The Patentability of Digital “Manufactures” as 3D Printing Expands Into the 4D World

ABSTRACT

Technological advances have always been supported by a robust patent system that encourages disclosure of inventions by providing protection to the inventor. Society has benefitted from this system, which has relied on a definition of “manufacture” that has essentially remained unchanged for over 200 years. However, with the advent of digital technologies, and in particular Four-Dimensional Printing, courts have been inconsistent in evaluating the patentability of such inventions. Recent Supreme Court and Federal Circuit decisions have indicated that some software may be eligible for patent protection. This is particularly important for 4D printing wherein the manifestation of the printed product is inherently connected to the software. This Note explains why the patent system should recognize CAD files, particularly as they relate to 4D printing, as patentable subject matter under Section 101 of the Patent Act of 1952.

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In 1991, a top-of-the-line computer costing over $4,000 had a storage capacity of 200 megabytes, and owners proudly thought they had more space than they would ever need. Today, twenty-five years later, technological innovations cause us to look back and wonder how we were able to survive with storage space in the megabytes.\(^1\) In the case of traditional technological advances, the patent system served as an effective tool to encourage the disclosure of innovation by offering protection for inventors, but the patent system has shown reluctance

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towards change in the area of digital manufacturing technologies (DMT). As time moves forward, technological advances are soaring, and the meaning of “manufacture” is changing. Technology is emerging rapidly, and society is about to embrace and adapt to such advances regardless of whether the legal system provides adequate protection through patent law. As we teeter on the edge of the next technology, we are moving toward a futuristic world in the fourth dimension of time through the advent of 4D printing.

Unlike previous technology, 4D printing allows an object to change shape after it finishes printing. This is made possible through the use of programmable matter (PM), which is preprogrammed to react to various external stimuli such as water and heat. Existing examples of how researchers are utilizing PM include: finding methods for buildings to self-assemble; targeting specific cancer by using preprogrammed DNA to self-assemble nanorobots; developing products that take up minimum space but transform to other shapes for space applications; and building ten self-assembling one story houses in a day. Even the US military is researching and using these additive manufacturing technologies.

With the fourth dimension of an external stimuli introduced to the portfolio of emerging technologies, the patent system needs to recognize that the archaic definition and interpretation of “manufacturing” should be updated to include certain types of digital

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2. See Mark Crawford, 4D Printing: The Next Level of Additive Manufacturing, ASME (Apr. 2014), https://www.asme.org/engineering-topics/articles/manufacturing-processing/4d-printing-next-level-additive-manufacturing [https://perma.cc/8AAA-KHQG] (PM may come in multiple forms: (1) where objects are pre-connected elements that are 4D printed or assembled as one complete structure for self-transformation or (2) unconnected voxels that can come together or break apart as a result of predetermined programming).


manufacturing technologies that may lack adequate protection if claimed as a “process.”

In a world of shape-shifting and 4D printing, there is a need to find a balance that promotes the innovation required by the Patent Act, maintains the high level of patent protection that renders inventors’ patent rights viable, and does not inadvertently provide patent protection to historically unpatentable creations. Because emerging technology eventually becomes outdated, the legal system must realize the potential implications and negative externalities associated with the lack of a workable patent doctrine for digital manufactures. Currently, as a result of fast-paced technological and digital advances, a lack of clarity surrounding patentability of these digital “manufactures” has emerged. Because the meaning of “manufacture” is unclear, inventors of both 3D-printable and 4D-printable products are at a disadvantage concerning the enforceability of potential patent rights in their inventions. Without a process to patent these valuable new 4D-printing computer-aided design (CAD) files, the enforceability against infringement will remain limited and the disclosure of these inventions to the public may decrease. This Note attempts to explain why the patent system should recognize CAD files, particularly as they relate to 4D printing, as patentable subject matter (PSM) under Section 101 of the Patent Act of 1952.

Part I explains what 4D printing is and how the 4D technology works. Part II explains statutory patentability and the judicially created abstract idea doctrine. In Part III, this Note analyzes the challenges of patentability in the area of digital manufacturing by using 4D-printing CAD files to explain how “manufacture” can encompass a transformative 4D-printing CAD file under Section 101 and why a CAD file—even if found only to be patentable as a “process”—is not abstract

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10. Digital manufacturing refers to a manufacturing process though digital files, like a CAD file, as opposed to traditional manufacturing techniques that were around when the patentability requirements were created.

11. See Brean, supra note 8, at 863 (explaining that “[d]esigners of 3D products are” at a disadvantage concerning the enforceability of patent rights).

under current Section 101 case law. Part IV provides a potential solution and two alternative solutions for the Judiciary and Congress.

I. THE TECHNOLOGY

A. The Technological Superpowers of 4D Printing

Four-dimensional printing is the process of using a 3D printer to create objects that change shape after printing as a result of external stimuli. This pre-printing process is made possible through the use of CAD files, which are created by computer systems to aid in the creation, modification, analysis, or optimization of a design. In 2013, Massachusetts Institute of Technology (MIT) researchers produced the first successful programmable matter (PM) that reacts to external stimuli in a specific manner. PM is the science, engineering, and design of physical matter that has the ability to change form and function due to an intentional method of programming. By incorporating shape-memory polymer fibers—smart fibers or programmable matter—into composite materials, the process of 4D printing allows a 3D printer to be used to print a 3D object that, when later exposed to certain stimuli, will transform into a different 3D shape. Unlike 3D printing, 4D printing requires a type of programmable fiber containing a printed active component (PAC) that is preprogrammed by using a CAD file specific for the manufacture of the final product. This PAC is programmed to react in a certain, predetermined way once the object is printed using a specialized printer. With 4D printing, instead of staying static once printed, the printed objects change embodiments as a reaction to the stimuli, and the CAD file is inherently part of the final transformation of the programmable material.

13. Alice Corp. v. CLS Bank Int'l, 134 S. Ct. 2347 (2014); BASCOM Glob. Internet Servs. v. AT&T Mobility LLC, 827 F.3d 1341, 1343 (Fed. Cir. 2016); Enfish, LLC v. Microsoft Corp., 822 F.3d 1327 (Fed. Cir. 2016); TLI Commc'ns LLC v. AV Auto. LLC, 823 F.3d 607 (Fed. Cir. 2016).
17. Id.
18. Id.
19. Id.
B. The Fibers

At present, the PACs are soft materials that are thermomechanically programmed to assemble three-dimensional configurations such as bent, coiled, twisted strips, folded shapes, or contoured shapes with non-uniform curvatures.\(^{21}\) This programming allows the fibers to shape-shift.\(^{22}\) The shape change is controlled through design of those ordered materials at a micrometer scale, and those widely used inhomogeneities\(^{23}\) are typically arranged randomly, and the arrangement is difficult to control.\(^{24}\) However, with 4D printing, researchers are confident they have full control over the fibers.\(^{25}\) As technology races forward, the range, properties, and capabilities of PACs are expected to expand.\(^{26}\)

C. Limitations of the Printed Materials

These fibers do not come without limits. As an emerging technology, there are still some unknowns. Researchers at the Georgia Institute of Technology have actively determined limits of the fibers utilized and are working toward overcoming them.\(^{27}\) These limits include: (1) one-way actuation (meaning that, in order for the materials to fold or change in more than one way, there must be a second programming), (2) the PM can be slow to react to the external stimuli, and (3) the printed materials tend to break easily.\(^{28}\) However, while inhomogenities are known for being random and difficult to control, 4D programming makes these materials sturdy and more controllable.\(^{29}\)


\(^{22}\) Crawford, *supra* note 2.

\(^{23}\) See Marcelo Epstein & Marek Elzanowski, *Material Inhomogeneities and Their Evolution: A Geometric Approach* 3 (2007); *Ultrasonic Methods in Evaluation of Inhomogenous Materials* (A. Alippi & Walter G. Mayer eds., 2012) (explaining that inhomogeneities are located in the intrinsic parameters of a medium and generally cause a propagating acoustic or elastic, measurable wave to scatter, resulting in a velocity or direction of propagation of the incident wave—either planar or spherical).

\(^{24}\) Crawford, *supra* note 2.

\(^{25}\) *Id.*

\(^{26}\) *Id.*

\(^{27}\) Mao et al., *supra* note 21, at 7.

\(^{28}\) *Id.*

\(^{29}\) Crawford, *supra* note 2 (asserting that 4D-printed materials are easier to control than inhomogeneities).
D. Future Developments

Further development of this technology is leading to products that self-assemble, change shape, and change properties when exposed to predetermined or preprogrammed stimuli, such as air, water, or heat, due to the chemical interaction of the materials used in their manufacture.\(^\text{30}\) The technology surrounding matter and fibers is changing quickly and has a wide range of potential applications in areas such as fashion,\(^\text{31}\) the military,\(^\text{32}\) and space.\(^\text{33}\)

Currently, the US Army Research Office has awarded research grants to multiple universities to analyze and identify different applications of use in the military.\(^\text{34}\) The military is researching camouflaged-fiber application for clothing that changes form when exposed to various conditions,\(^\text{35}\) drones that are programmed (within the material itself) to self-destruct if presented with an unfamiliar or dangerous climate,\(^\text{36}\) war weapons that are easily portable in one shape but convert when exposed to external stimuli, and, as a future goal, programmable fibers that oscillate on their own.\(^\text{37}\) Finally, research...
suggests that it may be possible to preprogram materials to change and become invisible once they reach a certain temperature.\textsuperscript{38}

II. STATUTORY & JUDICIAED CREATED PATENTABILITY DOCTRINES

The patent system was developed to "promote the progress of science and useful arts."\textsuperscript{39} Wrapped up in patent policy is a right to exclude others from making, using, and selling a patented invention without permission.\textsuperscript{40} Before an inventor can assert the right to exclude afforded through patent litigation, he must pass the patentability hurdles required to obtain a valid patent through prosecution, which is the process of drafting, filing, and negotiating between the United States Patent and Trademark Office (USPTO) and the inventor’s representatives.\textsuperscript{41} There are two types of patentability requirements that an inventor must overcome to obtain a patent: statutory patentability requirements under Section 101 and judicially created patentability exceptions, which deem an application unpatentable if it is directed at laws of nature, natural phenomena, or abstract ideas.\textsuperscript{42} One of those hurdles—the bar against patenting an abstract idea—has been in limbo since the 2014 Supreme Court decision of Alice Corp. v. CLS Bank Int’l.\textsuperscript{43}

A. Statutory Eligible Subject Matter Under Section 101

In order to be a statutory patentable subject matter (PSM), an invention must fall within one of the four PSM categories set forth in 35 U.S.C. § 101 of the Patent Act of 1952,\textsuperscript{44} which are a process, machine, composition of matter, and manufacture.\textsuperscript{45} Three of the categories—machine, manufacture, and composition of matter—are


\textsuperscript{39} U.S. CONST. art. I, § 8, cl. 8.

\textsuperscript{40} 35 U.S.C. § 271(a) (2012).

\textsuperscript{41} See General Information Concerning Patents, USPTO (Oct. 2015), http://www.uspto.gov/patents-getting-started/general-information-concerning-patents [https://perma.cc/B7PX-AWPG] (if a product of a manufacturer is unlawfully made, used, or sold, the inventor needs an available recovery method for such copying).

\textsuperscript{42} JANICE M. MUELLER, PATENT LAW 343, 362 (4th ed. 2013). A patent must also satisfy other requirements under patent law to issue. The other Sections that an invention must survive to issue the patent include 28 U.S.C. §§ 102, 103, & 112. Id.

\textsuperscript{43} Alice Corp. v. CLS Bank Int’l, 134 S. Ct. 2347 (2014).

\textsuperscript{44} 35 U.S.C. § 101.

\textsuperscript{45} Id.
said to refer to a physical object, while “process” refers to an act.\textsuperscript{46} Until recently, this has been interpreted to mean that, except for process claims, the PSM must exist in some tangible form.\textsuperscript{47} These four categories together constitute the exclusive reach of PSM. In choosing such expansive terms, “Congress plainly contemplated that the patent laws would be given wide scope.”\textsuperscript{48} If a claim covers any material not found in any of the four statutory categories, that claim falls outside the plainly expressed scope of Section 101 and will be unpatentable, even if the subject matter is otherwise new and useful.\textsuperscript{49} As technology has advanced, courts have addressed this issue in contrasting ways, which sometimes seem like trying to put a square peg into a round hole; if the square peg is small enough and the hole is large enough, it fits, but it does not fit neatly. This becomes particularly problematic for the newer applications of digital CAD files related to 4D-printing inventions because, without these files being recognized as PSM, they will have limited patent protection under the current regime.\textsuperscript{50}

The four categories of statutory subject matter in Section 101 have remained unchanged since 1790 with the exception of the substitution of “process” for “art” in the Patent Act of 1793.\textsuperscript{51} One of these categories, “manufacture,” has been statutorily recognized as PSM since the enactment of the 1790 US Patent Act.\textsuperscript{52} However, when Section 101 was enacted, the state of manufacturing technologies was not yet in the sphere of digital objects, but rather just the physical.\textsuperscript{53}

\textit{B. The Muddy Meaning of “Manufacture”}

The term “manufacture” is the lynchpin that connects the digital world to the historically physical world. However, throughout the past decade, this connection has been tenuous and inconsistent. Courts have historically relied on dictionary definitions to justify their

\begin{itemize}
\item \textsuperscript{46} In re Bergy, 596 F.2d 952, 974 n.11 (C.C.P.A. 1979), off'd sub nom. Diamond v. Chakrabarty, 447 U.S. 303 (1980); IRAH H. DONNER, BLOOMBERG BNA: CONSTRUCTING AND DECONSTRUCTING PATENTS 467 (2d ed. 2015).
\item \textsuperscript{47} Digitech Image Techs., LLC v. Elecs. for Imaging, Inc., 758 F.3d 1344, 1348–49 (Fed. Cir. 2015) (“To qualify as a manufacture, the invention must be a tangible article that is given a new form, quality, property or combination through man-made or artificial means.”); Chakrabarty, 447 U.S. at 308; see Daniel J. Gervais, The Patent Target, 23 FED. CIR. B.J. 305, 354 (2013).
\item \textsuperscript{49} In re Nuijten, 500 F.3d 1346, 1353 (Fed. Cir. 2007).
\item \textsuperscript{50} See Diamond v. Diehr, 450 U.S. 175, 185 (1981); DONNER, supra note 46, at 467.
\item \textsuperscript{51} Patent Act of 1793, ch. 9 § 1, 1 Stat. 318 (1793); In re Nuijten, 500 F.3d at 1360–61 (Linn, J., dissenting).
\item \textsuperscript{52} Patent Act of 1790, ch. 7 § 1, 1 Stat. 109 (1790).
\item \textsuperscript{53} See Brean, supra note 8.
\end{itemize}
interpretation of “manufacture” for the evaluation of patentability.\textsuperscript{54} These varying interpretations leave the field of 4D-printing CAD files without clear boundaries as to what a manufacture includes.\textsuperscript{55} The definition of “manufacture” has been upheld in numerous Supreme Court cases as a “comprehensive class of inventions” that includes “every article devised by man except machinery upon the one side, and compositions of matter and designs upon the other.”\textsuperscript{56} This would be the accepted position today but for the 1931 pre–digital age decision of \textit{American Fruit}.\textsuperscript{57} Unfortunately, this pre–digital age interpretation of “manufacture” has left the legal practitioner in the uncomfortable position of applying legal precedence that was forged in the absence of the understanding of how future advances would be impacted.

Like many Supreme Court cases, the \textit{American Fruit} decision and ensuing cases hinged on the parsing of individual words. For digital manufacturing, the critical cases address the Court's interpretation of the term “manufacture.” The Court's decisions have not clarified the issue. The Supreme Court, in \textit{American Fruit},\textsuperscript{58} quoted the Century Dictionary definition to define “manufacture” as “the production of articles for use from raw or prepared materials by giving to these materials new forms, qualities, properties, or combinations, whether by hand-labor or by machinery.”\textsuperscript{59} This pre–digital age interpretation has been used in subsequent cases, such as the 1980 \textit{Diamond v. Chakrabarty} decision.\textsuperscript{60} While the Court in \textit{Chakrabarty} used the definition from \textit{American Fruit}, it only did so in order to find the term “manufacture” compatible with the broad concept of a “manufacture” in citing the legislative history of the 1952 Patent Act.\textsuperscript{61} Taking such an expansive approach, the Court found a genetically altered living microorganism patentable because PSM includes “anything under the sun that is made by man.”\textsuperscript{62}

However, whether the statutory category “manufacture” is limited to tangible subject matter is not fully resolved or explained, and

\begin{itemize}
  \item \textsuperscript{54} \textit{Chakrabarty}, 447 U.S. at 308; Am. Fruit Growers v. Brogdex Co., 283 U.S. 1, 11 (1931).
  \item \textsuperscript{55} See \textit{Chakrabarty}, 447 U.S. at 303; \textit{Am. Fruit}, 283 U.S. at 1.
  \item \textsuperscript{56} DONALD S. CHISUM, A TREATISE ON THE LAW OF PATENTABILITY, VALIDITY AND INFRINGEMENT: CHISUM ON PATENTS § 1.02 (2016).
  \item \textsuperscript{57} Id.
  \item \textsuperscript{58} In re Nuijten, 500 F.3d 1346, 1358 (Fed. Cir. 2007) (Linn, J., dissenting).
  \item \textsuperscript{59} Id. at 1356, 1359 (quoting \textit{Am. Fruit}, 283 U.S. at 11) (quoting CENTURY DICTIONARY 3620 (William Dwight Whitney ed., 1895)); see CHISUM, supra note 56 (explaining that the \textit{American Fruit} Court relied on prior decisions—none of which concerned patent law).
  \item \textsuperscript{60} \textit{Chakrabarty}, 447 U.S. at 308–09.
  \item \textsuperscript{61} See In re Nuijten, 500 F.3d at 1360 (citing \textit{Chakrabarty}, 447 U.S. at 308–09).
  \item \textsuperscript{62} Id. at 1362–63 (explaining the broad terms constituting PSM).
\end{itemize}
what constitutes “tangible” is still unclear. More recently, cases concerning the patentability of computer software and printed matter suggest that a patent claim to information embedded in a medium, such as a computer readable storage device, may satisfy Section 101, but may not satisfy two other requirements to obtain a patent: novelty and nonobviousness. Other cases have suggested that computer programs that can be embedded in a tangible medium, such as a floppy disk, are PSM. The lack of clarity in the meaning of “tangible” is particularly important when claiming a digital manufacture, and these seemingly conflicting interpretations leave the 4D CAD files in limbo regarding patentability.

C. The Dissenting Opinion Effect of In re Nuijten: There May Be Hope for Digital Manufactures

Court decisions are rarely unanimous, and dissenting opinions provide alternative interpretations that can be drawn upon for future arguments. In the case of digital patents, In re Nuijten provides that possible avenue through significant dissenting opinions. While the majority and dissenting opinions in In re Nuijten disagree on how far the scope of statutory subject matter extends, the two opinions can be reconciled to read “manufacture” as including an intangible product that lasts more than a transitory duration—a major step toward protecting emerging technologies. The majority, relying on the American Fruit definition, reads “manufacture” to address articles of manufacture as tangible articles or commodities. Importantly, Judge Linn’s dissent in In Re Nuijten argued that this definition does not require that a manufacture be tangible or a non-transitory invention by its own terms, explaining that the raw

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64. See In re Ngai, 367 F.3d 1336, 1338–39 (Fed. Cir. 2004).
65. In re Beauregard, 53 F.3d 1583, 1584 (Fed. Cir. 1995).
66. In re Nuijten, 500 F.3d at 1359 (Linn, J., dissenting).
67. See id. at 1355, 1358. The Supreme Court has defined “manufacture” in its verb form as “the production of articles for use from raw or prepared materials . . . .” Id. at 1358 (quoting Diamond v. Chakrabarty, 447 U.S. 303, 308 (1980) and Am. Fruit Growers, Inc. v. Brogdex Co., 283 U.S. 1, 11 (1931)).
68. See In re Nuijten, 500 F.3d at 1358–59, 1362 (explaining that, by lasting more than a transitory duration, copyright law could provide thin copyright protection where patent law leaves off).
69. Id. at 1356–57 (majority opinion).
70. Id. at 1358 (Linn, J., dissenting).
71. Id. at 1359.
materials that take new form to become a “manufacture” do not need to be tangible or permanent inputs. The dissent further explained that deeming an invention patentable does not require that patentable manufacture to be a tangible thing; rather, the tangible result “is one indication that it is not an unpatentable abstract idea.” Judge Linn explained that, in determining whether something is an abstract idea under Section 101, the only requirements for an invention to fall within one of the statutory subject matter categories is whether the invention is “new” and “useful.” The “new” and “useful” requirements are limits on the four statutory categories that otherwise encompass “anything under the sun that is made by man,” as explained in Chakrabarty. This viewpoint aids in interpreting the intent behind the enactment of Section 101. Chakrabarty affirmed one definition of “manufacture” used in American Fruit to explain that a “manufacture” can be afforded patent protection for any invention made “for use from raw or prepared materials.”

Despite such broad guidelines, the 2014 Digitech decision explained that to qualify as a “manufacture,” an invention must “exist in some physical or tangible form” that is given a new form, quality, property, or combination through man-made or artificial means. The Federal Circuit explained that the digital signals in that patent could be tangible if directed toward a tangible embodiment of this information in physical memory or another medium. However, the technology in that case involved “device profiles” that contained intangible information concerning color and spatially related aspects of the digital display, and those device-profile claims required no physical embodiment. Therefore, these claims were even broader than those in In Re Nuijten.

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72. Id. (citing CENTURY DICTIONARY 3657 (William Dwight Whitney ed., 1895) (defining material as “that which composes or makes a part of anything”).
73. Id.
74. Id. at n.1.
75. Id. at 1358 (citing Diamond v. Chakrabarty, 447 U.S. 303, 309 (1980)).
76. Id.
77. Id. at 1359 (quoting Chakrabarty, 447 U.S. at 308).
79. Id. (citing Chakrabarty, 447 U.S. at 308).
80. Id. at 1349.
81. Id. at 1348, 1351 (holding that such a process “is directed to an abstract idea and is not patent eligible under section 101”).
82. Id. at 1349. Compare id. at 1351 (asserting process claims directed at an abstract idea), with In re Nuijten, 500 F.3d at 1353 (asserting claims involving physical but transitory forms of signal transmission).
C. What Qualifies as an Abstract Idea Under Alice, Enfish, TLI, and BASCOM?

Despite the relative breadth of patent-eligible subject matter, the Supreme Court has recognized limited judicial exceptions from patent eligibility for “laws of nature, natural phenomena, and abstract ideas.” These exceptions are intended to prevent the monopolization of “the basic tools of scientific and technological work,” since patents covering such topics “might tend to impede innovation more than [they] would tend to promote it.” While the exceptions are used to prevent stifling innovation, the Supreme Court has also recognized that too broad an interpretation could weaken patent law.

1. Supreme Court Cases

In *Mayo Collaborative Services v. Prometheus*, the Supreme Court created a two-step framework that allows a court to determine whether a patent claiming a law of nature, a natural phenomenon, or an abstract idea is patent eligible. This framework—created by the Supreme Court—was reaffirmed in the 2014 *Alice Corp. v. CLS Bank International* decision and is the current test for the determination of abstractness. The first step requires a court to determine whether the claims are “directed to patent-ineligible concept[s]” (i.e., judicial exceptions such as laws of nature, natural phenomena, or an abstract idea). If the claim itself is patent-ineligible, then the court must consider the claim elements on a claim-by-claim basis and determine whether these elements, as a whole, transform the nature of the originally ineligible claims into a patent-eligible application. It is at

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85. *Id.; see also Diehr*, 450 U.S. at 188–89 (recognizing that the issues of novelty and nonobviousness do not bear on the question of whether an invention is PSM).
87. *See Alice Corp. v. CLS Bank Int'l*, 134 S. Ct. 2347, 2355 (2014) (citing *Mayo Collaborative*, 132 S. Ct. at 1302) (explaining that allowing a patent on a gene widely used in research may have forced many to license the use or stop research all together). It should be noted that determining eligibility is USPTO jurisdiction. *See General Information Concerning Patents, supra note 41.
89. *Id. at 2350*
this second step that the court evaluates on a case-by-case basis whether there is an “inventive concept.”

While courts have refused to set clear boundaries as to what constitutes an abstract idea, *Mayo Collaborative* says that a patent-eligible claim must include elements that add “significantly more” to the basic principle. This ambiguous language has led to more confusion. Since the Supreme Court has not provided the precise contours of the abstract ideas category, it is difficult to determine whether an idea is abstract or is patent-eligible subject matter.

2. The Federal Circuit

The Federal Circuit has reaffirmed the principles in *Alice*, stating that, without more than simple manipulation of data, “invocation of computers adds no inventive concept.” *DDR Holdings* is the first case since *Alice* in which the Federal Circuit found an inventive concept. In that case, the court upheld the eligibility of a patent, finding “something more” where the purpose of the invention was to allow a website to display “a third-party merchant’s product” and holding that the claims were eligible specifically because they “recite[d] an invention that is not merely the routine or conventional use of the Internet.” Similarly, in denying a petition for rehearing of *Ariosa Diagnostics v. Sequenom, Inc.*, the concurring opinion explained that abstract ideas are essentially mental steps that are not tangible even if written down or programmed into a physical machine, but that “steps that involve machines, which are tangible steps that involve

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91. See *Alice*, 134 S. Ct. at 2357 (citing *Mayo Collaborative*, 132 S. Ct. at 1294) (“Inventive concept is an element or combination of elements sufficient to ensure the patent in practice amounts to significantly more than a patent upon the ineligible concept itself.”).
93. *After Mayo Collaborative*, which appeared to narrow the field of patentable subject matter *Alice* took a broad view on the unpatentability of abstract ideas by treating claims on their substantive merits, which supports the patenting of CAD files. See generally *Alice*, 134 S. Ct. 2347. See Ognjen Zivojnovic, *Patentable Subject Matter After Alice—Distinguishing Narrow Software Patents from Overly Broad Business Method Patents*, 30 BERKELEY TECH. L.J. 807, 816 (2015) (asserting that *Mayo Collaborative* “in effect rendered the validity of most software patents uncertain.”).
94. *Alice*, 134 S. Ct. at 2357.
95. Internet Patents Corp. v. Active Network, Inc., 790 F.3d 1343, 1347 (Fed. Cir. 2015).
96. See *buySAFE*, Inc. v. Google, Inc., 765 F.3d 1350, 1355 (Fed. Cir. 2015).
98. *Id.* at 1249, 1259 (supporting the patenting of a CAD file); see also *Alice*, 134 S. Ct. at 2354.
transformation of tangible subject matter, or tangible implementations of ideas or abstractions” are not abstract.\textsuperscript{100}

Additionally, the Federal Circuit has found that, while claims could be directed to an abstract idea, additional elements in those claims could amount to significantly more than the abstract idea if they show either an improvement in the functioning of a computer itself or show an improvement to another technology or technological field.\textsuperscript{101}

Conversely, in \textit{Intellectual Ventures},\textsuperscript{102} the Federal Circuit held that customizing data based on information known about a user was abstract under the first step of the \textit{Alice} test because the claimed invention was simply implementing a known method of aggregating data on a computer that other media outlets, such as newspapers, had utilized variants of for decades.\textsuperscript{103} Under the second step, the Federal Circuit held that the claims contained no inventive concept because they consisted of the use of “conventional computer components, such as databases and processors operating in a conventional manner.”\textsuperscript{104} In a related case, \textit{Digitech}, the Federal Circuit justifiably held that the Digitech patents were invalid because they did not have any additional elements that could amount to more than abstract ideas themselves.\textsuperscript{105} There, the claims merely recited known math techniques.\textsuperscript{106} As a result of these decisions, not all software-related innovations are considered abstract and unpatentable.\textsuperscript{107}

However, in two of the three most recent eligibility decisions, the Federal Circuit explained that it has “found software-related [or computer-implemented] patents eligible under both steps of the test \textit{Alice} sets out.”\textsuperscript{108} In June 2016, the Federal Circuit decided two cases,
Enfish LLC v. Microsoft Corp. and In re TLI Communications LLC v. AV Automotive LLC, which significantly impacted the two-part Alice test. In Enfish,\(^{109}\) the Federal Circuit found under step two—for the second time since Alice—that a software-related invention was not abstract because it was an “improvement to computer functionality itself.”\(^{110}\) While this decision momentarily seemed to give new life to patents involving software, this changed two days later in In re TLI Communications. There, the Federal Circuit stepped back from Enfish, explaining that claims relating to methods for taking, transmitting, and organizing digital images were abstract.\(^{111}\) This case initially appeared to distinguish Enfish as an exception to Alice.

On June 27, 2016, the Federal Circuit addressed the abstract idea issue again in BASCOM Global Internet Services, Inc. v. AT&T.\(^{112}\) There, the court found that BASCOM’s patent—related to techniques for filtering age-appropriate internet content—was directed toward an abstract idea at step one of the Alice two-step because it was claiming a specific implementation that did not change the step one analysis.\(^{113}\) However, once the court got to step two, it concluded that there was an inventive concept to transform the abstract idea into PSM because the claims involved described unconventional technological solutions to a technological problem.\(^{114}\) The court found the process of installing the filter at a remote location from end users while still performing user-specific customization to be inventive.\(^{115}\) Further, Judge Newman’s concurrence proposed “returning to the letter of Section 101,” meaning a broad conception of patentability.\(^{116}\) These three decisions are important to 4D CAD file eligibility because they demonstrate that the Federal Circuit recognizes the importance of protecting these emerging technologies.

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109. Enfish, 822 F.3d at 1336. (citing Alice, 134 S. Ct. at 2355)
110. DDR Holdings, 773 F.3d at 1265 (upholding eligibility of questionably abstract claims for the first time since Alice).
111. See TLI Communications LLC v. AV Auto. LLC, 823 F.3d 607, 610 (Fed. Cir. 2016).
112. BASCOM, 827 F.3d at 1348.
113. Id.
114. Id. at 1352.
115. Id.
116. Id. at 1353 (Newman, J., concurring).
III. 4D-PRINTED MANUFACTURES MAY BE PATENTABLE SUBJECT MATTER

As current patent law stands, courts have not directly afforded patent protection to 4D CAD files. This poses a particular issue for 4D-printed objects. However, the case for affording patent protection to 4D-printing CAD files may be easier if these files are recognized as PSM. This is particularly true given the recent Federal Circuit decisions. The desire to obtain patent rights must be balanced with the need for an innovative and progressive society as the traditional meaning of “manufacture” changes to encompass transformative digital files.\textsuperscript{117} By claiming 4D-printing CAD files as a manufacture instead of a process, the Alice analysis will not need to occur.

The judicial landscape related to the patentability of 4D CAD files is so barren that most of the literature on digital manufacturing technology focuses on physical printers of the “printed matter” as opposed to the contents of the CAD file.\textsuperscript{118} Some patent scholars have suggested that the statutory language of Section 101 and the judicially created patentability exceptions afford protection to a CAD file.\textsuperscript{119} Meanwhile, others suggest that courts have not adequately addressed whether current patent law covers the scope of a CAD file.\textsuperscript{120} To date, a CAD file has not been recognized to meet the statutory requirements to afford it patent protection due to the requirement and uncertainty of a “tangible” manufacture.\textsuperscript{121}

\textsuperscript{117}. The term “transformative digital file” or “4D printing CAD file” refers to a file where an end product could not exist without the digital file itself.

\textsuperscript{118}. In re Russell, 48 F.2d 668, 669 (C.C.P.A. 1931) (explaining that printed matter is information associated with an article of manufacture and claimed to distinguish an article from similar articles already in the prior art); Timothy R. Holbrook & Lucas S. Osborn, Digital Patent Infringement in an Era of 3D Printing, 48 U.C. DAVIS L. REV. 1319, 1325–34, 1367 (2015) (offering the first exploration of “whether the patent system should recognize infringement based on these digital files alone”). Professor Brean explained that 4D-printing CAD files differ from the construction of 3D-printing CAD files because 4D printing requires more than simply downloading a CAD file to print. He explained that two hurdles stand in the way of patenting a CAD file—the abstract idea hurdle and the prohibition of patenting mere printed matter. Brean, supra note 8, at 840, 848–49. See also DONNER, supra note 46, at 451 (mere arrangement of printed matter on a surface is not considered PSM); CHISUM, supra note 56, at 4 (explaining that Printed Matter Doctrine developed when printing was the primary means for recording and communicating information).

\textsuperscript{119}. Brean, supra note 8, at 848 (“A sliced CAD file, however, behaves more like the software code that provides algorithms and instructions for computers and is commonly covered by a Beauregard claim.”).

\textsuperscript{120}. Holbrook & Osborn, supra note 118, at 1327 (suggesting courts have not addressed this issue yet).

\textsuperscript{121}. USPTO, Patent Subject Matter Eligibility, MANUAL OF PATENT EXAMINING PROCEDURE 2106 (9th ed., rev. 7, 2015) (citing Alice Corp. v. CLS Bank Int’l, 134 S. Ct. 2347, 2357 (2014)), https://www.uspto.gov/web/offices/pac/mpep/s2106.html [https://perma.cc/8YZL-EMHA] (“[I]f a claim is directed to a judicial exception, it must be analyzed to determine whether the
A. Transformative 4D-Printing CAD Files Can Fit into “Manufacture”

It is possible for the transformative, digitally manufactured, 4D-printing CAD file to fit into “manufacture” within the Patent Act of 1952 because the CAD file represents the physical article of manufacture that could not exist without the CAD file—there is no other way to create the article. A CAD file, for purposes of 4D printing, is transformative, distinguishable from a blueprint, and more than mere instructions.122 Furthermore, a CAD file does not need to be packaged as an article of commerce to constitute a “manufacture.”123

Judge Linn’s dissent in In re Nuijten effectively explained that the definition used in American Fruit is not limited to tangible or non-transitory inventions given its plain meaning.124 This can be reconciled with the Chakrabarty Court, which used the same definition to explain that the term “manufacture” is expansive and that “Congress plainly contemplated that the patent laws would be given wide scope.”125 The Court did not attempt, in either American Fruit or Chakrabarty, to determine whether “manufactures” needed to be physical permanent forms or tangible in order to be patentable.126 The Court simply determined whether to issue a patent or not.127 Conversely, the Bayer court took a different approach than Nuijten and Chakrabarty to determine that “manufacture” is used as a noun in Section 101, not a verb, explaining that in the noun form “manufacture” includes “articles” produced from the process of manufacturing.128 However, it did not clarify whether the noun form extends farther than the verb form to include non-physical articles. Following the interpretation in Bayer, a 4D-printing CAD file, as a noun, would fall under the statutory meaning of “manufacture.” Given that reasoning, elements of the claim, considered both individually and as an ordered combination, are sufficient to ensure that the claim as a whole amounts to significantly more than the exception itself—this has been termed a search for an inventive concept.”); Mayo Collaborative Servs. v. Prometheus Labs., Inc., 132 S. Ct. 1289, 1293–94 (2012) (citing Diamond v. Diehr, 450 U.S. 175, 187 (1981)); see Egyptian Goddess Inc. v. SWISA Inc., 543 F.3d 665, 680 (Fed. Cir. 2008) (en banc) (explaining that CAD files are unpatentable).

122. CHISUM, supra note 56, at 8 (“[T]he American Fruit meaning of ‘manufacture’ is of little or no precedential value because no patent policy is served by requiring a product differ in name, appearance or character from current products to be considered a ‘manufacture.’”).


124. In re Nuijten, 500 F.3d 1346, 1353 (Fed. Cir. 2007) (Linn, J., dissenting).

125. Id. at 1360 (citing Diamond v. Chakrabarty, 447 U.S. 303, 308 (1980)) (explaining computer readable storage media are not patent eligible because they may encompass unpatentable transitory signals under In re Nuijten).

126. Id.

127. Id.

a “manufacture” can include something that adds more than just a traditionally unpatentable instruction and is transformative. As a result of these decisions, the 4D CAD file improving the functionality of the overall product resulting from the unique programming may be claimed as a manufacture.

B. The Differences Between 3D and 2D-Printed Files Are Analogous to the Differences Between 3D and 4D CAD Files.

Four-dimensional-printing CAD files are transformative enough that a court could find them patent eligible. At their core, 4D CAD files are not a new way to improve on an old manufacture. Instead, they provide a way to make something new, and there is no other method to produce the same results. Using a simple example, consider a recent TED talk by MIT researcher Skylar Tibbits. Mr. Tibbits demonstrated that the 4D-printed material was programmed to change form into the letters “M.I.T.” when external energy was applied to it. In this case, the 4D CAD file is essential to the material and the material is essential to the final product. This is revealed by the fact that the digital manufacture is not reproducible simply by creating an image of the product and printing it on a 3D printer. If a person takes the 4D-printed MIT letters and creates a 3D CAD file, it would not print out as the same shape-shifting manufacture, but rather as a plain, 3D-printed representation of the letters.

The differences between the varying dimensions are substantial. The similarities between 2D drawings and 3D printing end at the drawings. The similarities between 3D printing and 4D printing end at the printer. The 3D CAD file is a multi-dimensional representation of several 2D specification drawings. The 3D files are used to create a final version of the 2D drawings using the multistage printing process of a 3D printer. Because the final manufacture may be produced directly from the 2D drawings independent of the 3D CAD file, the patentability of 3D CAD files is debatable. However, this cannot be said about 4D printing where the 4D CAD file is intrinsically linked to digital PM. Because of this, “manufacture” can be interpreted to include transformative 4D CAD files.

129. Id. at 1374.
130. See generally In re Russell, 48 F.2d 668 (C.C.P.A. 1931); Brean, supra note 8, at 854 (stating that CAD files do not violate the Printed Matter Doctrine).
131. TED2013, supra note 20.
132. Id.
1. 4DP v. 3DP CAD Files

The fourth dimension of printing makes an even better case for recognizing a 4D-printing CAD file as PSM under Section 101. The value of the 4D-printed product rests in the preprogrammed material within the CAD file. Unlike 3D printing, where there may be another method for creating a printed object, with 4D printing, the material and the final transformable product could not exist without the CAD file. The final product and the 4D CAD file are co-dependent; there are no other ways to make the product because the 4D CAD file is an integral component of the PM. Thus, without recognizing the 4D-printing CAD files as PSM, an inventor would be unable to protect his potentially novel and useful invention.

C. 4D Computer-Aided Design Files Are NOT Blueprints or Mere Instructions

Historically, for an invention to be patented, the law required tangible embodiments of an invention—with some exceptions—even for infringing sales. This presents an issue for creators of CAD files for purposes of 4D printing. Some have argued that a CAD file is no different from a blueprint and will not qualify for patent protection. While such an argument can be justified using a variety of conflicting court opinions, there are just as many opinions that justify the converse and show that, in the case of 4D printing, the arguments against patentability are invalid because CAD files are not simply blueprints of a printed device. A blueprint, which is not afforded patent protection, is basically instructions to use preexisting technologies to construct a new item. A 4D CAD file is intrinsic to the final manufacture. Using the previous analogy of a self-assembling box, the value of the PM is in the fact that the box self-assembles without direct human interaction after printing, due to the transformative CAD file. In brief, the value of the PM is in the transformative 4D CAD file. These 4D-printing CAD files are intrinsic to a particular item and, thus, a specific patented invention.

134. Ebrahim, supra note 101, at 47.
135. Holbrook & Osborn, supra note 118, at 1330.
136. Id. at 1333.
D. CAD Files for Purposes of 4D Printing Are Not Abstract Ideas and Could Be Claimed as a Manufacture as Opposed to a Process.

The definition of “abstract idea” is still quite confusing and is particularly difficult to define in the field of digital technology. The underlying value of 4D-printing technology is in the 4D CAD file and, with 4D printing, the value of the property is in the CAD file, not in another means for manufacturing the product. Without such a CAD file, the desired goals of 4D-printing technology cannot be achieved.

Even if a 4D-printing CAD file is found to be abstract under the Alice two-step, it will be considered an inventive concept and PSM because, like in Enfish and BASCOM, a 4D CAD file discloses an inventive concept. The patent claims would not just recite an abstract idea and apply it to the old 3D-printing method, and the files do not preempt all ways of manufacturing a new 4D-printing product. Rather, the claims would be limited to covering fewer embodiments.

Applying Alice, it is likely that a court could find that the 4D-printing CAD file itself is not abstract when considering the patent claims on both a claim-by-claim basis and as a whole, particularly if they are drafted in a way that distinguishes and covers the product, not the function. The fact that the end product cannot be produced without the digital 4D CAD file transforms the nature of the claims into a patent-eligible application because the CAD file would constitute “something more” than simply an inventive concept.

In Alice, the Court found that an abstract idea is not transformed into a patent-eligible invention by merely implementing it on a computer. However, the court in Enfish and BASCOM found that the idea was transformed into PSM when it added to the functionality of the overall device by improving it. In the case of 4D printing, the file is not simply “implemented on a computer”; rather, the final

137. See Brean, supra note 8, at 847.
139. See BASCOM Glob. Internet Servs. v. AT&T Mobility LLC, 827 F.3d 1341, 1350 (Fed. Cir. 2016) (“The inventive concept inquiry requires more than recognizing that each claim element, by itself, was known in the art.”).
140. Alice, 134 S. Ct. at 2360.
141. BASCOM, 827 F.3d at 1352 (where the claims have an inventive distribution of functionality within a network); Enfish LLC v. Microsoft Corp., 822 F.3d 1327, 1336 (Fed. Cir. 2016) (where the claims were designed to “improve the way a computer stores and retrieves data in memory”). But cf. Elec. Power Grp. v. Alstom S.A., 830 F.3d 1350, 1356 (Fed. Cir. 2016) (explaining that the claims at issue “do not include any requirement for performing the claimed functions of gathering, analyzing, and displaying in real time by use of anything but entirely conventional, generic technology. The claims therefore do not state an arguably inventive concept in the realm of application of the information-based abstract ideas.”).
composition of matter is preprogrammed on the computer.\textsuperscript{142} This distinction transforms the CAD file into a patent-eligible subject matter, meaning it is not abstract. In this circumstance, the value of the CAD file cannot be separated from the end product, and the courts should afford protection. The Court in \textit{Alice}\textsuperscript{143} took a broad view of unpatentable and abstract computer-implemented inventions, considering the claims on their substantive merits. In \textit{BASCOM}, the Federal Circuit recognized that an inventive concept can be found in the unconventional and specific arrangement of known conventional processes. So, where the court had originally found an abstract idea, it also found that something more transformed into PSM. One scholar explains that, because the \textit{Alice}\textsuperscript{144} Court considered “method, system, and the computer-medium claims” to be directed at the same invention, \textit{Alice} supports treating the corresponding CAD files as independently eligible for patent protection.\textsuperscript{145}

Further, a 4D-printing CAD file is very different from the claimed information in the \textit{Digitech}\textsuperscript{146} case. In \textit{Digitech},\textsuperscript{147} the information claimed was not connected to a physical product. A 4D-printing CAD file, however, is connected to a physical product resulting from the 4D-printing process and is clearly “made by man,” as opposed to the data in the case of \textit{Digitech}.\textsuperscript{148} This is an important distinction that directly relates to the evaluation of abstractness.

Some courts have recognized the difference between digital creations and basic instructions that would be unpatentable.\textsuperscript{149} \textit{Alice} indicated that application of the abstract idea might be patent eligible,\textsuperscript{150} and \textit{Enfish} and \textit{TLI Communications} explain that the software patents may be patentable if they improve the functionality of the computer itself. In the recent concurrence in the denial of the petition for rehearing \textit{en banc} in \textit{Ariosa Diagnostics}, the Court explained that “[n]either of the traditional preclusions of laws of nature or of abstract ideas ought to prohibit patenting of the subject matter in this case.”\textsuperscript{151} The same court held that there is nothing abstract about

\begin{itemize}
\item\textsuperscript{142} See Mao et al., \textit{supra} note 21, at 3–4.
\item\textsuperscript{143} \textit{Alice}, 134 S. Ct. at 2360.
\item\textsuperscript{144} \textit{Id}.
\item\textsuperscript{145} \textit{Id.}; Brean, \textit{supra} note 8, at 860.
\item\textsuperscript{146} Digitech Image Techs., LLC v. Elecs. for Imaging, Inc., 758 F.3d 1344, 1347 (Fed. Cir. 2015).
\item\textsuperscript{147} \textit{Id.} at 1349.
\item\textsuperscript{148} \textit{Id}.
\item\textsuperscript{149} Microsoft Corp. v. AT&T Corp., 550 U.S. 437, 449–52 (2007); see also Ebrahim, \textit{supra} note 101, at 64.
\item\textsuperscript{150} \textit{Ariosa Diagnostics, Inc.} v. \textit{Sequenom Inc.}, 809 F.3d 1282, 1284 (Fed. Cir. 2015) (Lourie, J., concurring) (quoting \textit{Alice Corp. v. CLS Bank}, 134 S. Ct. 2347 (2014)).
\item\textsuperscript{151} \textit{Id}.
\end{itemize}
performing actual physical steps. Because the courts have recognized the differences in CAD files and instructions, and understand that connection to the physical product, CAD files for 4D printing should not be considered an abstract idea. Regardless, the 4D CAD file would likely amount to something more under step two of Alice, but recognizing this invention as a “manufacture” could alleviate the issues that this same technology would encounter if claimed as a “method” or “process.”

E. Infeasibility of Patent Enforcement Without Specific Protection

Much like 3D printing, 4D printing could make it very difficult for consumers and lawyers to trace the origins of products. As such, enforcement of intellectual property rights is difficult without specific protections. While 4D printing is in its infancy, there may be potential for someone to copy patented products and, without proper protections, innovation could be stifled because an inventor would choose to suppress information and not disclose his innovation. Further, the legal implications of distributed manufacturing could pose challenges regarding patent infringement as 3D printers become more affordable and the demand for product-specific 4D CAD files increases.

It is apparent, when applying the dissent’s analysis from In re Nuijten, that a transformative 4D-printing CAD file is not abstract. Such a file is both sufficiently “new” and “useful” to afford it patent protection if Congress recognizes these files under “manufacture.” Not only are these files new in the sense that this has never before been achieved, but these files are useful for both the progression of technology and the evolution of an innovative society.

IV. SOLUTION: NEXT STEPS FOR CONGRESS

In order to live in a technologically advancing world, it is important to recognize the need for a patent framework that is adaptable to futuristic challenges that arise with emerging technologies like 4D printing. As digital manufacturing advances, Congress should consider updating the patent system to reflect these technological and computing progressions. To incentivize innovation and accomplish the goals of the patent system, Congress must recognize the patentability of transformative 4D-printing CAD files. Ideally, Congress should view

152. Id. at 1285.
153. See Mao et al., supra note 21, at 6 (relating that researchers at the Georgia Institute of Technology have successfully created a structure that folds itself to mimic a USPS mailbox).
154. In re Nuijten, 500 F.3d 1346, 1358 (Fed. Cir. 2007) (Linn, J., dissenting).
upcoming patent-reform discussions as an opportunity to update the patent laws in a way that clarifies the treatment of disclosure and protection of all types of digital technology (including 4D printing and CAD files). However, until laws are changed, it is important to have a mechanism that recognizes the innovative and patentable nature of emerging technologies like 4D CAD files. As such, this Note suggests allowing for transformative 4D-printing CAD files to be considered a “manufacture” under the existing statutory guidelines. In the alternative, it suggests allowing inventors to draft claims that encompass the specific details of the 4D-printing CAD file separate from the fibers that make up the object of additive manufacturing.

A. Recognition of 4D CAD Files as a Manufacture Under Section 101

If CAD files are recognized as a “manufacture” under Section 101, they will probably not be required to overcome the Alice issue of whether the claims are abstract—one of the judicial exceptions to patentability. This is because the files themselves would be outwardly recognized within the PSM category as opposed to requiring them to be claimed as a “process”—the one category currently without a tangibility requirement. As such, transformative 4D-printing CAD files should be recognized as PSM as a “manufacture” under Section 101 of the Patent Act. In this manner, the patent would provide the necessary protections to encourage the disclosure of new, innovative, and useful technologies that benefit society and would effectively achieve a major goal of the Patent Act by providing the inventor a limited monopoly in exchange for the disclosure of inventions. By providing the incentive offered by patent protection, when someone owns the patent to a transformative CAD file—such as the self-assembling box—the owner will have protection under direct infringement if someone is creating self-assembling boxes without a license to make or use the patent. This is a critical step in moving toward a society that benefits from the distributed manufacturing of innovative products.

156. See MUELLER, supra note 42, at 345 (four statutory PSM categories).
158. MUELLER, supra note 42, at 343 (goals of the Patent Act include: (1) natural rights, (2) reward for services rendered, (3) monopoly profits incentive, and (4) the quid pro quo of patents).
159. Distributed manufacturing applied to a current manufacturing scenario: a company creates multiple versions of the same items and stores them in a warehouse, shipping them to clients as orders come in. In a distributed manufacturing world, the need for inventory storage and transportation costs of the final product are minimized through sale and license to use the
As the analysis demonstrates, courts have struggled to determine if and when a digital creation is patentable, and there are valid arguments on both sides of court decisions. If Congress ultimately read “manufacture” to encompass transformative digital CAD files—and other digital files that are inherently connected to a final product—it would provide more insight into Congressional intent of the Patent Act instead of relying on the USPTO to issue guidance for courts and practitioners to interpret. While these guidelines are detailed and useful, it remains difficult for courts to find these digital files patentable as a manufacture without a clear interpretation of the word “manufacture” by Congress. A 4D CAD file, however, does not face the same problems as the claims in existing case law when determining whether it meets the PSM requirements because 4D CAD files are intrinsic to, and improve functionality of, the manufacture by allowing the material product to shape shift.

1. Four-Dimensional CAD Files Should Qualify as a “Manufacture” under Section 101

Critical to this interpretation is an acknowledgement and understanding that the 4D-printing CAD files are transformative in nature and are intrinsic to the ultimate outcome—there is no other way to produce a self-assembling box without the transformative 4D CAD file. As with current debate, CAD files that are simply representations of an invention would not be considered transformative and would not afford separate protection because the invention can be produced without the file. To preempt problems of interpretation of what constitutes a “transformative” 4D-printing CAD file so the file would be PSM, it will be important to understand that “transformative” is used to represent a product that could not exist without the file. This reasoning allows 4D-printing CAD files to be a progressive and ideal example for Congress in setting such a patent precedent.

If Congress explicitly affords transformative CAD files patent protection, it will be possible to clean up recent unclear patent decisions that have caused confusion. By recognizing the need to read “manufacture” to include 4D-printing CAD files and other, similar, transformative 4D CAD file. This concept will work with 3D CAD files as well, but these are not considered in this analysis.


162. See Enfish, LLC v. Microsoft Corp., 822 F.3d 1327, 1335 (Fed. Cir. 2016) (creating a potential exception depending on how this case is interpreted in the future).
transformative files, areas of the law that are ambiguous may become clearer. This is because an actual line can be drawn as to what constitutes a transformative CAD file. It is obvious that a 4D-printing CAD file is transformative; the final product could not exist without this file. This could be applied to other future digital manufactures and other emerging technologies. In essence, the 4D CAD file is an intrinsic part of the overall product.

The concept of disclosure in the patent system is one of the main goals that this recognition serves to protect. Inventors may decide to withhold such inventions from the public without adequate protection of these transformative CAD files. As a result, this could stifle and have serious negative implications on innovation. While some critics of this approach may argue that an inventor could patent the end result and would have to disclose the contents of the CAD file in order to satisfy the enablement requirement in patent law, the inventive concept inherent in the file would go unprotected unless the contents of the file were protected as a separate invention. Further, patentability is not intended to cover whether an invention is disclosed; it is intended to be a broad initial subject matter determination. Only patenting the fibers of the final shape-shifted product would not afford appropriate protection to the invention. Patenting the fibers alone is not enough protection because the physical printed product changes and has multiple embodiments that need to be protected in their digital form to maintain the authenticity of the shape-shifting invention itself. Protecting the digital 4D CAD file is necessary in order to prevent the unauthorized file sharing, prevalent in copyright laws, to spill over into patents.

Congress has an opportunity to take an expansive reading on the word “manufacture,” and some may argue that this could allow too much flexibility in Section 101, which could ultimately lead to double patenting. However, double patenting would not be much of a concern because the patent for the transformative digital manufacture would be on the substance of the CAD file, not the final product, and the text of Section 101 is intended to encompass broad inventions rather than looking at enablement or obviousness. The post-Alice cases have demonstrated that the Section 101 analysis has allowed that section to improperly flush out patents early, without allowing other patent statutes to serve as the proper check on whether a patent is issued after

163.  Mueller, supra note 42, at 36 (explaining the patent disclosure function is one of the many goals in patent law).
164.  See generally A&M Records, Inc. v. Napster, Inc., 239 F.3d 1004 (9th Cir. 2001).
the application has met Section 101 requirements. Patenting the final product alone would not address the concerns for protection in the era of wide-range global file sharing, but patenting the file would afford protection over intellectual property of the new invention. In short, by patenting the transformative CAD file instead of the final product, double patenting can be prevented; materials used in the printing process and other innovations would have to go through separate patent prosecution.

2. Potential Alternative Solutions

If a CAD file is not recognized as a “manufacture” under Section 101, two alternative solutions could be implemented: (1) industry-specific patent claiming that applies patent rules for enumerated technological industries and (2) limiting the patent term, which is the duration of the patent.


Industry-specific patent claiming could develop a detailed set of rules for a particular type of invention by including specific claim language. In effect, the claims would be limited to a specific industry. For example, the patentee could claim:

Claim 1. A method for 4D printing [a product] within the digital manufacturing industry comprising: [list the steps here].

The benefit of this claiming structure for digital manufactures is that the claims would not be overly broad; they would be tailored to what the patent actually claims. One patent could not claim to cover all digital manufactures, but, rather, only the specific embodiment of the proffered digital file. Therefore, a new patent would be filed for each embodiment of the 4D-printing CAD file—placing no limits on future innovators. This set of rules could also examine whether the claimed invention is a technical solution within a technical field. If it is a technical solution then the patent would be eligible under Section 101. However, this solution is limited because it would require an amendment to Section 101, and the industries would have to be

165. Patent Subject Matter Eligibility, supra note 121 (citing 35 U.S.C. §§ 102 (novelty), 103 (non-obviousness under pre-AIA jurisprudence), and 112 (specification)).

166. This allows for the very specific patent claiming of the CAD file that is inherent to the final manufacture. The final manufacture would need separate patents.

specifically described by Congress for those inventions within the industries to count as PSM.

**b. Second Alternative Solution: Limiting Patent Terms**

The next alternative solution deals with concerns over long patent terms. In the *Alice* dissent, Judge Linn and Judge O’Malley suggested that Congress could limit the term of software patents or limit the claim scope by requiring functional claiming—the invention would be claimed in terms of what it does rather than what it is—if Congress is concerned about computer-related patents. In the pharmaceuticals industry, patent terms are already treated differently than in other industries. Like in the pharmaceutical industry, this patent term limitation could offer a solution to those individuals concerned about patent terms for CAD files and other enumerated fields.

By using functional claiming language, such as means-plus-function or method-by-process claiming, patent claims may be expressed as a “means for performing a specified function without recital of the structure.” In terms of patent eligibility, this type of claiming would benefit CAD files by allowing them to satisfy Section 101 before the product is printed. However, in order to draft claims for such files and overcome potential *Alice* issues, the claims would need to cover more than just the steps telling the printer what to do and cover the narrow contours of the 4D-printed object itself. This was the distinction between allowing the patented software in *Enfish* and *BASCOM* and not allowing the patent in *TLI Communications*.

Additionally, during patent prosecution, the specification should include technical details for the tangible object in addition to technical

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172. *Alice Corp.*, 717 F.3d at 1333 (dissenting Judges O’Malley and Linn suggest Congress “should develop special rules for software patents. It could, for instance, limit their life by limiting the terms of such patents” or “Congress could limit the scope of software patents by requiring functional claiming”).
173. *TLI Communicns LLC v. AV Auto. LLC*, 823 F.3d 607, 609 (Fed. Cir. 2016) (explaining that, aside from the tangible article already known in the art, the specification did not discuss technical aspects of the tangible article).
details for the transformative 4D CAD file. This should eliminate any judicial exceptions to patentability.174

V. CONCLUSION

It is apparent that fast-paced innovations are changing the way “manufacture” is viewed. While 4D printing is a very new technology, it is important for Congress to recognize the challenges of regulating and protecting such a cutting-edge industry. Recognizing that fast-paced technological changes are here to stay—the first step toward a patent policy that is adaptable, flexible, and consistent with the goals of the Patent Act—Congress should consider affording patent protection to more than just physical inventions and include transformative 4D-printing CAD files as a digital manufacture that is patent-eligible subject matter under Section 101 of the Patent Act. This Note concludes that a transformative CAD file, particularly as it relates to 4D printing (1) should be recognized as a “manufacture” and PSM under Section 101, (2) is not abstract under Alice and post-Alice cases because the final product could not exist without the inventive concept connected to the digital file, and (3) is more than just a blueprint or instructions because of the transformative nature of 4D printing. With the pace of technological advances, courts should take steps now to alleviate future problems. In this manner, Congress and the courts can advance goals of the Patent Act by protecting the appropriate digital innovations.

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