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3D Printed Firearms:
Can we smell the cordite?

By Alexander Goodwin[1]

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Contents

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Abstract

Over this last year there has been a lot of media attention and controversy about a potential new crime wave of untraceable three dimensional (3D) printed firearms. However, the question remains is this all necessary? This research through a critical review of the current and potential impacts of 3D printed firearms aims to determine the level of concern that is required in relation to 3D printed firearms. An extensive amount of secondary literature has been used to enable the examination of the historical context that 3D printed firearms are placed in and the potential effects of these firearms. Secondary literature was also used for cross cultural analysis to determine the effects in the UK and the USA.

This researcher found that the advent of 3D printed firearms have the potential to radically improve the quality and standardisation of homemade firearms. Development of 3D printable firearm designs based online, have drastically improved in durability, accuracy and reliability since the development of the first 3D printed firearm, the Liberator in May of 2013. The policing of these designs online have also been shown to be problematic. 3D printable firearm designs can be considered in the same manner as the policing of copyright fraud. This research also identified problems with current regulatory systems and with the online policing of 3D printable firearm designs. The current regulation systems in both the UK and the USA have been shown to be in need of substantial reform from the findings of this research. Changes are necessary to fully embrace and deal with the new issues and problems associated with the production of 3D printed firearms and the storage of their designs online.

This research enquiry has predicted that 3D printed firearms will become synonymous with black market weapons, as the cost of 3D printers continue to reduce and increase in use. This research also predicts the potential misuse of 3D scanners in the duplication and dissemination of existing commercial firearms designs.

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Introduction

Over this last year there has been a lot of media attention and controversy about a potential new crime wave of untraceable three dimensional (3D) printed firearms, with changes in laws in both the UK and USA. However, the question remains is this all necessary? New technology is notoriously difficult to regulate effectively without suffocating such technology or having ineffective regulation. This research will attempt to address the level of concern that is required in relation to 3D printed firearms.

Three dimensional printing builds up objects through the progressive layering of plastic or metal by reference to a 3D design file (Rimmer, 2012). It differs from traditional methods of manufacture which subtract material in order to achieve a certain shape (Ibid). Historically, 3D printers have been very large and expensive, however, new models and manufacturers continually enter the market, meaning that 3D printers are becoming smaller and cheaper to purchase and run. An example of this is the MakerBot Replicator 2 (Ibid). New models of 3D printers are now as inexpensive as $199, and the materials used by these printers being of negligible cost (Murray, 2013). Nevertheless, the more complex and metal based designs require more expensive printers, with printers capable of printing in metal costing upwards of £250,000 (Bloomberg TV, 2013). 3D printers were initially developed during the 1980's and the 1990's to produce objects for prototypes, but it was soon realised a wide range of materials and shapes could be produced in high quality for a fraction of the price (Birtchnell and Urry, 2013). Objects that can be produced include: individually designed shoes, dental crowns, bionic arms and car and aerospace parts (Ibid). Alongside this, are an increasing number of websites, including open source and peer to peer variants, freely offering user submitted designs of products ranging from household objects to luxury items (Ibid).

While there are many positives which have been made available by this technology, it has not been without some unintended consequences (Rimmer, 2012). Many writers have identified 3D printing as a potentially disruptive technology, such as Matthew Rimmer who states '3D Printing is the latest in a long line of disruptive technologies – including photocopiers, cassette recorders, MP3 players, personal computers, peer to peer networks, and wikis - which have challenged intellectual property laws, policies, practices, and norms' (2012:6). In relation to 3D Printing, problems have been predicted in patent law, copying products, copyright, and the difficulty of preventing violation of these laws (Rimmer, 2012) (Weinberg, 2010). However, what differentiates 3D printers from the other disruptive technologies mentioned is the physical nature of the objects it produces. While it shares some of the same policing problems and difficulties that peer to peer networks offer, it differs completely in the potential negative effect of this technology. Due to the physical nature of the objects it produces, the potential negative ramifications of abuses of this technology go well beyond the previously mentioned disruptive technologies. Examples of this include, the printing of card skimmers, which are inserted over bank machine and designs of printable plastic knuckles with spikes on (Morelle, 2013) (DEFCAD, 2013F).

