasts*"[93], it is believed that this group of users are likely to be

87 See *supra* n. 84.

88 Shapeways, *Bugaboo Repair Guy*, at http://www.shapeways.com/shops/bugabooparts

89 Shapeways, *Ikea Shop* at http://www.shapeways.com/shops/IKEAshop.

90 For more on Thingiverse, see http://www.thingiverse.com and also, Study I of this two-part Study: Mendis D., & Secchi D., '*A Legal and an Empirical Study of 3D Printing Online Platforms and an Analysis of User Behaviour*'.

91 Replacement parts on Thingiverse can be accessed at http://www.thingiverse.com/search?q=replacement&sa=

92 See *supra* n. 84.

93 The Big 3D Printing Survey 2014, Econolyst Ltd. Available at http://www.econolyst.co.uk/index.php/home/econolyst-launches-2014-big-3d-printing-survey

much more tolerant of the inherent problems and issues with home 3D printing than a typical consumer would be.

At present, the process to print a replacement part for a domestic appliance requires the user to create a 3D model of the part. Depending on the complexity of the part, this can be a difficult and time-consuming process, requiring knowledge of Computer Aided Design (CAD) software. It may also require scanning technology or specialist measurement tools. (For further details of the reverse engineering process, see the Scanning and Reverse Engineering Case Study)[94]. It is interesting to note that a *Thingiverse* user developing a small dial cover for his washing machine had manufactured six iterations of the design before finding one that worked sufficiently[95].

In the future, appliance OEMs may choose to release the digital files of their parts to enable consumers to print their own parts at home; this could make the process of printing components at home more accessible to people who do not have CAD skills. However, this is not expected to happen in the near future, as the design of traditionally manufactured parts often has to be modified to make them printable[96]. It is likely that OEMs will only have access to printable files if they have originally designed the parts to be printed within their original supply chain. Given the high volume production of most domestic appliances and the high cost of 3D printed parts relative to moulded plastic parts it is not anticipated that 3D printing will be used widely in the manufacture of mass-produced domestic appliances for many years to come. OEMs are therefore unlikely to generate printable digital files for their customers, as this will require additional work with uncertain revenue streams.

It is also important to bear in mind that being able to repair an appliance depends upon more than just access to tangible parts, as it also requires a successful diagnosis of the problem. Not all consumers have the ability or confidence to do this and will wish to use an experienced repair service. Again, there is scope for repair services to develop printing capabilities that will enable them to service client's needs quickly without having to wait for the part to be supplied from the distributor. However, it is likely that a repair service will suffer from the same problems with printing that a consumer would face, in terms of obtaining the digital file and printing a successful component.

The aesthetics of home-printed parts are also likely to limit their widespread acceptance; parts printed on today's home printers generally have very poor surface finish and there are limited colours available, which are unlikely to match the paint finishes used on most domestic appliances. It is, therefore, seen as likely that the majority of consumers would not be satisfied with a printed part as a permanent solution if the part were visible.

Moreover, the materials that are available for home 3D printers may also not be suitable for manufacturing long-term replacement parts. Consumer-grade 3D printers are only capable of manufacturing plastic parts, which means that metallic components would need to be replaced by plastic ones, which may be inferior. The polymers used by consumer 3D printers are also limited and are unlikely to be suited to applications with extreme temperatures such as fridge

94 See *infra* Case Study IV.

95 Thingiverse, *Washer Knob*, (2011) at http://www.thingiverse.com/thing:10724

96 See *supra* n. 71

freezers, cookers or microwaves[97]. In addition, some consumer 3D printers use photo-curable resins, which are hygroscopic and UV-unstable; this means that they will absorb water, discolour and distort over time making them unsuitable for applications in appliances such as washing machines and dishwashers[98]. Consequently, these printers could not be used to produce permanent replacement parts, greatly limiting their practical application in the spare parts market. It must also be considered that industrial products are rarely made of a single material and are often the result of multiple part assemblies. It is unlikely therefore that a consumer 3D printer will be able to print all the materials needed to produce such an assembly.

Additionally, the mechanical properties of printed parts are often lower than traditionally made components. This means that consumers may not achieve the same level of performance that they experienced from their original part. Even though the design of the component may be identical, the way in which it is printed and the material that it is printed in can result in a weaker, lower-quality part. This therefore presents the risk that these sub-standard components may cause damage to the appliance or injury to the user. This is a factor that would need to be considered by OEMs considering the release of digital models to the public to enable them to manufacture spare parts at home. OEM's are constrained by accepted manufacturing quality standards and legislation such as CE marking[99]. They will not look to jeopardise or conflict such standards by allowing consumers to engage in the manufacturing of replacement parts using their data.

The Industry Viewpoint

To understand the viewpoint of industrial leaders within the domestic appliance aftermarket, the leading company within this sector was approached to understand their view on the impact of home 3D printing[100]. The company was very much interested in the technology and are currently engaged in a research project to understand how much it will affect their business. However, they stated that 3D printing has not yet had an impact on the aftermarket and that consumers who are using home 3D printing to produce parts are very much a niche community, which posed no perceived threat.

One area of interest for the company was that 3D printing could drive greater engagement between consumers and OEMs, as increasingly connected devices enable OEMs to remotely detect problems with appliances. However, the company expressed a concern that there was not a clear understanding of the intellectual property issues involved in reproducing spare parts, and that this needed to be clarified to enable third parties to look at the viability of reproducing spare parts using 3D printing.

97 The most popular brand of consumer 3D printer, MakerBot, sells four types of polymer material for their printer: PLA and ABS (both engineering polymers), Flexible and Dissolvable. Available at http://www.makerbotuk.com/filament.html

98 Liow F., *Rapid Prototyping and Engineering Applications: A Toolbox for Prototype Development* (CRC Press; 2007) p. 247.

99 See *infra* n. 139.

100 See *supra* n. 82.

Conclusions and Recommendations

It is envisaged that, in the next ten years, the manufacturing of replacement parts for domestic appliances at home will continue to be carried out primarily by DIY and 3D printing enthusiasts. This is primarily due to the low maturity of home 3D printing technology and the anticipated rate of development. If the technology - including hardware, software and materials – reaches a point where a product can be printed easily and quickly and it will work in the appliance without having to modify the part through iteration, a wider consumer base may adopt the technology. Until that point, it is unlikely to have a significant impact on the domestic appliance aftermarket. We do not expect to reach such a point within the next 10-years given the current trajectory of 3D printing development or the current rate of technology adoption within the OEM market.

It should still be noted that, although the printing of spare parts for domestic appliance parts is not widespread today, it is occurring to a limited extent – as shown by the spare parts found on 3D printing websites. It is highly likely that many of these parts are not being created and distributed under licence from the rights-holder. Supporting the recommendations made in Study I of this two-part study[101], it is therefore, recommended that clarification is sought particularly in relation to the legalities of designing, distributing and manufacturing spare parts using unlicensed 3D models, including when these are not produced for commercial gain. It is recommended that a public body such as the Intellectual Property Office produce guidelines to assist the general public and, specifically, 3D printing users in understanding the intellectual property implications of designing and printing spare parts for domestic appliance. It is expected that this would benefit both designers and consumers who may be unaware of the legal implications of printing parts at home.

101 Additional recommendations based on a study of the use of online 3D printing file sharing platforms are provided in Study I of this two-part Study: Mendis D., & Secchi D., *'A Legal and an Empirical Study of 3D Printing Online Platforms and an Analysis of User Behaviour'*.

CUSTOMISED GOODS

INTRODUCTION TO CUSTOMISED GOODS

There are over 7 billion people in the world comprising of different cultures, religions and colour with differing levels of income and different levels of state support[102]. In short, as a varied population, our needs differ; either as consumers for the things we want, or patients for the healthcare solutions that we need to provide two examples.

Product customisation is the manufacturing response to consumer individuality. Within a customised supply chain, the manufacturing process is configured in such a way that input from the consumer can be taken into account during the creation of the product. The concept of customisation is not new; many bespoke clothing items have been customised to the individual wearer for millennia. However, the concept of mass-customisation is a more recent phenomenon, where manufacturing supply chains and factories are configured to respond to high volume demands for customisation[103]. Example of mass customisation include the manufacture of *NikeiD*[104] training shoes, which are personalised by the consumer, or the *Audi* A6, which can be configured online by the buyer[105].

However, customisation has now progressed beyond footwear and executive cars and is becoming a common addition to the AM and 3D printing supply chain. To enable customisation, consumers now have access to a range of design tools with which to input their requirements into the manufacturing supply chain. Such tools include desktop and web based design interfaces and affordable scanning and reverse engineering hardware from which they can produce printable data. Within the next two case studies we will consider the implications of product customisation where consumers use web based software tools to engage in the product design process and where individuals use 3D scanning and reverse engineering hardware to produce copied or customised product data. However, before moving on to the case studies, the intellectual property implications associated with product customisation will be explored.

102 http://www.worldometers.info/world-population/

103 Tseng M., Jiao J., Mass Customization, in: *Handbook of Industrial Engineering, Technology and Operation Management* (New York: Wiley; 2007) p. 685.

104 *NikeiD* at http://www.nike.com/gb/en_gb/c/nikeid

105 Build Your Audi at http://www.audi.co.uk/explore-models/audi-car-configurator.html

Intellectual Property Implications Relating to Customised Goods

Implications for Copyright Law

Scanning and customising products for 3D printing presents a host of intellectual property issues relating to ownership/authorship and raises questions about the 'originality' of the existing product in the market. Although the scanning process requires skill and, often, artistic interpretation to create a useful 3D model, if the aim was to reproduce the original component exactly, the user could find that they have infringed intellectual property laws. In the case of customising goods borne out of scanning and reverse engineering, there has to be some form of 'material alteration or modification' to ensure that the intellectual property rights are not infringed[106].

Some of the most pressing concerns relating to scanning and customising of 3D printed products arise from the laws of copyright and the concept of 'originality'. Originality is not defined in the UK *Copyright, Designs and Patents Act 1988* (CDPA 1988) but is clarified through case law. The term 'originality' is expressed clearly by Pearson LJ in the case of *University of London Press v. University Tutorial Press*[107]:

> The word "original" does not in this sense mean that the work must be the expression of original or inventive thought … but with the expression of thought.... The originality, which is required relates to the expression of the thought. But the Act does not require that the expression must be in an original or novel form, but that the *work must not be copied from another work – that it should originate from the author*[108].

In other words, to satisfy the criteria for originality, a creator must show his or her skill, labour, effort and judgement[109]. There is no need for quality or merit of the work and copyright does not impose a requirement of aesthetic or intellectual quality[110] – it simply must be the creator's own work; it should not be copied. More recently, European jurisprudence has shed new light on originality, establishing that it should be the "own intellectual creation of its author"[111]. This signals a move away from UK's age-old doctrine of skill, labour, effort and judgement to focusing on the authorial input of the creator.

The widespread use of web-based software tools[112] has meant that users have the opportunity to modify/customise products. However customising a product, which is already in the market, throws up intellectual property issues relating to 'ownership' and 'authorship'. Considering the

106 *See below, Interlego v. Tyco* [1988] RPC 343.

107 *University of London Press v. University Tutorial Press* [1916] 2 Ch 601.

108 *Ibid*.,Pearson LJ at 608.

109 *Ibid*.,p. 610.

110 *George Hensher Ltd v. Restawhile Upholstery* (Lancashire) Ltd [1976] ac 64; *Green v. Broadcasting Corp of New Zealand* [1988] 2 All ER 1056 (Privy Council).

111 Case C-5/08 *InfopaqInernational A/S v. DanskeDagbladesForening* [2009] ECR I-06569.See also, Rahmatian A., Originality in UK Copyright Law: The Old "Skill and Labour" Doctrine Under Pressure [2013] 44(1) *International Review of Intellectual Property and Competition Law*, pp. 4-34.

112 For more information about these web-based software tools, see also, Study I, which provides details on 123D's *Meshmixer; GrabCAD's Workbench*; Thingiverse's *MakerBotCustomizer*; Shapeways' open-source *MeshLab* and *AccuTrans* for Windows, for example.

case studies below, interesting questions arise in relation to UCODO (User Co-Design Objects) used by the company *Digital Forming*. UCODO, as explained below, is a web based software tool developed by *Digital Forming* which allows consumers to access a variety of products which they can customise using the UCODO toolset, within set parameters. This tends to blur the line of the creator – i.e. is the creator *Digital Forming* or the consumer who completes and modifies the product? To clarify the situation, UCODO has coined the term ODO (original design object) and CODO (co-design object) which implies an acceptance of the existence of an original creator followed by a number of co-creators – which might also be the trend in the 3D printing future.

At present, it is interesting to consider the intellectual property implications arising from this business model made possible by 3D printing. The important question is whether the modified or 'derivative' product created through the use of the UCODO software tool, for example, will attract new copyright? The current UK law states that "there must be … some element of material alteration or embellishment which suffices to make the totality of the work an original work ... even a relatively small alteration of addition qualitatively may, if material, suffice or convert that which was substantially copied from an earlier work into an original work... But copying, per se, however much skill or labour may be devoted to the process, cannot make an original work"[113].

