Legal Aspects of Protecting Intellectual Property in Additive Manufacturing

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Chapter 4

LEGAL ASPECTS OF PROTECTING INTELLECTUAL PROPERTY IN ADDITIVE MANUFACTURING

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Abstract Additive manufacturing has emerged as a transformative technology that will play a significant role in the future. Also broadly known as 3D printing, additive manufacturing creates 3D objects by incrementally adding successive layers of materials. Whereas traditional manufacturing requires materials and customized components, molds and machinery, additive manufacturing merely requires materials and a 3D printer. Without the need for expensive customization, the entrance barriers for additive manufacturing are drastically lower than those for conventional manufacturing; overhead and maintenance costs are reduced, allowing for smaller, flexible and competitive business models. The decentralized market for production is also a decentralized market for piracy. In traditional manufacturing, the copying of a design can be readily traced to a source because an infringer would require an infrastructure for fabrication and a marketing platform for sales. However, in the decentralized additive manufacturing environment, there is neither a need for a specific infrastructure nor a marketing platform. This chapter focuses on legal solutions available to intellectual property owners in the United States for blueprints, objects and processes used in additive manufacturing. Also, it establishes a baseline for the current federal protection environment and outlines the principal issues encountered in protecting intellectual property.

Keywords: Additive manufacturing, 3D printing, intellectual property, legal aspects

1. Introduction

Advances in technology have led the manufacturing industry through several transformative phases – from manual formative processes to automated factories. Although it has been enhanced by the proliferation of computers for orchestrating construction and assembly, traditional manufacturing is hindered

by its inherent requirement of a specifically-designed infrastructure to fabricate a limited set of products. Due to the expense of the machine array and high operational overhead, traditional manufacturers maintain profitability via economies of scale.

Additive manufacturing or 3D printing resolves many of the difficulties in traditional manufacturing. Whereas traditional manufacturing relies on multiple machines to generate relatively few products, additive manufacturing can create a variety of components by employing a single 3D printer. Additive manufacturing is decentralized in nature and enhances flexibility and scalability in the supply chain; also, it reduces startup capital for operations and lowers entrance barriers into the market [2]. However, a major challenge with regard to additive manufacturing is the protection of intellectual property, which is exacerbated by its decentralized nature [5]. Software-driven supply chains coupled with the commoditization of 3D printers have eroded many of the former barriers to intellectual property infringement of proprietary designs and products. Indeed, additive manufacturing exposes industry to increased privacy threats [5] as well as external attacks [50].

Additive manufacturing is not the first industry to face a degradation in intellectual property protection. Prior to the introduction of the printing press, the manual copying a printed work was such an expensive and arduous process, that a published work was implicitly protected against wanton copying [11]. Peer-to-peer file sharing and website distribution have given the public the tools to copy and disseminate electronic documents and digital media files [6]. The ubiquity of high-quality 3D printers renders it both difficult and expensive to prevent unauthorized replications. Federal privacy protections preserve the anonymity of individual infringers by transforming their homes into veritable safe houses. Without probable cause, the Fourth Amendment prevents state agents from surveillance activities that would reveal cases of infringement. Existing United States intellectual property safeguards are antiquated and do not provide full protection against the threats posed by additive manufacturing. This chapter discusses the legal solutions available to intellectual property owners in the United States with regard to their blueprints, objects and processes used in additive manufacturing.

2. Related Work

The literature on intellectual property protection for 3D printing predominantly focuses on the difficulties with regard to patents providing effective recovery to intellectual property owners. To complement this body of work, this research analyzes diverse protection mechanisms and considers their applicability to secure outsourcing in additive manufacturing environments.

Yampolskiy et al. [49] have presented an outsourcing model that expresses the relationships between three parties: (i) designer of a printed object; (ii) manufacturer of the printed object; and (iii) experts responsible for tuning the manufacturing process. After assessing the risks to actors in the model, Yampolskiy et al. propose several protection goals for outsourcing activities in

additive manufacturing, but they do not consider the limitations with regard to intellectual property protection offered by the U.S. federal government.

Resai and Magliocca [6] provide an overview of intellectual property protections in the area of 3D printing. Using personal computers for product fabrication enables consumers to customize products and generate replacement parts. Resai and Magliocca also discuss patents, copyrights and trademarks that apply to 3D printing.

Depoorter [5] describes changes in the manufacturing industry that increase its exposure to decentralized piracy. Practical and societal sources are cited as complicating the task of enforcing intellectual property rights.

Doherty [7] identifies difficulties in applying patent protections to 3D-printed objects. Because patents guarantee rights to an object or a design, potential legal arbitrage regarding patent limitations can eliminate the practical effects of having patents. Doherty suggests modernizing patent laws to prevent unenforceability of existing protections. Likewise, Brean [1] surveys possible theories for providing patent protection to 3D-printed inventions. After discussing the flaws in each approach, Brean considers the applicability of copyright law for effective protection. Holbrook and Osborn [9] concur in the inappropriate fit of patents as an enforcement mechanism against infringers who use 3D printers. They propose nontraditional theories for inferring direct infringement that would attach greater significance to the blueprint file that creates the patented object.

Holbrook [8] discusses the scope of patent infringement with respect to intangible products. An argument is made that, by protecting against the offer to sell inventions, not all patent infringements require a tangible manifestation. Holbrook also asserts that the statutory language should be construed broadly to provide more effective protections.

While several researchers discuss how patents pertain to additive manufacturing, the literature does not address other forms of protection. Furthermore, the existing literature is primarily concerned with protecting objects and does not address the protection of blueprints, designs and processes.

3. Intellectual Property Risks

To secure outsourcing activities in additive manufacturing, intellectual property must be protected at every level. According to the model of Yampolskiy et al. [49], this means taking precautions against the unauthorized use of a design by the tuning expert and the manufacturer. Likewise, protections must be in place to preserve the use restrictions for the process tuned by the expert [49]. Taking these two forms of intellectual property into consideration, four types of property have to be protected in an additive manufacturing environment: (i) blueprint with the design schema; (ii) manufacturing process used during production; (iii) printed object; and (iv) creative and original designs manifested in the printed object.

Additive manufacturing presents a new arena for intellectual property considerations because the possession of a blueprint enables any party with a

printer to create the corresponding object. The disclosure of a blueprint file potentially enables another party to infringe on the patent by printing the object. As such, object designers are required to protect their objects through rigorous monitoring of the parties that are in possession of the files. Furthermore, because the manufacturing process is privy to a multitude of designers, as opposed to a relatively small set in traditional manufacturing, additive manufacturing increases the risk to intellectual property.

4. Federal Protections

The United States Code (U.S.C.) details the forms of protectable intellectual property: (i) patents (Title 35); (ii) copyrights (Title 17); and (iii) trademarks (Chapter 22 of Title 15).

Upon application, a patent can be granted to novel and non-obvious inventions or discoveries. Section 145 of Title 35 guarantees a patent holder the right of exclusion for "making, using, offering for sale, or selling" the protected invention for a period of 20 years from the application date.

Under Section 101 of Title 17, copyright automatically protects "original works of authorship fixed in any tangible medium of expression" that can be communicated. Furthermore, copyright protection extends to compilations and derivative works pursuant to Section 102. Sections 107 through 122 grant copyright holders exclusive authority to reproduce works, create derivative works and distribute copies. The protection persists until 70 years after the date of the death of the last surviving author.

Trademarks can be granted to "any word, name, symbol, or device" to be used in commerce. Section 1058 gives ten years of protection. Rights holders can renew trademark registrations indefinitely upon demonstrating that the trademarks are still being used.

While federal provisions afford robust protections, the respective statutes must be applicable for enforcement to be considered. In 3D printing, the form of protection available to a blueprint owner depends on the nature and use of the design. When extended to the additive manufacturing process, rights holders have business relationships with manufacturers, but activities that directly infringe may emanate from unrelated third parties rather than manufacturers. Unfortunately, in the current decentralized environment with anonymous infringement, inadequate attribution and enforcement mechanisms remove many of the teeth present in existing intellectual property law. Table 1 provides a summary of the various forms of federal intellectual property protection and some of their specific differences.

4.1 Patents

The patent system was designed to promote the "creation and disclosure" of technological advances by awarding exclusive rights to the use of an invention for 20 years [41]. However, there is a counterbalance. Pursuant to Sections 111 and 112 of Title 35, in exchange for federal protections, inventors must disclose

Table 1. Federal protections.

	Protected Entity	**Needed for Protection**	**Trigger for Protection**	**Duration of Protection**
Patent	Invention	Novel and non-obvious	Application	20 years
Copyright	Expression	Originality	Automatic	Life of author plus 70 years
Trademark	Symbol	Use in commerce	Application	10 years plus renewals

the data necessary for others "skilled in the art" to create the invention. By protecting creators, thus encouraging innovation, U.S. Congress intended to bring new designs into the public domain [3]. However, not every discovery can be protected by a patent. According to Title 35 of the United States Code, for a design to be patentable, the claimed subject matter must be both novel and non-obvious. The novelty requirement is satisfied under Section 102 when the discovery has been filed prior to any other patent, description in a printed publication or presence in public use or commerce. In order to be deemed non-obvious, Section 103 demands that the differences between the invention to be patented and any previous similar designs must not be obvious "to a person having ordinary skill in the art."

Employing patents to protect 3D-printed objects may prove to be difficult for rights holders. Any party with the infrastructure and blueprints can manufacture patented designs. Printers for additive manufacturing can be obtained more cheaply than the array of equipment required for traditional manufacturing. Additionally, it is not necessary to produce units in bulk to justify costs and third parties can more discretely print patented objects. Efficacious protection, therefore, hinges on the ability of patent law to protect the blueprints. After a party comes to possess a blueprint, infringement becomes trivial.

However, using patents to protect blueprints may not be possible in the current legal framework. Printed matter such as blueprints do not satisfy the requirement for "new and useful" compositions. Although there are cases in which printed matter may be patentable, courts "look to the underlying invention" to determine whether or not legal protection should be afforded [16]. For example, the U.S. Court of Appeals (Federal Circuit) [13] found that a computer program is protectable under a patent for the process executed by the program instructions. This case does not offer a good precedent for an inference of blueprint patentability because the underlying facts can be easily distinguished.

In the case of a traditional manufactured object, a patent holder obtains protection for the object – not the process by which the object was created. While an improvement to the 3D printing process would be patentable, a blueprint is merely a tool used by an existing process. A blueprint by itself is not novel [6];

only the underlying object being printed could be patentable [9]. With regard to a utility patent, the blueprint does not possess the protected function; for a design patent, the protected design is on the printed object instead of in the blueprint. Although an argument could be made that protection of a blueprint would be a reasonable proxy for more effective enforcement overall, no standing case law supports this proposition. Nevertheless, patent holders are not completely without recourse for enforcing their rights. As described below, Title 35 details three distinct theories of patent infringement.

Direct Infringement. Section 271(a) describes a direct infringement as the making, using, offering to sell, or selling of a patented invention without authorization. For patented subject matter to be made within the understanding of Section 271(a), a court has to determine if the item was operably assembled [38]. In the case of 3D printing, using a blueprint produces the patented subject matter and is, therefore, a direct infringement. Printing an object from an altered blueprint may also constitute an infringement if the differences between the original and altered objects are "insubstantial" [43]. The doctrine of equivalents codified in Section 112(f) establishes an infringement when a patented function is performed by an altered design. An altered design that "performs substantially the same function in substantially the same way to obtain the same result" constitutes an infringement under this doctrine [36]. Because a patent does not pertain to a blueprint, the sale or distribution of the file does not directly infringe the patent for the underlying object. While a patent infringement does not necessarily require tangible embodiment [8], without a supporting legal precedent, there is no basis for a court to infer patent protection for a blueprint file.

In the case of additive manufacturing, a theory of direct infringement is ill suited to combat insider threats. A manufacturer of an object has not committed a direct infringement if the object blueprint was distributed by the licensed party by malice or negligence. This is because at no point does the distribution of the blueprint result in the making, using, offering to sell, or selling of the printed product. Until a court rules that the sale of a blueprint carries the same effect as the sale of a patented invention, a direct infringement claim against the manufacturer would fail; but this theory would not be applicable even if the file was stolen or freely given without obligation [14].

A theory of joint (or divided) infringement may present an alternative approach to hold a manufacturer liable for direct infringement. Joint infringement occurs when the actions of different parties taken together constitute direct infringement. To assert a successful claim, the rights holder must show that a single party exerted "control or direction" over the infringing actions [15]. Therefore, to be liable, an additive manufacturer should be able to exercise authority over the third party that prints the unauthorized units. Determining whether or not a manufacturer controls or directs the actions of a third party compels a court to consider the nature and extent of the relationship between the parties [15]. Without lasting engagements or mutual benefits, the inference

of a relationship that gives rise to joint activity is tenuous. In Limelight Networks, Inc. v. Akamai Technologies, Inc. [47], the defendant performed some steps outlined in the underlying patent before encouraging its customers to complete the remaining steps. The U.S. Supreme Court found that the level of control and direction employed by Limelight was insufficient to establish joint infringement – although the act of encouragement was sufficient to find inducement [47].

Internet anonymity coupled with an environment that encourages a decentralized collection of private infringers significantly threatens patent enforcement [7]. Ease of accessibility to resources can give rise to numerous and diverse infringements. Digital copyright owners have struggled to combat Internet piracy for nearly 20 years [10]. Whereas digital copyright infringement can occur after a blueprint is downloaded, patent infringement does not occur until the blueprint is used to print the protected design. For an actor who prints a patented invention within the privacy of his/her home, the Fourth Amendment prevents investigators from searching the premises for evidence of infringement without a warrant. Indeed, effective enforcement against all instances of private patent infringement for 3D-printed inventions is not possible without diminishing constitutional privacy protections [4].

Induced Infringement. If the success of a direct infringement claim against a manufacturer seems unlikely, a claim under Section 271(b) that the manufacturer actively induced a third party to commit a directly infringement may be easier to establish. While demonstrating inducement appears to be trivial, the U.S. Supreme Court has determined that proving induced infringement "requires knowledge that the induced acts constitute patent infringement" [46]. A defendant can be liable for induced infringement only if he/she is found to have known that his/her conduct induced another to commit a direct infringement [38]. Inducement without intent does not constitute a valid claim under this doctrine. Nonetheless, a manufacturer would be unsuccessful in an attempt to refute inducement on the basis of a good faith belief in the invalidity of the underlying patent [48]. An infringement inquiry should not be conflated with an inquiry to determine validity [48].

The U.S. Supreme Court limits the scope of the doctrine with a two-step analysis: (i) the manufacturer "must subjectively believe that there is a high probability that a fact exists;" and (ii) the manufacturer "must take deliberate actions to avoid learning that fact" [46]. For additive manufacturers that are licensed to print a patented invention, knowledge of the underlying patent has already been established [46]. Because the only purpose of a blueprint is to print a design, it seems straightforward to conclude that a contracted manufacturer would appreciate the high probability that any unauthorized distribution of the blueprint would result in an infringement. Even online file distributors can be liable for induced infringements, especially if the products are marked with United States patent numbers [1]. The final hurdle for a rights holder to demonstrate induced infringement is to prove that the inducement resulted

in a violation of Section 271(a) [38]. A defendant cannot be held liable for induced infringement "when no one has directly infringed the patent" [47]. Even if concerns regarding the practicality of enforcement can be overcome in a particular case, because the blueprint is not directly protected, the possession, duplication or distribution of the file is not a direct infringement but merely potential evidence to demonstrate inducement.

Contributory Infringement. The third form of patent infringement, which is outlined in Section 271(c) of Title 35, is known as contributory infringement. It holds liable anyone who offers to sell, sells or imports a material component of a patented invention with knowledge that the component was specially made or adapted for an infringing use. As with induced infringement, these actions must have culminated in acts of direct infringement [38]. Likewise, the statutory language only pertains to sales and offers, not thefts or gratuitous transfers [14]. Additive manufacturing, however, does not assemble an invention from component parts; instead, it constructs an object by combining materials through additive layers. Even if the raw materials used by 3D printers were considered components of the printed invention, as long as there are non-infringing uses of the materials, a strictly definitional interpretation of contributory negligence can lead to a harsh outcome.

Unfortunately for patent holders, a blueprint is not a combinable component of a device within the understanding of the statute [45]. However, because such a ruling would effectively bar recovery via a contributory infringement claim for 3D blueprint creators, a court may be amenable to inferring a limited exception as a matter of policy. In a recent case addressing whether software could be a component, the U.S. Supreme Court distinguished "software in the abstract" from a copy of the software on a medium [45]. Although the Court rejected the argument that software detached from any medium qualifies as a component, a copy of software encoded on a medium can potentially receive protection as a component [45]. However, the example of a suitable medium proffered in the case opinion was a CD-ROM [45]; it is an open question as to whether or not a digital file could likewise be considered a medium.

If a blueprint is ever judicially regarded as a component, claims of contributory infringement would become accessible. Materiality is trivial to establish because a blueprint file is necessary to give instructions to the printer. Scienter (i.e., intent or knowledge of wrongdoing) is more easily found for contributory as opposed to induced infringements because a contributory infringer need only be aware that the component has no substantial non-infringing use [44]; the infringer does not have to have an intent to infringe. Notwithstanding the relative ease of meeting these requirements for a contributory infringement, practical barriers to proving that a direct infringement occurred can completely bar recovery under this doctrine.

4.2 Copyrights

While a patent offers a monopoly over an idea, a copyright protects the expression of an idea. Section 102 of Title 17 grants rights to an author of an original work expressed on a fixed tangible medium. A protected work can be communicated directly or with the aid of a device. A copyright holder gains exclusive rights under Section 106 to produce copies, prepare derivative works and distribute copies to the public. Section 1201(a)(1)(A) grants the privilege to encrypt a work without destroying the underlying copyright. An attempt to circumvent a technological measure that controls access qualifies as an infringement under Section 501.

Originality is the hallmark of eligibility as a copyrightable design. According to the U.S. Supreme Court, "the requisite level of creativity is extremely low;" as long as the work possesses "some creative spark," it will receive Title 17 protection [42]. An author need only contribute more than a trivial distinction from an existing piece [22]. Nevertheless, there are exceptions when determining if a work is copyrightable. Section 113(b) withholds protections for useful articles that are defined in Section 101 as having intrinsically utilitarian functionality beyond the mere portrayal of creative works. For instance, a painting on a canvas is copyrightable although the canvas has a purely utilitarian function. Because the purpose of the canvas is to serve as a medium for the painting, Section 113(b) does not exclude the work. There are times when a copyrightable work may not receive protection. Drawing on the dichotomy between idea and expression, the merger doctrine can be applied to deny copyright protection when an expression has merged with an idea [12]. If an idea can only be expressed in a limited or singular fashion, then the expression will receive little or no copyright protection lest the author receive a monopoly on the underlying idea itself [27].

A copyright infringement occurs when a third party uses the rights exclusive to the holder without authorization. The threshold for stating an infringement claim is set relatively low – the rights holder need only provide indirect evidence demonstrating that the alleged infringer had access to a protected work and produced something substantially similar [18]. Articulating a second theory of infringement, the U.S. Supreme Court brought the claim for inducement from patent to copyright [44]. A manufacturer can be liable to a designer if the manufacturer had taken "active steps" to encourage direct infringement [31]. However, proving this claim presents a challenge. Mere knowledge of the potential for infringement is insufficient to validate a claim [40]. If a manufacturer is negligent in safeguarding a copyrighted file or design, there is insufficient basis to establish intent. Even if a manufacturer had actively distributed a file, there are three probative elements of intent to induce copyright infringement [44]. Specifically, the manufacturer must have: (i) an unlawful objective that promoted the infringement; (ii) neglected to diminish the potential for infringement; and (iii) implemented a business model dependent on third party infringement [44]. These requirements imply that a manufacturer must profit from encouraging third parties to directly infringe. Nonetheless, there are sev-

eral avenues for a copyright to provide a remedy for designers of 3D-printed works: when the printed object is copyrightable in its entirety, when a design on the printed object is copyrightable, and for the 3D blueprint itself. The application of copyright subtly differs based on the subject matter that is being protected.

Printed Creative Works. A straightforward application of copyright for a 3D-printed object pertains to the printed object receiving complete protection. As an original expression, the work cannot be printed without authorization, but the merger doctrine may provide a small loophole for would-be infringers. If a third party constructs a design whose similarity primarily relates to the abstracted ideas that gave rise to the design, an infringement has not occurred [17]. Similar to the case of a patent, because the protected subject matter is the printed object, the distribution of the blueprint file does not constitute an infringement of the copyright of the resulting work. As this form of piracy gains prominence, barriers to practicality diminish the likelihood of effective enforcement.

Designs on Printed Objects. A copyright can also be used to protect a decorative design or ornamentation on an end product. If a useful article contains an original work of authorship independent of the functional components of the article, the original work may be independently copyrightable under Title 17, Section 101. Not intending to protect utilitarian products that appear "aesthetically satisfying and valuable" by serendipity, the U.S. Congress made the cornerstone for the determination hinge on whether the design is "physically or conceptually" severable [33]. To distinguish between "applied art" and "industrial design" [20], courts question whether a work reflects "independent, artistic judgment" [25]. When answered in the affirmative, a design is deserving of copyright as being conceptually separable from the function of the object. Conversely, if the design appears to have been motivated by "utilitarian pressures" as much as by "aesthetic choices," copyright protection is properly denied [21]. Phrased differently, the primary role of a design must independently lie in its artistry and not in its industrial necessity. Note that, in these circumstances, if a copyright protects a design as an original work of authorship, but not the printed object, then only the design is protected. To circumvent this form of protection in additive manufacturing, a blueprint need only be modified to remove the copyrighted design. Then, the object could be printed without risk of infringement. Without additional forms of protection, a designer who outsources the printing process risks much of the work product without legal recourse.

Blueprint Files. Section 102(a)(5) protects "pictorial, graphic, and sculptural works" that include "technical drawings" within its definition in Section 101. Despite the artistic value of a technical drawing likely being predominated by its utilitarian function, a 3D blueprint file is protectable subject matter [29].

A blueprint meets the definitional requirements of the statute because it is a fixed tangible means of expression perceived with the aid of a machine to construct an object. However, not every blueprint is copyrightable. Although the threshold for originality is low, a digital model created via a 3D scan is not sufficiently original to give rise to protection [26]. Having a copyrightable blueprint does not guarantee full protection for rights holders. Instead, copyrighting a blueprint supplements other forms of protection. Because the subject matter of a copyright is the blueprint, the rights are attached to the blueprint, not to the products made when the blueprint is executed. Infringement of a copyright on a blueprint occurs when the blueprint file is copied or altered without authorization. Printing objects using the blueprint file does not violate the copyright. Lacking a contract stating otherwise, a party with an authorized blueprint can print an unlimited number of objects without infringing the blueprint copyright.

Also troubling to a rights holder is the potential for an entity to use blueprint information without violating its copyright. In defining protections available for technical drawings, Section 101 states that protection applies to the form of the works, not their utility. Consider a scenario where an adversary has captured the instructions sent to a 3D printer from the application that read the blueprint and uses the instructions to print the object again without recreating the blueprint. Because the specific form of expression has changed, a court may hesitate to find that a blueprint copyright was infringed if its instructions were used to fabricate unauthorized copies of the printed object. While this scenario seems incredulous, it can be readily analogized to architectural works of construction. Prior to the enactment of the Architectural Works Copyright Protection Act of 1990, architectural blueprints received protection while the structures did not [34]. Cases leading to the statute's amendment held that the rights holder of a copyrighted blueprint does not have a protectable interest in the building depicted [32]. Additive manufacturers may find themselves postured similarly when cases increase in frequency. Barring congressional mandate, courts may hesitate to extend copyright protection to cover a 3D-printed article.

4.3 Trademarks

Trademarks, which differ significantly in purpose from other forms of intellectual property protection, are intended to alleviate customer confusion about brands in the marketplace [35]. Consumers can rely on these marks as "concise and unequivocal identifier[s]" for product expectations and responsibilities [24]. Since assuring brand integrity for consumers pertains to events preceding transactions, Section 1114 of Title 15 protects a registered mark for use in commerce. Given the underlying goal of a trademark, the strength afforded to a specific mark varies with the potential for commercial confusion [28]. For example, if a particular brand with a registered mark improves the scale and scope of business, then the trademark is logically more recognizable, leading to more severe economic consequences if the mark is misused. When protection is available, it can extend beyond a specific word or symbol.

Direct Infringement. Under Section 1114(1)(b), the reproduction, counterfeiting or copying of a registered mark is not an issue unless it is "intended to be used in commerce." Infringement occurs when a product is sold bearing a design that resembles a registered mark [37]. To evaluate resemblance, courts question the likelihood that consumers would be confused by considering factors such as the strength of the trademark, degree of similarity and proximity of the markets for the product [19]. Note that, unlike patents and copyrights, timing matters. If a product does not ever enter the stream of commerce, there is no trademark protection because consumer confusion is not at issue. As a result, an individual possessing a 3D printer can print an object bearing a trademark for personal use without an infringement.

In additive manufacturing, a trademark on a printed product may not receive as robust a protection as a rights holder may desire. As in the case of a copyrighted design on a printed object, a trademark can be easily circumvented. If the trademark is removed prior to printing, there is no infringement. Likewise, as long as a printed object bearing an unauthorized trademark does not enter the stream of commerce, there is no violation. Although a design may have been stolen and a mark copied, if there is no potential for consumer confusion, a rights holder cannot make a claim.

Indirect Infringement. The statutory text is silent about the alternative forms of trademark infringement, but courts have judicially constructed two forms of indirect infringement: (i) contributory; and (ii) vicarious.

A claim of contributory infringement can be made when a party either induced the direct infringement by a third party or when the party should have known that its distribution of a product was infringing a mark [39]. Although it is called a contributory infringement, the scienter requirement for knowing cooperation more closely resembles that required to establish induced patent infringement.

Conversely, vicarious infringement does not require intent, but evidence of cooperation. The claim arises when an enabler and the direct infringer have an apparent or actual partnership [23]. Web service owners whose services are used to distribute unauthorized products bearing trademarks may be found vicariously liable [30]. As with patents and copyrights, to file a successful claim of indirect trademark infringement, a plaintiff must show evidence that the mark was directly infringed by a third party. If a manufacturer distributes or makes available a blueprint of an object bearing a registered mark, although the acts constituting indirect infringement are readily apparent, a rights holder cannot find recourse without evidence of a direct infringement having taken place.

5. Conclusions

While the United States Code provides robust protections for a variety of forms of intellectual property, the unique additive manufacturing environment prevents effective enforcement. Table 2 summarizes the shortcomings and

Table 2. Intellectual property protection limits for additive manufacturing.

Blueprint	**Patent:** N/A, not novel; uses pre-existing tools and processes. **Copyright:** Yes, technical drawing; scans are not original. **Trademark:** No, unless the blueprint possesses a trademark and is used in commerce. **Problems:** Impractical enforcement against direct infringers.
Process	**Patent:** Yes, if novel and non-obvious. **Copyright:** N/A, not an expression. **Trademark:** N/A, no registered mark present. **Problems:** Impractical enforcement against direct infringers.
Printed Object	**Patent:** Yes, if novel and non-obvious. **Copyright:** Yes, if an original expression. **Trademark:** Yes, if the object possesses a trademark and is used in commerce. **Problems:** Removable trademark; impractical enforcement against direct infringers.
Design on Object	**Patent:** N/A, form of expression. **Copyright:** Yes, if original and separable from the utilitarian function of the object. **Trademark:** Yes, if the design possesses a trademark and is used in commerce. **Problems:** Removable design and/or trademark.

caveats for the various forms of intellectual property protection. The availability of multiple avenues for infringement reveals the many inadequacies in the existing U.S. legal framework. Greater reliance on a blueprint as a means for facilitating piracy almost necessitates an evolution in patent law to address this important issue. Until sufficient deterrents are in place to render Internet piracy manageable, federal protections will be insufficient to deter many forms of infringement.

While the statutory limitations are apparent, private contracts in the form of licensing agreements may be used as a supplement. However, if a contract claim proceeds to trial, there must be evidence of misconduct to support the claim. Absent technical evidence that provides factual proof of misconduct, a rights holder has little hope for recourse. The best approach may be to incorporate technical adaptations in additive manufacturing processes that would enhance the likelihood of positive attribution.

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