However, 3D printable firearms have caused the most controversy, in both the media's reaction and in legislative responses. 'The possibility of homemade guns has aroused the ire of gun-control advocates as much as it's sparked the excitement of gun aficionados' (Lallanilla, 2013). In 2012, a self-styled 'crypto-anarchist' called Cody Wilson alarmed law enforcement officials when his non-profit organization, Defense Distributed, posted plans on the Internet for making a 3D-printable plastic firearm (BBC, 2013B) (Lallanilla, 2013). From this first design, plastic 3D printable firearms have evolved, improved and diversified into a number of different designs, including some designs that boast semiautomatic fire functionality. In addition to the development of plastic 3D printed firearms, there have been developments in the field of additive manufacture using metal. The first fully metal 3D printed firearm was produced by ‘Solid Concepts, based in Austin, Texas, USA, replicated the parts of a classic Browning 1911 pistol’ (Gibbs, 2013). While there have not yet been any prosecutions involving 3D firearms, the continually reducing cost of 3D printers and their growing availability in homes around the country, suggest that 3D printed firearms are likely to be increasingly problematic and extremely difficult to police in the near future.

To fully determine if the concern regarding 3D printed firearms is justified and necessary. This dissertation will start with some historical context of homemade firearms. It will then explore the continued development and effectiveness of these firearms. After that, consideration will then be given to the current firearm regulation systems and current responses in the UK and the USA to their development. Finally, this dissertation concludes with some evidenced predictions for some likely future trends regarding these weapons.

Method

To assess the need for concern regarding 3D printed firearms, large amounts of secondary data were consulted and analysed. Some of these sources include; academic books and journals, newspaper articles both online and offline variants, parliamentary reports and official statistics. There is a need for an eclectic mix of sources to enable an informed analysis of the available secondary research. Primary research was considered to achieve the aim, however, as the subject area relates to objects that are illegal to make, sell, buy or own without a licence in the UK, this research will need to be conducted through literary analysis (Svetlik, 2013). In addition to this, even if legality wasn't a concern, primary research doesn't correlate well with the aims of this research. As this is the only viable and effective form of research available to me, a critical review of the current and potential impacts of 3D printed firearms through the collection of secondary research and analysis of the literature, will allow me to gain a well-balanced analysis of events through a variety of sources with different viewpoints and cultural backgrounds (Walliman, 2001). The definition of a literature review is encapsulated by Chris Hart who stated that 'The selection of available documents both published and unpublished on the topic, which contain information, ideas, data and evidence written from a particular standpoint to fulfil certain aims or express certain views on the nature of the topic and how it is to be investigated, and the effective evaluation of these documents in relation to the research being proposed' (1998:13).

One of the main benefits of secondary literary analysis is the saving in cost and time. Secondary research allows the chance to access large amounts of data for a fraction of the cost in both monetary terms and in time (Bryman, 2008). Along with the large saving in time and money, a lot of sources of published literature used during this literature review will be of extremely high quality, allowing for an accurate overview to be obtained for the entire subject area (Ibid). Another advantage of secondary literary analysis is the opportunity for cross- cultural analysis, due to the global nature of 3D printed firearms; it is necessary and important that different cultural viewpoints are taken into account. While there are some associated problems with applying research conducted in one country to other countries, important analysis can be drawn from the different viewpoints and aims of research based in different countries (Ibid). Data collection is time consuming, however, due to the nature of this research area, primary research is both unviable and ineffective allowing for more time to be spent on literary analysis and synthesis (Ibid). The final advantage that can be associated with secondary literary analysis are the new interpretations that can be gained through reanalysis. Due to the global nature of 3D printing, new interpretations of published literature will enable a comprehensive analysis of the subject area (Ibid).

While secondary literary analysis has a great many positives associated with it, it is not without its negative attributes. The first is related to the foreign nature of the published literature and its associated analysis. This lack of familiarization with the literature will need to be taken into account during this analysis, through more time being devoted to analysis (Ibid). Linked to the lack of familiarly to the date, is the complex nature of some of the sources that I will use. To account for this, a large amount of time will need to be devoted to achieve the necessary understanding (Ibid). As some of the literature will have been written for different aims, caution will need to be taken to make sure the literature is fit for purpose (Ibid) .The final potential weakness of using secondary literary analysis is while lots of published literature is of high quality not all of it will be. This means care will need to taken with regards to the selection of reputable and reliable sources (Ibid).