On the other hand, *MakiLab's* customised dolls[114] will satisfy the criteria for originality. As discussed below, *MakiLab's*, entire business model rests on the low volume, individualised manufacturing nature that AM enables. The dolls – *Makies* as they are known – are customised and designed by the consumer, made using additive manufacturing. Currently, each doll can be classified as 'original' according to the law; however if the data files or AM manufactured dolls make their way to an online platform, presenting the opportunity for scanning and reverse – engineering, then issues of intellectual property infringement will begin to arise.

In a 3D printing scenario, customising a product reflecting material alteration or embellishment could obtain a new copyright whilst scanning products for 3D printing, will be seen as an infringement even though, the scanning process may have required skill, labour, effort and judgement on the part of the individual. As Lord Oliver reasoned in *Interlego v. Tyco* the product would have to be materially altered or embellished to an extent to qualify for a new copyright and scanning *per se*, will lead to the creators' copyright being infringed.

Scanning and reverse engineering also present a number of intellectual property issues; clearly the ability to replicate objects that are subject to intellectual property rights suggests that infringement will inevitably occur. However, unlike reproducing music or sharing eBooks where the owner's copyright is infringed, the objects that are scanned may be functional items covered by copyright, trade marks, design rights and/or by patents. Consequently, there is likely to be confusion over the legalities of scanning a part for the purposes of 3D printing.

First, it is important to note that scanning an object will not automatically lead to a useable 3D object. As described below, to obtain a useable, printable 3D model through scanning, the scanned data has to be supplemented by further work – which includes clean up of the data in preparation for conversion into CAD data – which will ultimately lead to a copy of the existing

113 *Interlego.v. Tyco* [1988] RPC 343 at 371 per Lord Oliver.
114 *See infra*, p. 38.

product. This process clearly requires much 'skill, labour, effort and judgement' – the criteria required for originality under UK copyright law or the "own intellectual creation of its author" which forms the basis for originality under recent European jurisprudence. However as Lord Oliver points out in *Interlego v. Tyco* "… copying, *per se*, however much skill or labour may be devoted to the process, cannot make an original work"[115]. Therefore according to the present law, although skill, labour, effort and judgement will be used in the process of scanning and reverse engineering, it will be insufficient to generate a new copyright, unless there is some form of modification or material alteration[116].

Scanning and reverse engineering also raises issues relating to other types of intellectual property rights, of which the implications for patent law, in particular, are discussed below.

Patent Law – Implications for the 3D Sector

Patent law[117] protects an invention, which is "new, involves an inventive step and is capable of industrial application". According to section 60(1)(a) of *Patents Act 1977* (as amended) (hereinafter PA1977) "a person infringes a patent which is in force – which in the UK is normally up to 20 years from grant of the patent" – [where] ... he *makes, disposes of, offers to dispose of, uses or imports the product or keeps it whether for disposal or otherwise..."*[118]. Whilst it is important to know the kind of invention that is being dealt with, in order to establish whether there has been an infringement, it is not a requirement to have knowledge of the existence of the patent. This means that an innocent infringer can be liable if he carries out any of the acts detailed in section 60(1)(a) which deals with product inventions if the patent is in force[119].

Furthermore, following on from the wording of section 60(1)(a) referring to "... makes, disposes of...", it will also be an infringement to modify an invention under patent protection which goes beyond 'repair' leading to a new infringing product. In the case of 3D printed products, where intricate or significant changes will be possible by tweaking the CAD file, the question will be whether a 'tweaked' or 'modified' product will fall foul of section 60(1)(a). According to the present law, acts, which are prohibited by section 60 are infringing acts whether or not they are categorised as repairs. However genuine repair of a patented product does not amount to 'making' that product.

The second part of section 60(1)(a) which relates to "disposing of, offering to dispose of, or using the invention" concerns the commercialisation of infringing copies of an invention... Miller *et al in Terrell on the Law of Patents* interprets 'dispose' as commercial sale or loan or proposals to do so[120].

115 *Interlego.v. Tyco* [1988] RPC 343 at 371 *per* Lord Oliver.

116 Burton O., Originality From Copying: Fitting Recreative Works Into The Copyright Universe [2010] (2) *Intellectual Property Quarterly*, pp. 165-191.

117 The discussion on patent law is adapted from Mendis D., "Clone Wars"; Episode I – The Rise of 3D Printing and its Implications for Intellectual Property Law: Learning Lessons from the Past? [2013] 35(3) *European Intellectual Property Review*, pp. 155-169.

118 Section 60(1)(a) *Patents Act 1977 (as amended)*.

119 See Waelde C., Laurie G., Brown A., Kheria S., & Cornwall J., *Contemporary Intellectual Property: Law and Policy* (Oxford: Oxford University Press; 2014) p. 485.

120 Miller R., Burkill G., Hon Judge Birss, Campbell D.,*Terrell on the Law of Patents*, (17th Revised ed.), (London: Sweet & Maxwell; 2010).

The issue of repair or modification by 3D printing could be impacted by section 60(2) of PA 1977[121]. Section 60(2), deals with *indirect infringement* which arises when someone facilitates a directly infringing act by supplying or offering to supply any of the means, relating to an essential element of the invention, for putting the invention into effect and with actual or constructive knowledge that those means are suitable for putting, and are intended to put, the invention into effect in the UK. One important point to note here is that patents are territorially limited and so infringement proceedings in the UK can only be brought with respect to activities within the UK.

It is interesting to consider the effect of these sections when they are applied to 3D designs for printing 3D products made available on online platforms leading to the product being modified numerous times. A consideration of these sections, particularly, section 60(2) leads to a number of conclusions.

Whilst section 60(2) of PA 1977 was drafted and amended a long time before online sharing platforms came into being, the section captures such activities, which fall within its ambit. An initial reading of the section, suggests that supplying or offering a 3D CAD file on online platforms will infringe patent law. However it is not very clear whether such a file constitutes "means" as set out in section 60(2). Bradshaw, Haufe and Bowyer contend that it could be interpreted to mean that a

> "3D printer, raw materials and a 3DPDF for a patented item together counts as a kit for making that item, on which basis the 3DPDF is the essential "means" that the 3D printer user would require to infringe the patent, thus bringing supply of it within the scope of section 60(2)"[122].

In 2010, the Court of Appeal established that cases under section 60(2) – known as 'kit cases' – introduced a new form of liability in the UK[123]. The Court also made the following observations in relation to section 60(2). First the supply of the essential means (i.e. conduct in question) must occur in the UK, whereby something 'tangible' is offered to the primary infringer – in our case the 'tangible something' will be the 3DPDF or 3D design file. Secondly, the tangible object should be an essential element of the invention – which in the present context will be the CAD file[124]. Thirdly, the infringing conduct must put the invention into effect. Simply, it means that it

121 **Section 60(2) –**. "A person (other than the proprietor of the patent) ... infringes a patent for an invention if, while the patent is in force and without the consent of the proprietor, he *supplies or offers to supply* in the United Kingdom a person other than a licensee or other person entitled to work the invention with *any of the means, relating to an essential element of the invention*, for putting the invention into effect when he knows, or it is obvious to a reasonable person in the circumstances, that those means are suitable for putting, and are intended to put, the invention into effect in the United Kingdom".

122 Bradshaw S., Bowyer A., & Haufe P., The Intellectual Property Implications of Low-Cost 3D Printing (April 2010) Vol. 7, Issue 1 ***Script-ed*** pp. 1-31 at p. 27.

123 *Grimme Machinenfabrik GmBH v. Scott* [2010] EWCA Civ 110. Formerly, such cases were dealt with under section 7(4) *Registered Designs Act 1949*.

124 As to whether something is an essential element will depend on a case-by-case basis and will depend on the Court's interpretation of the claims of the patent. Therefore section 60 has to be read in conjunction with section 125 of the PA 1977, which states the extent of the invention. **Section 125(1) –**."... be taken to be that specified in a claim of the specification of the application or patent, as the case may be, as interpreted by the description and any drawings contained in that specification, and the extent of the protection conferred by a patent or application for a patent shall be determined accordingly".

must make the invention work. As far as 3D printing is concerned, it is the design CAD file, which will be modified and re-modified to personalise and customise the product, before pressing 'print'. Without a 3DPDF or CAD file, a 3D printed product cannot be realised[125].

Implications for Trade Mark Law

Trade mark issues relating to 3D printing arise where a 3D printed product is *scanned and reverse engineered* that includes a trade mark embedded into it, which will infringe the existing trade mark in accordance with section 10 of the *Trade Marks Act 1994* (as amended) (hereinafter TMA 1994). As such, *commercial* use of a trade mark without the consent of its proprietor will infringe the trade mark. The assumption then is that use of a trade mark by 3D printing a product/object for personal or private use will not infringe the trade mark. This assumption becomes complicated when faced with online platforms, which allows for those 3D printed or scanned products to be shared online.

Furthermore and as discussed in the 'Replacement Parts' section, in accordance with section 11(2)(c) of TMA 1994[126], where a 3D product file is uploaded or scanned and sold *without the trade mark* embedded on to the product, there will be no infringement of trade mark law. For example, if the uploader of the 3D file removes or omits the trade mark before uploading it on to an online platform, the person who downloads it will not be infringing the law, as long as they label the product as representing that particular brand thereby working within the parameters of the law. It appears that section 11(2)(c) can work in favour of the user; whether users will be mindful of the law to avoid infringement is uncertain at this time.

125 For an interesting insight into patent law from a USA-point of view and a consideration of a solution in the form of 'micropatents' see, Susson M., Watch the World "Burn": Copyright, Micropatent and the Emergence of 3D Printing [April 2013] Available at SSRN http://dx.doi.org/10.2139/ssrn.2253109 ; Lipson H., & Weinberg M., At Issue: Is A New "Micro-Patent" Needed To Protect 3D Innovators? [2012] No. 22 CQ Researcher; available at http://photo.pds.org:5012/cqresearcher/getpdf.php?id=cqresrre2012120700&PHPSESSID=57f58hjrtepjdd4cuprdhessn1

126 **Section 11(2)(c)–** "a trade mark is not infringed by the use of the trade mark where it is necessary to indicate the intended purpose of a product or service (in particular, as accessories or spare parts), provided the use is in accordance with honest practices in industrial or commercial matter".

Case Study III:

Engaging the Consumer: When We All Become Designers

This case study will consider the implications of what happens when consumers engage in the design process. The case study will consider the implications of consumers using predominantly web based software tools to select and manipulate geometric data and how the resulting data can then be used to enable either commercial AM or home based 3D printing technologies.

Why Will Consumers Become Designers?

The market for customised products is anticipated to grow as a result of widespread AM adoption. Reducing machine and material costs along with increased software accessibility will undoubtedly drive growth within the 3D printing market, which is one day estimated to reach 2% (£125 billion) of the global manufacturing economy[127]. As technology, up-skilling, awareness and product development specifically for 3D printing consumer customisation increases, the value of this sector will certainly account for a significant portion of this total projected market[128].

AM technologies will be key to the growth in the customised goods sector for a number of reasons. Firstly, because 3D printing is cost effective in producing batch down to a unit volume of one part; every item produced can be individual. Moreover this system can be placed within a traditional manufacturing framework. Automation tools within the AM workflow mean existing manufacturing companies (third party or in-house) can, with relative ease, integrate an AM product customisation solution[129]. With continued investment and innovation in customisation options, interfaces and sales channels a company offering this service, and being the first in their sector to offer said service, could become the market leader and win a significant market share over their competitors. Beyond this, even a minor AM offering could be used to generate Public Relations (PR) and brand awareness to increase sales in other departments. For example, *Selfridges* recently incorporated AM services into their product offering and offered promotional 3D printed *Selfridges Bags* and Mini-Me's in order to increase store traffic[130].

Design and scanning software is increasingly becoming available within the consumer market, specifically for tablets and mobile devices. Worldwide sales in tablets are set to overtake traditional Personal Computers (PCs) by 2015 at 349 million units sold against 263 million. (296 million PC's against 195 million tablets in 2013)[131]. This clearly demonstrates a significant opportunity for CAD developers and scanning software developers to focus efforts on delivering accessible, appropriately designed interfaces to the consumer. The state-of-the-art in this market is currently, and likely to remain for the foreseeable future. Autodesk's[132] suite of tablet

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127 Wohlers Associates Report 2014, *Service Provider Market* at http://wohlersassociates.com/2014report.htm at p. 116.

128 Forecasts are based on interviews with industry experts.

129 Materialise, Software for additive manufacturing at http://software.materialise.com/streamics

130 Wainwright O., 3D mini-me statues: 'This must be what Z-list celebrity feels like' (23 October 2013) *The Guardian* at http://www.theguardian.com/artanddesign/2013/oct/23/3d-mini-me-statues-models-printing

131 Rama G., *Gartner, Tablet Shipments To Overtake PCs by 2015* (27 March 2014) at http://rcpmag.com/articles/2014/03/27/tablet-shipments-to-overtake-pcs.aspx

132 For more about *Autodesk*, the web based software tools and implications for intellectual property laws, see Study I of this two-part Study: Mendis D., & Secchi D., '*A Legal and an Empirical Study of 3D Printing Online Platforms and an Analysis of User Behaviour*'.

based design and scanning software is an example of the current state-of the-art and market. These free-to-download 'apps' are targeted directly at the emerging consumer market, as well as 'makers', hobbyist and the so-called "prosumers" – consumers who purchase products that fall between professional grade and consumer grade standards. Within some of these apps also lies an export to print function, closing the loop within *Autodesk's* system from data creation to physical creation, which then stimulates consumer use and purchase of 3D prints from an ease-of-use perspective; "everything you need in one place" psychology similar to that exploited by *Amazon* and *eBay* with their 'one-click' purchase option via *PayPal*.

The Scale of the Market

With the increasing media attention surrounding 3D printing, consumers are facing greater exposure to the technology and the advantages that it provides. The most prominent of these advantages is the ability to personalise an object by the consumer, for the consumer, and in some cases, then fabricated by the consumer in their own home. A small yet growing industry has now surfaced to capture this fledgling market of consumer design makers.

In order to stimulate and then acquire this market, companies and business models have emerged to provide platforms that allow the layman to utilise 3D design software tools, which have until now been a complex and highly skilled process requiring significant training.

Rapid prototyping service "bureaus" are one such model well positioned to capture the emerging consumer personalisation market. Bureaus have been present since the late 1980's providing an industrial sub-contract service making rapid prototyping models for industrial clients involved in product development and low volume manufacturing. There is still a large industrial prototyping bureau market, however the players in this space have now expanded their services to offer higher volume Additive Manufacturing production, and part finishing, design and consultancy services[133].

Some of these established service bureaus have also developed web-based offerings where any company or consumer can source parts online by simply uploading design files. In 2013, the size of the market for printed parts sold by AM bureaus worldwide was valued at £649 million, with annual growth of 21.4% and an average of 25% annual growth over the last 3 years[134]. These bureaus, such as *Shapeways*, who were the first dedicated consumer service bureaus along with *iMaterialise* and *Sculpteo* amongst others, have significantly driven the consumer market by stimulating interest and providing an accessible means to produce personalised goods by file upload and providing a range of suitably priced materials.

More recently we have seen a further addition to the consumer bureau model with bureaus either hosting third party apps or developing their own in-browser design customisation applications or apps. These apps typically work by using a text input, component selection or modification parameters to create customised or personalised goods[135].

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133 As an example of multidisciplinary bureau, see Materialise at www.materialise.com

134 Wohlers Associates Report 2014, *Service Provider Market* at http://wohlersassociates.com/2014report.htm at pp. 114-115.

135 As an example of customisable 3D Printed jewellery, see Jweel at www.jweel.com

The most prevalent use for these customisation apps is the design and manufacture of jewellery. The apps drive consumer purchasing by providing an accessible means to customise 3D printing without the need to possess specific 3D design skills or software knowledge. Although almost all of these design apps are provided for free, hosting a bureau platform is beneficial as once the consumer finalises a design, selects a material and purchases the item, the host bureau acts as the manufacturer profiting from the ultimate part production.

Software accessibility (skill and cost) is perhaps the biggest step that requires addressing by companies seeking to monetise a customisation service based on AM. Companies can approach this issue with a variety of strategies. One can either, as with the popular consumer bureaus, invest in consumer level, demographically targeted in-browser apps such as those on *Shapeways* to generate a demand for additive manufactured goods. This will provide the app developer a profit from a mark-up on their in-house AM capacity.

Alternatively, 3D printer machine vendors can develop free downloadable software or apps that allow their domestic printer customers more opportunities to use their machines, thus increasing the demand for printing consumables which can then be purchased from the 3D printer machine vendor. Furthermore, as with *Autodesk*, software companies can monetise a portion of the 3D printing process via CAD software. In this case the development of free 'design-to-print' apps (downloadable, in-browser, mobile, tablet) will increase brand awareness and loyalty through user investment in skills. These software-specific skills can then be monetised by offering the 'loyal' market a premium CAD package with a greater degree of capability for a fee[136]. *Autodesk123D* is a prime example of software developed to stimulate growth in the consumer customisation market. 123D is a suite of apps for use on both desktop PC's and progressively mobile devices, deliberately targeting a rapidly growing mobile market. 123D covers a range of applications such as remixing meshes and sculpting[137] amongst others. Within these free-to-download apps lies the function to upload, share and export directly to a service bureau offering a range of manufacturing processes including laser cutting, Computer Numerical Control (CNC) machining and additive manufacturing. These pieces of software make it easier for consumers to transition from digital creation right through to physical creation via 3D printing; this is considered to be the most potent method for generating increased market growth through 3D printing.

Demand for personalised product data has also been driven by the increasing penetration and adoption of home consumer and prosumer 3D printing. A drop in the price of technology and a significant increase in the number of technology vendors now servicing the global market has driven this increase in adoption. Both of these factors contribute greatly to the rapidly increasing access to domestic 3D printers. One hundred thousand domestic printers have been sold to date, with 48,000 of those being the most popular domestic brand *Makerbot*. Worldwide sales of domestic 3D printers have grown with a unit sales growth over the past four years of 171.4%. Revenues from domestic printer sales worldwide increased 116.7% to £52,300,000[138] in 2013.

136 For various membership levels at Autodesk, see, https://www.123dapp.com/gopremium

137 See *supra* n.112.

138 Wohlers Associates Report 2014, at http://wohlersassociates.com/2014report.htm at p. 100.

Use Cases of Additive Manufacturing in Personalised Product Creation

The following examples describe a range of additive manufacture product offerings where the original design of the product is undertaken directly by the consumer based on their personal tastes and needs.

MakiLab

MakiLab is a 3D printed customisable doll company with its dolls or '*Makies*' exhibited in a variety of exhibitions including the London Design Museum. *Makies* are also cited in various magazines, journals and newspapers, yielding considerable brand and product awareness.

Makies are partly AM customised dolls which are designed by the consumer and are made using additive manufacturing. They are delivered as an out-of-the-box articulated doll, CE and Lion marked[139]. The dolls cost £69[140] which is substantially more than typical toy shop dolls at roughly £10-£20[141]. *MakiLab's* USP of consumer design, has led to a growing percentage of their sales coming from children or adults buying for children. Originally priced at over £100, *Makie* dolls will follow the declining price of AM and with time will reach a mass consumer price point.

The selling focus of this product, whilst still promoting the additive manufacturing aspect of the final product, is the element of customisation in the products design. *MakiLab's* business model could not exist without the low volume, individualised manufacturing nature that AM enables.

139 CE Marking is the verification by the manufacturer that a product meets EU health, safety and environmental requirements. The Lion Mark is a consumer symbol shows that a toy meets standards set by the British Toy and Hobby Association.

140 For more about Makie Dolls, see www.makie.me

141 As of 21st August 2014, the high street retailer "Toys R Us" offered 126 variations of Barbie Dolls. Of these, 42% were in the price bracket £10 - £20. www.toysrus.co.uk

N-E-R-V-O-U-S System

Nervous System – a design studio specialising in jewellery and art – is one of a small number of consumer product companies that have fully realised the design potential enabled by AM[142]. Unlike most other design companies, *Nervous System* has developed a unique design aesthetic stemming from algorithmic design generation. This means that designs are 'grown' from a variable set of mathematical parameters rather than pieced together from component parts or generated from pictorial or text based data. This approach means every piece is unique. Due to the complex and unique nature of the designs, there would be no other way to economically manufacture their products; AM is the only viable manufacturing technique.

UCODO

UCODO (User co-design objects) is a web based software tool developed by the company *Digital Forming*[143]. Through the UCODO website, consumers can access a variety of products, which they can customise using the UCODO toolset within set parameters. This business model and consumer psychology is at the heart of *Digital Forming's* attitude to future product retail; that everything will be customised by the consumer before purchase, and manufactured locally using digital fabrication technologies.

To clarify this attitude, UCODO has coined the term ODO (original design object) and CODO (co-design object). Both these terms explain both the process and future assumptions in product retail in an age of widely accessible AM. Firstly, *Digital Forming* enables product designers, artists or businesses to rapidly, and with minimal investment produce a customisable 3D printed consumer product. In varying price bands, *Digital Forming* will manage this process at a fee, enabling more businesses to enter the market, and subsequently charge a licence fee or percentage of revenue generated from sales. Secondly, the closed loop app can be embedded into the original designer's website, or linked to the UCODO store amongst many other personalisation apps. Finally, consumers can access this app and generate a CODO, which can then be purchased and sent to print via *Digital Forming's* links to various 3D printing bureaus.

This process is a working microcosm of how the majority (mass media and public) view the future of retail and manufacturing; infinite customisation, re-shoring of manufacture and an almost total transition into digital retail[144]. Realistically, this total radicalisation of global retail supply chains will not happen within the first half of this century, mainly due to the relatively high cost of AM production methods when compared to traditional manufacturing using existing, well established supply chains.

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142 For more about Nervous System and the design of jewellery and art, see http://n-e-r-v-o-u-s.com See *also*, Hoskins S., *3D Printing*: *For Artists, Designers and Makers* (London: New York: Bloomsbury; 2014), pp. 100-101. The two co-founders of *Nervous System* graduated from MIT and together specialised in Architecture, Biology and Mathematics. This creative and technological partnership is the driving force behind *Nervous Systems*' design strategy.

143 For more details about UCODO, see http://www.ucodo.com/Home/About

144 Thompson S., 3D Printing, is it really all that (16 October 2012) *New Statesman* at http://www.newstatesman.com/economics/2012/10/3d-printing-it-really-all

The Limitation to AM Adoption Within the Consumer Goods Market

Some products lend themselves to customisation via AM by virtue of their design, use, price or material. For example, a poor product choice for an AM customisation solution would be garments and clothes. There has been work done in the field of 3D printable, wearable clothing, but these are usually of an either artistic, research or proof-of-concept nature[145,146]. For example, Janne Kyttanen's 3D printed chainmail 'fabric', are avant-garde in nature and more suited to catwalks and exhibitions. But aside from an aesthetic exclusivity, the price point for such items is high compared to even high-end more traditional high street brands such as *Jaeger*, *Karen Millen* and *Reiss*. So a combination of manufacturing costs and cutting-edge aesthetic style relegate 3D printed garments to an exclusively niche market[147].

Those that are better suited to AM customisation include jewellery, accessories, headwear and shoes due to their size and complexity, as there is a direct correlation between part size and cost. As such, smaller objects like jewellery are more reasonably sized and hence more economical in a competitive product market. Examples of companies providing customised AM jewellery, accessories and shoes include *Nervous System, Jweel, Continuum Fashion, Freedom of Creation, Freakin' Sweet Apps, Mymo* and *Electrobloom* amongst others. These companies produce affordable products with a varied customisation capability, in a variety of low cost to precious materials. The price for these products relative to the design aesthetic of AM products makes them competitive within a fashion product market.

Toys are another example of how smaller objects can stand to benefit from AM by virtue of their diminutive size. Children's toys ranging up to 1:6 12" (standard action figure size) are within an economic printing size to be competitive in the toy market.

Additive manufactured home wares are less prevalent than fashion or toys, partly because of the economies of scale mentioned previously. Most items in the home are neither small nor made entirely from plastics. This means the range of home products viable in a mass consumer market are small, and feature mainly vases, cups, small storage and lighting fixtures. There are examples of larger pieces such as furniture, but these are typically concept models or artistic pieces, which have been commissioned or exclusively designed as limited runs[148]. *Assa Ashuach Studios* and *Freedom of Creation (FOC)* both service this market, providing high-end AM design studio services to clients and commissions. Some online stores such as Materialise MGX do feature larger pieces such as furniture and large lighting pieces, but these are far above what the majority would or could afford to pay for that category of product on the high street[149].

145 Kyttanen J., 3D prints essential travel items with Lost Luggage Kit, Dezeen Magazine at http://www.dezeen.com/2014/05/07/janne-kyttanen-3d-printed-lost-luggage-kit/

146 N12 Bikini, Continuum Fashion at http://continuumfashion.com/N12.php

147 As of 21st August 2014, the Freedom of Creation Drape dress retailed for £1179 at http://cubify.com/Store/Design/AA8wgScGs54M. In contrast, dresses sold by high street retailer Reiss ranged from £48 to £495 at http://www.reiss.com/womens/dresses/

148 For more about 3D Printed furniture, see Designer Daily at http://www.designer-daily.com/10-ingenious-furniture-designs-made-with-3d-printing-33685

149 As of 21st August 2014, the Chaos table lamp from Materialise MGX was £396 at www.mgxbymaterialise.com Similar sized lamps from homeware store *Ikea* range from £2.75 to £110. See www.ikea.com

Moreover, these products are designed by professionals with experience in AM processes with no design input from the consumer. Apart from MGX and FOC, other companies do provide more affordable AM home wares and allow for product personalisation, such as *Cubify*. The *Cubify* website has adapted over time to become an online marketplace retailing AM fashion, home ware and toy products[150]. *Cubify*, aside from retailing lower priced goods, also offer free download options for selected products, intending for them to be printed on a *Cube* home 3D printer which can also be purchased through the *Cubify* site.

With regards to AM home wares, it is anticipated that this market will not expand in any great significance until a broader range of affordable AM processes with greater levels of capability are provided for.

The Industry Viewpoint

in order to understand the impact that 3D printing and consumer personalisation could have on high value small status products, a range of designers, academics and thought leaders were interviewed for this research[151,152,153]. There were some differences of opinion on the importance of 3D printing and AM in enabling mass customisation. Some commentators believed that the technology was key to the growth of the industry whereas others felt that it was merely a tool that happened to be well suited to low-volume manufacture, but that was not essential to mass customisation.

The commentators that were interviewed for this case study were confident that mass customisation and product personalisation would disrupt a wide range of businesses, forcing them to change their existing business models. It is believed that an increase in widespread access to technology and data, such as 3D printing equipment, open source hardware and online repositories of shared data, will create new infrastructures that enable consumers to manufacture low volumes of products locally, without the need for large capital investment.

It was commented several times that existing business models are ill-equipped to deal with mass customisation using either AM or 3D printing and that although there are clear business benefits, there are no major, established brands which have introduced a comprehensive mass customisation model. The only model that exist at the moment is used for marketing purposes. This means that there is a risk that a parallel consumer model may begin to emerge, competing against traditional business models of mass manufacture that will utilise digital manufacturing tools to enable consumers to produce their own parts.

However, as one commentator noted, producing parts using 3D printing requires skill and this requirement is only going to increase as designers produce increasingly complex models. An analogy that was provided is that there are a huge number of sewing-machines around the world and yet only a small proportion of machine owners make their own clothes, due to the high level of skill required. The size of the parallel consumer model may therefore be constrained by the difficulties of engaging in this process.

150 For more information about Cubify, see www.cubify.com

151 Interview with the Co-Director of the MIT Smart Customisation Group (June 2014).

152 Interview with Founder of Continuum Fashion (June 2014).

153 Interview with Founder of UCODO (June 2014).

Conclusions and Recommendations

In conclusion, it is clear that both industrial additive manufacturing and consumer 3D printing provide routes to market for products that have been designed by the consumer and that, over time, online software tools and cloud computing will make co-design possible.

However, this will, for the foreseeable future, remain only a small proportion of the market place and be constrained only to physically small sized and high value products, such as jewellery and art. This is due to the high cost of additive manufacture, the low capabilities of consumer 3D printing and the lack of truly flexible and intuitive consumer focused design tools. It is expected that over time, the cost of industrial additive manufacturing will fall, which will open up the market for more affordable products, but this will take some time - possibly another decade - given the current trajectory of technological development. Similarly, the capability of home 3D printing technologies will remain limited for many years, with current technologies lacking in accuracy and scale and in the ability to produce truly robust parts in a sufficient variety of materials to make desirable consumer products.

It is however expected that consumer orientated software tools will develop significantly in the coming years, through increased awareness by software vendors relating to design and personalisation demands. Furthermore, the technical skills level of consumers will increase in relation to the use of web-based toolsets. This in turn will increase creativity driven through the resurgence of making products within the home and community.

As it is predicted that the manufacture of consumer-designed products using AM technologies will be used primarily for high value items such as jewellery, this will result in the digital 3D models having a high value associated with them. Designers will want to prove that they are the original creator of the product, even if the consumer has modified it. On the other hand, consumers will seek assurances that the provenance of the customisable design is authentic. Additionally, the consumer may also seek guarantees that their product is truly unique, and that their personal design is not going to be replicated elsewhere by the designer or manufacturer. To this end, developing AM-specific Technological Protection Measures (TPM)[154] as discussed previously[155] is recommended. These would ensure that the value of the product remains with the designers, manufacturers and consumers.

154 Rightsholders use Technological Protection Measures (TPMs) to prevent any use of the work, which has not been authorised by them. TPMs are themselves legally protected as a form of quasi-copyright. See also, Directive 2001/29/EC (*infoSoc Directive*).

155 For further details regarding the use of TPMs to protect printable files, see the recommendations made within the Automotive Aftermarket case study, p. 21.

Case Study IV:

Scanning and Reverse Engineering: Taking the Tangible Back into the Electronic

This case study evaluates the impact that scanning technologies could have on intellectual property rights. The study looks at the scanning technology that is available today for both consumers and professionals and questions their impact and ability to easily generate digital models of existing physical objects.

What is Scanning and Reverse Engineering?

Scanning technologies offer an alternative solution to creating digital content from existing physical objects – a technique commonly referred to as "Reverse Engineering".

Although scanning technology has existed for approximately thirty years, the industry is experiencing high growth as a result of the emergence of low-cost systems; improved scanning capabilities; and the increased availability of data storage and data processing capabilities. A wide range of industries are now embracing this technology, including medical, automotive and the creative industries, as well as hobbyists and consumers.

Companies such as *Google*[156] and *Microsoft*[157] have incorporated scanning technologies into their products. Moreover, there has recently been a surge in consumer-focused scanning devices such as the *Makerbot Digitizer* and the *3D Systems Sense* with many of these systems targeted at the home 3D printing user market[158]. Scanning has also caught the attention of the media as a result of devices such as the *Fuel3D* and *Matterform* scanners, which have been launched through popular crowd-funding websites[159]. This media interest has already caused many to question how widespread 3D scanning capabilities, combined with 3D printing, will impact intellectual property rights[160].

At the other end of the spectrum, accessibility to professional-grade scanning systems is increasing, enabling start-ups and small businesses to realise new opportunities. Niche markets have opened up paving the way for the scanning varied items from classic cars[161] to family pets[162].

156 The Google Project Tango mobile device incorporates multiple cameras for 3D scanning. https://www.google.com/atap/projecttango/#project

157 The XBox Kinect device can easily be used as a 3D scanner and is one of the most popular low cost scanners available.

158 For more information about consumer 3D scanners, see http://3dprintingindustry.com/3d-scanner/

159 In September 2013, the Fuel3D scanner successfully raised $325,343 through crowd funding website Kickstarter, with a campaign target of $75,000.

160 Mendis D., Clone Wars: Episode II –The Copyright Implications relating to 3D Printing and Computer-Aided Design (CAD) Files [2014] 6(2) *Law, Innovation and Technology* pp. 265-281.

161 Companies such as 3D Engineers specialise in scanning classic cars for restoration purposes, at www.3dengineers.co.uk

162 Companies such as Captured Dimensions enable scanning of pets, at www.captureddimensions.com

At present, there are two key types of consumer scanners available: table-top scanners in which the object is placed on a turntable and handheld scanners in which the user moves the scanner around the object. The type of scanner that is being used affects the type of product that can be scanned, with table-top scanners being more suited to scanning small objects and handheld scanners more commonly being used to capture larger objects[163].

Due to the accuracy and size limitations, table-top scanners are primarily being used to recreate non-functional, decorative objects to support hobbies and gaming. The top ten most popular models on online platform *Thingiverse* that have been scanned using a table-top *Makerbot Digitizer* are exclusively models of gnomes and animals figurines[164].

Handheld consumer scanners are much better suited to capturing data from large objects and, as such, are widely used to scan the human body. This allows people to create digital versions of themselves, which they can then print or that can be used as a digital avatar for computer gaming purposes[165]. Members of the 3D printing community have used this technique to produce models that can be used, for example, as wedding cake toppers. It should be noted however, that only certain scanners are able to collect data about the colour of an object and there are no consumer-grade 3D printers that can print in full colour. Consequently, printed models of humans made on consumer 3D printers are likely to be single-colour prints.

Beyond consumer scanners, the professional grade systems are able to scan much more complex objects with greater accuracy[166]. They have found use in scanning a wide range of objects, large and small, in industries such as healthcare, archiving and restoration, automotive, marketing and film making.

Scanning technologies could therefore allow consumers to recreate any object, without having access to manufacturer's digital files. This could put designers and manufacturers at risk of widespread intellectual property infringement. However, the limitations in the capabilities of today's scanners could mitigate this risk for the foreseeable future.

The Scale of the Market

Although scanning technology was first developed in the 1960's, it was not until the mid-1980s that the technology began to develop rapidly. The 3D scanning market was estimated at £1.37 billion in 2013; with a Compound Annual Growth Rate (CAGR) of 14.6%. This is expected to grow to £2.71 billion by 2018[167]. In comparison, the 3D printing market is expected to reach £8.31billion by 2018[168].

163 An example of a tabletop scanner, the Makerbot Digitizer, can be seen at http://www.makerbotuk.com/digitizer.html

164 Most popular scanned items on Thingiverse, as at 20th August 2014: http://www.thingiverse.com/search/prolific/things?q=digitizer

165 An example of a handheld scanner can be seen at http://cubify.com/Products/iSense

166 For examples of professional grade scanning systems, see www.faro.com

167 3D Scanning Market: *Worldwide Market Forecasts and Analysis* at http://www.marketsandmarkets.com/Market-Reports/3d-scanning-market-1110.html. Compound Annual Growth Rate is the year-on-year growth rate over a specified period of time.

168 Wohlers Associates Report 2014.

In addition to using scanning technologies for 3D printing purposes, 3D scanning is expected to be necessary for the growth of virtual reality devices; for example, the device could be used to detect the user's surroundings and then superimpose this into the gaming environment[169]. With the incorporation of this technology into popular consumer devices such as smartphones, developers will have the ability to create much more complex scanning apps and software than is currently available, thus driving the market.

The Barriers to Scanning Adoption

There is a common misconception that reverse engineering via scanning enables the user to quickly and easily generate a digital file for printing, in a similar way to using a photocopier. In an ideal world, this could then be sent directly to a 3D printer for exact replication. In reality, this is rarely the case as digital models generated by the scanning process are typically of very poor quality.

Although errors in scanned digital models can be rectified, this can be a highly complex procedure, requiring skill, time and expensive software; often the scanning element is only a small part of the reverse engineering workflow. The diagram below shows the 3D scanning workflow prior to 3D printed part production.

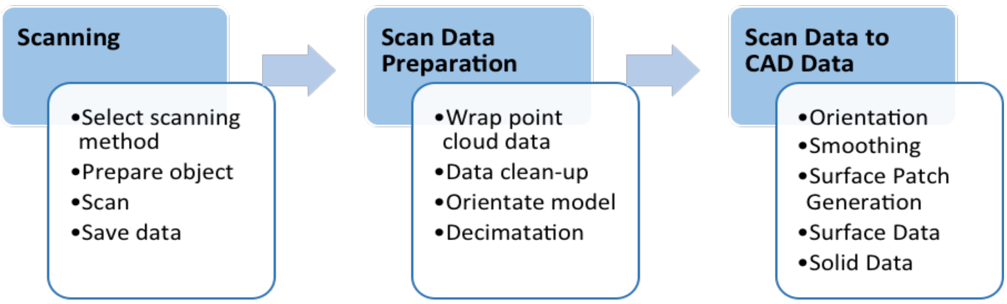

Figure 1: Workflow for scanning an object

As can be seen, this is not an instantaneous process; it requires skill and specialist resources to obtain a useable, printable file. This is currently a barrier to the widespread adoption of scanning technology and will remain so until there is a more simplistic workflow.

169 Szabo C., Korecko S., Sobota B., Processing 3D Scanner Data for Virtual Reality (2012) 26(1) *Advances in Robotics and Virtual Reality*, pp. 333-361.

The Industry Viewpoint

To gain a deeper insight into the scanning market and its applications within AM, experts from within the industry were interviewed about their views on the state of the scanning market; issues regarding intellectual property implications; and the future of the technology[170,171].

There was a general consensus that the 3D printing market is driving the growth in the scanning market and that there is a natural fit of scanning technology with AM and consumer 3D printing technology. Areas of particular growth that were noted were in the archiving industries and in the toys industry. However, each expert was keen to stress the limitations of consumer scanning systems today and, because of this, the low threat to intellectual property rights.

Interviewees strongly emphasised that, although the professional grade machines are capable of producing high quality scans, the consumer-grade scanning systems have limited capabilities and, therefore, limited potential. It was stated that low-end systems cannot achieve an exact digital replica of a product. The industry experts also stressed the limitations of existing scanning systems with regard to the amount of data that they can capture. For example, low-end systems can only scan the external features of a product, which means that they cannot capture the internal details of a product. Additionally, the systems lack the intelligence to recognise component parts within an assembly. These limitations restrict the number of useful applications for scanning and printing products. It was noted that this reduced capability is expected to clash with customer expectations – both from professional users who have experience with capable, high-end systems as well as from novice consumers who have unrealistic expectations – which could lead to disenchantment with the technology.

With regard to intellectual property infringement, it was noted that at present, the type of products that are being scanned and printed are not products that could be reproduced exactly and therefore are not likely to harm intellectual property owners. Luxury goods, for example, would be difficult to replicate using this technology. This is primarily due to low scanning and printing capabilities.

With regard to the future of the scanning industry, each commentator expected the market to grow in parallel with the printing market; it was even stated that the adoption rate of scanning technology could be equal to that of 3D printers and that new printing systems could incorporate scanning technology. It was also predicted that consumer devices such as mobile phones with embedded 3D scanning technology would significantly influence the market.

It was further mentioned several times that brands and designers will need to proactively address the risk of consumers infringing intellectual property rights through the use of scanning technologies. However, by developing legitimate channels through which consumers can purchase authorised digital copies, the risk of infringement can be mitigated. The difficulties involved in scanning a replacement part are substantial. Recognising such challenges, the experts were of the opinion that consumers will only resort to scanning methods if there is no other way to access the part.

170 Interview with Commercial Director of *Fuel3D* (June 2014), a consumer scanner manufacture. More information at http://www.fuel-3d.com

171 Interview with Founder of *Flexiscale* (June 2014), a model train company that uses scanning to produce products. More information at http://www.flexiscale.co/

Interestingly, all the commentators said that the most important area for scanning growth was in the education sector, as children will become more confident with scanning and printing technologies, thus driving the demand for these systems. In addition, the applications for which children will use scanning will not be technically demanding and therefore quality and accuracy issues will be less important. As one commentator said "the excitement of printing stripy *Lego* overcomes any concerns over quality" which will not be a viewpoint that will necessarily be shared by the brand owner trying to maintain their market position based on quality.

Conclusions and Recommendations

Consumer-level scanning and 3D printing technology today is not currently capable of producing exact replicas of objects and it will be a significant number of years until the technology is capable of this. Due to the poor quality of the digital models that are created and the type of products that are being scanned at present, brands and designers are likely to be unconcerned about the impact that scanning will have on their business and the risk of infringement of their intellectual property. However, organisations that have intellectual property rights over objects that could potentially be 3D printed should begin to consider developing legitimate channels through which they can provide consumers with access to legal downloads of their products for 3D printing. They may wish to do this using data files with embedded Technological Protection Measures (TPM) systems as mentioned above.

The capabilities and opportunities, which are made possible by scanning technologies, will entice users to replicate products that are protected by intellectual property laws. As such and as mentioned above, a legitimate channel of providing consumers with access to legal download will become ever more important. This could come about in the form of a one-stop-shop, similar to the *iTunes* model, as mentioned in Study I of this two-part study[172] or though licensing CAD files, which will avoid a possible monopoly situation borne through a one-stop-shop. Ultimately, what is more important is the regulation of CAD data files and the traceability of such files. In this regard, it is recommended that the focus of regulation be placed on the CAD data files as opposed to the 3D printers. The significance of the current proposition can be clarified by drawing a parallel to the *iPod/MP3 revolution*. In drawing on this analogy, it is clear that it was more important to monitor the download and sharing of MP3 files rather than regulate MP3 players such as *iPods*. The same is true in the current 3D printing landscape. Rather than focus on the regulation of the hardware such as 3D printers, it will be more important to place emphasis on the regulation of the digital CAD files.

172 Additional recommendations based on a study of the use of online 3D printing file sharing platforms are provided in Part I of this two-part Study: Mendis D., & Secchi D., *'A Legal and an Empirical Study of 3D Printing Online Platforms and an Analysis of User Behaviour'*.

HIGH VALUE, SMALL STATUS GOODS

INTRODUCTION TO HIGH VALUE, SMALL STATUS GOODS

There is an ever-growing market for products, which are termed "high value, small status" consumer goods[173]. These products include branded collectables such as historical toys, keepsakes or giveaways, personalised figurines or avatar characters generated from computer games data. Other high value small status products could include home ware such as vases, ornaments or curios such as paperweights.

The market for high value small status goods is not new; with many household names such as ceramics companies *Wedgwood* and *Spode* producing high value 'collectables' all the way from the Victorian period. However, given the low volume high value nature of these products they were typically produced by hand using significant levels of manual labour. It is this low-volume high value niches that 3D printing and AM is now able to fulfil, as the need for manual labour is replaced with process automation.

Given that the new high value small status supply chain can now be driven by digital data rather than manual dexterity and skill, it is important to consider how new products can be both monetised and protected. The traditional factory can be replaced by a 3D printer in the home or through online access to a professional AM platform. Moreover, the enabling digital data can easily be duplicated and passed from consumer to consumer with no recourse to the data originator or owner.

This case study will examine high value small status products that are being derived from digital data produced within computer games, along with digital data being produced by professional artists and digital artisans.

173 Frank R., What the Wealthy Collected While the Market Slept (12 March 2013) *CNBC* at http://www.cnbc.com/id/100545945#

The Current Intellectual Property Position of Digital Data Relating to 3D Printing

Writing a computer program involves the expression of an analysis of the functions to be performed as a set of algorithms (set out as a flowchart); followed by its restatement (by a programmer and/or by a computer) in computer language (the source code); and finally the translation by a computer running under a compiler program of the source code into a machine-readable language (object code)[174] which will result in a computer program at some stage[175]. As such, it can be a complex process.

The current intellectual property framework provides for some clarity in relation to computer programs, including computer games and characters and protection is provided at both EU[176] and UK level[177]. The law states that computer programs, including their preparatory design material are protected by copyright as literary works[178].

174 Waelde et al., *Contemporary Intellectual Property: Law and Policy* (Oxford: Oxford University Press; 2014) pp. 64-65.

175 *Ibid*.

176 EU Software Directive 2009/24 Of The European Parliament And Of The Council of 23 April 2009 On The Legal Protection Of Computer Programs provides for this protection. Directive 2009/24 repealed Directive 91/250 on the legal protection of computer programs. Article 4 of the *World Intellectual Property Office (WIPO) Copyright Treaty 1996* uses the same formulation as Directive 2001 which is also implemented in Directive 2009. Such provisions are also on a par with Article 10 (1) of the *Agreement on Trade-Related Aspects of Intellectual Property Rights 1994*, (the TRIPS Agreement). *See also*, Report From The Commission To The Council, The European Parliament And The Economic And Social Committee on the implementation and effects of Directive 91/250/EEC on the legal protection of computer programs, Brussels, 10.04.2000 COM(2000) 199 final at p. 9.

177 Computer programs were first protected in law by *Copyright (Computer Software) Amendment Act 1985. Today protection is afforded under the Copyright, Designs and Patents Act 1988 (as amended)*.

178 Within the meaning of Article 2 of the *Berne Convention for the Protection of Literary and Artistic Works 1886 (as amended September 28, 1979). See also, Case C-406/10 SAS Institute Inc., v. World Programming Ltd* [2012] ECDR 22 (ECJ) at para. 40: *"to accept that the functionality of a computer program can be protected by copyright would amount to making it possible to monopolise ideas, to the detriment of technological progress and industrial development"*.

Implications for Copyright Law

A computer program is capable of protection and is considered 'original' in the sense that it is the authors' own intellectual creation. No other criteria are applied to determine its eligibility for protection[179] except for two limitations established in the case of BSA[180]. In this case, the Court stated that the functionality of a computer program is not protected by copyright; nor are the ideas and principles including those, which underlie its interfaces[181], are protected[182]. Functionality of a computer program can however be protected by patent law and is considered below in this discussion.

In the UK, computer software as a subject matter was first recognised by law under the *Copyright (Computer Software) Amendment Act 1985*. Today computer programs receive protection under the *Copyright Designs and Patents Act 1988* (as amended) (CDPA 1988). However, a computer program is not defined under CDPA 1988. Although in the UK, a computer program receives protection under copyright as a literary work, a legal definition of 'originality' for the purposes of such a computer program is lacking. The law continues to apply the 'skill and labour' test which is an overarching definition for all types of copyright works and as such it remains to be seen whether this will lead to an over-extensive protection of computer programs in the UK"[183].

Within a 3D printing context, the relevance of this protection applies to the CAD file or design document, which embodies the definition of a computer program. A CAD file and its embedded data for example – may be considered a literary work under copyright law[184]. In the case of *Nova v. Mazooma Games Ltd*.,[185] Jacob LJ referring to the Software Directive implemented by the *Copyright, Designs and Patents Act 1988* (as amended) confirmed that for purposes of copyright, the program and its preparatory material are considered to be one component as opposed to two. From a computer games point of view, it has been established that source code is protectable as copyright[186] and a computer game simulating a game of pool is also considered a computer program, protected by copyright[187].

179 Council Directive 2009/24/EC Art 1(3).

180 *Bezpecnostni Softwarova Associace — Svaz Softwarove Ochrany v. Ministerstvo Kultury* [2011] ECDR 3 at para. 37.

181 Laddie, Prescott and Vitoria, *The Modern Law of Copyright and Designs*, Part II: Copyright and Related Rights, (4th ed.) (London: Butterworths Law; 2011) 'Computers and Copyright' at p. 1505: *"An interface refers to information which allows a person, a computer, computer program, to communicate with a computer program. In the case of device drivers, the interface can be as primitive as a set of numbers which are the locations in the memory chip of the beginning of the useful functions which the driver provides."*

182 Council Directive 2009/24/EC Art 1(2).

183 Report From The Commission To The Council, The European Parliament And The Economic And Social Committee on the implementation and effects of Directive 91/250/EEC on the legal protection of computer programs, Brussels, 10.04.2000 COM(2000) 199 final at page 10.

184 Section 3(1)(b) CDPA 1988.

185 [2007] RPC 25.

186 *Ibcos Computers v. Barclays Mercantile Highland Finance* [1994] FSR 275.

187 *Nova Productions Ltd., v. Mazooma Games Ltd*., [2007] RPC 25 (CA).

However where the data extraction and printing process goes beyond the control of the software authors', issues can arise. This was seen in the case of *Fabjectory*, which allowed 11 million subscribers of the *metaverse* game 'Second Life' to have their personally designed avatar characters printed in full colour[188]. It was questionable whether Linden Laboratories (creators of Second Life) had any control over the printed avatar characters' intellectual property and *Fabjectory* was ultimately short lived.

However more success was experienced by *FigurePrints* (see below) in 2008 who under licence from games developer Blizzard Entertainment, took 3D character data from the online game "World of Warcraft" to print gamer's avatars in full colour using 3D Systems printers (formally Z Corporation). Once printed, the parts were then boxed and shipped directly to the customer by *FigurePrints*. *FigurePrints* presents a very similar business model to that of *MakiLabs* as discussed in earlier case studies.

Over and above 3D printing avatars and characters drawn from computer games (considered below under trade marks), the unauthorised 'modification' of a CAD file can lead to an infringement of copyright[189]. In the context of the law and computer programs, this means an arrangement or altered version or a translation[190]. This was established in cases such as ***John Richardson Computers*** and subsequently in *Ibcos Computers*[191] and *Cantor Fitzgerald*[192]. In the latter case, Pumfrey J., stated that the substantiality of what had been taken has to be judged in relation to the criteria for the originality of the copied work; the extent to which the skill and labour of the first author has been taken[193].

However it is important to note that elements such as the logic, algorithms and programming language lying behind the source code will be unprotectable as they comprise ideas and principles – not the expression of those ideas, needed for copyright[194] which has prompted intellectual property experts to question whether copyright law is the best way to protect computer games[195].

188 *See infra*, p. 55.

189 See Study I of this two-part Study: Mendis D., & Secchi D., *'A Legal and an Empirical Study of 3D Printing Online Platforms and an Analysis of User Behaviour'*.

190 *Copyright, Designs and Patents Act 1988 (as amended)* s. 21(3)(ab), (ac). For the purpose of a computer program, "translation" includes a version of the game, which is written into or out of a different code (or computer language). *See, Copyright, Designs and Patents Act 1988 (as amended*) s. 21(4).

191 *Ibcos Computers v. Barclays Mercantile Highland Finance* [1994] FSR 275 as per Jacob J at p. 302: Jacob J found infringement as it involved line-by-line copying of certain routines and substantial parts of the structural elements.

192 *Cantor Fitzgerald International v. Tradition UK Ltd* [2000] RPC 95 (Pumfrey J).

193 *Cantor Fitzgerald International v. Tradition UK Ltd* [2000] RPC 95 (Pumfrey J).

194 *Navitaire Inc., v. EasyJet Airline Co Ltd.*, [2006] RPC 3.

195 *See*, Gordon S., The Very Idea! Why Copyright Law Is An Appropriate Way To Protect Computer Programs [1998] *European Intellectual Property Review,* pp. 10-23.

Implications for Patent Law

Article 52(2) of the *European Patent Convention* (EPC) 2000, equated in section 1(2) of the ***UK Patents Act 1977*** states that computer programs are excluded from patentability "as such". However, it has been debated that this is somewhat illusionary and the European Commission confirmed in 2002 that the European Patent Office (EPO) had granted over 20,000 computer-implemented inventions[196]. The inconsistency in approach can be illustrated with reference to *Viacom*, where the Board of Appeal expressly stated that a computer program itself was not patentable[197]. Furthermore, In *Shopalotto.com's Application* 2006[198], Pumfry J., showed inconsistency with the EPO approach when considering the real question to be whether there is a technical effect that contributes to the art over and above that to be expected from the mere loading of a program into a computer. He reasoned that in considering if the only contribution to the art lies in excluded subject matter, then it is not patentable[199]. However the more recent decision in *Halliburton* clarifies the position. In this case, Judge Birss stated:

> "It is far from clear to me that the EPO's approach when applied as a whole and correctly is any more favourable to patentees than the UK approach. However, self evidently the law is not concerned with the attitude of either Office. The difficulties perceived in the UK with the way the EPO now approaches computer implemented inventions are genuine jurisprudential concerns of respectful nature. As a matter of law computer implemented inventions are just as patentable in the UK as in the EPO. The Patents Act is in accordance with the EPC in that both contain an exclusion for computer programs as such"[200].

A reading of the above quote illustrates that the interpretation that Pumfry made in *Shopalotto* may have diverged from that of the EPO; however the more recent decision in *Halliburton* corrected the current approach.

Implications for Trade Mark Law

Elements of a computer program, particularly elements such as characters, symbols, name, logo and colours amongst others can also be protected under trade mark law[201.] This is particularly relevant in relation to the 3D printing of characters – or avatars – as discussed in the case studies relating to *Fabjectory* and *FigurePrints* discussed above and below[202].

In respect of registered marks, use of a trade mark by players within a computer game is unlikely to constitute infringing "use" for the purposes of section 10(4) of the *Trade Marks Act*

196 European Commission, Proposal for Directive of the European Parliament and of the Council on the patentability of computer-implemented inventions, COM (2002) 92 final, 20.02.2002, page 2.

197 *Viacom* [1987] EPOR 74 at para. 81.

198 *Shopalotto.com's Application* [2005] EWHC 2416 (Pat); [2006] RPC 293.

199 *Shopalotto.com's Application* [2005] EWHC 2416 (Pat); [2006] RPC 293, note 6, paragraph 9.

200 [2011] EWHC 2508 (Pat); Appeal Nos: CH/2011/0154.

201 "Any sign capable of being represented graphically, particularly words, designs, letters, numerals, sounds, shape of goods or the packaging thereof, as long as it is a sign that is capable of being represented graphically and the mark is capable of distinguishing the goods or services of one firm from those of others" – section 1 *Trade Marks Act 1994* (as amended).

202 See *infra* pp. 75-79.

1994, since the mark is not being "affixed" to goods or packaging, nor being used for import, export, or advertising purposes"[203]. Section 10(4) of the ***Trade Mark Act 1994*** provides a non-exhaustive list of examples when a sign which is identical to a registered trade mark is "used"; e.g. affixed to goods or packaging, offers to supply or market, import / exports, use the sign on business paper.

Issues also arise in relation to character merchandising. For example, in the case of *Mirage Studios v. Counter-Feat Clothing Ltd*.,[204] the defendants applied images of the popular *Teenage Mutant Ninja Turtles* characters to clothing products without having a licence to do so. In this case the Court held that it was passing off. "Even where the character or personality is already being used under licence to market goods, English judges have argued that the use of the image is not seen by the public as a representation of a connection with, or authorisation by, the originator of the character in question or by the personality. If there is a false claim of authorisation – for example, a claim that the merchandise is 'official' – then, but only then, may there be a misrepresentation"[205].

More recently in *Betty Boop* - *Hearst Holdings Inc., v. AVELA Inc*.,[206] Birss J.'s findings suggested that, although characters ***per se*** cannot be registered, protection of a brand or a mark might extend beyond the specific words and device registered where substantial reputation and goodwill has been created and consumers have been educated to believe that an official source of that character merchandise exists.[207]

In *Sieckmann v. Deutsches Patent-und Markenamt*[208], the ECJ developed a test for graphical representation, in that images, lines and characters must be clear, precise, self-contained, easily accessible and objective.

> "The importance of brands is linked to the traceability of a product or service at a given source and the reputation that is recognised. As part of the software distribution features, the ensemble of functionality, interfaces, security, architecture and performance help create the user experience that is then associated with a particular source or project. The relationship between brand and quality is reflected in the trade mark licences area."[209]

The law of trade marks has mainly been used in this area to protect characters. As seen in the *FigurePrint* scenario where the data is licensed it can lead to a successful outcome although the situation could be different in relation to merchandise of those characters from video games. In this respect, it can be argued that 3D printing is no different to 2D printing where copyright must be acknowledged and respected accordingly.

203 Lee P., Heroes or villains? Marvel Seeks To Enforce Image Rights In Online Gaming (2005) 16(6) *Entertainment Law Review* pp.159-161 at p.160.

204 *Mirage Studios v. Counter-Feat Clothing Ltd*., [1991] FSR 145.

205 Waelde et al., *Contemporary Intellectual Property: Law and Policy* (Oxford: Oxford University Press; 2014) pp. 778-779.

206 [2014] EWHC 439 (Ch) (IPEC).

207 Mehta K., & Shaw K., Betty Boop: Hands Off, She's Mine! Hearst Holdings Inc v. AVELA Inc. [2014] 25(4) *Entertainment Law Review*, pp. 163-165, p.165.

208 *Sieckmann v. Deutsches Patent-und Markenamt* (C-273/00) [2003] 3 WLR 424.

209 Guarda P., Looking for a Feasible Form of Software Protection: Copyright or Patent, is that the question? (2013) *European Intellectual Property Review* 35(8) pp. 445 – 454 at p.445.

Case Study V:

Realising the Virtual to the Physical: Computer Games & Computer Generated Imagery (CGI) Studios as a Data Source

This case study considers the intellectual property implications of extracting printable data and content from sources of computer-generated imagery (CGI) such as computer games. This case study has been selected for investigation as the gaming and CGI industries offer a wealth of content that could be used to create printable 3D models.

What are the Opportunities for High Value Small Status Goods Presented by Computer Games?

Many computer games already use complex three-dimensional software to represent characters or 'assets' within the on-screen environment. Moreover, many major films also use 3D Computer Generated Imagery (CGI) as part of film production, promotion and advertising. These assets can now be digitally extracted from the computer world and used as input data within consumer 3D printing and industrial additive manufacturing[210].

Games publishers and CGI Studios have vast libraries of 3D models that can be extracted for printing using AM technology, enabling fans and collectors to own unique and personalised models. Although there have been some cases of users extracting data from games using home printers, the poor quality of these prints means that the models have limited appeal to collectors. Instead, intellectual property owners have engaged in licensing agreements with AM service providers to offer higher quality prints.

In some cases, data can be extracted by game players from PC and online games and used to drive local 'home' printing. In other cases, data can only be taken from gaming servers from where it is transferred securely to AM facilities.

As interest in consumer 3D printing grows, the cost of accessing higher fidelity printing services will fall and online web based printing services will become more accessible. As such, the ability to produce ever more realistic models will increase. This may drive collectors and consumers away from mass-produced merchandise towards lower volume, personalised and AM produced products.

Accessible AM will pave the way towards more intuitive and immersive gaming experiences, where gamers will play an ever more important role in character design. As online design and data manipulation tools grow in capability, it will be more and more likely that the 'consumer' will demand a higher degree of manipulation to the characters they play with. This will ultimately lead to the point where the customer not only edits existing design data, but also generates it, which then leads to the question of who is in control of the intellectual property.

210 See examples from *Figureprints* http://www.figureprints.com and Fabzat http://www.fabzat.com/en/

Use Cases of Additive Manufacturing and Computer Gaming

The first example of AM being used to provide consumers with a personalised product made using computer game data was established by Mike Buckbee in 2006[211]. Buckbee developed *Fabjectory*, which allowed 11 million subscribers of the metaverse game 'Second Life' to have their personally designed avatar characters printed in full colour. By extracting the avatar design code from the game, Buckbee was able to use this data to drive an AM machine. Due to the open source architecture of Second-life, this data extraction and printing process was beyond the control of the software authors Linden Laboratories. Moreover, given that the characters within the Second Life game were wholly generated by the games players it was questionable whether Linden Laboratories had any control over the printed avatar characters' intellectual property[212]. Interestingly, *Fabjectory* was short lived, as there was very little demand from Second-lifers to realize their virtual avatars into tangible figurines.

Subsequent virtual-to-physical content providers have now developed systems that allow for a much higher-degree of consumer personalisation and appeal, but prevent the download of any virtually generated data to the consumer. Rather these solutions use closed loop and manage back-end AM fulfilment solutions, or regulated third party licencing.

The first instance of a fully-integrated closed-loop online design platform came in 2007 in the form of *Jujups*, a spin off from the National University of Singapore. The company designed a 'portal' for customers to digitally design products, such as 3D picture frames, gifts and jewellery, which were then printed for a fee. The closed loop portal design meant that no digital data could at any point be extracted by the user and subsequently be taken and used to drive AM outside of the *Jujups* print network[213]. Many similar solutions have been launched over the intervening 7-years focused on toys, gifts, games and consumer products along with jewellery and home ware as discussed in earlier case studies.

An alternative to the closed loop systems is to adopt a more traditional licensing model, where a third party manufacturer pays the intellectual property owner a royalty fee for each product produced against a contract.

The first example of this model was commercialised in 2008 by *FigurePrints* who, under licence from games developer Blizzard Entertainment, took 3D character data from the online game "World of Warcraft" to print gamer's avatars in full colour using 3D Systems printers (formally Z Corporation)[214]. Once printed, the parts were then boxed and shipped directly to the customer by *FigurePrints*.

211 Reeves P., Tuck C., Hague R., Additive Manufacturing for Mass Customization in Fogliatto F. S., da Silveira G. J. C., (eds)., *Mass Customization* (London: Springer-Verlag; 2011), chapter 13.

212 Reeves P., Tuck C., Hague R., Additive Manufacturing for Mass Customization in Fogliatto F. S., da Silveira G. J. C., (eds)., *Mass Customization* (London: Springer-Verlag; 2011), chapter 13.

213 Core77, JuJups 3D Design and Print Portal. http://www.core77.com/blog/technology/jujups_3d_design_and_print_portal_8429.asp

214 *FigurePrints*, FAQ at http://www.figureprints.com/wow/Help/FAQ.aspx

More recently, in 2013, the industry started to see intellectual property owners themselves developing 3D printed value propositions. *Disney*, for example, developed "Carbon Freeze Me", an on-site digitising service that allows the consumer's face to be superimposed digitally onto *Star Wars* characters with the resulting digital data then being used to drive the 3D printing of figurines[215].

Following the *Disney* example, there has been considerable media interest in branded goods manufactured via AM, with some sources suggesting that soon all games and (digital) media data will be 'fair game' for AM technologies via sub-contract service bureaus or even domestic 3D printers[216].

This maybe partially true, given that computer games and 3D digital media are well suited to conversion into the files needed for 3D printing. However, this does not take into consideration the skill required to extract, fix and convert games data into the 3D printing file needed, or the economics of purchasing an appropriate printer and suitable materials[217]. It also overlooks the end quality, aesthetic and appropriateness of the product for its intended use. In short, it is easy to access 3D digital data from computer games; but it is far more complex to turn this into a viable product value proposition.

The Current State-Of-The-Art in Commercialising Games Data Using 3D Printing

The most developed 3D printing offering to the games community to-date comes from *Fabzat*. *Fabzat* have a number of licensing agreements with the games content creators. The success of their business model hinges on the vast quantity of digital assets readily available from computer games, which are becoming more immersive, detailed and social[218].

Games companies are offered a fully managed service which takes the enabling data from the computer game and prepares it for consumer manipulation prior to 3D printing. As is the case with most 3D printing facilitators, the creative data remains in a closed loop, ensuring that there is no chance of infringement or misuse for the intellectual property owners. The IP owner then receives revenue from *FabZat* for each model printed.

The alternative to extracting pre-designed character data from a computer game such as *FabZat* or *FigurePrints*, is to provide the consumer with a dedicated online design tool, where they can create their own character with the intention of then going on to realise the character as a tangible artefact using 3D printing.

One such design tool is *Monstermatic*, a "Virtual Pet" app which allow users to style, personalise and interact with a virtual creature; a popular game category amongst younger audiences.

215 For more information about Disney's Carbon Freeze Me, see http://www.insidethemagic.net/tag/carbon-freeze-me/

216 Wee J., Driving Consumer Adoption of 3D Printed Products In A Licensing Value Chain (2014) *International Conference of Additive Manufacturing, Nottingham*, UK. See http://www.am-conference.com/index.php?main_page=document_general_info&cPath=17&products_id=356

217 Interview with CEO of *Fabzat* (May 2014).

218 More details about *FabZat* at http://www.fabzat.com/

Monstermatic allows the user to design a creature and interact with it, share it and superimpose it onto images taken with a smart-phone camera[219]. However users also have the option to 3D print their creation in full colour. This feature is in fact the only realistic revenue stream for *Monstermatic*, with the download of the app and creature design elements being free. The intention of this business model is that the user will grow sufficiently attached enough to 'their' creature to pay £15.50 for a 2 inch printed static figurine[220].

A very similar business model is that of *MakiLabs* as discussed in earlier case studies.

The commonality between *Monstermatic, FigurePrints, MakiLabs* and many of the *FabZat* creations is that the avatar character designer is also the consumer. Does that mean that the consumer will naturally claim ownership of the character design? Of course, this may depend on the terms and conditions of usage of the web based design software used to create the character.

For most consumers this will have little importance. However, some interesting questions can arise if a celebrity uses an online design tool to design his or her own avatar. Unless the terms and conditions of the website prohibit it, the website owner may be in their rights to replicate and sell copies of the celebrities' own avatar to the celebrities' fans. Inversely, the celebrity may not be allowed to scan and reverse engineer their own avatar for retail to fans, as this may infringe the intellectual property rights of the website. In both cases however, it is the terms and conditions of the online platforms that will set the legal responsibilities[221].

The Limitations to Widespread Adoption and Infringement

The major barriers that are foreseen for this market are the capability of current technologies, as parts must be aesthetically appealing, robust and economically viable.

Aesthetic appeal includes factors such as surface roughness and tactility and the vibrancy of colour on the part surface. The only viable printing methods to produce full colour parts use either ceramic powder 'glued' together using a liquid binder (3D Systems ProJet 360 / 460 / 660 / 860) or the Projet 4500, which uses a polymer powder fused together with a chemical binder[222].

Unfortunately, ceramic 3D printed powder parts are particularly fragile and susceptible to damage. For this reason companies such as *FigurePrints* supply their figurines within transparent Perspex display boxes, which although acceptable for a high cost figurine, is less appealing for a toy[223].

219 *Monstermatic* at http://www.monstermaticapp.com/ For more information about design tools, see also, Study I of this two-part Study: Mendis D., & Secchi D., *'A Legal and an Empirical Study of 3D Printing Online Platforms and an Analysis of User Behaviour'*, pp. 6-15.

220 *Monstermatic* was funded through crowd funding website Kickstarter in October 2013. For more details of the business, see https://www.kickstarter.com/projects/claytonmitchell/monstermatic-the-first-3d-printing-game

221 See also, Study I of this two-part Study: Mendis D., & Secchi D., *'A Legal and an Empirical Study of 3D Printing Online Platforms and an Analysis of User Behaviour'* in particular the dicussion on the 'Operation and Regulation of Online Platforms' at pp. 15-23.

222 Interview with Founder of *Figureprints* (May 2014).

223 See *supra* n. 214.

For more robust parts, companies such as *MakiLabs* use the Selective Laser Sintering (SLS) process, which uses a laser beam to melt particles of nylon powder into a more robust part. The main limitation of this process is the lack of colour during the printing process, with the part produced taking on a bright white appearance. Block colour can be added to parts after manufacture by dyeing[224].

Relative to injection moulding, both ceramic and polymeric 3D printed parts are expensive to produce. They also have a rough surface texture with a matt finish, which requires either coating or sealing to prevent discoloration during prolonged handling. With this said, there are far less barriers to the adoption of 3D printing within the computer games and digital industries, when compared to other proposed applications such as the automotive aftermarket or the consumer goods spares market.

The Industry Viewpoint

To understand the views of the users within the AM and computer gaming industry, two companies that produce models via AM from gaming content were interviewed for this case study[225,226]. Both companies have business models that are based on 3D printing's ability to create unique, customised parts from digital data.

Whilst there was excitement about the opportunities and potential scale of the market, it was stressed by one company that the technology is still very limited and consequently the impact on the film and game industry is currently minimal. The process requires extensive manual labour to prepare the avatar for print; it is not simply a case of exporting the game and clicking "print". The customers who purchase their products are avid gaming fans for whom accuracy of representation is very important. This cannot be obtained without painstaking, highly-skilled work. In addition, there is only one suitable machine for producing these models in full colour at a sufficient quality and this technology is not well-suited to large-scale production. It was believed that the industry would not develop until there had been substantial technological advancements in terms of economics, speed and quality.

It was also commented that designers were becoming increasingly conscious that their 3D designs may be used for purposes other than simply on-screen representations, such as for AM purposes. Consequently, it has been noted that some publishers are making a concerted effort to ensure that models are designed in such a way that the pre-processing of the digital models is kept to a minimum when the file is being prepared for printing. This practice may become increasingly common if the games industry embraces AM as a revenue stream.

There were very few perceived risks to intellectual property, at present, from using data from games and films to produce printed parts; the companies interviewed were confident that there were sufficient systems in place to protect the creators' intellectual property. At least this is true of the current 3D printing landscape. The companies were very clear that, no matter how much the avatar had been modified by the consumer, the rights remained with the content publisher. The rights management is determined when users accept the terms and conditions of the

224 Makies, Colours are Go at http://makie.me/campaign/colours/

225 See *supra* n. 217.

226 See *supra* n. 222.

game, and companies already have mechanisms such as encryption to protect their data. Additionally, because of the limitations of home printing technology and the amount of skill required to produce high quality prints, there was little concern about the risk of consumers obtaining the data. It was believed that it would be at least ten years before the technology had advanced sufficiently to enable high quality printing at home.

The only intellectual property issue that was foreseen by the companies was the introduction of consumers scanning themselves to play games “in person”, instead of using a customised avatar. Games consoles such as the *Xbox Kinect* have the ability to do this and a number of consumer devices such as smartphones are beginning to integrate the technology. This could create a grey area for intellectual property within games, although it is seen as likely that the publishers will create appropriate clauses in their terms of play to accommodate this. It was also noted that it was not likely to be a widespread practice to bring the consumer’s scan into the game for two reasons. Firstly, games publishers believe that it hurts the image of the game as it offers the user too much freedom over the aesthetics. Secondly, the most successful games are those which enable character development through in-game achievements which would not necessarily be possible if using a self-representation.

Moving forward it is expected that many of the barriers preventing the wide scale adoption of AM in the computer games and entertainment industry will be removed. Recent developments in photopolymer jetting systems, such as the *Stratasys Connex 3*, are moving closer towards full colour polymeric parts that are both robust and of acceptable surface roughness. Research and development is also underway to develop coloured powders for the nylon SLS process along with post process surface treatments to improve the tactility and aesthetic of parts.

A number of solutions are also under development to track and maintain the provenance of 3D printed and branded products produced using intellectual property protected data, one such solution being Radio Frequency Identity (RFID) tagging. Initially, it is expected that RFID tags in the form of inserted chips and adhesive labels added onto AM products will provide intellectual property provenance. However, over time with the development of multifunctional AM, direct writing technology and printed electronics, it is not inconceivable to imagine RFID functionality being printed directly into AM parts.

Conclusions and Recommendations

To date, AM has had a very small impact on the gaming and CGI industry. However, the technology aligns well to the sector and presents some significant potential revenue streams. The technology is not sufficiently advanced to create high-quality models from digital data at the moment and therefore there has been very limited growth in this area. There are a number of examples of companies using the technology such as Disney and *FigurePrints*, but these remain very high-value products, targeted at a niche market. As the technology improves, however, it is likely that companies will wish to incorporate the ability to create personalised, unique products into the value proposition and the industry will grow. It is unlikely that there will be significant intellectual property ramifications from this; as there are clear mechanisms already established regarding the ownership of the data and protecting the intellectual property rights of the designers and publishers. It is felt that the terms and conditions that consumers agree to when engaging in online games provide sufficient protection for the rights holders over the ownership of the data.

Case Study VI:

The Designers Perspective: How to Protect and Monetise Your Digital Assets

This case study looks at how artists and designers protect their digital content from intellectual property infringement that is enabled through commercial AM technology and home 3D printing. The case study questions whether greater intellectual property protection is required and how mechanisms such as Creative Commons are currently being used.

Why is Data So Important in the Value Stream of 3D Printing and Additive Manufacturing?

All AM technologies have a fundamental requirement for a digital model of the part to exist prior to production of a physical object. As with music and films, these digital files can be easily shared through online platforms and a number of online repositories for 3D files have emerged to support this, many of which are based on open-source philosophies. The consumer 3D printing market largely grew out of the open-source *RepRap* project[227]. At present, a significant number of these repositories exist, enabling users to download files for free. However, the significant market growth in the consumer 3D printing sector has seen a number of similar commercial ventures established and a growing market for paid-for printable content. As this trend continues to increase in popularity, so do the risks of intellectual property infringement, as digital data that is intended to remain protected finds it way illicitly into the public domain.

There has, therefore, been a concerted effort by some organisations within the 3D printing community to develop mechanisms through which designers can both share and protect their work. Encryption and streaming services, as well as managed print services all offer designers and rights-holders the ability to retain control of their intellectual property, thus creating new value streams.

227 The RepRap project was started at Bath University, UK in 2005, with the aim of creating a self-replicating manufacturing machine. The project is open-source and has been credited as being the inspiration for the home 3D printing movement.

The Scale of the Market

Sharing files on online platforms has been prevalent in the entertainment industry for well over a decade starting in 1999 with *Napster*. *Pirate Bay* is one of the most well-known and controversial online sharing platforms and the 73rd most popular site on the Internet[228], enabling users to illegally share copyrighted files. The platform has been blocked in several countries, including in the UK as a result[229]. To date issues arising from such sites has predominantly been around copyright infringement with the law calling for a 'three-strikes' graduated system to deal with it[230]. The industry has responded by developing mechanisms to address the growing file-sharing culture by providing legitimate sales channels and business models such as *iTunes*, for example. *Netflix, Amazon Instant, NowTV* and *Love Film* are other business models that enable licensed streaming or temporary download of films for a monthly subscription fee, guaranteeing consumer quality and availability at an acceptable price.

There has been much debate on the subject of economic damage caused by illegal file sharing[231]. Meanwhile, the Recording Industry Association of America (RIAA) states that music sales in the US have dropped by 47% from £8.6 billion to £4.5 billion per annum since the emergence of Napster in 1999[232]. However, these estimates are contentious and questions relating to combatting piracy continue to be raised[233].

With regard to the sharing of 3D printed and CAD files through peer-to-peer networks, the size of this market appears to be very low. The *PirateBay*, for example, hosts a 'Physibles' category through which users can download files intended for 3D printing. The total number of files tagged with 'Physible' on *PirateBay*, to date is 180, compared to the approximate 3 million other files available for download on the site[234]. This would seem a very small number, given that Physibles was established in January 2012[235], suggesting there is little interest in uploading or downloading 3D printable data to the site.

3D Printable files are much more likely to be hosted on popular 3D printing sites like *Thingiverse* and *Youmagine*. These repositories give far more insight into the behaviours of 3D printing

228 Alexa – Top 500 sites on the web, http://www.alexa.com/topsites

229 *Dramatico Entertainment Ltd*., *& Ors v. British Sky Broadcasting Ltd*., & Ors [2012] EWHC 1152 (Ch) Case No: HC11C04518.

230 Mendis D., Digital Economy Act 2010: Fighting A Losing Battle? Why The 'Three Strikes' Law Is Not The Answer To Copyright Law's Latest Challenge [2013] 27 *International Review of Law, Computers and Technology*, pp. 60-84; Farrand B., The Digital Economy Act 2010 – A Cause For Celebration, Or A Cause For Concern? [2010] 32(10) *European Intellectual Property Review*, pp. 536–541; Cusack N., Is the Digital Economy Act 2010 The Most Effective And Proportionate Way To Reduce Online Piracy? [2011] 9 *European Intellectual Property Review* pp. 559–564.

231 *See*, Cusack N., Is the Digital Economy Act 2010 The Most Effective And Proportionate Way To Reduce Online Piracy [2011] 9 *European Intellectual Property Review*, pp. 559–564.

232 RIAA – FAQ, http://www.riaa.com/faq.php

233 Steadman I., Study: copyright takedown notices are ineffective at stopping piracy (10 January 2013) *Wired Magazine* at http://www.wired.co.uk/news/archive/2013-01/10/blocking-no-effect-filesharing

234 Softpedia – The PirateBay reaches 10 millionth torrent milestone, http://news.softpedia.com/news/The-Pirate-Bay-Reaches-10-Millionth-Torrent-Milestone-438660.shtml

235 Scott K., The Pirate Bay Adds ''Physibles' 3D Printing Category (24 January 2012) ***Wired Magazine*** at http://www.wired.co.uk/news/archive/2012-01/24/pirate-bay-introduces-physibles

users, the type of models that are being printed and the extent of 3D file sharing[236]. Unlike *PirateBay, BitTorrent or isoHunt, Thingiverse* is *not* an illegal file-sharing platform. *Thingiverse* encourages the design and creation of 3D designs as well as facilitating the sharing of these files[237]. It is also a dedicated open-community website encouraging the use of Creative Commons Licence as discussed and explained in Report I of this two-part Study. The range of products on the site varies from repair components and spare parts (as discussed), to a T-Rex skull and a stiletto shoe.

In addition to these free repositories, there are also a number of commercial sites that enable consumers to purchase digital files to print at home arising from products that have been designed by other users. These are known as "bureau services" as explained above. One of the most popular bureau services is *Shapeways* – an online platform that allows designers to create "Shops" through which they can sell their own products, which are manufactured on demand by *Shapeways* own internal bureau service function. This model ensures that the designer's data remains secure, as it is only shared with *Shapeways*, not with the consumer. It also ensures that the consumer has a degree of protection against the purchase being defective. As the manufacturer, *Shapeways* is liable for the production of the part and, therefore, any issues concerning the quality of the part can be raised with them, reducing the designer's responsibilities to the customer.

However, companies that provide manufacturing services on behalf of designers take on responsibility for intellectual property infringement. If *Shapeways* manufacture and sell a product that is found to infringe someone's intellectual property, *Shapeways* are likely to be found liable (see also Study I of this two-part Study for further information on terms and conditions of these services). At present, *Shapeways* checks for intellectual property infringement before proceeding to print and manufacture the product. If *Shapeways* is of the opinion that there is ground for infringement they will refuse to manufacture the part[238]. Similar intellectual property infringement protocols have also been observed in other service bureaus including *iMaterialise*. However, this is a subjective process that is liable to human error. It is also potentially not a scalable process as file checking is a time consuming and labour intensive process, which may incur non-productive costs. Moreover, as additive manufacturing service bureaus become more automated, through software tools such as *Streamics*[239], the opportunity to manually check 3D design files prior to printing will diminish.

236 An insight into the user behavior on online platforms such as Thingiverse is outline in Study I of this two-part Study: Mendis D., & Secchi D., *'A Legal and an Empirical Study of 3D Printing Online Platforms and an Analysis of User Behaviour'*.

237 *Thingiverse's* IP policy can be found at http://www.thingiverse.com/legal/ip-policy

238 See *Shapeways* Content Policy and Take Down Procedure at http://www.shapeways.com/legal/content_policy

239 Materialise's *Streamics* automated factory software http://software.materialise.com/streamics

Examples of Intellectual Property Infringement

There have already been a few intellectual property infringement developments, which have occurred on 3D printing online platforms such as *Thingiverse*.

Warhammer, which is a table top war game owned by Games Workshop, was the subject of an intellectual property infringement scenario. *Games Workshop* issued a takedown notice to *Thingiverse* claiming copyright infringement as a result of a *Thingiverse* user uploading a *Warhammer 40k* figurine to the site[240]. *Thingiverse* obliged, and removed the model in accordance with the *Digital Millennium Copyright Act 1998*. However, at the time of writing, *Thingiverse* still returns 179 results for *"Warhammer"* figurines. In addition, there are many examples of clear copies or alterations of *Games Workshop* figures that are not labelled as such.

Another example of apparent intellectual property infringement that has been seen within the 3D printing community is with the 3D printing designer Asher Nahmias and two of the larger 3D printing technology vendors. After uploading his mathematically based 3D designs onto *Thingiverse* and protecting them with Creative Commons and GNU General Public Licence, Nahmias discovered that both companies had downloaded and printed his designs for use to market 3D printers at trade shows. As per Creative Commons Attribution Non-Commercial use licence, these two companies infringed on Nahmias' copyright. Nahmais' designs have since been removed from *Thingiverse*.

Technological Protection Measures

In response to the growing emergence of 3D file sharing and the intellectual property risks therein, companies are developing methods to protect digital data from being mistreated. These include for example, mechanisms such as Technological Protection Measures (TPM)[241] streaming and encryption software. This describes a range of access control technologies used by those (manufacturers, publishers, rights holders) who wish to protect an asset through limiting the use of the information or digital device[242]. This protects rights holders from having their intellectual property or digital assets copied or converted without permission and is typically applied to music and films. Companies have widely integrated this technology into their business models, including organisations such as *Amazon, AT&T, AOL, Apple, Google, BBC, Microsoft, Electronic Arts* and *Sony*.

There is however a counterintuitive aspect to using TPMs to protect copyrighted content such as music. In 2007, EMI Music lifted its Digital Rights Management (DRM) protection on all its music files. This was counter to the behaviour of market competitors such as *Sony, Universal*

240 Thompson C., 3D Printing's Legal Morass (30 May 2012) *Wired Magazine* at http://www.wired.com/2012/05/3-d-printing-patent-law/

241 For more on TPM provisions, *see*, Directive 2001/29/EC of the European Parliament and of the Council of 22 May 2001 on the Harmonisation Of Certain Aspects Of Copyright And Related Rights In The Information Society. *See also*, Sookman B. B., Technological Protection Measures (TPMs) and Copyright Protection: The Case for TPMs [2005] 11(5) *Computer and Telecommunications Law Review*, pp. 143-159.

242 Computer forensics, investigating network intrusion and cyber crime, *Computer Hacking Forensic Investigator* pp. 9-23.

and *Warner* who all had DRM on their digital assets. It took the industry by surprise to see a sharp rise in EMI's music sales by 10%[243]. A study by the University of Toronto revealed that lifting of the DRM protection was one of the main reasons for this. Furthermore, *EMI Music* did not displace top-selling album revenues, suggesting that this category of music is so prevalent through media outlets such as radio and television that consumers did not need to pirate it. It did, however, stimulate the sales of low-selling albums (25,000 or less) by up to 30%. The conclusion from this research was that by allowing and accepting a level of 'sharing' within a community, one could gain higher revenues from increased consumer exposure of the product[244].

Streaming

Protected streaming is a TPM technology that encrypts streamed data through the flash-player software in real time. This process differs somewhat from *Microsoft's* streaming encryption where the data is encrypted when transmitted. The advantage of protected streaming is that the data is never stored as a local file on the user's device, and as such, they cannot copy or share the file. This method is popular amongst digital multimedia providers and is the basis of web media services such as BBC iPlayer.

Given the success of the technology as a secure revenue generator for digital media companies to sell their product with flexibility and with little risk of piracy, protected streaming may be a suitable fit for the 3D printing media market. This would have to be developed however in conjunction with all printer manufacturers under a mandate that ensures all printers have the correct decryption protocols and software to stream legitimate 3D files. It would also allow for enforceable liability warranties to be created, giving consumers the confidence that only content of sufficient quality or providence can be 3D printed. This may mean, however, that protected streaming is only a viable option for large corporations and not for individuals who may not wish to have the responsibility of ensuring the quality of downloads.

One practical example of 3D print streaming has been developed by US start-up *Authentise*. The latest software release from *Authentise* that has been presented is a means of securely streaming 3D printing files via an Application Programming Interface (API). This provides the rights-holder with the ability to be paid per file printed. Rather than sending the CAD file to the consumer, the build instructions are sent directly to the printer, which, in turn, prints out the number of objects that have been purchased. This solution attempts to address the issue that 80% of premium designers face when required to release the 3D digital elements of their work online[245]. *Authentise* provides designers with a secure method of transferring data to potential customers, which guarantees revenue. *Fabsecure* and *Secure3D* have also developed similar solutions.

243 Zhang L., Intellectual property strategy and the long tail: Evidence from the recorded music industry (4 November 2013) at http://inside.rotman.utoronto.ca/laurinazhang/files/2013/12/jmp_nov25.pdf

244 Zhang L., Intellectual property strategy and the long tail: Evidence from the recorded music industry (4 November 2013) at http://inside.rotman.utoronto.ca/laurinazhang/files/2013/12/jmp_nov25.pdf

245 Authentise launches streaming service for 3D print files, (4 April 2014) at *3ders.org* http://www.3ders.org/articles/20140404-authentise-launches-streaming-service-for-3d-print-files.html

The Industry Viewpoint

To understand the mechanisms that are required in order to enable designers to protect and monetise their intellectual property, leading designers and thought leaders were interviewed. It was clear from these interviews that most of the designers considered the digital files that they create to be of high value, even when there was no monetary value in the designs. There was sometimes a reluctance to share large amounts of work under a Creative Common licence.

The interviewees noted that in order to protect and monetise digital assets, designers and brands must develop legitimate channels through which consumers can easily access designs. If these channels do not exist, consumers will resort to infringement. These channels will clearly define where the intellectual property rights lie.

Some of the designers stated that they were already employing encryption methods to protect their work, although this is for a multitude of reasons. Whereas some wished to prevent the unauthorised manufacture of their designs; others wished to be able to hide the fact that their designs infringed other people's intellectual property rights.

However, it was also envisaged that design software may enable consumers to move towards a product "mash-up" culture, where different products are combined to form a new product. This could present a range of intellectual property issues, for which protection mechanisms and guidelines may need to be developed, as there was clearly extensive confusion over what constituted infringement.

It should be noted that several of the designers that were interviewed stated that they were more concerned about inadvertently infringing other people's work, and the ramifications that this could have for them, than about other people infringing their own work. This could be because the designers are aware that they can limit the amount of content that they release online. Several interviewees acknowledged that there was an inherent risk of infringement by making their files available to the online community and that one only engaged in online sharing if they were prepared to see their work manipulated and changed. One designer stated that they had very stringent Terms and Conditions to protect his work that he felt protected him sufficiently. In contrast, it was acknowledged that if they were to use elements from another designer's files, they could fall foul of the law. One designer stated this was something that concerned him considerably, especially with regard to inadvertently infringing.

Conclusions and Recommendations

As a result of the legacy and history of online sharing and the entertainment industry's battle against copyright infringement, companies from all industries are acutely aware of the risks to their businesses presented by the online sharing of data. In addition to copyright infringement, 3D printing raises new challenges, such as how to protect designs, trade marks and patented products from being widely shared and replicated. Although the legalities of infringing content that is covered by copyright are well understood and there are extensive mechanisms in place to protect rights-holders, there may need to be additional measures implemented, to protect rights-holders from the new threats of widespread infringement that 3D printing presents. As recommended in Study I[246] of this two-part study, it is reiterated that guidance should be provided to designers to raise awareness of the mechanisms available to them to protect their intellectual property rights. This could be achieved through online file sharing platforms providing more detailed guidance about the types of licences that are available and are appropriate (such as Creative Commons licences). Public bodies such as the Intellectual Property Office could also publish guidance for designers to assist them in understanding the nuances of each licence and, specifically, how this relates to AM technology.

The growth in legal file sharing platforms suggests that there could be opportunities for the sharing of printable files. This creates market opportunities for companies to develop technologies to protect rights-holders' digital assets while also enabling new sales channels and revenue streams. As discussed previously[247], this could be achieved through the implementation of a 3D object design file store, similar to *iTunes*, through which designers can sell secure copies of their work, ensuring revenue streams are maintained and the consumer receives the original file as intended. However, it is unlikely that this will take place unless rights-holders are confident that they can release their designs without the threat of infringement.

246 Additional recommendations based on a study of the use of online 3D Printing file sharing platforms are provided in Study I of this two-part Study: Mendis D., & Secchi D., '*A Legal and an Empirical Study of 3D Printing Online Platforms and an Analysis of User Behaviour*'.

247 *See* recommendations made in Automotive Aftermarket case study, p. 21-22.

CONCLUSION

In conclusion, this research would suggest that it is unlikely that AM will present significant challenges to the UK's existing intellectual property framework over the next ten years. The limitations of the technology are substantial – especially with regard to consumer-level technology - and this will hinder widespread adoption within this time frame. It is anticipated that there will inevitably be instances of infringement that is enabled by AM technology, such as in the manufacture and distribution of unlicensed spare parts, however this infringement is covered by the UK's intellectual property framework and there are well-established mechanisms in place for rights-holders to address these incidents.

The Replacement Parts case studies showed that there will be very little commercial impact on either the automotive or domestic appliance aftermarket within the next decade as a function of either consumer 3D printing or industrial additive manufacturing. Current technologies do not produce parts that are of a suitable quality to replicate traditionally manufactured automotive or domestic appliance components. Where the technology is technically acceptable, the economics of AM production are greater than the accepted price point of current spare parts.

If hardware and software reach a point where a product can be printed easily and quickly without any issues and it will work in the appliance or vehicle without having to modify the part through iteration, a wider consumer base may adopt the technology. Until that point, it is unlikely to have a significant impact on the aftermarket, given the current trajectory of technology development or the current rate of technology adoption within the OEM market. Adoption of 3D printing and additive manufacturing in the aftermarket will only occur if original piece part components are designed for manufacture using AM processes from the outset. At present this seems unlikely given the limited capabilities of available processes and the economics of the parts produced.

Over time industrial additive manufacturing will drop in price and will open the market for more affordable products; but this will take some time. Similarly, the capability of home 3D printing technologies will remain limited for many years, with current technologies lacking in accuracy and scale and in the ability to produce truly robust parts in a sufficient variety of materials to make desirable consumer or automotive products. However this may change in time. Consumer-level 3D scanning and subsequent 3D printing is not capable of producing exact replicas of objects and it will be a number of years until the technology is capable of this. Due to the poor quality of the digital models that are created and the type of products that are being scanned at present, brands and designers will be unconcerned about the impact that scanning will have on their business and the risk of infringement of their intellectual property. However, organisations who have intellectual property rights over objects that could potentially be 3D printed should begin to consider developing legitimate channels through which they can provide consumers with access to legal downloads of their products for 3D printing. They may wish to do this using data streaming technologies or using files with embedded Digital Rights Management (DRM) systems.

Consumer orientated software tools will develop significantly in the coming years, through increased awareness by software vendors relating to design and personalisation demands.

Along with this the technical skill level of consumers will increase along with an increase in creativity driven through the resurgence of making within the home and community.

In summary, there is no immediate concern posed by the growth of industrial AM or consumer 3D printing in relation to intellectual property. There is no evidence to suggest that file sharing of illicit material is rife, largely as the value proposition of the parts being printed is very small. Existing mechanisms are in place for illicit materials to be removed from websites and those websites operating outside the law appear to have little traction. Mechanisms are being developed to ensure valuable and desirable content is made available to consumers easily through secure methods such as streaming. Moreover, the threat posed by 3D scanning and reverse engineering remains minimal, as the technology remains largely one of an expert system.

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