Department of Management *Chair of Intellectual Property Rights*

TITLE

3D printing, challenges for the future of Intellectual Property Rights

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Introduction

The scope of this work is to explain and analyze how the new 3D printing technology is rapidly rising in the last years and the consequences that it will have (and is already having) on the current legal framework.

The aim is to show how intellectual property rights are exposed to the 3D printing technology and what challenges they are starting to face and will be increasingly facing in the near future. It is extremely important to know and understand the criticalities and the disruptive reach of the innovation in order to be able to generate a legal response to ensure an adequate protection of those intellectual property rights, if not they may become useless, giving rise to uncontrolled copying.

The main problems arise from the aging of the rules which become less and less able to be effective in the real world which changes faster than the legislation that now needs a boost to avoid becoming useless and uncertain. Those conditions are imperative to not hinder the innovation process, exposing innovator to the risk of not having a compensation (usually given by the intellectual property rights) for the work done, thus not encouraging further research and innovation, but also for those who use the new technology to avoid being accused of infringement involuntarily because of the uncertainty of the norms that may lead to illegal behaviors not willfully.

The work is structured as follows:
The first part is more explanatory and describes what the 3D printing technology is and how it works, giving an insight of the numbers reached by this sector, showing the various types of printers and materials and explaining the differences, their weaknesses and strengths and for what they are better suited. In this part there will be also some examples of industries that have adopted this technology for some processes and how they benefitted from it.
In the second part the legal aspects and the current intellectual property rights framework is analyzed in order to understand the main protection issues that arise with the new technology. After that some relevant court cases are shown that help us to understand how the courts tend to interpret the legal framework and decide on the situations where 3D printing is involved and how they deal with liability and infringement of intellectual property rights. The third part aims

to explain how to deal with the current legal framework, especially from a rightsholder perspective in order to prevent infringement and the strategies that can be used to protect each intellectual property right, but also from the view of a company or a consumer that uses the 3D printing technology and how it can avoid liability, for that a case study on 3D chocolate printing helps to show all the steps necessary to do a business with this technology and what to do to avoid being sued for infringement of intellectual property rights.
The last part tries to give some advices and some insights on how to reframe intellectual property rights with some recommendations and what the future could reserve for them, suggesting what direction could be taken and what solutions can be adopted for them to be effective once again.

The final objective of the work is to underline the characteristics of the 3D printing technology and the effects on the intellectual property rights framework. It will be noted how the current legal framework is no longer well suited to protect the rightsholders satisfactorily. By analyzing it and looking at the actions that the courts but also the rightsholders and the users of the technology are taking we will be able to see the criticalities of the laws and the potential solutions to adapt the legal framework to today's needs to continue fostering innovation.

1. 3D Printing

1.1. Key aspects of the technology

3D printing is a manufacturing process based on a unique principle, a digital model is turned into a physical three-dimensional object by adding a layer of a given material at a time, reason why 3D printing is also defined as "additive manufacturing"[1]. It has attracted a lot of attention during recent years for his strong potential, it was defined by Forbes magazine as the "transformative technology of 2015 - 2025 period"[2] but the first 3D printer was released back in 1987 by Chuck Hull the technologies evolved in the 90's and 00's. Finally, in the late 00's the patents expired[3] and the prices went down, since then the adoption of 3D printers keeps growing (around one million 3D desktop printers were sold in the period 2015 – 2017)[4].

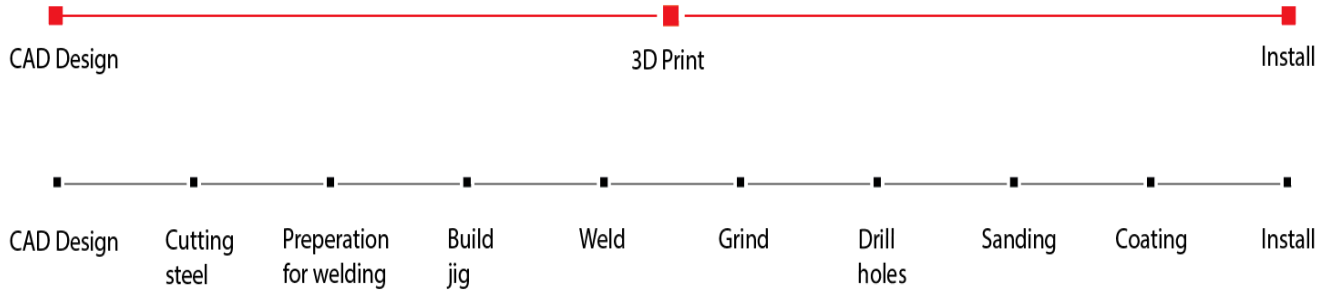
A big advantage of this technology compared to traditional manufacturing technology is that no special tools are required - one size fits all – in order to create very different objects.

The process starts with the digital model, blueprint of the physical object, sliced into two-dimensional layers and transformed into instructions in machine language for the printer to do. The materials and physical properties of the objects can vary (usually plastic, but metals can be 3D printed as well).

As of now, 3D printing cannot replace the traditional manufacturing system for bulk volumes it requires a lot of time (it can take from 4 up to 18 hours to complete one object, which usually will also require post-processing to obtain the desired surface finish, hence requiring additional time and effort)[5]. On the other end it is suitable for custom and limited-edition products, difficult to realize with bulk volume factory tools. 3D printing also allows realizing in a single piece objects which traditionally would have been produced as multiple components and by producing grids and hollow structures it can make lighter objects in comparison to traditional manufacturing[6]. So, while being slower for bulk volumes of simple products it has a flexibility and speed advantage in the creation of complex objects/prototypes.

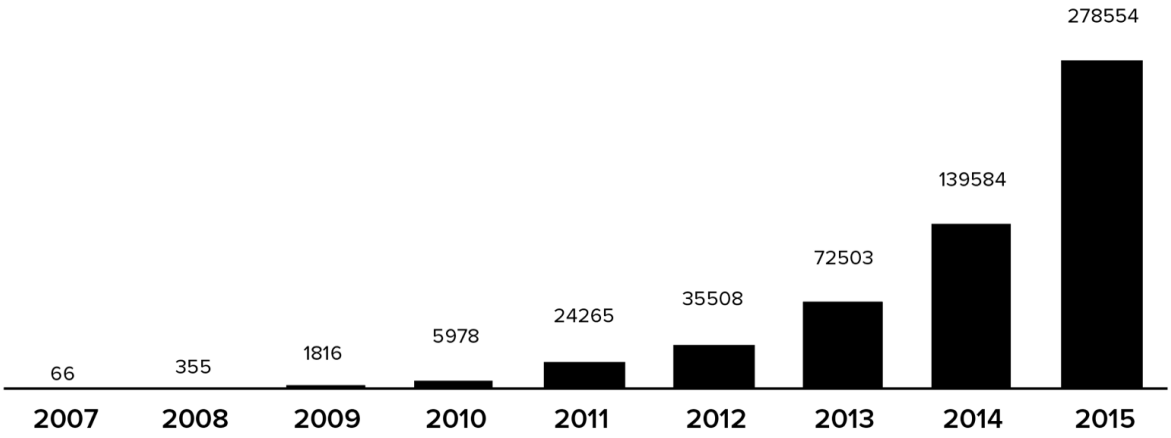
[1] What is 3D printing? The definitive guide, How does 3D printing work? (pp.5-7), retrieved from 3Dhubs database.
[2] Karlgraad (2011), Forbes Magazine.
[3] Terry Wohlers and Tim Gornet (2014), history of additive manufacturing.
[4] Wohlers (report 2018), 3D printing industry.
[5] What is 3D printing? The definitive guide, Benefits & Limitations of 3D printing (pp.8-10), retrieved from 3Dhubs database.
[6] Ben Redwood, The Advantages of 3D Printing, Basic Manufacturing Principles, retrieved from 3Dhubs database.

Here is an example concerning the realization of custom steel brackets[7]:



As we can see 3D printing requires fewer steps thus reducing dependence on different manufacturing processes giving greater freedom to the designer (who won't have the constraints that the different processes require).

There is also an important component of risk and overall cost reduction, given by the ease of access of the technology[8]:



Number of printers under 5000$ sold globally every year – Wohlers report 2015

What was a niche technology is now a cost competitive method of part production.

About the cost reduction we should also consider that traditional manufacturing methods such as subtractive manufacturing remove parts of the material from the initial block causing a high amount of waste, while additive manufacturing uses only the quantity of material needed to

[7] Ben Redwood, The Advantages of 3D Printing, Single step manufacture, retrieved from 3Dhubs database.
[8] Ben Redwood, The Advantages of 3D Printing, Ease of access, retrieved from 3Dhubs database.

build the part and most raw materials used in the process can be re-used for other creations, being at

the same time cost effective and environmentally friendly[9].

3D printing also contributes to the risk reduction for the designer, imagine creating a prototype and then needing to adjust it, even slightly, that would mean sustain all the cost of creating the unique pieces (like a particular mold or specific tools for example) every time a small adjustment is needed, while thanks to 3D printing the designer is able to make all the adjustments and print the new prototype as many times as necessary just by changing the digital model, the only cost to sustain is that of the raw materials used in the process. It is a great achievement not only for the risk reduction in terms of costs for the designer, but it makes possible to print different prototypes and test them in order to verify their quality before making any large investment required for mass production level.[10]

Maybe the biggest limitation of this technology is that, being built layer by layer, the 3D printed parts tend to be weaker than their traditional counterparts, this is why usually plastic 3D printed parts aren't used for critical functional applications. However, there are production techniques of metal 3D printed parts that offer even better properties than the bulk material.[11]

[9] Ben Redwood, The Advantages of 3D Printing, Sustainability, retrieved from 3Dhubs database.
[10] Ben Redwood, The Advantages of 3D Printing, Risk mitigation, retrieved from 3Dhubs database.
[11] What is 3D printing? The definitive guide, Benefits & Limitations of 3D printing (pp.8-10), retrieved from 3Dhubs database.

1.2. Applications

1.2.1. 3D printing categories

There are seven different 3D printing categories defined by the ISO/ASTM 52900 standard[12], briefly listed[13][14]:

- Material Extrusion (FDM): The material is selectively dispensed through a nozzle or orifice. In fused deposition modelling a spool of filament is loaded into the printer and then dispensed from the extrusion head. The filament is melted and dispensed through the nozzle, the printer moves the extrusion head laying down the melted material that cools and solidifies in precise locations. The process is repeated layer by layer until completion. It is the most cost-effective way of producing 3D printed objects and the most diffused technology. On the other hand, it has the lowest accuracy and resolution compared to others 3D printing techniques and it is weaker (unsuitable for critical applications)

- Vat Polymerization (SLA & DLP): Liquid photopolymer in a vat is selectively cured (solidified) by UV light.

Stereolithography (SLA) and Digital Light Processing (DLP) are similar processes that use a UV light to solidify liquid resin in a vat layer by layer. SLP uses a single point laser to do it while DLP uses a digital light projector to flash a single image of each layer at once. Those techniques can produce highly accurate and detailed parts ideal for visual prototypes, a large range of materials are available for them. SLA/DLP parts are pretty fragile, so they are not suited for functional prototypes, SLA parts must not be used outside because UV radiation exposure can alter its properties.

- Powder Bed Fusion (SLS, DMLS & SLM): A high-energy source selectively fuses powder particles.

The Selective Laser Sintering (SLS) process begins with heating a bin of polymer powder just below its melting point, then a thin layer of powder is deposited onto the building platform. A CO2 laser scans the surface and selectively sinters the particles, binding them together, and then the process repeats for each layer.

As a result, you get a bin filled with arts surrounded by unsintered powder. Those parts have excellent mechanical properties and are great for functional parts and prototypes. SLS printers

[12] Additive manufacturing - General principles - Terminology (2015), International Organization for Standardization.
[13] What is 3D printing? The definitive guide, 3D printing processes (pp.17-28), retrieved from 3Dhubs database.
[14] Processes - Make, 3D printing - Additive (pp. 7-8), retrieved from 3DEXPERIENCE Marketplace database.

are usually high-end industrial systems, this limits the availability of the technology which has high costs and turnaround times. Direct Metal Laser Sintering (DMLS) and Selective Laser Melting (SLM) produce parts similarly to SLS, a laser selectively bonds together powder particles layer by layer. The main difference is that DMLS and SLM produce parts from metal. SLM melts completely the powder particles while DMLS heats the particles to a point that they fuse together on a molecular level. DMLS and SLM are ideal for manufacturing complex metal parts that cannot be produced traditionally, those parts have excellent physical properties, surpassing even the strength of tough metal. The costs are very high, the cost of the parts ranges between 5000 to 25000 dollars (metal powder costs about 450 dollars per kilogram)[15], they should be used only for low volumes and parts that cannot be manufactured with any other method.

- Material Jetting (MJ): Droplets of material are selectively deposited and cured.

This technique works like a standard inkjet printing, but instead of printing a single layer multiple layers of material are deposited in order to create a solid product. Multiple print heads jet droplets of photopolymer onto the build platform that are later solidified by an UV light source. It is the most accurate of all 3D printing techniques and offers multi-material full-color printing possibilities. Material jetted parts are perfect for realistic prototypes. All those great features are balanced by the costs, in fact it is one of the most expensive 3D printing process making it financially impossible for some applications. In addition, those parts are not best suited for functional applications because they tend to be brittle and sensitive to sunlight which can alter its properties and colors.

- Binder Jetting (BJ): Liquid bonding agent selectively binds regions of a powder bed.

Binder Jetting is a very flexible technology, where a large variety of materials, sizes and colors are available. A thin layer of powder particles is deposited onto the build platform, then droplets of adhesive are dispensed by an inkjet printhead to bind selectively the particles together and built a part layer by layer. At this stage the part is very fragile and additional post processing is required. This technology allows to produce metal parts and full-color prototypes at a sensibly lower cost than DMLS, SLM or material jetting techniques. Metal Binder Jetting parts tend to have worse mechanical properties than the bulk material because of their porosity.

- Direct Energy Deposition (LENS, LBMD): A high-energy source fuses material as it is deposited.

[15] Alkaios Bournias Varotsis, Common SLM & DMLS materials, Introduction to Metal 3D printing, retrieved from 3Dhubs database.

That is a technique which creates parts by melting materials and deposing them layer by layer, it is generally used with metal powders and wire source materials. The technology is good not only for the creation of new parts but can also be used to fix complex damaged parts (i.e. turbines). Laser Engineering Net Scaping[16] (LENS) uses lasers to build objects directly from powdered metal, alloys, ceramics or composites. The material is delivered to the material deposition head, when complete the deposition head moves on to the next layer. Laser Beam Micro Drilling[17] (LBMD) is a non-contact machining process of materials that are difficult to manufacture conventionally. Parts created with this technology tend to be weaker and have a lower fatigue limit than the raw material. Direct Energy Deposition 3D printers are usually industrial machines

that require a closed and controlled environment to operate. The process is similar to Material Extrusion 3D printing technique, but the nozzle can move in multiple directions and up to five axes (instead of three like most other machines).

- Sheet Lamination (LOM, UAM): Sheets of materials are bonded and formed layer by layer.

Sheet Lamination technique consists of superpositioning different layers of material composed of foil in order to obtain an object. Laminated Object Manufacturing[18] (LOM), a system developed by Helisys Inc., where layers of adhesive coated materials are glued together and cut to shape with a knife or a laser cutter.

Ultrasonic Additive Manufacturing[19] (UAM) is ideal to bond metals with different properties together, regardless of thickness. An ultrasonic printhead weld together strips of metal along a build plate, each layer is welded to other until a 3D object is formed. Sheet Lamination is a low-cost technique thanks to availability of raw materials and dimensional accuracy, while not being the best, is pretty high.

[16] Laser engineered net shaping, retrieved from Wikipedia Database.
[17] Homola P., Ruzek R., Waset, Open Science Index, Aerospace and Mechanical Engineering, Vol:12, N°8 (2018) Laser Beam Micro Drilling.
[18] Laminated Object Manufacturing, retrieved from Wikipedia Database.
[19] Ultrasonic Additive Manufacturing: rapid prototyping & (UAM) 3D printing services, retrieved from 3D Printer Pro database.

1.2.2. Fields of use

The additive manufacturing technology has been introduced in many industries.[20]
The automotive industry benefitted from it for the ease of customization offered by that technology, 3D printed parts could be printed overnight and tested immediately on the assembly line, having a rapid feedback that allowed to create the perfect part in short time (and at very low cost). 3D printing allows manufacturers to build models using a variety of materials, the technology is still in a nascent stage in that sector, but the market is expected to grow in the coming years. Reduction in lead time and costs will push to the adoption of 3D printing for prototyping and manufacturing complex parts.[21]
In the entertainment industry it allows creating great props for movie makers thanks to its design flexibility at a lower cost and in a quicker way than before, going directly from computer sketches to usable physical objects to film. It is a great leap forward because it also enhanced traditional methods, by reducing time and effort put in time consuming tasks it allows model makers to concentrate their know-how and efforts on creativity, thus realizing better props in less time.[22]
It is the perfect tool for the Do It Yourself industry, new technologies accelerated the DIY (Do It Yourself) phenomenon and it is expected to be worth around 13,9 billion USD by 2021.[23] This growth will lead to 3D printing sector growth as well, in fact, allowing the makers to produce an unlimited range of spare parts and customize their designs without relying on external vendors is the ultimate way for makers to express their own creativity and with 3D printers it is finally possible.[24]
In the educational environment 3D printing can bring to life the course subjects giving the students a practical experience (for example models for aerospace engineering students). The practical application of a subject can simplify difficult theoretical concepts for students. They can acquire knowledge about new technologies, while at the same time student can benefit from

[20] What is 3D printing? The definitive guide, Applications of 3D printing (pp.11-13), retrieved from 3Dhubs database.
[21] Seapee Bajaj, Automotive 3D printing market by component and application - Global opportunity analysis and industry forecast 2017-2023, retrieved from Allied Market Research database.
[22] Lana Lozova (2016), The future of filmmaking: 3D printed props, retrieved from Ultimaker database
[23] Technavio (2017), Global Do It Yourself tools market forecast, retrieved from BusinessWire "A Berkshire Hathaway Company".
[24] Joel Comm (2017), Why the huge Do-It-Yourself market is just getting started, retrieved from Inc. com database.

it in various fields, from Mathematics to geography to art... [25] "education must be involved to prepare students for the future"[26]

With this technology product designers are able to customize the products at no extra costs and it accelerates the design cycle, designers can get feedback in early design stages and test the idea before making higher investments. Designers can get feedback in early design stages[27]

In the industrial tooling sector, 3D printing is used to develop low-run injection molds they are created using recently developed 3D printing materials with high heat resistance and stiffness. Those molds are used to produce a low number of parts compared to traditional metallic molds but costs a fraction of those and they can be manufactured overnight. This is ideal for low-volume and low-cost production, allowing to create custom parts quickly. Additive manufacturing increases productivity of the tools and product quality, in fact, traditional specialist tools production is one of the most expensive, technically demanding and time-consuming part of the process while also limiting design and construction freedom.[28] It can also give indirect benefits, such as the case of the Czech tool manufacturer Innomia that managed to reduce its time-to-market by nearly a third (-28%) from 18 to 13 days achieving a competitive advantage thanks to the use of the new technology.[29]

Healthcare and prosthetics field benefited from 3D printing by making custom shapes such as hearing aids, or personalized prosthetics, manufactured from a digital file scanning the patient's body. Thanks to that the output is of better quality (fits perfectly each patient body) and is obtained at a lower cost. Bioprinting and tissue engineering is also a major technological breakthrough, medical technology is now trying to build tiny organs using stem cells as printing material, those organs will then be able to grow and take over when the patient's organ fails. 3D printing skin is also a thing, in Spain. a 3D bioprinter prototype that can produce human skin was revealed[30], the life-changing possibilities offered by this technology in the future are endless.[31]

[25] Is the implementation of 3D printing in education a necessity? (2018), retrieved from 3Dnatives database.
[26] Elvira Rach, head of education at iGo3D GmbH.
[27] 3D printing in product design, retrieved from Ultimaker database.
[28] Industrial 3D printing for Tooling - Function integration, faster amortisation, retrieved from EOS database.
[29] Wiebke Jensen, Tooling: Innomia - Czech Tool Manufacturer Relies on Additive manufacturing for Complex Customer Projects, retrieved from EOS database.
[30] Nieves Cubo, Marta Garcia, Juan Francisco del Canizo, Diego Velasco, Jose L. Jorcano, (5 December 2016), Biofabrication, 3D bioprinting of functional human skin: production and in vivo analysis, retrieved from Universidad Carlos III de Madrid database.
[31] Avi Reichental, (2018), how 3D printing is revolutionizing healthcare as we know it, retrieved from techcrunch database.

In space and aerospace industry additive manufacturing is used for high-performance parts, it gives the possibility to reduce the number of components into a single part, reducing the lead time and overall weight of the product (even up to 60%)[32], fuel consumption, material costs and CO2 emissions. Complex parts can be manufactured quickly and cost-effectively.[33]

3D printing is the main manufacturing technology in the field of robotics and automation because of its speed, design freedom and possibility of high customization needed to develop new robotic mechanisms. In this field the main constraint was represented by the possibility to use existing off-the-shelf parts, while now it is possible to design and print each part exactly how it is needed[34]

It is now time to move on and start analyzing the legal aspects of the current legal framework.

[32] Lightweight Construction, retrieved from EOS database.
[33] Industrial 3D printing of high-tech aerospace components, retrieved from EOS database.
[34] TJ McCue, (October 2014), Robots and 3D printing, retrieved from Forbes database.

2. Additive manufacturing and IPR: Legal aspects

2.1. Protection issues

The rise of 3D printing brings out unique intellectual property challenges, counterfeiting requires just a three-dimensional computer model (CAD - Computer assisted design) of the product and a 3D printer to make it. The current Intellectual property legal framework does not address effectively those infringement issues.[35] The idea to see printable files everywhere on the Internet takes us back to the past during the 90's and 00's when digital music files could be found everywhere with consequences for authors in terms of profits and creative recognition. Especially at the household level, if 3D printing becomes ubiquitous it would be a serious challenge for policymakers.[36] To understand 3D printing related IPR laws we should define primary (direct) liability, which arises when a party is held directly responsible for legal harm to another (like downloading and printing infringing materials) while secondary liability is referred to third parties who facilitate the use of 3D printing technology enabling the direct infringers to do so (for example online service providers who host digital files that may be used to print 3D objects).[37] Some international harmonization of the IP law exists, also in form of multilateral trade agreements. WIPO (world intellectual property organization) recognized 3D printing as one of the frontier technologies that could boost future growth, it acknowledged the role of open innovation for the technology development but also its criticality making the existing IP rights enforcement more difficult (in terms of costs and ease of identification of the infringers). The main discussion is about how appropriate the existing legal frameworks are when applied to the new reality of 3D printing.[38]

[35] Michael Henry, (August 2018), How 3D printing challenges existing intellectual property law, how 3D printing affects the patent system retrieved from Henry patent law firm database.
[36] Thomas Birtchnell, Angela Daly, Thierry Rayna, Ludmila Striukova, Business and Social Science views of 3D Printing and IP, 3D printing and IP (pp.12-14), Intellectual Property Office (2018/03), 3D Printing and Intellectual Property Futures.
[37] INTA, International Trademark Association - Design committee & Designs Communications Subcommittee (August 2017), Introduction (pp.1-3), 3D printing: Key Legal Issues and Options for Change.
[38] Thomas Birtchnell, Angela Daly, Thierry Rayna, Ludmila Striukova, Legal views of 3D printing and IP, By jurisdiction (pp.16-17), Intellectual Property Office (2018/03), 3D Printing and Intellectual Property Futures.

2.1.1. IPR on 3D printed Original Creations

Copyright	Patents	Design	Trademarks	Trade Secrets
-The copyright is the legal device which gives the creator of a literary, artistic, musical or other creative work the sole right to publish and sell such work.[39]	- A patent is "a set of exclusive rights granted to an inventor for a limited period of time in exchange for detailed public disclosure of that invention".[40]	- A design is "the appearance of the whole or a part of a product resulting from the features of the product and/or its ornamentation"[41].	- A trademark is a recognizable sign, design or expression which identifies products/services of a particular source from those of others, it can be a name, logo but also a specific color, shape, smell or sound.[42]	- A trade secret is a formula, practice, process, design, instrument, pattern, commercial method or compilation of information not generally known or reasonably ascertainable by others by which a business can obtain an economic advantage over competitors or customers.[43]

The first legal aspect that needs to be clarified when speaking about 3D printing is the relationship between the 3D printed creations and the current IPR framework, and how the creations can be protected by the different laws

Intellectual property rights play a fundamental role in pushing innovation and especially in 3D printing history, many pioneers of the technology started companies based on their patented inventions and later commercialized them.

[39] Declercq Advocaten - Notarissen, Leiden/Den Haag, Netherlands (November 2015), Copyright Law (pp3-6), White Paper, The Legal Aspects of 3D printing from a European perspective.
[40] Declercq Advocaten - Notarissen, Leiden/Den Haag, Netherlands (November 2015), Patent law (pp.6-7), White Paper, The Legal Aspects of 3D printing from a European perspective.
[41] Declercq Advocaten - Notarissen, Leiden/Den Haag, Netherlands (November 2015), Design Rights (pp.7-8), White Paper, The Legal Aspects of 3D printing from a European perspective.
[42] Declercq Advocaten - Notarissen, Leiden/Den Haag, Netherlands (November 2015), Trademark Law (pp.8-9), White Paper, The Legal Aspects of 3D printing from a European perspective.
[43] Trade secret, Retrieved from Wikipedia database.

There are various processes in 3D printing which could be protected by the different Intellectual Property Rights. The code of the design file, the design itself and the physical object can be protected by the copyright law, as the CAD file can be considered a literary work. Same for the physical object that can be considered a kind of sculptural work or more broadly as a work of artistic craftmanship. Some of the objects based on a 3D printing design file have been defined not enough original to attract copyright protection on their own and, as also the patent law requires, they have to meet some standards of novelty, inventive/non-obviousness and industrial application/utility. Speaking about patent protection for 3D printed objects, it has to be said that an application is needed, so it is known exactly which objects are protected by this IPR and those which are not. The physical object can benefit from patent law protection if it meets the required novelty standards. [44]

Design patents/rights represent the right to exclude others from making, using or selling the patented design, the patent may issue for the design of the whole product or a part of it.[45] Those rights may have a rise in popularity because of 3D printing because they are a very valuable tool in fighting 3D printed counterfeits, to show an example, a CAD file may not be well protected by other intellectual property rights but it may contain proprietary designs which can be protected, and in turn, will also protect the final object from being counterfeit. Design rights have also the big advantage that they can be obtained in short time (3/4 months to 1 year) allowing to protect the product while it is still in the heart of its life cycle and enabling designers to keep their share of profit. 3D printing may be a big problem for many industries, there will be the possibility to produce certain products with the same physical appearance as the legitimate ones, resulting in a significant flow of counterfeit goods to the marketplace. Trademark owners' exclusive rights are related to the use of it as an indicator of the source/origin in the course of trade, those rights can be used against others using the mark as an indicator of source/origin in a way which is likely to confuse consumers. Trade secrets, like recipes or business practices will be affected by 3D printing, preventing trade secrets' leak will be a key challenge in the near future.

[44] Lucas Osborn, 3D printing and intellectual property rights (pp. 255 - 271), 3D printing and Patents, Research handbook on digital transformations.

[45] INTA, International Trademark Association - Design committee & Designs Communications Subcommittee (August 2017), Utility and Design Patent (pp.12-19), 3D printing: Key Legal Issues and Options for Change.

2.1.2. Intellectual Property Rights Controversies

After the explanation on which rights can protect 3D printed objects, their requirements to apply and what they exactly protect, the main goal is to show the problems that 3D printing brings to the IPRs application and how those apparently simple to understand rights do not or cannot apply in many situations.

The problems emerge because there are still divergencies in the different jurisdictions. Parties who 3D print objects upon customer requests have to make sure that the object or file is original so that it does not infringe third party rights, but it is not as easy as it would seem. For example, the CAD file is capable of being protected under copyright law in some countries (as the UK) but not in others (US) because of a creative/functional distinction in its IP law. The CAD files by themselves neither seem patentable (being a form of software, and the law is uncertain about the permissible patent claims directed to software).[46] Also, there is no consensus on whether the design should enjoy protection or not, it is argued that the protection could depend on what design is contained (if the file contains the design of an object who will be protected by the copyright law or not). [47] Divergencies of view exist also within the same legal system, in the US it is debated that the design may be protected under copyright law not as a literary work but as a "technical, mechanism, engineering or architectural drawing".

The printed object itself could also attract copyright protection, in the US legal system sculptural works enjoy it, but useful articles are excluded, so, many 3D printed object should be evaluated in order to decide if they are protected or not by the copyright protection because they carry both aesthetic and functional aspects. Similarly, in the UK "works of artistic craftmanship" are deemed valuable to be protected by copyright but industrial prototypes have been excluded by case law[48].

Finally, when addressing private use the European copyright legislation states that a private can 3D print a protected work without permission of the IP holder (even if downloading CAD files from illegal sources is prohibited also in this case), but when a commercial party prints upon a

[46] Lucas Osborn, 3D printing and intellectual property rights (pp. 255 - 271), 3D printing and Patents, Research handbook on digital transformations.

[47] INTA, International Trademark Association - Design committee & Designs Communications Subcommittee (August 2017), Copyright (pp.3-4), 3D printing: Key Legal Issues and Options for Change.

[48] Thomas Birtchnell, Angela Daly, Thierry Rayna, Ludmila Striukova, Legal views of 3D printing and IP, Copyright (pp.17-19), Intellectual Property Office (2018/03), 3D Printing and Intellectual Property Futures.

private request the situation is not clear (that being a commercial undertaking) and varies from country to country once again.[49]

Proving patent infringement is a struggle too, usually the patentee was only concerned with suing large companies who would invest a lot to engage in mass production of the patented invention, and by suing them he would capture damages for all the infringement in one lawsuit but now they will have either to assert their patents against a myriad of end users that bears difficulties and high expenses or sue the counterfeiter for indirect infringement, which generally is more difficult to prove.[50] Right now it is not clear what would give rise to that, as an example, in UK law "supplying the means relating to an essential element of the invention"[51] would entail an infringement but what are the "means" needed to constitute an infringement is still discussed. There are some problems for design patents as well, "design patents have almost no scope and are limited to the ornamental design shown and described in the patent drawings", the patent is invalid if the design is dictated by function. To make a claim of infringement where certain elements of the design have functional purposes, such aspects should be well defined to avoid the claim from encompassing the general design concept of the functional elements,[52] plus, there is the non-commercial use and fair dealing exceptions who may exempt from liability many 3D printing activities, in this situation intermediary liability (like file sharing sites) is unclear as regards the operation of these exceptions. The issues arise because sharing unauthorized files would not constitute infringement if done for non-commercial purposes, file sharing sites may be liable for secondary or indirect infringement only, but once again, the detection of such liability and the proof of copying can be great obstacles to a rightsholder asserting its rights. About the trademarks, it may be difficult to find infringement occurring in 3D printing, because the use of others' trademarks may not qualify as indicator of source/origin in the course of the trade. As for the others intellectual property rights, the personal use of a trademark (not for commercial purposes) is generally not considered an infringement. As soon as it is used in the course of trade (even if sold informally) the conduct will be liable, it is

[49] Thomas Birtchnell, Angela Daly, Thierry Rayna, Ludmila Striukova, Legal views of 3D printing and IP, Exceptions to infringement (p.19), Intellectual Property Office (2018/03), 3D Printing and Intellectual Property Futures.

[50] INTA, International Trademark Association - Design committee & Designs Communications Subcommittee (August 2017), Utility and Design Patent (pp.12-19), 3D printing: Key Legal Issues and Options for Change.

[51] Declercq Advocaten - Notarissen, Leiden/Den Haag, Netherlands (November 2015), Indirect Infringement (p.7), White Paper, The Legal Aspects of 3D printing from a European perspective.

[52] INTA, International Trademark Association - Design committee & Designs Communications Subcommittee (August 2017), Utility and Design Patent (pp.12-19), 3D printing: Key Legal Issues and Options for Change.

debated that just displaying the product to the public may entail infringement[53] (the question is for example, if a pair of 3D printed shoes with a popular brand on it, used for personal use can still infringe trademark law when worn in public as they may induce confusion and dilute the brand). "If a manufacturer/distributor intentionally induces another to infringe a trademark, or if it continues to supply its product to one whom it knows or has reason to know is engaging in trademark infringement, the manufacturer/distributor is contributorily liable for any harm done as a result of the deceit", but it has to be proven that the contributor have knowledge that the users of its services were engaging in infringement, or in case of willful blindness (if someone suspects wrongdoing but intentionally fails to investigate).[54]

Copyright	**Patents**	**Design**	**Trademarks**
- Some legislations give copyright protection to CAD files and others do not - It is not clear if design should enjoy copyright protection (divergencies are present even within the same legislation) - The physical objects may enjoy copyright protection but first need to be evaluated so there is no guarantee of protection - Private Copy Exception extent is not well defined and may lead to infringement against the rightsholder	- CAD file is a form of software and the law is uncertain about the permissible patent claims directed to software - Proving patent direct infringement is nearly impossible, and proving indirect infringement is not clear. - Supplying the means relating to an essential element of the invention entails infringement but what are the "means" needed to constitute it is still discussed	- If certain elements of the design have functional purposes, such aspects should be defined to avoid the infringement claim from encompassing the general design concept of the functional elements - Non-commercial use and fair dealing exceptions may exempt intermediaries from liability, the operation of these exceptions is unclear, file sharing sites may be liable for secondary or indirect infringement only	- Difficult to find infringement occurring in 3D printing, the use of others' trademarks may not qualify as indicator of source/origin in the course of the trade - Just displaying the product to the public may entail infringement but it is debated. - It has to be proven that the contributor have knowledge that the users of its services were engaging in infringement, or in case of willful blindness but it is very difficult.

[53] Thomas Birtchnell, Angela Daly, Thierry Rayna, Ludmila Striukova, Legal views of 3D printing and IP, Trade Marks (pp.22-23), Intellectual Property Office (2018/03), 3D Printing and Intellectual Property Futures.
[54] INTA, International Trademark Association - Design committee & Designs Communications Subcommittee (August 2017), Trademarks, Trade Dress and Passing Off (pp.9-12), 3D printing: Key Legal Issues and Options for Change.

2.1.3. Current legal framework Issues

The application of the current legislation may lead to a paradoxical situation, the third party can physically produce the copyright protected object upon a private individual's request invoking the private copying exception, but not the digital file of that same object. That paradox shows how the actual legislation does not always provide a good answer to the new problems that arise.[55] The issue with 3D printing is that it is easier to make patent protected objects (less time, costs and skill needed for the construction of the object), but it may entail an increase in the number of patent infringers.[56] This situation presents a challenge to patent enforcement, counterfeiters will shift from manufacturing counterfeit products to distributing computer files to consumers who will print the counterfeit product at home and by doing so it will be difficult for patent holders to stop the illegal behavior. There are indeed some exceptions, for example it is generally considered legal to manufacture a replacement part of a patented item (as long as the part itself is not patented). Another exception is, as for the copyright, for private use/non-commercial purposes, but also for "experimental purposes". With the current legal framework there are risks for patent holders, in fact the patent holders will not aim to sue the end user (cost and reputation inefficient) but will still go against the intermediary (who once was the large, deep-pocketed company who directly infringed the law who would pay a compensation if the infringement was proven, but now those intermediaries usually are Online Service Provider which, even if the infringement is proven, will not have such deep pockets so the suing company in the end will probably not get a compensation or just a small part of it), leading to uncertainty for the patent holders.

Design rights seem a strong tool to strike fast. Protecting the appearance of the product (its design), but also portions of the product (such as particularly designated pieces and so on) will provide the designer with a multi layered strategy, useful to prevent counterfeiters (who usually tend to change small parts of a product to circumvent design protection).[57] However, holders of design rights have basically no remedy against those who print for private use and not for commercial purposes, plus, the law does not clarify the extent to which an intermediary (like a

[55] Declercq Advocaten - Notarissen, Leiden/Den Haag, Netherlands (November 2015), Private copy exception (p.5), White Paper, The Legal Aspects of 3D printing from a European perspective.
[56] Thomas Birtchnell, Angela Daly, Thierry Rayna, Ludmila Striukova, Legal views of 3D printing and IP, Patents (pp.20-21), Intellectual Property Office (2018/03), 3D Printing and Intellectual Property Futures.
[57] Justin E. Pierce, Steven J. Schwarz, (April 2015), Intellectual Property Strategies for Dealing with 3D Printing, Design Patents, United States: IP Strategies For The Rise Of 3D Printing, retrieved from Mondaq database.

3D print shop) can make, at a private's request, a 3D printout of a protected object. For design rightsholders it is imperative to be able to invoke other intellectual property laws as well.[58]

3D printing may have an impact on trademarks, diminishing the importance of brands as marks of origin when everyone can print out objects themselves, putting in charge of the creation and selection of materials the end-user. A common justification against infringing goods is that they typically are of lower quality (and in that way they damage the brand or the consumer itself), but 3D printing may change that. Trademarks owners will have to change their way of protecting their rights, not relying on a consumer protection or a brand tarnishment claim but purely defending their property rights, owners will argue that they have property rights in their trademarks and thus can exclude others regardless of any characteristic of the infringing item. At the current state, infringement is difficult to prove because the provider would be liable if it encourages unlawful copying by others but CAD files do not replicate the physical object protected (and so the providers do not use the mark themselves) and it will be difficult to prove that the provider of the file tried to mislead users as to the origin of the file. Infringement is unlikely to be established because the use of the mark in relation to the file does not affect the essential function of the trademark (it does not confuse users). Lawmakers will have to carefully distinguish legitimate uses (and accommodate them) from harmful behaviors (which shall be clearly defined and prohibited).[59] At last, trade secrets covering physical items will be disrupted. As of now reverse engineering is pretty difficult because the parts of the products are engineered in ways difficult to replicate (a certain amount of tolerance, a certain metal alloy difficult to understand and reconstruct). With 3D printing those problems will be eliminated, 3D scanners can obtain precise measurements and 3D printers are able to print to exacting standards.[60] Rightsholders will need to use contracts which prevent reverse-engineering, else, enforcing their rights (by enforcing patents and rights in confidential information) will be nearly impossible, those are reactive actions meaning the damage (the disruption of the trade secret) already occurred., so developing contracts and confidentiality agreements is the only way to go, even in the case of a trade secret theft, those agreements will put the rightsholder in a better

[58] Declercq Advocaten - Notarissen, Leiden/Den Haag, Netherlands (November 2015), Indirect Infringement (p.8), White Paper, The Legal Aspects of 3D printing from a European perspective.
[59] Lucas Osborn, 3D printing and intellectual property rights (pp. 255 - 271), 3D printing and Other IP, Trade Secret Law, Research handbook on digital transformations.
[60] Lucas Osborn, 3D printing and intellectual property rights (pp. 255 - 271), 3D printing and Other IP, Trade Secret Law, Research handbook on digital transformations.

position to enforce its rights in trade secret litigation because it will be able to object the confidentiality contract.[61]

To conclude, the existent legal framework does not seem to protect an original 3D printed creation very well, because of the uncertainty of the law and because of some features of the new technology the intellectual property rights could face an unprecedented crisis if they won't be able to change and cope with the novelty.

Copyright	**Patents**	**Design**	**Trademarks**	**Trade Secrets**
- Third party can produce the copyright protected object upon a private individual's request invoking the private copying exception, but not the digital file of that same object	- Patent enforcement is challenged; counterfeiters will shift from manufacturing products to distributing CAD files to consumers who will print it at home - Patent holders won't sue the end user (cost and reputation inefficient) but will go against the intermediary usually OSPs, the problem is that the suing company probably won't get a fair compensation or just a small part of it), leading to uncertainty for patent holders	- No remedy against those who print for private use and not for commercial purposes - Law does not clarify the extent to which an intermediary can make, at a private's request, a 3D printout of a protected object	- Diminishes the importance of brands as marks of origin (everyone can print out objects by themselves) - Trademarks owners need to change their way of protecting their rights, (not relying on consumer protection or brand tarnishment but purely on their property rights) - Infringement is difficult to prove and unlikely to be established (use of the mark in relation to the file does not affect the essential function of the trademark)	- Trade secrets covering physical items will be disrupted. - Rightsholders will need to use contracts which prevent reverse-engineering, else, enforcing their rights will be nearly impossible - It is necessary to develop contracts and confidentiality agreements

[61] Thomas Birtchnell, Angela Daly, Thierry Rayna, Ludmila Striukova, Legal views of 3D printing and IP, Trade Secrets (p.24), Intellectual Property Office (2018/03), 3D Printing and Intellectual Property Futures.

2.1.4. Other legal issues

Other than Intellectual property and liability aspects legal issues may arise regarding 3D printing. Safety and security issues are a very important topic, as an example the creation of a 3D working plastic gun that everybody can download and reproduce is very concerning and it led to the first person getting arrested for the possession of a plastic gun in 2014.[62] It happened in Japan, a 27 year old college employee posted footage on the internet showing him shooting the guns, the police investigation recovered five 3D printed weapons and a 3D printer in his home in Kawasaki, near Tokyo. It was the first-time firearm control law has been applied to the possession of objects produced by 3D printers. The suspected admitted the allegations saying, "I did not think it was illegal".[63]

The development of 3D printing technology is a big challenge for legislators, those kinds of weapons are not detectable with standard security equipment leading to fears that they may be used freely, escaping controls. The low awareness about this topic may also lead people to do illegal actions (like in the case of the Japanese college employee) without fully realizing that, exposing not only others, but also themselves to dangerous situations.

Issues relating to environmental aspects could occur as well, (for example regarding material safety, hazardous materials and so on).[64]

[62] Declercq Advocaten - Notarissen, Leiden/Den Haag, Netherlands, (November 2015), Other legal issues (pp10-11), White Paper, The Legal Aspects of 3D printing from a European perspective.
[63] Preston Phro, 27-year-old in Japan arrested for 3-D printed pistol, says he didn't know it was illegal, (May 2014), retrieved from Sora News 24 database.
[64] Japan makes first arrest over 3-D printer guns (May 2014), retrieved from Phys.org database.

2.1.5. Recap[65]

Intellectual property right	Registration and protection period	Conditions for protection	What is protected?	What is not protected?
Copyright	-No registration, protection until 70 years after the author's death.	-Originality (required level for this condition is low) -Applies automatically if the object meets the originality criteria under applicable law.	-Original, creative objects. -A 3D CAD file written from scratch (not a 3D scan from an existing object) could fall in this category because of its technical drawings, diagrams and models. -Derivative works (3D CAD can be a derivative work).	-Specific materials used for the production. -Shapes with a purely technical function, such as moulds for another object. In some countries useful objects may be excluded.
Patent rights	-Needs registration, it stops after legal protection period expires.	-New. Inventive. Industrially applicable. -Licit.	-The innovation and technology contained in the object. -A CAD file that contains a	-Esthetic lay-out.

[65] Overview of 3D printing & intellectual property law, (September 2016), Relevant Intellectual property rights in the context of 3D printing (pp.11-13) Under the contract with the Directorate General Internal Market, Industry, Entrepreneurship and SMEs.

			plan for a patented item, certainly if cited in the patent claims.	
Design rights	-No registration required, protection during 3 years from the date of disclosure, not renewable, registration required for long- term protection, renewable every 5 years (maximum 25 years).	-New appearance and individual character of the whole or part of an object towards the informed user (overall impression of dissimilarity to previously existing designs).	-The external shape and features of the whole or part of the product.	-Raw materials. -Internal parts not visible during normal use. -An object that is commonplace in the relevant technical field. -Design features
Trademark	-Registration required, renewable. -In rare cases registration is accepted for the shape of products.	-Graphic representation. Distinctive. Licit. -Available.	-The use in trade of the trademark as registered, including sharing on the Internet.	-The private use of the trademark, because the user will not be confused about the origin when he adds the trademark himself.

2.2. Court cases

In this part we are going to show some of the most interesting court cases regarding intellectual property rights and 3D printing that will help us understand how the current legal framework is handled to solve the problems that arise.

2.2.1. Invisalign vs. Clearcorrect

An important case which had a profound effect on the 3D printing industry is the case Invisalign vs. Clearcorrect.[66]

There are not only cases in which companies who have a product sue other companies who, by the use of 3D printing, are liable for IPR infringement, but also cases of established 3D printing companies who now try to defend their position and their market share against new 3D printing competitors. 3D printing companies increasingly find themselves in court asserting or defending against infringement claims.

The dispute arose from Align Technology Inc. who filed a suit against ClearCorrect Operating LLC for patent violation on its Invisalign products. Those plastic teeth aligners eliminate the need for metal braces. Align's method scans the client's teeth and convert them into digital files that are later used to create 3D models of the plastic aligners customized to fit each client. Align's patent cover the producing method rather than the product itself, and accused ClearCorrect of unfair practices in import trade, asking the ITC (US International Trade Commission) to protect Us intellectual property rights from foreign infringement. In an attempt to skirt Align's US patents, ClearCorrect produced the original teeth scans in the United States, then sent the files to Pakistan where the digital data were converted to 3D models and then sent back to ClearCorrect where the actual molds were printed.[67] The central question was if the electronic transmission of digital files could be considered an importation of articles. On April 3, 2014, the ITC found a patent infringement violation, ITC's administrative Law Judge determined that the digital data sets that were produced by using Align's patented method must be considered articles in that they infringed claims of Align's patents. Infringement of digital patents do not need to be based on tangible products. This decision has very profound

[66] Scott J Grunewald, (Nov 9, 2015) 3D printing, 3D scanning, 3D software, Business - Can 3D Digital models be patented? Federal Courts to make key decision this summer, retrieved from 3D print database.

[67] Dennis Crouch, Lucas Osborn, Digital Patent Infringement and the ITC, Campbell University School of Law (April 2014), retrieved from Patentlyo database.

implications in 3D printing technology fields, in fact, with the greater availability and easier accessibility of digital files potential infringers won't be companies like in this case, but individuals working at home and printing their own articles. It is highly recommended for companies who want to protect physical product to think about protection the digital versions of them as well.[68] On ClearCorrect's motion, the issue was presented to the Federal Circuit which reversed the ITC's decision and remanded the case to the ITC, the most important issue concept in the opinion was the consistency of the term "article" seen as a material object and the court concluded that articles cannot be defined to include electronic transmissions. Judge Newman dissented from the court decision explaining that "Patents are for things that did not previously existed, including kinds of technology that were not previously known... There is no basis for excluding imported infringing subject matter, whatever its form".[69] The result of the decision would apply not only to patents but to any intellectual property infringement claim brought against accused digital files imported to the United States. The case has yet to reach an end, and the United States supreme court shall have the final word on it, keeping in mind that each decision will have strong repercussions, if ITC's ruling is uphold, companies that 3D print parts from third party digital models without a license could be patent infringers while on the flipside of the coin, companies with profitable parts of their businesses are worried that those parts may be 3D scanned, and that such parts will be converted to 3D printable digital blueprints and customers will stop buying the parts because they can 3D print them in-house from such blueprints. This is why one side pushes for a "liberalization" of 3D printing, while the other would prefer to have a strong intellectual property protection for digital models. If the final ruling is in favor of the latter and digital models will be considered as articles, companies may be able to patent those models, that will give them a very powerful weapon for preventing the copying of profitable parts from unlicensed third parties.[70]

[68] Carlos Rosario & John Hornick, Court to decide key question on patentability of 3D digital models, (June 2015), retrieved from 3D printing industry database.
[69] Edward Chalfie, (January 2017), Brace Yourselves: 3D Printing IP Issues Are Here, retrieved from Dennemeyer IP blog database.
[70] Carlos Rosario & John Hornick, Appeals court rules on the transmission of 3D files (December 2015), retrieved from 3D printing industry database.

2.2.2. Envisiontec vs. Formlabs

In this case we have Massachusetts based Formlabs Inc. creator of popular and low-cost vat polymerization printers accused of patent infringement. Michigan based Envisiontec Inc. filed a complaint on September 12, 2016 in the federal court in the central district of California where it accused Formlabs of infringing two of its US patents by making, using and selling some of its 3D printers.[71] The first patent claims a 3D printing apparatus that includes a recipient for holding material that can be solidified under the influence of light with a transparent plate under it and a resilient layer on the plate and side wall of the recipient from which the material is easier to detach than from the transparent plate. The second one claims a 3D printing apparatus for separating hardened 3D printed material from the build plate using a film-like material between the plate and the material.

Envisiontec asks for a jury trial which declares Formlabs infringement and monetary damages for the lost profits caused by it, furthermore it asks an injunction preventing Formlabs from making, using and selling the infringing products. Under current case law it is very rare for courts to grant injunctions, to obtain it Envisiontec needs to prove that it has suffered an irreparable injury as a result of the infringement and that monetary damages are inadequate to compensate for it. It also has to prove that to balance the hardships between the actors an injunction is necessary, and that the injunction is not contrary to public interest.[72] Proving all of the points is not easy under current law. The case is still in progress, to respond, Formlabs will probably argue that it does not infringe Envisiontec patents or that they are invalid for various reasons. Formlabs may even decide to assert its own patents against Envisiontec or they could negotiate a settlement. Because a lot of patent infringement cases are intricated and there are many reasons each party can object, the lawsuit could take years, also, by looking at the fact that those cases rarely reach the final jury, a settlement seems to be the most likely option. In fact, 70% of patent cases in the US result in voluntary dismissals or settlement. Those Envisiontec patents have never been litigated before so no prior rulings that foreshadow the potential outcome of the case are present, the outcome remain to be seen.

Speaking about frequency of settlements and patent infringement accusations by competitors it has to be noted that it is the second time in four years that Formlabs found itself accused. In the

[71] Scott J Grunewald, (Nov 9, 2015) 3D printing, 3D scanning, 3D software, Business - Can 3D Digital models be patented? Federal Courts to make key decision this summer, 3D print.

[72] John Hornick, (Oct 3, 2016), 3D printers, 3D printing, Business - Envisiontec patent suit against Formlabs: An IP perspective, retrieved from 3D print database.

first one Formlabs settled the infringement suit filed by 3D systems (one of the oldest and largest 3D printing companies) in 2014 agreeing to pay them a percentage of their net sales for an unspecified amount of time.[73]

2.2.2.1. Liability for 3D printers' manufacturers

It is important to note that generally, manufacturers of 3D printers can defend themselves from accusations of infringement arguing that the printers have substantial non-infringing uses and that they cannot be held liable for infringement without engaging in additional infringing conduct.[74] This interpretation stems from a 1984 decision of the US Supreme Court where it stated, in the context of Sony's Betamax video tape recorders, that the sale of a copyright infringing device was not contributory infringement where the device was in fact, capable of "substantial non-infringing uses"[75]

[73] Brian Krassenstein, (Dec 2, 2014), 3D printers, 3D printing - 3D Systems' Lawsuit Against Formlabs is Dismissed, retrieved from 3D print database.
[74] INTA, International Trademark Association - Design committee & Designs Communications Subcommittee (August 2017), Copyright - Secondary Liability (p.6), 3D printing: Key Legal Issues and Options for Change.
[75] Sony Corp. v. Universal City Studios, 464 U.S. 417 (1984), retrieved from JUSTIA US Supreme Court database.

2.2.3. Other relevant cases

There are interesting copyright infringement cases who deserve mention. To understand how courts are likely to act in the 3D printing context we should consider a scenario where the company A sues the company B because the latter is selling a 3D printed product that infringes the copyrighted design or shape of company A's water container. The court finds the water container is "similar to modern sculpture" and "has a distinctive shape". However, applying the conceptual separability concept, the court finds impossible to conceptually separate the distinctive appearance element from its functional element of holding content. So, even if the facts show it is likely that company B copied the design of company A, it is not liable for copyright infringement. The reason is that the primary purpose of company A's water container design is to provide a useful function and that copyright can only protect non useful objects. Useful objects can be protected by others intellectual property rights like patents which protect novel elements of how a useful object works.[76]

A multilayered protection strategy seems to be the best option to cover and protect each aspect of a determined product.

Recently Ugg's brand shoes maker filed a suit against retailers for trademark, trade dress and design patent infringement, the case is still in progress, but the multiplicity of protection types has increased its probability of success and control over the brand. The case does not involve 3D printed but seemed interesting to cite in order to show how knowing how to act in such situations is an invaluable tool for protecting functional objects which would have been non copyrightable.

Against unauthorized entities offering 3D printed goods protected by intellectual property rights, the DMCA (Digital Millennium Copyright Act), can be an important tool to enforce protection. The DMCA is a 1998 US copyright law that implements two treaties of the world Intellectual property organization and criminalizes technologies, devices or services intended to circumvent measures that control the access to copyrighted works. The simple act of circumventing is criminalized, even when there is no actual infringement of copyright himself. DMCA's principal innovation is the exemption from direct and indirect liability of internet service providers, later adopted by the UE in 2000. 1996 WIPO copyright treaty was implemented in Europe with the 2001 copyright directive. For example, HBO used it recently

[76] Justin E. Pierce, Steven J. Schwarz, (April 2015), Intellectual Property Strategies for Dealing with 3D Printing, Copyright, United States: IP Strategies For The Rise Of 3D Printing, retrieved from Mondaq database.

to force a company making 3D printed phone chargers modeled after the iron throne (from the popular show "Game of Thrones") to cease their conduct. Many similar rightsholder actions have resulted in the online removal of a lot of infringing 3D printed items.

However, there is a downside, these notices often result in the removal of the infringing item from 3D printing websites, but the requests to cease and desist (often published online) are usually subject to strong critics by the public. Rightsholders have to think carefully about the effect of their legal claims on the consumers, sometimes trying to protect the brand may cause more harm to the company than not.[77]

Having now shown the principal legal aspects, and the issues of the current framework, also with the help of some relevant court cases to better understand how the courts act with the current laws and problems that arise with 3D printing and intellectual property rights protection; let's now take a look on the measures to prevent liability and infringement in order to deal effectively with the current legal framework and protect original works from being unlawfully copied.

[77] Justin E. Pierce, Steven J. Schwarz, (April 2015), Intellectual Property Strategies for Dealing with 3D Printing, Copyright, United States: IP Strategies For The Rise Of 3D Printing, retrieved from Mondaq database.

3. How to deal with the current legal framework

3.1. How to prevent liability and infringement

We saw in the part two of this work the main issues with the current framing of intellectual property rights explaining how infringers may circumvent the rules and how difficult is for rightsholders to enforce their rights. Another important legal aspect to discuss is how to protect the creations that are copied and reproduced with additive manufacturing. In order to do this, we will analyze the current legal framework from a rightsholder perspective and try to give some insights on how they can use the current framework in a more efficient way and what actions may be put in place to deal with infringers.

3.1.1. Copyright

Since a lot of 3D printed objects are protected by copyright, infringement can easily rise, to try avoiding it, it is necessary that parties who print them on behalf of customers' requests should check if the object or CAD file is not infringing third parties' rights (or at least that liability lies directly and only with the customer). Legally-binding general conditions are fundamental to shift liability from the contractor to the assignor.[78] On the other side, for the rightsholders it is essential to prevent infringement of their rights, the problem is that typically there are many infringers, making it impossible to defend the rights effectively against all of them. Existing copyright laws can be used against people who upload or download CAD files and people who copy or distribute a copyrighted file or a 3D object.[79] The preferable option is to focus on intermediaries that offer the CAD files, but as said earlier they can easily manage to shift liability to their customers, for the rightsholder a proactive management of their rights, also with the help of digital rights management (DRM), that is a systematic approach to copyright protection for digital media which purpose is to prevent unauthorized redistribution of digital media by restricting ways in which consumers can copy the content they have purchased typically by embedding code that limits some actions like copying, accessing ecc... in terms of time or number,[80] is essential. This approach is temporary, because it still remains difficult to catch law-breakers and the current laws, but also the current business models should change in the long run.[81]

[78] Declercq Advocaten - Notarissen, Leiden/Den Haag, Netherlands (November 2015), How to prevent liability (pp3-4), White Paper, The Legal Aspects of 3D printing from a European perspective.
[79] INTA, International Trademark Association - Design committee & Designs Communications Subcommittee (August 2017), Copyright - Direct liability (pp.4-6), 3D printing: Key Legal Issues and Options for Change.
[80] Digital rights Management (DRM), retrieved from SearchCIO/TechTarget database.
[81] Declercq Advocaten - Notarissen, Leiden/Den Haag, Netherlands (November 2015), How to prevent infringement (pp4-5), White Paper, The Legal Aspects of 3D printing from a European perspective

3.1.2. Patents

The patent grants the inventor a temporary monopoly in exchange for the description of how to achieve such invention. Direct infringement of a patent requires that the object is made, used, displayed or sold. Consumers and companies that use 3D printers in order to make, use and sell those infringing products are obviously direct infringers, so intermediaries who 3D print files into objects on request can face liability for direct infringement, while a blueprint or software instructions for creating 3D printed objects are generally not enough to configure liability (mere distributors are very unlikely to be held liable for direct infringement).[82] Similarly to copyright, it is important for the intermediaries which 3D print for third-parties, to have general conditions and contractual provisions that switch the liability to the customer.[83]

Patent holders can also sue for indirect infringement those who supply means that enable their patents to be infringed if those means are an essential element of the invention. For those who want to take action against CAD file suppliers that can be used to infringe a patent the law is uncertain, it is not well defined if that file can be considered as a mean or not, this issue could be an obstacle to the further development of the 3D printing industry because patent holders will probably try everything to hinder it and protect their inventions, and the others will be reluctant to develop the technology because they do not want to risk to be held liable. It is imperative to develop the current law and define precise rules about what constitutes infringement and what not.[84]

[82] INTA, International Trademark Association - Design committee & Designs Communications Subcommittee (August 2017), Utility and Design patent, Direct liability (pp.14-16), 3D printing: Key Legal Issues and Options for Change.

[83] Declercq Advocaten - Notarissen, Leiden/Den Haag, Netherlands (November 2015), Patent Law, direct infringement (pp.6-7), White Paper, The Legal Aspects of 3D printing from a European perspective.

[84] Declercq Advocaten - Notarissen, Leiden/Den Haag, Netherlands (November 2015), Patent Law, indirect infringement (p.7), White Paper, The Legal Aspects of 3D printing from a European perspective.

3.1.3. Design

To understand if there is direct infringement of a design patent "an ordinary observer, familiar with the prior art should view the challenged design as substantially similar to the patented one, such that the observer would be deceived into purchasing one design supposing it to be the patented design." "Where a design contains both functional and non-functional elements, the scope of the claim must be construed in order to identify the non-functional aspects of the design as shown in the patent" and "such functional aspects at least necessitate cabining the scope of the design claim in order to prevent the claim from encompassing the general design concept of the functional object". Basically, the design infringement claim can be made if the design is not connected to the functionality of the object, the design has to be non-useful.[85]
Secondary liability can be applied for inducement of infringement (willful blindness can be a cause of secondary liability). Generally, private and non-commercial use of a design does not constitute infringement, but the publication or offer for sale of it is punishable by the law, its main purpose is to protect rightsholders not only against direct infringers but also against those who facilitate the illegal conduct.[86]

[85] INTA, International Trademark Association - Design committee & Designs Communications Subcommittee (August 2017), Utility and Design patent, Direct liability (pp.14-16), 3D printing: Key Legal Issues and Options for Change.
[86] INTA, International Trademark Association - Design committee & Designs Communications Subcommittee (August 2017), Utility and Design patent, Secondary liability (pp.16-19), 3D printing: Key Legal Issues and Options for Change.

3.1.4. Trademarks

The rightsholder, in order to take action for a trademark infringement, has to claim and prove that the challenged use was in commerce, 3D printing at home of an object with someone else's trademark just for personal use is unlikely to constitute an infringement, that is, if the home printed object is not offered or displayed to the public. If the product is offered, displayed, sold, or whatever use that may dilute the mark makes trademark infringement claim actionable. A brand owner who thinks that others are using his trademark causing damage to him (actual damages, but also disgorgement of profits) he can apply for direct infringement. In the case of counterfeiting the owner may be entitled automatically to attorney's fees and statutory damages. So, trademark owners can prosecute as direct infringers those who use in commerce 3D objects they make that display other's trademarks. [87] It is not the only way to catch infringers, if they are not the direct infringers, a secondary liability may be applicable, many courts recognized that someone who knowingly participates in furthering the infringement is liable as contributory party. The contributor must be shown to have knowledge that the users of its services were infringing, however, there is no need of intention to be considered a contributor to the infringement. For example, a mere willful blindness (when you suspect someone's wrongdoing and decide to not investigate) may meet the standard for contributory infringement. If the direct infringer provides a service, the court "must consider the extent of control exercised by the defendant over the third party's means of infringement" and "for liability to attach, there must be direct control and monitoring of the instrumentality used by a third party to infringe" the plaintiff's trademark. There has to be a material contribution toward infringement, providing direct infringers with server space may satisfy the standard, because of being essential to the infringement process. For trademark law there is no statutory safe harbor (like DMCA for copyright which protected online service providers from liability for third parties' infringements), to avoid liability several service providers implemented voluntarily notice-and-takedown procedures to try keeping potential plaintiffs from proving contributory infringement. A party creating or uploading a file may be held contributorily liable if it encourages unlawful copying (it is also applicable to file hosting websites and print shops that rent 3D printers). [88]

[87] INTA, International Trademark Association - Design committee & Designs Communications Subcommittee (August 2017), Trademarks, Trade Dress and Passing Off, Direct liability (p.10), 3D printing: Key Legal Issues and Options for Change.

[88] INTA, International Trademark Association - Design committee & Designs Communications Subcommittee (August 2017), Trademarks, Trade Dress and Passing Off, Contributory infringement, (pp.11-12), 3D printing: Key Legal Issues and Options for Change.

3.1.5. Recap[89]

Intellectual property right	What can be protected?	What can constitute infringement?	What use can be non-infringing?
Copyright	-The object itself -3D scanning software -A CAD file -The 3D printed object as a copy of the original product	-Digitization of an object with a 3D scanner -Private use if valid exceptions do not apply -copying the CAD file -Actual reproduction by the maker of the 3D printed object -Sharing the CAD file	-Private use if the user can validly invoke an exception (private copying, repair...) -Copy for private use must be made from a lawful source -Reverse engineering can be possible -Not sharing the CAD file
Patent rights	-The innovation and the technology in the object -The object itself -The innovation and the technology contained into the CAD file.	-Using or producing the invention. -Rightsholder can argue the CAD file to be a copy device -Reverse engineering may constitute an infringement -Independent creation if exceptions do not apply -Making the object -Uploading the CAD file -Selling/trading the 3D object copying the invention	-Creating a CAD file from scratch without copying the patented technology/innovation -Copying unpatented parts of the patented object -Printing for personal use -Private use of the 3D printed object -Sharing a new and non-infringing CAD file
Design rights	-Shape and configuration of the object	-Digitization of an object if the 3D model is used in the course of trade	-Private and non-commercial use do not constitute an infringement

[89] Overview of 3D printing & intellectual property law, (September 2016), Infringement of intellectual property rights in the context of 3D printing, (pp.14-18) Under the contract with the Directorate General Internal Market, Industry, Entrepreneurship and SMEs.

	-The CAD file protection by design rights is debated	-Manufacturing a product incorporating a protected design for commercial purposes -Putting the product with the protected design on the market, offering it for sale, marketing and importing/exporting the product.	
Trademark	-The trademark as it has been officially registered -Using the name on the CAD file	-Commercial 3D printing using the trademark in a way that consumers would think the object is produced by the owner of the trademark -Using the trademark when commercially disseminating the CAD file and/or the 3D printed object	-Privately printing at home -Using the trademark when using the CAD file in non-commercial ways

3.2. Case study on 3D chocolate printing[90]

We will now analyze on 3D chocolate printing, in order to see and try to understand how a business out of 3D printing technology is made and the steps to take to avoid intellectual property rights problems of infringement and liability, in the first part the case will be analyzed as a whole and then the focus will be on what can be learned from it.

3.2.1. Overview of the case

3D printing is a technology who could generate enormous benefits for the society in various fields, but, to realize those benefits a lot of attention has to be put into the study of the current legal framework, in this case study in particular the attention should be given to product liability, health, safety and environmental law. The paper studied copyright implications of designing and manufacturing 3D printed chocolate products using a co-creation business model. A research group at the University of Exeter created a co-creation website platform that would allow chocolate lovers to print custom-made sweets.[91] The main focus of the case will be on two aspects:

-the liability for authorization of infringement of copyright and about the artistic works.

-the consequences of reproducing two-dimensional works in three dimensions (the originality requirement to enable copyright protection) and the copyright implications of co-creation. In 2007, Dr. Liang Hao of Exeter University developed a chocolate manufacturing technology to create artistic and personalized chocolate products that could be sold to consumers. Engineering students constructed a chocolate additive layer manufacturing prototype and a spin-out company was formed to commercialize this technology.[92]

In 2012 the first 3D chocolate printer was made, the product idea and design were conceptualized and digitized through various means (using 3D modelling software, reverse engineering through 3D scan technology, converting a 2D image to a 3D model...). The design generated would then be converted into a stereolithography file, the most common file format for 3D printers. The file is then imported into the machine control software package and the

[90] Phoebe li Stephen Mellor, James Griffin, Charlotte Waelde, Liang Hao and Richard Everson, Intellectual property and 3D printing: a case study on 3D chocolate printing, Authorization of infringement, (p.10), Journal of intellectual property rights and practice, 2014.

[91] Chocolate printer to go on sale after Easter, (April 2012), Technology, retrieved from BBC news database.

[92] Chocedge, chocedge.com

machine parameters are set up according to product features and specifications. The raw material is prepared, and the manufacturing cycle is started, the design is built up in successive layers until its completion, once the design is finished the product is left to cool and is then ready for eating or for distribution.

3.2.2. Intellectual Property Rights challenges

3D printed chocolate products and their designs are likely to fall in the category of an artistic work, which has to be "visually significant" or "made to look at"[93]

By looking at the chocolate printed works in this case, there is no doubt that they are works of art (Image of a footballer by Liang Ho). It is debated in which copyright category should it fall, is it a drawing? a graphic work? a collage? or also a sculpture once made into chocolate?

That is the first point to define in order to understand which law and case law is applicable. In the case the "sculpture" definition seemed to be the most suitable one, the case law is pretty mixed, to be a work of artistic craftmanship, it must be of quality, and this is not a problem, but the characteristic of craftmanship, it is argued, may not be present. To counter this argument, it is noted that a craftsman uses tools and machines for shaping objects, a 3D printer is just another tool reach his goal of producing a work of artistic craftmanship.

Another problem may arise, for the purposes of copyright infringement because 3D printing is a representation of a two-dimensional artistic work in three dimensions. In the case there is an example that representing in three dimensions a drawing of a cartoon figure protected by artistic copyright and the other way around representing a three-dimensional cartoon character protected by artistic copyright in the form of a flat chocolate can expose to liability for copyright infringement, because the reproductions are within the exclusive rights of the owner of the copyright. For the representation to be non-infringing, consent from all the rightsholders is needed, but in case of a 3D printed product who is the owner of it?

First, we should acknowledge if the work is original, then it is possible to identify the author, who often is the copyright owner. For copyright protection to be given, appropriate creative effort or originality must be present in the artistic work, the European Union Court of Justice explained that to be original, a creation has to be the author's intellectual creation, independently from that being an artistic work, a drawing a collage or else, if it falls under Berne's convention definition of it: "The object of this paragraph is to define the expression "literary and artistic works". It does this in two ways: the wording envisages all productions in the literary, scientific

[93] Tomasz Rychlicki, Legal Questions About Illegal Art, (2008).

and artistic domain, and permits of no limitation by reason of the mode or form of their expression."[94] "The Convention thus asserts the principle of an all-embracing protection for the benefit of all productions in the literary, scientific and artistic domain, and, in a second assertion, lays down that the mode or form of expression of a work in no way affects its protection."[95] and "Although paragraph (1) of Article 2 refers to literary and artistic works, it must not be taken to intend a division into two mutually exclusive categories."[96] Basically, what is not protected is expression which is limited by its technical function so if choices are dictated by technical considerations, rules or constraints where no creative freedom is possible the criteria are not met. In our case, there is a strong copying possibility, in fact, if a substantial part of another work is taken, the copyright in the first work will be infringed so if the consumer starts with an existing artistic work to print a three-dimensional chocolate that will infringe the copyright of the first work. This is the general rule, but for simple artistic works the copyright is thin so, for example, a 3D chocolate printed Christmas tree will not constitute an infringement regarding the copyright owner of the Christmas tree design if it is not an identical copy. So, the discussion on the originality of the creation is concluded, now we still have to answer the question about who the copyright holder is. In our case, consumer engagement is fundamental for the realization of the product, it is a case of co-creation. For the law, it is still difficult to protect works where there are multiple authors, there must be a work produced by the collaboration of two or more authors in which the contribution of each one is not distinct from that of the others when you look at the final work,[97] contributing only by bringing ideas is not enough. In our case those conditions seem to be respected, the contributions to the designs of the works are not distinct (one is not able to tell who contributed for what), and the authors collaborated not only with ideas by also in the execution (by making the design) so all of the contributors are likely to be protected as joint authors. It is crucial to be clear about who are the authors, because (excepted the works made in the course of employment) the first owner of the copyright is the author. The last question that arises in the case is the one about authorization of infringement, that occurs when one party authorizes another in the eyes of the law to commit

[94] Berne Convention, art. 2.1. (p.12), Guide to the Berne Convention for the protection of literary and artistic works (Paris Act, 1971), WIPO.
[95] Berne Convention, art. 2.4. (p.13), Guide to the Berne Convention for the protection of literary and artistic works (Paris Act, 1971), WIPO.
[96] Berne Convention, art. 2.5. (p.13), Guide to the Berne Convention for the protection of literary and artistic works (Paris Act, 1971), WIPO.
[97] Copyright, Designs and Patent Act, 1988, Section 10, art. 1, retrieved from legislation.gov.uk database.

copyright infringement,[98] in those cases the authorizer is also liable for infringement. In the 3D chocolate production example two questions need to be answered:[99]

-If the 3D chocolate printer is used to print out three-dimensional chocolates that infringe copyright, would the provision of the 3D printer amount to authorization of infringement?

-If the Coco Works website is used by the co-creators to develop designs for chocolates which infringe copyright, if for example, they use pre-existing designs, would the provision of the website amount to authorization of infringement?

By the law, creating opportunities for others to infringe by providing machinery (like in this case the 3D printer or the website) is not considered authorization of infringement when it can be used for legitimate purposes, liability for authorization of infringement in the case's example seem to be a possibility only if the facilities are used to infringe copyright where such infringement could be prevented and it is known that there has been infringement. An appropriate notice on the website to warn and deter infringers can be a solution to avoid liability (of course, if the infringement continues and the person able to control it is indifferent to it, there can still be liability for authorization of infringement.

[98] Copyright, Designs and Patent Act, 1988, Section 16, art. 2, retrieved from legislation.gov.uk database.
[99] Phoebe li Stephen Mellor, James Griffin, Charlotte Waelde, Liang Hao and Richard Everson, Intellectual property and 3D printing: a case study on 3D chocolate printing, Authorization of infringement, (p.10), Journal of intellectual property rights and practice, 2014.

3.2.3. What can we learn from the case?

3D printing technology could lead to reshaping business processes from design to consumption by enabling co-creation. The consumer becomes an active part of the production process having an interactive role in the design of the product, a prosumer (combination of producer and consumer).[100] The co-creation concept allows businesses to shift from a manufacturing-centric mass production to a consumer-centric mass innovation/customization.[101] This shift brings up also some problems, with the traditional production methods the producer would own the copyright and the exclusive control over its value, with co-creation there is a struggle in identifying the author and so the owner of the rights over a product. Other difficulties regarding the originality of the work, the consequences in terms of liability and copyright infringement of reproducing in three dimensions two-dimensional works and also the liability of the provider of the 3D printing equipment arise and need to be addressed in order to be sure that the product that one is going to create does not infringe any existing property right, but also in order to know what are the conditions to be considered the rightsholder and to obtain legal protection of one's work from intellectual property rights. In other words, it is necessary to know and discuss the intellectual property rights issues and be aware of them to ensure that one's business stays within the boundaries of the law.

[100] Alvin Toffler, 1980, Prosumer, retrieved from Wikipedia database.
[101] Frank T. Piller, Mitchell M. Tseng, The customer centric enterprise, Advances in mass customization and personalization, Customer Driven Manufacturing Versus Mass Customization (pp.71-84), Springer.

4. Reframing intellectual property rights

In the last part of this work some proposals on how to change the legal framework and what can be done to find a solution to the issues posed by the 3D printing sector will be discussed. In this last part there will also be an overview on the future of the 3D printing industry in correlation with the intellectual property rights.

4.1. Recommendations

Different ideas and potential solution can be considered in order to develop a new way of balancing interests. New frameworks with tight regulation of the 3D printing industry where registration of 3D printer and printing activity tracking were suggested to balance rightsholders interests and general public freedom of use, the system would allow a nearly free use of 3D printing but warns the users when they attempt to print illegal/potentially infringing products, while also alerting the rightsholders and public safety officials. The model can be easily fitted into current laws and with some accommodations, become functional.[102]

Another proposed solution is a licensing platform for protecting copyrighted 3D designs and product, an iTunes-like model under which a usage fee including a royalty would be paid in order to have legal access to downloading files.[103] Generally speaking, the most advisable option (and probably the easiest to implement in terms of time and effort) would be to follow the example of the music and video/film industries which faced similar problems not too long ago. The way to go is to develop new business models including customer-friendly platforms that offer authorized CAD files for a reasonable price. (not only iTunes as said earlier, but also business models like those of Spotify or Netflix).[104]

It is not recommended, at least at this stage, to stifle innovation and penalize new technology by taking strong measures without having at least made a comprehensive review of the 3D printing impact (given the fact that now it is a growing phenomenon but still small in general trends). Once the phenomenon becomes broader, the impacts of it can be assessed more

[102] Yanisky-Ravid, Kwan, 3D printing the road ahead: The digitization of products when public safety meets intellectual property rights - A new model (pp. 101 - 138), Conclusion, Cardozo law review.
[103] INTA, International Trademark Association - Design committee & Designs Communications Subcommittee (August 2017), Options For Change (pp.19-21), 3D printing: Key Legal Issues and Options for Change.
[104] Declercq Advocaten - Notarissen, Leiden/Den Haag, Netherlands (November 2015), Copyright Law (pp3-6), White Paper, The Legal Aspects of 3D printing from a European perspective.

precisely and punctual and effective corrective actions could be undertaken, it will be important for policy makers to look holistically at the intellectual property system in light of the technology, the law tries to prevent free-riding by granting an exclusive IP right because it fears that inventors will no longer innovate if they cannot retrieve the costs of their creative process, if this cost was zero, then the IP rights would probably disappear because they would be no longer needed, once the costs to invent are low enough, non-monetary motivations will be sufficient for pushing innovation. 3D printing can alter the cost/benefit calculation that underlie the current IP system (by making some of those cost significantly lower, like building and modifying prototypes) so it should be considered whether, even if we are not to the point of such low costs for the inventing process, to rebalance IP laws to adapt to the current technology and the current cost/benefit calculation because if on one hand is true that not enough IP protection may hinder the innovation process, on the other it is also true that too much protection, such as IP terms that are too long impose significant costs on society by preventing access to innovations at a competitive market price. The sooner innovations enter the public domain, the sooner they can be improved and transformed.[105] Nevertheless a legal clarification of existing theoretical IP issues exposed by 3D printing is highly recommended, especially in identifying activities which constitute direct and secondary infringement, and how exceptions to infringement work. One question that needs to be clarified rapidly is if and to what extent a CAD file is capable of copyright protection,[106] this needs to be done in order to give more certainty to the current legal framework and use it as a base for future actions (of the stakeholders) and decisions (of the courts).

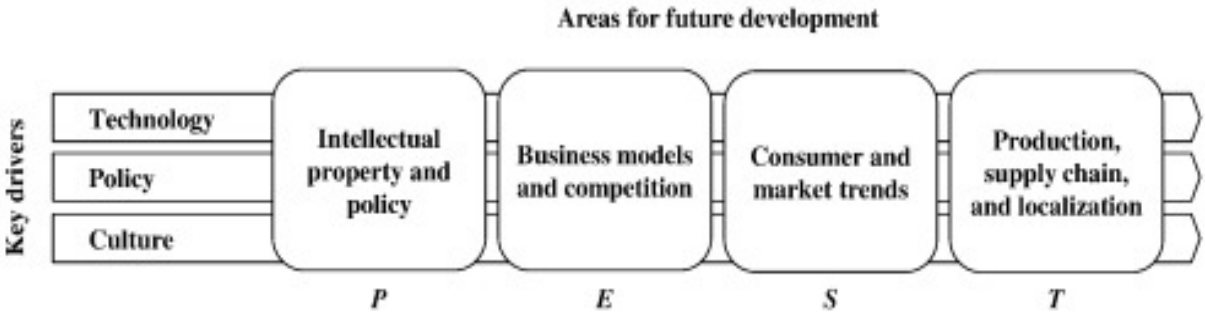
[105] Lucas Osborn, 3D printing and intellectual property rights (pp. 255 - 271), Rebalancing IP in a post-digital world, Research handbook on digital transformations.
[106] Overview of 3D printing & intellectual property law, (September 2016), Conclusion and recommendations, (p.22) Under the contract with the Directorate General Internal Market, Industry, Entrepreneurship and SMEs.

4.2. what future for 3D printing industry and IPR?

What can we expect for the future of the 3D printing technology and the intellectual property rights?

For sure this technology has the potential to disrupt many industries and processes, some examples may regard the way we intend supply chains making them way more efficient (by reducing storage and shipping costs and digitizing many steps of the supply management dynamics) the product warranties (which may no longer be useful because there may be no way to tell the difference between an original product and a copy, or no longer needed because one could simply print the product once again when it breaks), this technology may also provide gains in sustainability by reaching an higher level of resource efficiency (less waste than subtractive manufacturing and better recycling). The possibilities for businesses are endless, they will be able to produce better tailored products (thinking for example at the healthcare sector, making specific needs easier to supply, while also reducing the treatment costs.[107]

In a study conducted in 2017, the views on four areas (production, supply chain and localization; business model and completion; consumer and market trends; IP and policy) of many academics and industry experts were gathered using a PEST framework to assess the areas in which government policy and changes in legislation affect the economy and the specific industry.[108] According to the study, 3D printing impact is likely to affect mostly the supply chain area (3D printing of spare parts by end users) and the intellectual property and policy one (with possible emergence of new types of IPRs and the question of illegal file sharing).[109]



[107] Thomas Birtchnell, Angela Daly, Thierry Rayna, Ludmila Striukova, Business and Social Science views of 3D Printing and IP, Potential industrial impacts (pp.9-10), Intellectual Property Office (2018/03), 3D Printing and Intellectual Property Futures.

[108] Kenton, PEST Analysis, Retrieved from Investopedia database.

[109] Ruth Jiang, Robin Kleer, Frank T. Piller, Predicting the future of additive manufacturing: A Delphi study on economic and societal implications of 3D printing for 2030.

If 3D printing becomes ubiquitous enormous threats may arise for intellectual property rights, there will be a need to rethink the bases of IP in terms of private and public domains, idea of use, temporary terms of protection, the idea that copying can be prevented, enforcement ways, and how to incentivize innovation.[110] Carefully performing this reevaluation will secure a positive future for IP regime goals, ignoring technology's effects may lead to under or overprotective IP laws, and in this way, retarding innovation.[111]

[110] Thomas Birtchnell, Angela Daly, Thierry Rayna, Ludmila Striukova, Legal views of 3D printing and IP, Future Scenarios (pp.27-28), Intellectual Property Office (2018/03), 3D Printing and Intellectual Property Futures.
[111] Lucas Osborn, 3D printing and intellectual property rights (pp. 255 - 271), Conclusion, Research handbook on digital transformations.

Main Findings/Conclusion

This work tried to explain how the Intellectual Property Rights have been affected by the rise of the 3D printing technology. From what we have seen analyzing the current legislation, it emerged the criticality of those rights to grant a solid and clear protection of the rightsholders, many dark areas are present in the norms where the companies and the customers can easily access and copy IPR's protected objects without having to deal with the consequences, putting in serious danger the future of Intellectual Property Rights that do not seem able to cope with the development of this technology.

However, by looking at the court rulings and rightsholders actions, something seems to be changing, there is yet a long way to go but some solutions may enable to protect one's rights. We saw that a multilayered strategy, which means protecting an object with different IPR's for each of its characteristics in order to give it a stronger protection, is one of the best solutions with the current legal framework. For the future, plausible solutions like paying a fee in order to have a legal access to IPR's protected objects (like it already happens for music streaming services or video streaming ones) seems to be a good way for both parties, giving the rightsholder a fair compensation for his work and giving the users the possibility to use and copy those protected objects at a fair price and without risking infringement procedures.

Anyway, 3D printing is a very useful technology that is just starting to rise (thanks to the expiration of many patents) and has an immense growth potential in terms of diffusion, quality, fields of use and so on, it is fundamental to know the intellectual property rights issues to be sure that one's action does not go against the law. That is necessary to allow a harmonious development of the technology without obstacles that a strict legislation (due to the necessity to contrast illegal behaviors if they are too diffused) may involve.

If the legislation is able to adapt once again to the current needs, the Intellectual Property Rights themselves can once again become a strong incentive to the innovation process, if not, the problems we deal with today may worsen and hinder the development of the 3D printing technology that will know a stronger and stronger opposition from the intellectual property rightsholders. As a consequence, they will no longer have the will to pursue innovation because the intellectual property rights will not grant them a compensation for the efforts made and will prefer to resist and squeeze the most out of their current rights, thus stopping any progress initiative. Furthermore, legal concern about product liability, quality, health and safety regulation and public order will rise with the development of this technology.

To conclude the challenges for the future of Intellectual Property Rights are real and complicated, but new solutions keep coming in order to update the legal framework and the way we intend those rights. How we will deal with the evolution of this technology and adapt our laws to it will direct our future development and must therefore be consider very carefully, or else the intellectual property rights will become useless, bringing problems for the future of innovation.

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Summary

3D printing technology, despite being a relatively old innovation, has known a rapid growth in the recent years, bringing with it many new possibilities nut also important legal issues, especially in the field of intellectual property rights who need to be addressed in order to overcome the obstacles to a desirable development of this innovation.

What is 3D printing? Also known as additive manufacturing, it is a manufacturing process where a digital model is turned into a three-dimensional object adding a layer of material at a time. The first 3D printer was released in 1987 by Chuck Hull, and kept evolving in the following years, the late 00's were fundamental because many patents expired bringing the prices down and the adoption of the technology grew enormously. This technology allows to create very different objects without requiring special tools for it, it is suited especially for complex objects and prototypes, lowering costs sensibly and giving a broader degree of freedom to the designer. The limitation is that, being built layer by layer, 3D printed parts tend to be weaker than traditional ones, however some production techniques of metal 3D printed parts overcome this problem, offering even better properties than traditional ones.

The applications are various, seven different 3D printing categories exist, those are:

- Material Extrusion (FDM): The material is selectively dispensed through a nozzle or orifice.
- Vat Polymerization (SLA & DLP): Liquid photopolymer in a vat is selectively cured (solidified) by UV light.
- Powder Bed Fusion (SLS, DMLS & SLM): A high-energy source selectively fuses powder particles.
- Material Jetting (MJ): Droplets of material are selectively deposited and cured.
- Binder Jetting (BJ): Liquid bonding agent selectively binds regions of a powder bed.
- Direct Energy Deposition (LENS, LBMD): A high-energy source fuses material as it is deposited.
- Sheet Lamination (LOM, UAM): Sheets of materials are bonded and formed layer by layer.

Additive manufacturing technology has been introduced in many industries, some of the most relevant examples are:

- Automotive industry benefitted from the technology for its ease of customization, in short time the parts could be tested and modified.
- Entertainment industry was allowed to create great props for movie makers thanks to the design flexibility of the technology at a way lower cost and much quicker.

- Do It Yourself industry found in 3D printing technology its perfect tool to express the makers' own creativity
- Education, 3D printing brought to life course subjects, focusing the attention of the students and giving them practical experience.
- Design, it is now possible to customize the products with basically no extra costs and much faster.
- Industrial Tooling sector profited from 3D printing to develop low-run injection molds that are easier to produce and a lot less expensive even if the last less than their traditional counterparts.
- Healthcare, custom shapes for prosthetics gave to the patients a better-quality product and an overall better service fitting exactly each patient body.
- Space and aerospace industry, here 3D printing technology helped to reduce lead time, weight of the product and fuel consumption.
- It is the main manufacturing technology in robotics industry thanks to its speed, customization and design freedom that is fundamental to develop new mechanisms.

3D printing gave rise to unique intellectual property challenges that the current legal framework does not address effectively. Infringement issues are multiple, there can be direct liability, where a party is held directly responsible for harm to another and secondary liability where third parties facilitate the use of 3D printing technology for direct infringers. The technology has the potential to boost future growth but makes difficult to enforce the existing intellectual property rights which will be analyzed explaining how infringers can circumvent the rules and then by looking at how rightsholders can use the current framework to deal with infringers and what actions can be put in place. First we need to clarify the relationship between 3D printing, the 3D printed creations and the current IPR framework, and how the creations can be protected by the different laws. Intellectual property rights play a fundamental role in pushing innovation, and various processes in 3D printing could be protected by them. The code of the design file, the design itself and the physical object can be protected by the copyright law. Some of the objects based on a 3D printing design file have been defined not enough original to attract copyright protection on their own and, as also the patent law requires, they have to meet some standards of novelty, inventive/non-obviousness and industrial application/utility, the physical object can benefit from patent law protection if it meets the required novelty standards. Design patents/rights represent the right to exclude others from making, using or selling the patented design, the patent may issue for the design of the whole product or a part of it and they may

have a rise in popularity because of 3D printing because they are a very valuable tool in fighting 3D printed counterfeits. Design rights have the big advantage that they can be obtained in short time (3/4 months to 1 year) allowing to protect the product while it is still in the heart of its life cycle and enabling designers to keep their share of profit. Trademark owners' exclusive rights are related to the use of it as an indicator of the source/origin in the course of trade. Trade secrets, like recipes or business practices will be affected by 3D printing, preventing trade secrets' leak will be a key challenge in the near future.

The main goal is now to show the problems that 3D printing brings to the IPRs application and how those apparently simple to understand rights do not or cannot apply in many situations. The problems emerge because there are still divergencies in the different jurisdictions. For example, the CAD file is capable of being protected under copyright law in some countries (as the UK) but not in others (US) because of a creative/functional distinction in its IP law. The CAD files by themselves neither seem patentable (being a form of software, and the law is uncertain about the permissible patent claims directed to software). Also, there is no consensus on whether the design should enjoy protection or not, divergencies of view exist also within the same legal system, in the US it is debated that the design may be protected under copyright law not as a literary work but as a "technical, mechanism, engineering or architectural drawing". The printed object itself could also attract copyright protection, in the US legal system sculptural works enjoy it, but useful articles are excluded, so, many 3D printed object should be evaluated in order to decide if they are protected or not by the copyright protection because they carry both aesthetic and functional aspects. Similarly, in the UK "works of artistic craftmanship" are deemed valuable to be protected by copyright but industrial prototypes have been excluded by case law. Another issue, when addressing private use, is the European copyright legislation that states that a private can 3D print a protected work without permission of the IP holder, but when a commercial party prints upon a private request the situation is not clear and varies from country to country once again.

Proving patent infringement is a struggle, usually the patentee was only concerned with suing large companies who would invest a lot to engage in mass production of the patented invention, and he would capture damages for all the infringement in one lawsuit but now they will have either to assert their patents against a myriad of end users that bears difficulties and high expenses or sue the counterfeiter for indirect infringement, which generally is more difficult to prove. Right now, it is not clear what would give rise to that, in UK law "supplying the means relating to an essential element of the invention" would entail an infringement but what are the "means" needed to constitute an infringement is still discussed. Problems arise for design

patents as well, “design patents have almost no scope and are limited to the ornamental design shown and described in the patent drawings”, the patent is invalid if the design is dictated by function. To make a claim of infringement where certain elements of the design have functional purposes, such aspects should be well defined to avoid the claim from encompassing the general design concept of the functional elements, plus, there is the non-commercial use and fair dealing exceptions who may exempt from liability many 3D printing activities, in this situation intermediary liability (like file sharing sites) is unclear as regards the operation of these exceptions. About the trademarks, it may be difficult to find infringement occurring in 3D printing, because the use of others’ trademarks may not qualify as indicator of source/origin in the course of the trade.

The application of the current legislation may lead to a paradoxical situation, the third party can physically produce the copyright protected object upon a private individual's request invoking the private copying exception, but not the digital file of that same object. 3D printing is advantage is that it allows to produce patent protected objects easily but it may entail an increase in the number of patent infringers, this situation presents a challenge to patent enforcement, counterfeiters will shift from manufacturing counterfeit products to distributing computer files to consumers who will print the counterfeit product at home and by doing so it will be difficult for patent holders to stop the illegal behavior.

Design rights seem a strong tool to strike fast. Protecting the appearance of the product, but also portions of it will provide the designer with a multi layered strategy, useful to prevent counterfeiters, however, holders of design rights have basically no remedy against those who print for private use and not for commercial purposes, it is imperative to be able to invoke other intellectual property laws as well. 3D printing may have an impact on trademarks, diminishing the importance of brands as marks of origin when everyone can print out objects themselves, putting in charge of the creation and selection of materials the end-user. At the current state, infringement is difficult to prove, and it is unlikely to be established because the use of the mark in relation to the file does not affect the essential function of the trademark (it does not confuse users). Lawmakers will have to carefully distinguish legitimate uses (and accommodate them) from harmful behaviors (which shall be clearly defined and prohibited). At last, trade secrets covering physical items will be disrupted. The existent legal framework does not seem to protect an original 3D printed creation very well, because of the uncertainty of the law and because of some features of the new technology the intellectual property rights could face an unprecedented crisis if they won't be able to change and cope with the novelty.

Safety and security issues will also arise from the further development of the 3D printing technology, examples already exist, like the possibility to create a 3D working plastic gun that everybody can download and reproduce. It is a big challenge for legislators, those kinds of weapons are not detectable with standard security equipment leading to the fear that they may be used freely, escaping controls. The low awareness about this topic may also lead people to do illegal actions without fully realizing that, in this way endangering themselves and the others. Issues related to environmental aspects could occur as well, like material safety (hazardous materials may be used, also involuntarily, in the process) and waste disposal of the material.

Some court cases have been analyzed to understand how the legal framework dealt with 3D printing issues that arose.

Invisalign vs. Clearcorrect, 3D printing companies increasingly find themselves in court asserting or defending against infringement claims, in this case the dispute arose from Align Technology Inc. who filed a suit against ClearCorrect Operating LLC for patent violation on its Invisalign products. Align's patent cover the producing method rather than the product itself and accused ClearCorrect of unfair practices in import trade. To skirt Align's US patents, ClearCorrect produced the original teeth scans in the United States, then sent the files to Pakistan where the digital data were converted to 3D models and then sent back to ClearCorrect where the actual molds were printed. The central question was if the electronic transmission of digital files could be considered an importation of articles. On April 3, 2014, the ITC found a patent infringement violation and determined that the digital data sets that were produced by using Align's patented method must be considered articles in that they infringed claims of Align's patents. Infringement of digital patents do not need to be based on tangible products. Thinking about the future, it is highly recommended for companies who want to protect physical product to think about protection of the digital versions of them as well. On ClearCorrect's motion, the issue was presented to the Federal Circuit which reversed the ITC's decision and remanded the case to the ITC, the main issue was the consistency of the term "article" seen as a material object and the court concluded that articles cannot be defined to include electronic transmissions, but a judges till dissented from the explanation. The case has yet to reach an end, and the United States supreme court shall have the final word on it, keeping in mind that each decision will have strong repercussions. One side is pushing for a "liberalization" of 3D printing, while the other would prefer to have a strong intellectual property protection for digital models. If the final ruling is in favor of the latter, companies may

be able to patent the digital models and that will give them a very powerful weapon for preventing copying of profitable parts from unlicensed third parties.

Envisiontec vs. Formlabs, Envisiontec Inc. filed a complaint on September 12, 2016 in the federal court in the central district of California where it accused Formlabs of infringing two of its US patents by making, using and selling some of its 3D printers. Envisiontec asks for a jury trial which declares Formlabs infringement and monetary damages for the lost profits caused by it, furthermore it asks an injunction preventing Formlabs from making, using and selling the infringing products. Under current case law it is very rare for courts to grant injunctions, Envisiontec should prove that it has suffered an irreparable injury as a result of the infringement and that monetary damages are inadequate to compensate for it, plus it also has to prove that to balance the hardships between the actors an injunction is necessary, and that the injunction is not contrary to public interest. The case is still in progress but given that a lot of patent infringement cases are intricated and there are many reasons each party can object, the lawsuit could take years, plus, those cases rarely reach the final jury, so a settlement seems to be the most likely option, 70% of patent cases in the US result in voluntary dismissals or settlement. It is the second time that Formlabs found itself accused; in the first case it settled the infringement suit filed by 3D systems agreeing to pay them a percentage of their net sales.

A comment on liability for 3D printers' manufacturers seems useful, generally they can defend themselves from accusations of infringement arguing that the printers have substantial non-infringing uses and so they cannot be held liable for infringement. This interpretation comes from a 1984 decision of the US Supreme Court where the sale of a copyright infringing device was not considered contributory infringement because the device was in fact, capable of substantial non-infringing uses.

A multilayered protection strategy seems to be the best option to cover and protect each aspect of a determined product. Ugg's brand shoes maker filed a suit against retailers for trademark, trade dress and design patent infringement, the case is still in progress, but the multiplicity of protection types increased the probability of success and control over the brand for the company. Against unauthorized entities offering 3D printed goods protected by intellectual property rights, the DMCA (Digital Millennium Copyright Act), can be an important tool to enforce protection, where the simple act of circumventing is criminalized, even when there is no actual infringement of copyright himself. HBO used it recently to force a company making 3D printed phone chargers modeled after the iron throne to cease their conduct. Many similar rightsholder actions have resulted in the online removal of a lot of infringing 3D printed items. There is a downside, rightsholders have to think carefully about the effect of their legal claims

on the consumers which may critic the decision and trying to protect the brand may cause more harm to the company than not.

Another important legal aspect to discuss is how to protect the creations that are copied and reproduced with additive manufacturing. In order to do this, we will analyze the current legislation from a rightsholder perspective, for that we will see how to make a business out of 3D printing technology while dealing with the actual legal framework by taking a look at a case study on 3D chocolate printing made by lecturers at Sussex and Exeter universities.
The paper studied copyright implications of designing and manufacturing 3D printed chocolate products using a co-creation business model, they created a co-creation website platform that would allow chocolate lovers to print custom-made sweets. The case focuses on two aspects, the liability for authorization of infringement of copyright/artistic works and the consequences of reproducing two-dimensional works in three dimensions with the copyright implications of co-creation. The students constructed a chocolate additive layer manufacturing prototype and a spin-out company was formed to commercialize this technology, the product idea and design were conceptualized and digitized, the design generated was converted into a stereolithography file, imported into the machine control software package and the machine parameters are set up according to product features and specifications, finally the raw material is prepared, and the manufacturing cycle is started.
3D printed chocolate products and their designs fall in the category of an artistic work, but it is debated in which copyright category should it fall, and consequently understand which laws are applicable. Another point to discuss for the purposes of copyright infringement is that 3D printing is a representation of a two-dimensional artistic work in three dimensions and representing in three dimensions a figure protected by artistic copyright, or the other way around, can expose to liability for copyright infringement, consent from all the rightsholders is needed. In the case, there is a strong copying possibility, because a substantial part of another work is taken and by so the copyright in the first work is infringed. If the consumer starts with an existing artistic work to print a three-dimensional chocolate that will infringe the copyright of the first work (the rule does not apply in the case of simple artistic works, in those cases only an identical copy constitutes infringement). About who is the rightsholder, the law has difficulties in protecting works where there are multiple authors, the rule is that the contribution of each author is not distinct from that of the others when you look at the final work, only bringing ideas is not enough. In the case study the conditions are satisfied, the contributions to the designs of the works are not distinct (one is not able to tell who contributed for what), and

the authors collaborated not only with ideas by also in the execution (by making the design) so all of the contributors are likely to be protected as joint authors. Authors are fundamental because they generally are the first owners of the copyrights. Lastly, authorization of infringement occurs when one party authorizes another in the eyes of the law to commit copyright infringement, the authorizer is also liable for infringement but creating opportunities for others to infringe by providing machinery is not considered authorization of infringement when it can be used for legitimate purposes, so in our case study there should be no worries about this kind of liability. An appropriate notice on the website to warn and deter infringers can be a solution to avoid liability. 3D printing technology could lead to reshaping business processes from design to consumption by enabling co-creation. The co-creation concept allows businesses to shift from a manufacturing-centric mass production to a consumer-centric mass innovation/customization, not without bringing some peculiar problems, there can be a struggle in identifying the authors/the owners of the rights over a product, and there will be difficulties in verifying the originality of the work with the consequences in terms of liability and copyright infringement that the situation will bear. It will be necessary to understand the intellectual property rights issues and address them correctly to ensure that one's business stays within the boundaries of the law.

So, what can be done to solve the issues posed by the development of the 3D printing technology? To balance rightsholders interests and general public freedom of use new frameworks with tight regulation of the 3D printing industry where registration of 3D printer and printing activity tracking were suggested, it could be easily fitted into the current legal systems. Another solution would be a licensing platform where a usage fee including a royalty would be paid in order to have legal access to downloading files, this solution seems the most advisable, following the example of the music and video/film industries which faced similar problems. Customer-friendly platforms that will offer authorized CAD files for a reasonable price (like Spotify or Netflix did in their respective sectors). It is not recommended, at this stage, to stifle innovation and take strong measures without having made a comprehensive review of the 3D printing impact. 3D printing can alter the cost/benefit calculation that underlie the current IP so it should be considered whether to rebalance IP laws to adapt to the current technology. A legal clarification of existing theoretical IP issues exposed by 3D printing is highly recommended, especially in identifying activities which constitute direct and secondary infringement, how exceptions to infringement work and if and to what extent a CAD file is capable of copyright protection.

This technology has the potential to disrupt many industries and processes, for example making the supply chains more efficient by reducing storage and shipping costs and digitizing many steps of the supply management dynamics. Also, resource efficiency can be improved thanks to the minor waste than subtractive manufacturing and better recycling. According to the views of many academics and industry experts in the areas of production, supply chain and localization; business model and completion; consumer and market trends; IP and policy, 3D printing impact is likely to affect mostly the supply chain area and the intellectual property and policy one. There will be a need to rethink the bases of IP, if done carefully a positive future for IP regime goals is possible, ignoring technology's effects may lead to under or overprotective IP laws, thus hindering innovation.

From the analysis of the current legislation, it emerged that the actual Intellectual Property Rights are facing a hard time granting solid and clear protection to rightsholders. However, some solutions exist, a multilayered strategy can ensure a better protection (within the current legal framework). Future scenarios will probably necessitate new business models to give the rightsholder a fair compensation for his work and to the users the possibility to use and copy those protected objects at a fair price and without risking infringement procedures. 3D printing is a very useful technology that is just starting to rise and has an immense growth potential, it is necessary to know the intellectual property rights issues to allow a harmonious development of the technology. If the legislation can adapt to the current needs, the Intellectual Property Rights will constitute a strong incentive to the innovation process, if not, the problems we deal with today will worsen and hinder the development of the technology. How will we deal with the evolution of this technology and adapt our laws to it will direct our future development.