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The exclusive use of literary analysis allowed this topic area to fully address though a wide range of reputable and reliable literary sources. This would not have been possible through primary research, due to the nature of the research area and legality. The advantages of using literary analysis greatly outweigh the potentially negative effects of this type of research. Thus, a large and varied amount of published literature will enable this research to efficiently and effectively address the level of concern required regarding 3D printed firearms.

History of Homemade Guns

To fully address the potential effects of homemade 3D printed firearms, some acknowledgement will need to be given to the history and the historical effects of homemade weapons. Homemade firearms have been referred to by many names such as zip guns, zap guns or pipe/pop guns, however, the term 'zip gun' is the most citied in regard to scholars and refers to a 'crude home-made firearm' and can be traced back, to the USA in the 1950's(Cunliffe and Denton, 2008:216).

While scholarly material suggests that this term originated in the 1950's and/or the 1960's, there is evidence of this term being used as far back as the late 1940's to describe crudely made homemade firearms. Through research, it was easy to see a general consensus on the origin of the term 'zip gun' (Di Maio, 1999) (Hardy, 2012). With nearly all authors and scholars agreeing on not only the point of origin in time but also in space. As they identify the origin of the term coming from the 1950's to 1960's, and zip guns being used by juveniles in New York. However, through the use of a google book search and advanced setting specifying a year range, results were found as far back as the late 1940's; with references to zip guns increasing in frequency up until the 1950's and 1960's where this term was alleged to originate from.

The first use of the term was by James Benet in a book entitled A Private Killing published in 1949 with repeated references to zip guns. One such reference reads '"He was shot with a zip gun".' the context in which this word is used is important here, as no definition is given (1949:177). The context of the use of zip gun in this sentence helps to give credence to the idea that this term pre-dated the 1960's and even the 1950's. The lack of explanation of the term when it was first used in the book, helps to suggest that that this term was it in common use before this book was published. While the uses of the term zip gun clearly predate the agreed upon origin, the meaning of the term both pre 1950 and after are remarkable similar. Suggesting that the term gained increasing popularity and use from the late 1940's up to the 1950's and beyond.

For the purposes of this dissertation the term zip gun will refer to any homemade firearm from any era. Zip guns range from the very crude to the almost professional levels of sophistication, with the very crude variants being a greater danger to the firer than to the intended target (Di Maio, 1999). The levels of sophistication vary greatly, with near professional examples of instructional articles and books on how to make fully formed semi-automatic submachine guns, handguns and .22 Machines Pistols using commonly available equipment like files, chisels and a hand drill (Holmes, 1996). While very crude variations of zip guns can be made with a piece of water pipe and cycle frame serving as the frame and a nail serving the function of the trigger (Singh, 2007). Levels of sophistication vary with different designs, with mechanical knowledge being required for the more advanced variants such as; modified blank pistols, tear gas guns and cap pistols (Hissa et al, 2003) (Koffler, 1970).

In the majority of cases the effectiveness of zip guns tends to be of substantially lower quality than commercially made models. This is often down to a myriad of reasons; due to the smooth bore nature of the barrel, oversized muzzle and short barrel, the projectile often tumbles out of the firearm reducing the accuracy and terminal velocity of the projectile (Singh, 2007). Coupled with this is the usually irregular nature of the barrel, which increases the likelihood of explosions and ruptures in the barrel (Gojanovi, 1995). 'The danger of shots fired with homemade weapons is well known, these weapons are not reliable or safe, and may cause serious injuries. Complications include wounds from back-firing and shrapnel wounds from an exploding barrel' (Gojanovi, 1995:216).

Thus, the capacity to wound and kill with these guns varies considerably, not only from one firearm to another, but from one firing to another due to their normally fairly flimsy design and manufacture (Singh, 2007). However, in general the bullets fired from zip guns have low velocity, energy and due to the unstable nature of the projectile they are fairly inaccurate at medium to long ranges causing minimal damage if they reach their intended target (Singh, 2007). With Gojanovi stating 'Shooting with home-made firearms may not be efficient, particularly in distant shooting because of non-spinning missiles in smooth bore.' (1995:214). Despite the lower terminal velocity and tumbling of the projectile, if used at close range, injuries can be serious and often lethal (Gojanovi, 1995). Repeat firing is also problematic, as the majority of homemade zip guns can only fire one bullet at a time and many have a reloading process that can be described as cumbersome and complex (Hissa et al, 2003).

Historically, the use of zip guns is associated with criminal and terrorist acts as well as self-inflicted wounds (Hissa et al, 2003). While homemade firearms have been around as long as professional produced weapons, they reach their height of their popularity due to criminal activity in the United States during juvenile gang wars in New York in the 1950's and 1960's (Di Maio, 1999). Many of these guns were of low quality, manufactured with inexpensive materials, few tools and limited skills, often manufactured in high school shop classes (Ibid). Zip guns were most commonly encountered in poverty-stricken areas, due to their ease and low cost of manufacture (Ibid). However, this increased prevalence of zip guns wasn't to last. Due to increased mobility and affluence of the population alongside a dramatic increase in the availability of inexpensive commercially produced handguns, the use of zip guns in criminal activity reduced dramatically (Cunliffe and Denton, 2008). Zip guns are still occasionally used in cases where the subject has some mechanical knowledge and the necessary materials available; however, it is limited to a handful of cases a year (Ibid) (New Haven Independent, 2013).

What is quite evident is that zip guns historically have been easy to produce; many of them have been of questionable quality and effectiveness and more often than not, been more of a danger to the shooter than the intended target. However, with the ability to produce 3D printed firearms, it is quite reasonable to believe that moderately sophisticated 3D printed firearms could become the modern and much more effective substitute to traditional homemade firearms.

Development, Effectiveness and Dissemination of 3D Printed Firearms and Designs

Development of 3D firearm Designs

The first popularised fully formed 3D printable single shot firearm called the 'Liberator', was designed, produced and test fired by gunsmithing group 'Defense Distributed' in May of 2013 (BBC, 2013A) (Greenberg, 2013A). Before this, only component parts of firearms were produced, examples of this including the lower receiver of an AR-15 and the magazine of an AK-47 (Greenberg, 2013B) (Business insider Australia, 2013). The gun was called the 'Liberator', in reference to a pilot program during World War 2 who's aims was to create an easily produced, low tech firearm intended to put weapons into the hands of occupied Europe's disarmed population, to enable individuals to fight oppressive governments (Canfield, 2012). The concept of the liberator program, reportedly, was the motivation for this 3D firearm designs, as well as the aesthetic appearance of both guns being very similar (Morelle, 2013). 'It took Defense Distributed eight months to produce the firearm, which was assembled from separate components produced on an $8,000 (£5,000) 3D printer bought from auction site, eBay' (BBC, 2013A). The liberator is assembled from separate printed components made from Acrylonitrile Butadiene Styrene (ABS) plastic. The firing pin is the only metal component, as ABS plastic is unable to withstand the pressures of activating the primer of the bullet (Morelle, 2013). The liberator was designed to be an easy to print and assemble single shot firearm, because of this, the design is fairly simplistic and earlier versions of the liberator could even be described as crude. Defense Distributed published a video of the gun being test fired by hand on the 5th May 2013, with the address of the website that these online plans could be downloaded from (Defense Distributed, 2013).

The online 3D printing community tend to modify designs through, users posting their designs online and these designs being tested by the user that posted it, or but other interested users (Business Insider Australia, 2013). However, this process is exaggerated and sped up for the more highly demanded and popular designs (Business Insider Australia, 2013). Through this online process, designs have progressed dramatically from this first design by Defense Distributed. Plastic based designs of these firearms have continually improved and diversified into a multitude of different models, versions and types of firearms. Examples of improvements to the liberator design include 'new barrels for the Liberator pistol in an assortment of other calibres including .25 ACP, .44 Special, .45 ACP and 9x18mm Makarov' (Slowik, 2013). Improvements have also been made to the size and durability of the liberator design to enable it to withstand 10 shots before failing (DEFCAD, 2013A) (Slowik, 2013). The liberator design has also been made more accurate through rifling of the barrel (Anthony, 2013). In addition to improvement and modifications on the original designs, more complex designs have been created. One such design is called the "Liberator Pepperbox" that 'features a four-barrelled cylinder that promises increased durability over the original Liberator design and quadruple the capacity' (Slowik, 2013). The 'pepperbox' model is now into version three as the online community has continued to make improvements on this design (DEFCAD, 2013C). There are also designs online that boast semiautomatic fire functions. This model describes itself as a 3D printed semiautomatic printable firearm (DEFCAD, 2013B). Development has also been made in calibre sizes, with some designs claiming that .44 special round can be fired without losing structural integrity (DEFCAD, 2013D).

In addition to the development of plastic 3D printed firearm designs, there has also been a development in the field of additive manufacture using metal. Printing objects in metal through additive manufacture resolves some of the inherent problems that are associated with printing in plastic. The ability to 3D print in metal allows for the manufacture of substantially stronger, more complex models, widening the list of object that is realistically printable. Metal additive manufacture, in relation for 3D printed firearms, allows for the production of fully metal 'professional quality' firearms (Gibbs, 2013). The first fully metal 3D printed firearm was produced by 'Solid Concepts, based in Austin, Texas, USA, replicated the parts of a classic Browning 1911 pistol' (Gibbs, 2013). Solid Concepts successfully used the handgun to fire 50 rounds, claiming the project aim was to prove the quality and suitability of 3D printed parts for real world applications (Dezeen Magazine, 2013).

Effectiveness of 3D printed firearms

It is important to note that the development of 3D printed firearm designs has dramatically improved the effectiveness and durability of these firearms. Different designs will have different levels of effectiveness and durability and the same is true of different or more recent versions of the same design. The first designs of 3D printed firearms and component parts of guns could be describes as primitive, requiring a large amount of time to be invested into making the various designs functional. Throughout the designing and testing process, the component parts of firearms designed, printed and produced by Defense Distributed had varying levels of effectiveness, with most versions of their lower receiver of the AR-15 structurally struggling to cope with the recoil forces of firing (VICE, 2013). With Cody Wilson even stating when testing a lower receiver, 'this is gen three, we know how it's going to break' (VICE, 2013). When a third generation lower receiver lost structural integrity and split in half during a test firing (VICE, 2013). High Capacity magazines designed and printed by Defense Distributed also had functionality problems during the design process (Vice, 2013). In addition to the component parts produced by Defense Distributed, The Liberator firearm also had problems in the design and testing phases. During the design and testing process, many of the test guns didn't fire due to misalignment and printing issues. Test models even lost all structural integrity during the firing process, when the ammunition was changed to more powerful ammunition (DNews, 2013) (Greenberg, 2013B). However, despite these difficulties The Liberator successfully 'fired a standard .380 handgun round without visible damage' in May of 2013 (Greenberg, 2013A) (BBC, 2013A). The same is true with their component parts, as in March 2013, Defense Distributed released a YouTube video of a 3D-printed AR-15 lower receiver that fired a hundred rounds without failing' (Greenberg, 2013A). Other improvements made to 3D printed firearms by additive manufacturing firms include the world's first 3D printed metal gun. Produced by solid concepts the firearm reportedly 'functions beautifully and has already handled 50 rounds of successful firing' (Gibbs, 2013) (Solid Concepts, cited in Dezeen Magazine, 2013). The gun is made up of over 30 3D printed components, printed in a stainless steel and an nickel-chromium based alloy that is capable of hitting 'a few bulleyes at over 30 yard' (Gibbs, 2013). The inclusion of metal into additive manufacturing process allows for more complex, stronger and intricate designs to be made. The metal laser sintering process used by Solid Concepts to manufacture the different gun components, is one of the most accurate additive manufacturing processes available, allowing for the tight tolerances of this metal design to be met (Dezeen Magazine, 2013).

This improvement in effectiveness of 3D printed firearms and component parts can also be seen in relation to designs posted by the online community, with the effectiveness and durability of designs posted online increasing incrementally since the first test of the Liberator. Example of this include the ability to successfully shoot in calibres up to .44 special, which in comparison to the first firing of .380 handgun round in the original Liberator design, marks a dramatic increase in the durability of plastic 3D printed firearm designs (Slowik, 2013). Other improvements in effectiveness include rifling of barrels, the increase in the number of barrels and designs that claim semi-automatic firing functionality (Slowik, 2013) (Anthony, 2013). Improvements made to online design files are improved through a trial and error basis. This involves the design being put online, printed and tested by the same or different users. After the firearm has been tested, suggestions are made for improvements and the cycle continues (Business Insider Australia, 2013). However, this process is exaggerated and sped up for the more highly demanded and popular designs, which can help to explain the speed at which new designs are produced and improved by the online community (Business Insider Australia, 2013).

Another variable that needs to be taken into account is the quality of the printer that is printing the design. The printer used by Defense Distributed in the design and making of the Liberator is a high end printer costing $8,000 (£5,000), that can produce models in higher quality and finer detail then more standard 3D printers used at home (BBC, 2013A) (DNews, 2013). Demonstrating this, the Australian New South Wales Police, put out a video warning the public of the dangers of using these 3D printed firearms. They printed the Liberator design with a base entry level printer costing $1,700 dollars. All the printed firearms they produced and test fired using this printer suffered catastrophic structural failure, with the New South wales police stating that these firearms are ‘enormously dangerous, both to the person that you may be choosing to use it against and to yourself’ (Australia Videos, 2013) (The Independent, 2013). Worthy of note here is the cost disparity between low and high end 3D printers. New cheaper models of 3D printers are now as inexpensive as £199, and the materials used by these printers being of negligible cost (Murray, 2013). Nevertheless, the more complex and metal based designs require more expensive printers, with printers capable of printing in metal costing upwards of £250,000 (Bloomberg TV, 2013). So while online designs are progressing in both their durability and effectiveness, the quality of the printer still needs to be taken into account when producing a 3D printable design file. Despite this technology still being in its infancy, the continued developments in the different methods of manufacture and the increasing complexity of the designs freely available online, show that 3D printing technology will continue to developed and improve.

Dissemination of these designs

Both the effectiveness and the development of 3D printed firearms have been discussed, however, no discussion has been given to the sharing and the decimation of these designs online. 3D printable design files tend to be stored, shared and hosted on free to use websites like thingiverse.com. Thingiverse is a website run by a company that produces 3D printers called Makerbot. The website is used to, upload and browse uploaded 3D printable design files. Thingiverse states ‘MakerBot's Thingiverse is a thriving design community for discovering, making, and sharing 3D printable things. As the world's largest 3D printing community, we believe that everyone should be encouraged to create and remix 3D things, no matter their technical expertise or previous experience. In the spirit of maintaining an open platform, all designs are encouraged to be licensed under a Creative Commons license, meaning that anyone can use or alter any design' (Thingiverse, 2014). This was also true of printable firearms designs and printable designs of component parts of existing firearms. While these were in the minority of designs uploaded, they existed amongst the other printable design files on websites like Thingiverse (VICE, 2013). However, in the wake of the Sandy Hook school shooting, Makerbot pulled all blueprints of gun parts from its website, with the company stating 'it had the right to review and take appropriate action against Thingiverse users if they breached its terms of use' (BBC, 2012). In reaction to MakerBot's crackdown, Cody Wilson, founder of Defense Distributed, stated that he planned to create a new site for "hosting 'fugitive' 3D-printable gun files in the next few hours" (BBC, 2012). This website is a database for 3D pintable designs called DEFCAD, run by Defense Distributed. Dubbed as the 'Pirate bay of 3D printing' by the media, DEFCAD claims to be dedicated to copyright free blueprints for a range of 3D printable designs (BBC, 2013B). Available on this website for free download are various 3D printable firearms, covering different designs, calibre and firing capacities. As well as component parts of existing firearms including lower receivers and magazines. The liberator design on this website has seen over 400,000 downloads since the site launched (BBC, 2013B). Along with the single designs files available for download, are packs of designs put together. An example of a one such pack is entitled 'FOSSCAD mega pack v4.6'. This pack contains 17 different printable designs ranging from component parts of existing firearms to fully printable single shot firearms (DEFCAD, 2013E). In addition to website like DEFCAD, there are also peer to peer networks that allow for the download of 3D printable designs (Rimmer, 2012).

Current Regulation Systems Regarding Gun Control and Responses to 3D Printed Firearms

Regulatory systems for firearms differ greatly from country to country, however, for the purposes of this dissertation, two countries with very different values in regard to gun control have been chosen, namely the UK and the USA. This will enable the collection of a differing set of views to the effects of 3D printed firearms.

Regulation of firearms and individual component parts in the USA is based around controlling the manufacturing, importing and dealing of firearms, set out by the Gun Control Act 1968 and the National Firearms Act 1934. While each state enacts its own gun law, the Gun Control Act 1968 and the National Firearms Act 1934 give a general framework for each state (Krouse, 2012). This is done through a system called the Federal Firearm Licence (FFL), meaning that anyone involved in the manufacture, importation and dealing of firearms are required to have one, to legally operate (Zimring, 1975). The Gun Control Act 1968 requires each gun created by licenced manufacturers to possess a serial number that is required to be kept on record (Jensen-Haxel, 2012). Dealers need to keep records on almost all firearm transactions, including transfers in interstate commerce (Jensen-Haxel, 2012). 'Denying access to firearms to certain congressionally defined groups, including minors, convicted felons and persons who had been adjudicated as mental defectives or committed to mental intuitions' is the Act's main aim (Gun Control Act 1968, cited in Zimring, 1975:149). For regulatory purposes, when a firearm is broken down into component parts, the only piece that is considered a firearm is the central frame or receiver (Zimring, 1975). With all other domestically produced components for common firearms being unregulated. An example of a common firearm is a AR-15, as all the component parts apart for the lower receiver, are easily ordered over the internet without a licence or a check on the National Instant Criminal Background Check System (NICBCS) (VICE, 2013) (Jensen-Haxel, 2012). When a private individual attempts to purchase a firearm or a lower receiver of a firearm from a Federal Firearms Licenced dealer, they have to submit to a NICBCS. If they are not prohibited and are of age, the transfer is approved while the Federal Firearms Licenced dealer retains paper purchase records of the transaction. Ammunition can also be purchased without going through a NICBCS check as it is considered a domestically produced component (Jensen-Haxel, 2012).). In addition to this, it is also legal under the Gun Control Act 1968, for unlicensed individuals to make a firearm for his own personal use, but not for sale or distribution (ATF, 2014). Meaning that, producing a firearm at home through a 3D printer is legal as long as it is not for sale or distribution (ATF, 2014). While parts for common guns are unrestricted, heightened restrictions apply to fully assembled guns with certain component arrangements including individual parts that enable rapid fire under the National Firearm Act 1934 (Jensen-Haxel, 2012).

The regulatory system for Firearms and their component parts in the United Kingdom is very different, with the basic principle's being radically different from the USA's, the UK's firearms policy is based on the fact that firearms are dangerous weapons and the State has a duty to protect the public from their misuse. Gun ownership is a privilege, not a right.' (Home Office, 2013:5). There are a number of different laws that regulate firearms in the United Kingdom, including the Firearms Act 1968, the Export Control Act 2002 and the European Council Directive of 18 June 1991 on Control of the Acquisition and Possession of Weapons (Gun Policy, 2014). There are a limited number of firearms that may be licenced; these include shotguns, rifles and some air weapons. However there are some restrictions, while shotguns can be licenced self-loading or pump action shotguns are not permitted (Home Office, 2013). In relation to rifles, self-loading rifles are also prohibited and more generally any firearm which is so designed or adapted so that two or more missiles can be successively discharged without repeated pressure on the trigger are also prohibited (Home Office, 2013). Size limits are also placed on both firearms and calibre of the bullets that are licensable, as well as a complete restriction of firearms that are disguised as other objects (Home Office, 2013). Regarding ammunition, firearm and shotgun certificates are required in respect of the majority of firearm ammunition, however, a shotgun certificate is not required to purchase, possess or acquire shotgun cartridges if they don't exceed .36 inches in diameter (Home Office, 2013). Ordinary shot cartridges are covered in this description as they are less than .36 inches in diameter. Unlike the USA, all component parts of firearms fall under the same restrictions that those firearms would have if they were complete (Home Office, 2013). To obtain a firearms or shotgun licence, permission to possess, purchase, or acquire a firearm needs to be granted by the police (Home Office, 2013). The individual in questions need to not pose a threat to the public and must have a good reason to own a firearm (Home Office, 2013). For the latter to be met they must require a firearm on a regular legitimate basis, reasons include; sport, work or leisure (Home Office, 2013).

There have been a number of recent developments for regulation systems in regards to 3D printed firearms, in both the USA and the UK. The USA updated the Undetectable Firearms Act 1988 that was due to run out in December 2013, which 'makes it a federal offense to "manufacture, import, sell, ship, deliver, possess, transfer, or receive" a firearm capable of defeating airport metal detection' (Brown, 2012). Requiring that any firearm at the very least have 3.7 ounces of stainless steel (Brown, 2012). This law also prohibits the production and sale firearms, that don't look like firearms to an airport scanner (Brown, 2012). However, while Congress renewed the ban of undetectable firearms for the next ten years, it didn't add any new restrictions on plastic firearms, such as making the required amount of metal difficult to remove (Roberts, 2013). This can be seen in the liberator design, as the legally required metal in the design can be removed quite easily (Roberts, 2013). Along with the update of the Undetectable Firearms Act, 'Local governments have also made moves to regulate 3-D printed guns. In Philadelphia, the city council passed an ordinance that would hit anyone caught with a 3-D printed firearm with a fine of up to $2,000' (Wagstaff, 2013). State and local legislators in California, New York and Washington, D.C., have also proposed similar measures (Wagstaff, 2013).

Meanwhile, in the UK, there has been a clarification of current laws rather than an update or changes to current laws. 'The manufacture, purchase, sale and possession of 3D printed firearms, ammunition or their component parts is fully captured by the provisions in section 57(1) of the Firearms Act 1968' (Home Office, 2013:24). 'The expression "firearm" in the 1968 Act means a lethal barrelled weapon of any description, or component part of such weapon, from which any shot, bullet or other missile can be discharged' (Home Office, 2013:24). As 3D printed firearms, are potentially lethal barrelled weapons, they are viewed as firearms by the law, with the Home Office stating 'the method of manufacture is not material to this consideration' (Home Office, 2013:24).

So What?

Whilst the technical aspects, effectiveness, history of homemade weapons, the development of 3D printed firearms and current regulatory systems have been discussed, no discussion has been given to the level of concern that these 3D printed firearms pose. Thus, this section will attempt to; rationalise the effects of 3D printed firearms, the level of concern necessary and give a discussion into the unintended consequences of this technology.

Why are 3D printed firearms different from historically produced homemade firearms?

Historically, individuals have always had the ability to make firearms at home, with commonly available items like water pipes, cycle frames and nails (Singh, 2007). Thus, the advent of 3D printers and their use in regards to the printing of firearms can be considered to be new technology serving a historic function. However, there are a great many differences between historic methods of producing homemade firearms and 3D printed firearms. This section will attempt to highlight these differences, and show how the advent of 3D printers has radically changed the issue of homemade firearms.

In the majority of cases, homemade firearms made without the use of 3D printer are of substantially lower quality than commercially made models. With the very crude variants being of greater danger to the firer, than the intended target (Singh, 2007) (Di Maio, 1999). Common issue with firearms produced this way include; smooth bore and short barrels, oversized muzzles and irregular and rough designs (Singh, 2007). This often resulted in decreased accuracy, tumbling projectiles and increased chance of the firearm losing all structural integrity (Gojanovi, 1995). In this regard, homemade firearms created without the use of a 3D printer, are very similar to current models of plastic firearms produced by 3D printers, with many designs of firearms and component parts of firearms having accuracy, functional and structural integrity problems (DNews, 2013) (VICE, 2013). While, it can be seen that there are similarities regarding the quality of homemade firearms produced with and without 3D printers, there are also a great many differences. One of the main differences between firearms produced with or without the use of a 3D printer, is the different levels of mechanical knowledge required. