3D opportunity for intellectual property risk

Additive manufacturing stakes its claim

A Deloitte series on additive manufacturing

Deloitte University Press

About the authors

Matt Widmer

Matt Widmer is a principal with Deloitte Financial Advisory Services LLP and serves as the leader of Deloitte's Federal Advisory practice. He has over 20 years of experience helping clients address complex business challenges, and specializes in intellectual property, transactions, asset valuation, litigation consulting, and negotiation strategy matters.

Vikram Rajan

Vikram Rajan is a business technology analyst with Deloitte Consulting LLP in the Systems Integration service line. His focus is in life science and health care technologies and trends. Rajan also has intellectual property experience and is a registered patent agent.

Deloitte Consulting LLP's Supply Chain and Manufacturing Operations practice helps companies understand and address opportunities to apply advanced manufacturing technologies to impact their businesses' performance, innovation, and growth. Our insights into additive manufacturing allow us to help organizations reassess their people, process, technology, and innovation strategies in light of this emerging set of technologies. Contact the authors for more information, or read more about our alliance with 3D Systems and our 3D Printing Discovery Center on www.deloitte.com.

Contents

Introduction

ADDITIVE manufacturing (AM), also known as 3D printing, is changing the way in which physical products can be designed and produced, both by manufacturers and end users. Designs are created digitally and can theoretically be additively manufactured anywhere, at any time, by anyone with the means to do so.[1] In this way, AM represents a shift in the value chain from the physical object to the information that goes into producing it: Value rests in the design of the object, rather than the object itself.[2] The digitalization of physical products through AM may prove to be disruptive, pushing manufacturers to change their business models—and ways in which they approach ownership—in order to maintain their competitiveness.[3]

Yet the very quality that makes AM such a powerful manufacturing option¬—the ability to print a product or part anywhere, on any printer equipped to handle it, via streams of digital information¬—may create intellectual property (IP) challenges around the technology. Consider an example: Via AM technology, fan blades that previously needed to be purchased from the manufacturer could be scanned or modeled and produced in house, making information—not the product itself—the real object of value in the exchange. At the same time, failure to protect that information can lead to serious risks and vulnerabilities. For instance, modified illegitimate copies can be made that lack the robustness of the original but still maintain its markings, thus damaging brand reputation.[4] Additionally, with minimal regulation for the distribution of illegitimate copies, printers run the risk of having the printed item used for improper purposes by the end user. And these are just a few of the risks.

To be sure, this is not the first time a shift from physical objects to digital information has upended an industry. Indeed, the movie and music industries experienced similar upheavals; the advent of streaming meant that products that were accessible primarily through the regulated distribution of physical objects such as albums were summarily treated as digital information to be rapidly—and sometimes secretly—shared. But just as this opened up new opportunities for the movie and music industries to license and share their products, it also created attendant challenges in protecting assets and preventing IP theft.[5] AM faces a similar challenge as it moves towards wider adoption, one that may give manufacturers pause as they think through how the technology fits into their strategies.

> In this paper, we examine the challenges and risks AM leaders face as they seek to solve the IP puzzle.

As AM technology continues to advance rapidly, IP law struggles to keep pace. Unlike the music and film industries, as of yet, we have seen no watershed case to define the

direction AM IP law will take. AM's expansion has generated many questions and concerns and much uncertainty related to IP rights. In order to realize the full benefit of AM, IP leaders, including owners, makers, and users, require the ability to develop, expand, and operate with reduced threat of dispute or litigation. To accomplish this goal, AM IP stakeholders can consider proactively analyzing the subject of AM IP and developing economic models and licenses that allow all parties to move forward confidently.

In this paper, we examine the challenges and risks AM leaders face as they seek to solve the IP puzzle. By drawing on our experience examining the lessons and patterns of past scenarios in similar industries, we illustrate some of the risks posed by inadequately addressing IP for disruptive technology. Likewise, to consider potential outcomes for establishing standards in AM IP, we draw on the lessons of legal precedent in the music and film industries. Finally, through the use of our IP assessment framework, we illustrate various methods manufacturers can use to better understand the level of IP risk they may face in various scenarios and help to identify possible approaches, in consultation with their legal departments, for IP protection in AM adoption.

In our experience, failure to proactively address IP concerns has cost stakeholders in both financial and operational ways. In some industries, we have seen IP concerns addressed at the start of a project. This turn toward proactively addressing IP leads to greater efficiencies for both owners and users of IP.

Regardless of whether they use new or current product designs, new supply chain options, or entirely new business models, businesses must establish and communicate what constitutes appropriate use. IP owners may find that for many products, selling a design that

AM's roots go back nearly three decades. Its importance is derived from its ability to break existing performance trade-offs in two fundamental ways. First, AM reduces the capital required to achieve economies of scale. Second, it increases flexibility and reduces the capital required to achieve scope.6

Capital vs. scale: Considerations of minimum efficient scale can shape supply chains. AM has the potential to reduce the capital required to reach minimum efficient scale for production, thus lowering the manufacturing barriers to entry for a given location.

Capital vs. scope: Economies of scope influence how and what products can be made. The flexibility of AM facilitates an increase in the variety of products a unit of capital can produce, reducing the costs associated with production changeovers and customization and, thus, the overall amount of required capital.

Changing the capital vs. scale relationship has the potential to impact how supply chains are configured, and changing the capital vs. scope relationship has the potential to impact product designs. These impacts present companies with choices on how to deploy AM across their businesses.

Companies pursuing AM capabilities choose between divergent paths (figure 1):

Path I: Companies do not seek radical alterations in either supply chains or products, but they may explore AM technologies to improve value delivery for current products within existing supply chains.

Path II: Companies take advantage of scale economics offered by AM as a potential enabler of supply chain transformation for the products they offer.

Path III: Companies take advantage of the scope economics offered by AM technologies to achieve new levels of performance or innovation in the products they offer.

Path IV: Companies alter both supply chains and products in pursuit of new business models.

Figure 1. Framework for understanding AM paths and value

Graphic: Deloitte University Press | DUPress.com

customers print for themselves will be more profitable and less logistically challenging than manufacturing and distributing the product.[7] This model takes advantage of the full benefits of following path IV of our framework, such as mass customization and supply chain disintermediation. But to avoid potential IP disputes that occur with any new disruptive technology, manufacturers may consider adjusting their business models to the new economics of AM. This involves considering an appropriate agreement based on the role the product plays in the IP owner's and customer's businesses. In this way, they can work to capitalize on new opportunities, instead of fighting yesterday's legal battles with tomorrow's technology.

Upping the stakes

The business impact of IP uncertainty

INCREASINGLY, IP concerns strongly influence how AM decisions are made, and many organizations already display an abundance of caution with regard to how IP is distributed and used. Some of this is borne out of prior challenging experiences among IP holders and potential licensees that have resulted in business disputes and even litigation. The cost of an improperly thought-out or incomplete IP agreement can be high.

Examples of IP uncertainty and disputes can be found in virtually every industry. One illustrative example is the Department of Defense (DoD) and its important commercial defense contractors. The business relationship between these two stakeholders is critical to both parties' success, not to mention US national security, and both the DoD and its contractors strive to reach mutually beneficial and sustainable business deals. Both sides can also exercise a great deal of restraint around IP agreements—likely due in part to previous experiences.

Indeed, according to Tim Gale, president and CEO of AMS Group, a technology and logistics company, "The lack of agreement between defense contractors and the US DoD related to technical data rights has led to disputes, inefficiencies, and higher costs for both parties. The introduction and advancement of new disruptive technologies, such as additive manufacturing, present additional challenges related to intellectual property and business models for both defense contractors and the DoD."[8]

There are numerous examples where IP disputes resulted in inefficiencies, higher costs, and delayed development of solutions. In one example that we are familiar with, the lack of an IP agreement that provided clear contractual and economic terms regarding the technical data for a specific type of aircraft resulted in the inability to effectively maintain a supply of parts unique to the aircraft and to perform depot-level maintenance. This translated into a significant dispute and inability for both sides to move forward efficiently. Ultimately, the organization found itself forced to engage in dozens of individual partnerships with the subsystem vendors. This arrangement resulted

> Questions still exist as to whether the customer falling victim to a faulty print or failed part can seek damages from the IP owner or the printer manufacturer, or whether the blame—and thus risk—falls on the customer alone.

in increased costs, added complexity, and lost time.

There are many examples that highlight the importance of striving to reach an economic agreement as early as possible in the process, even if this agreement takes the form of a flexible licensing arrangement as opposed to a more complete approach. These lessons can also apply to IP issues surrounding AM.

Issues of liability with AM IP

The consequences of not addressing AM-specific IP concerns can prove similarly dramatic. For example, theoretically, anyone can print a pirated or unprotected design, regardless of the end purpose for its use—and also independent of any quality or fabrication measures the designer may have intended. This, in turn, creates attendant security and safety concerns and opens up potential liability issues for the designer. Weapons are one such example, with some designs of gun assemblies currently publicly available.[9] However, it is currently unclear who, if anyone, will be held responsible for enabling a legally unfit individual to access a lethal tool for unsanctioned use.[10]

Other concerns can arise if a publicly available or pirated design is modified with a defect—either intentional or unintentional—while still retaining the original brand markings. In this scenario, organizations run the risk of having their brand tarnished—or worse, finding the onus on them to prove it was not their original design that caused the flaw.

In a similar vein, legal implications can arise when a design is manufactured on an improper, incorrectly calibrated, or defective printer.[11] Unlike the outputs of traditional 2D printers, additively manufactured objects can have functional uses.[12] Questions still exist as to whether the customer falling victim to a faulty print or failed part can seek damages from the IP owner or the printer manufacturer, or whether the blame—and thus risk—falls on the customer alone.[13]

Responsibility on the part of all parties—and the outcomes—can be made clearer if, as with the DoD's IP dealings, these considerations are addressed in the initial contract between the involved parties.

Using examples from the past to navigate present AM IP uncertainty

AM IP law is still evolving. Indeed, while there have been skirmishes, a watershed case or cases have not yet established the rules of the road. At present, AM technology continues to outpace AM law, leaving many uncertain as to their responsibilities, legal obligations, and the risks they may assume vis-à-vis their designs.

However, previous analogous cases in associated industries can provide lessons for AM and suggest a potential path forward. Betamax and Napster are examples of industry cases related to the application of IP law.

Betamax: Taking the onus off the manufacturers

The *Betamax* case, formally known as *Sony Corp. of Amer. v. Universal City Studios*, addressed the argument that Sony's Betamax video tape recorders (VTRs) were being used by end consumers to record copyrighted shows that were being broadcast on television, thus violating the rights provided in the Copyright Act.[14] However, the court ruled that since the principal use of the VTRs was for purposes that the court viewed as legal, that is, non-infringing uses, Sony was not at fault.

AM may find some similarities here. As with VTRs and home recording, while AM technologies can be used for illegal reproduction of copyrighted material, the prevalent position is that technology is being used largely for legitimate purposes.[15] Thus, following on the precedent of the *Betamax* case, one potential outcome is that that manufacturers of AM printers and some associated devices may not be found to be at fault for copyright infringement by the end user.[16] As with *Betamax*, owners who feel their IP is being infringed upon would need to show that the technology in question, such as certain 3D scanning devices, have no legitimate purpose other than to copy existing IP before they can hope to be compensated for any losses incurred by the manufacturer of the technology.[17] For the most part, however, parties involved in legal disputes will likely be restricted to the designer and the businesses using the design.[18]

Napster: Anonymity as protection for IP impropriety

However, sometimes the outcome isn't so clear. In the music industry, the widespread use of MP3 players led to rampant music sharing, setting off waves in the music industry.[19] Prosecuting those who published or hosted music files illegally became difficult, while prosecuting those who consumed the music became impractical due to the vast number of consumers involved.[20]

The outcome of this challenge differed from that of the *Betamax* case 17 years earlier. The Napster case, known as *A&M Records Inc. v. Napster Inc.*, could be viewed as a technical win for IP owners but has played out in a much more uncertain fashion.[21] The case hinged on whether Napster was at fault for providing

users with the tools to infringe on copyrighted music, thus enabling the company to gain a user base that could lead to future revenue. The product it offered was free, but it provided users the ability to transfer music, formally copyrighted or not, to other users. To aid in the location of available music, Napster servers temporarily stored a list of the file names that each user was willing to transfer out while the user was online.[22]

To reduce the IP risk associated with running a business in the AM arena, focusing on the economics of the interaction between the parties involved may be a healthier choice. This requires addressing IP concerns up front, in such a way that neither side is taking advantage of the other.

The courts found Napster to be at fault, saying it directly facilitated the peer-to-peer interactions of its end users, and the main purpose of these interactions was to infringe on copyright. Although the end users themselves were the real culprits with regard to infringement, finding and prosecuting the vast numbers of anonymous people sharing music became impractical.[23] This similarity may potentially translate to AM, where catching all the people who use designs that infringe on others' IP, or who use personal 3D scanning devices to create their own digital copy of physical objects, will present an intractable task.

Interestingly, music industry business models adapted to these legal restrictions. Unquestionably, there is a significant volume of music that continues to be downloaded illegally. However, leaders in the music industry also created an opportunity out of the technological paradigm shifts: Outdated business models based on physical products were replaced by digital equivalents such as music streaming and download services—all of which made the legal use of paid music more convenient than the illegal alternative.[24]

Many of these streaming and download services have found acceptance from consumers while also forging sustainable business models. While the defining court case for digital music transfer ruled in favor of the producers, the successful businesses were ones that focused more on taking advantage of the economics of music digitalization.

To reduce the IP risk associated with running a business in the AM arena, focusing on the economics of the interaction between the parties involved may be a healthier choice. This requires addressing IP concerns up front, in such a way that neither side is taking advantage of the other. One way to consider what is best for both the buyer and the manufacturer is to evaluate the essential qualities of the product being sold, along with the role the product plays in both parties' business models. To that end, one must first understand the basic economics of AM.

Addressing the AM IP challenge

Providing a framework to assess IP risk

AM unlocks powerful opportunities in manufacturing; as with the music industry, digital information replaces fixed capital assets as an object of value and investment.[25] Whereas traditional manufacturing processes require heavy expenditures in labor, tooling, waste material, and shipping on a per-part basis—in addition to research and development, certification, and material costs—AM processes dramatically reduce the former components and, in some instances, shift the material costs to the buyer. These differences influence the risks assumed by both parties in a transaction and alter the logistics for reaching economies of scale and for distribution.[26]

These changing industry norms around investment in capital assets, responsibility for material costs, and ownership of transactional risk have an attendant impact on approaches to IP. As seen in the representative cases from the film and music industries—*Betamax* and *Napster*—the precedent for IP could take several paths in AM. To minimize risk, businesses may consider new approaches to striking IP agreements that take into account the changes to manufacturing resulting from AM: considering the characteristics of not only the end-use product itself but also on the design file, quality assurance data, printing specs, and other data in order to reach a collaborative agreement that benefits both the licenser and licensee.

> Even for a single licenser, the situation will change with each part or design, and it is important not to let one single IP approach rule the day for all agreements as the only right way.

This, of course, depends on the unique circumstances of each part, its use, and the industry in which it will be employed. Indeed, even for a single licenser, the situation will change with each part or design, and it is important not to let one single IP approach rule the day for all agreements as the only right way. For example, aerospace engineers designing hinge brackets for overhead luggage compartments may adhere to a different level of precision than when designing engine or wing parts. Factors such as complexity, importance, legal protection, and novelty contribute to the value of that particular design—and, by extension, the value of the IP. Thus, approaches to evaluating IP should be specific and tailored to each situation. With this in mind, a

framework is helpful for understanding how best to think about IP in each unique scenario, and what sorts of considerations should be taken into account when crafting an effective IP agreement.

The AM IP risk assessment framework

The AM IP risk assessment framework described below provides a method for analyzing the key characteristics of an AM product to determine potential appropriate licensing agreements and effective licensing of IP. These characteristics fall into two broad categories: operational risk and legal uncertainties. The framework suggests approaches for each. It is important to note that this framework is basic and does not incorporate many of the nuances one would expect to address in a more comprehensive economic or licensing partnership. However, it does provide useful directional guidance as one considers how to move forward.

Operational risk is a proxy for the logistical aspects of producing a part or product through AM methods. For example, depending on the structure of the part being made and the consequences of failure during use, different levels of quality controls will need to be implemented.[27] Under some circumstances, a part may also need to be customized for the needs of a specific customer. This customization can be handled with manual or automated algorithmic alterations to the computer design files, which bring about additional risks.

Legal uncertainties describe the extent to which the IP stakeholders expect their product, design, or other IP will be adequately protected. Factors such as the perceived value of the IP and related products increase, or decrease, the incentive to actively protect and monitor the subject IP. Additional considerations include the length of time that the product will have legal protection, potential technological obsolescence, and other factors.

The AM IP risk assessment framework provides a reference for IP stakeholders to consider the level of operational and legal risk to which each specific part, product, or design is exposed. This allows for the tactical IP approach to be customized based on the specific characteristics of each part or product and helps to create a roadmap of crucial factors to consider while determining the appropriate IP strategy to take.

Figure 2 details the framework for assessing IP needs, along with four broad product categories to help inform decisions on potential case-by-case approaches to IP. Industry standards and the relative actions of other players in the field will provide context to the individual business when determining where within the framework a product falls.

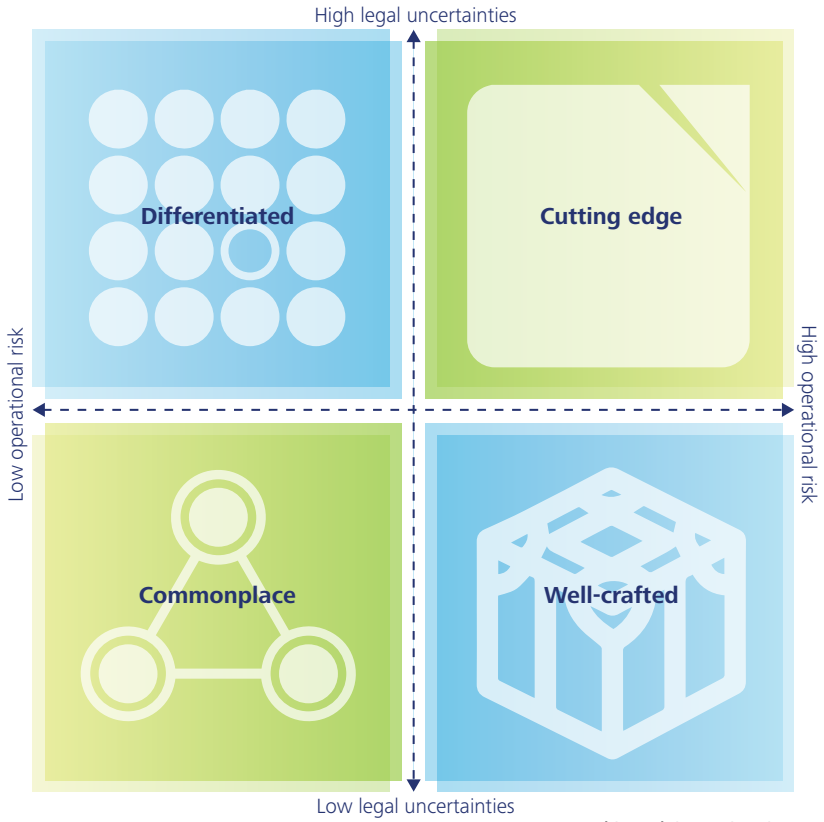
Applying the framework

Applying the AM IP risk assessment framework involves individually analyzing each part, product, use, and licensing scenario. The following are descriptions of broad categories that may describe a product, along with possible IP approaches based on the operational and legal risks involved. In each example, the framework can be used to classify parts and products, highlight operational vs. legal risks, and suggest key points to consider when determining the most appropriate way forward for IP.

Cutting edge: High operational and legal risk

This category includes mission-critical components whose proper functioning is crucial to any system in which they are used. Here, the risks of failure—and thus, the incentive to ensure high levels of IP protection—are quite high, both from a legal and operational perspective. Products in this category will likely be complex and valuable to the IP holder. The barrier to entry for competitors tends to be significant at this level, as investments in design development—both in terms of time and capital—are typically high. As such, the

Figure 2. AM IP risk assessment framework



Graphic: Deloitte University Press | DUPress.com

products might be manufactured with substantial quality controls and can be customized to the specific needs of each client or customer, adding still greater investments in the process.[28] An example of a part in this category is a combustion chamber in a turbo jet engine that has been custom-tuned to reduce fuel usage for aircraft of a particular airline, based on the average air density encountered when flying certain routes.

Businesses that make these sort of large investments in the design may expect the product to provide significant sustainable revenue and, as the stakes are higher for mission-critical parts, may desire stronger protection against potential infringement or misuse. At the same time, due to the customization and novelty of the product, licensees may also feel some level of risk or uncertainty in investing a higher amount to acquire the appropriate IP. One possible way of addressing these concerns up front may include a more flexible economic agreement, or even a joint venture. A license with scenario-based royalty rates and variable financial terms with clear incentives and upside for both parties may help to mitigate both parties' risk.

Well-crafted: High operational risk, low legal risk

"Well-crafted" products fulfill a critical function but are not significantly differentiated from other offerings in the marketplace. In this category, the IP holder has likely invested in quality control mechanisms to a higher degree, as the part or product's safe and optimal function is of the utmost importance; relatively lower investments tend to be made in proprietary research and design. A set of products that exemplify this category is chemistry lab glassware: They must be fabricated to withstand specific tolerances, but multiple manufacturers offer similar products.

In this scenario, IP owners would likely expect these products to generate revenue, but perhaps as part of a larger offering. Given the risks previously described, an agreement that emphasizes a lump-sum payment or a running royalty per unit may be considered.

Differentiated: High legal risk, low operational risk

Products considered "differentiated" are easily discernable from those of competitors. However, unlike cutting-edge or well-crafted products, these likely do not fulfill a critical functional or operational role for the customer, and thus may not need significant customization and can adhere to lower levels of quality assurance. Rather, their value comes from their unique properties and the amount of investment the IP owner has likely made into design and development. In this case, an example may be a specially designed ergonomic chair that has been tested through clinical trials to provably reduce pressure points while still maintaining a unique look that easily distinguishes it from competitors.

Due to the relatively higher research and development costs likely expended and the strong brand recognition potentially associated with the product or part, the IP owner might expect relatively higher revenue from its sale. As a result, the product could be protected legally through patents or copyrights. Since the major concern for the customer would likely be the IP rights of the IP owner, IP in this category may demand higher royalty payments, and nonexclusive licenses may prevail.

Commonplace: Low operational and legal risk

As the name suggests, products that would fall into this category tend to be standard parts that may have little stand-alone marketability from the IP owner's standpoint. Instead, they might act as vehicles to drive future sales of other products or services. Parts that are not highly differentiated from competitors—perhaps only by minor design elements—and less critical to overall function, and thus have higher tolerance for build fluctuations, belong to this category. One example is a semispecialized bolt used in fastening the external façade of a refrigerator to the main structure.

When it comes to parts and products in the commonplace category, IP owners might find that trying to protect low-value products from being infringed upon by anyone using AM technology is more expensive than the potential future revenue from direct sales of the part. In other words, the cost of protecting the IP is higher than the value of the part of product itself. In this case, the IP owner could consider making the product freely available and focus on selling the other components of the offering, or charging a nominal royalty to establish a relationship with the licensee and ensure quality components are being used in the offering.

As with any new technology, the best way forward is not always clear. The framework categories have loosely bounded edges, where the appropriate actions are not always apparent and must be determined on a case-by-case basis. For example, if a product is commonplace but sitting near the middle of the graph, a lump-sum payment below market rate might seem appropriate. However, as a product increases in operational risk and legal uncertainty, the ideal lump-sum payments could increase until the balance tilts in favor of the IP owner and the payment would be above market rate. Regardless, the same general principle of coming to a mutually beneficial licensing agreement based on the economics of the additively manufactured product still holds.

Conclusion

AM's focus on information over physical object as the source of value has the potential to dramatically change the way products are sold and distributed. To stay competitive in an increasingly digital marketplace, designers and manufacturers adopting AM may look at the best ways to protect and license IP as they seek to manage and protect the manufacture of their product.[29] While many IP issues as they relate to AM currently lack strong legal precedents, businesses should consider the importance of being proactive in addressing these issues while navigating the still-developing legal debate.

It may be useful, therefore, to consider the importance of developing mutually beneficial deals based on the economics specific to the product as the safest and most lucrative option. The qualities of the product as it relates to the business models of the IP holder and customer can inform this decision. In particular, the operational risk and legal uncertainty together establish scenarios where different types of licensing agreements are appropriate. As manufacturers seeking to harness AM explore a path forward, they can:

- **Understand the levels of operational risk and legal uncertainty inherent in the part or product in question**. Proactively analyze and assess (for example, use the AM IP risk assessment framework) the balance between these types of risk for each individual part or product, and use that insight to guide the most appropriate approach. This method has a precedent in past examples, where successful business models have emerged from the shift in value from the physical product to information, pushing IP issues to the fore.

- **Consider lessons from the past when approaching AM IP agreements**. When faced with similar scenarios of digitization of formerly physical and easily controlled products, companies that created profitable and sustainable businesses also focused on the economic realities of the new technologies, instead of attempting to decipher the complicated and sometimes undefined IP laws.

- **Keep the IP issue front and center to avoid inefficiencies later on**. By addressing

While many IP issues as they relate to AM currently lack strong legal precedents, businesses should consider the importance of being proactive in addressing these issues while navigating the still-developing legal debate.

the IP concerns up front when making a business deal, companies can avoid unnecessary legal costs and lost revenue. This is now a common practice during large-scale and critical acquisitions of traditionally manufactured parts that can translate to additively manufactured parts.

- **Accept that challenges may occur, but conduct analysis to ensure a formal agreement can achieve the appropriate return**. IP holders should also be realistic about the possibility of end users surreptitiously utilizing their IP, as has been the case with the music and movie industries. A clever business model that accepts this reality and provides end users a quality of service that they are willing to pay for may be a prudent way forward.

One way or the other, proactive analysis must be done to avoid pitfalls with AM-related IP. The AM risk assessment framework provides a foundation for IP owners and buyers while evaluating IP risk. Because AM technology is still young, a lot of the AM IP landscape has yet to be developed, but a strong way of mitigating IP risk is by striving to create mutually beneficial deals based on an understanding of the economics of AM.

Endnotes

1. Mark Cotteleer and Jim Joyce, "3D opportunity: Additive manufacturing paths to performance, innovation, and growth," *Deloitte Review* 14, Deloitte University Press, January 17, 2014, http://dupress.com/articles/dr14-3d-opportunity/.
2. John Hagel III et al., *The future of manufacturing*, Deloitte University Press, March 31, 2015, http://dupress.com/articles/future-of-manufacturing-industry/.
3. Thierry Rayna and Ludmila Striukova, "The impact of 3D printing technologies on business model innovation," *Digital Enterprise Design & Management*, 2014, http://link.springer.com/chapter/10.1007%2F978-3-319-04313-5_11.
4. For a discussion on how trademarks can be infringed upon with AM, see New Media Rights, "3D printing trademark basics," http://newmediarights.org/3d_printing_trademark_basics_0, accessed December 14, 2015. For a discussion of implications of trademark infringement and relation to AM, see Lijie Grace Zhang, John Fisher, and Kam Leong, *3D Bioprinting and Nanotechnology in Tissue Engineering and Regenerative Medicine* (New York: Elsevier Inc., 2015), p. 360.
5. William A. Simons, "IP issues with additive manufacturing: 3-D technology could revolutionize product design, production," *Connecticut Law Tribune*, April 15, 2013, http://www.ipo.org/wp-content/uploads/2013/08/IPIssueswithAdditive.pdf.
6. For a full discussion of these dynamics, see Cotteleer and Joyce, "3D opportunity: Additive manufacturing paths to performance, innovation, and growth."
7. Ibid.
8. Tim Gale (president and CEO, AMS Group), interview with the authors, January 12, 2016.
9. Casey Chan, "The world's first entirely 3D printed gun," *Gizmodo*, May 3, 2013, http://gizmodo.com/the-worlds-first-entirely-3d-printed-gun-489975583.
10. Roxanne Palmer, "3D printing risks: Not just plastic guns, but military parts, drugs and chemical weapons," *International Business Times*, May 24, 2013, http://www.ibtimes.com/3d-printing-risks-not-just-plastic-guns-military-parts-drugs-chemical-weapons-1275591.
11. Hod Lipson and Melba Kurman, *Fabricated: The New World of 3D Printing* (Indianapolis: John Wiley & Sons Inc., 2013), pp. 222–23.
12. Ibid.
13. Ibid.
14. Sony Corp. of Amer. v. Universal City Studios, Inc., 464 US 417 (1984), cited in Cornell University, https://www.law.cornell.edu/copyright/cases/464_US_417.htm, accessed December 14, 2015.
15. Phil Reeves and Dinusha Mendis, *The current status of 3D printing within the industrial sector: An analysis of six case studies*, Intellectual Property Office, UK Government, March 2015, p. 47, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/413673/The_Current_Status_and_Impact_of_3D_Printing_Within_the_Industrial_Sector_-_Study_II.pdf.
16. Ibid.
17. Ibid., p. 46.
18. Ibid., p. 47.
19. Mona Lalwani, "How a file format brought an industry to its knees," *Engadget*, June 26, 2015, http://www.engadget.com/2015/06/26/mp3-digital-music-piracy/.
20. A&M Records Inc. v. Napster Inc., 239 F.3d 1004 (9th Cir. 2001), cited in Lisa M. Sepeda, "A&M Records, Inc. v. Napster, Inc.," *Berkeley Technology Law Journal* 17, no. 1 (2002): pp. 71–90, http://dx.doi.org/doi:10.15779/Z38BM24.
21. Ibid.
22. Ibid.
23. Ibid., pp. 71–90.
24. For a discussion around the cases of Spotify and Pandora, see Sarah McHaney, "In the age of streaming music, just how much is a listen worth?" PBS NewsHour, February 4, 2015, http://www.pbs.org/newshour/updates/age-streaming-music-just-much-listen-worth/; for more on Spotify and iTunes, see Mic Wright, "Let's stop panicking about digital piracy. Legal content providers just need to get their act together," *Telegraph*, September 17, 2012, http://blogs.telegraph.co.uk/technology/micwright/100007692/lets-stop-panicking-about-digital-piracy-legal-content-providers-just-need-to-get-their-act-together/.

25. Cotteleer and Joyce, "3D opportunity: Additive manufacturing paths to performance, innovation, and growth."

26. Mark Cotteleer, Mark Neier, and Jeff Crane, *3D opportunity in tooling: Additive manufacturing shapes the future*, Deloitte University Press, April 7, 2014, http://dupress.com/articles/additive-manufacturing-3d-opportunity-in-tooling/.

27. Ian Wing, Rob Gorham, and Brenna Sniderman, *3D opportunity for quality assurance and parts qualification: Additive manufacturing clears the bar*, Deloitte University Press, November 18, 2015, http://dupress.com/articles/3d-printing-quality-assurance-in-manufacturing/.

28. For a deeper analysis of determining the appropriate level of quality assurance for additively manufactured parts, see ibid.

29. Jonathan Salem Baskin, "What happens when 3D printing turns consumer products into digital content?" *Forbes*, March 6, 2014, http://www.forbes.com/sites/jonathansalembaskin/2014/03/06/what-happens-when-3d-printing-turns-consumer-products-into-digital-content/.

Acknowledgements

The authors would like to thank **Brenna Sniderman** of Deloitte Services LP for her assistance in developing this paper.

Contacts

Mark J. Cotteleer
Center for Integrated Research
Research director
Deloitte Services, LP
+1 414 977 2359
mcotteleer@deloitte.com

Kelly Marchese
Principal
Supply Chain & Manufacturing Operations
Deloitte Consulting LLP
Mobile: +1 404 915 2346
kmarchese@deloitte.com

Matt Widmer
Principal
Deloitte Financial Advisory Services LLP
+1 571 882 5140
mwidmer@deloitte.com

 Follow @DU_Press

Sign up for Deloitte University Press updates at DUPress.com.

About Deloitte University Press

Deloitte University Press publishes original articles, reports and periodicals that provide insights for businesses, the public sector and NGOs. Our goal is to draw upon research and experience from throughout our professional services organization, and that of coauthors in academia and business, to advance the conversation on a broad spectrum of topics of interest to executives and government leaders.

Deloitte University Press is an imprint of Deloitte Development LLC.

About this publication

About Deloitte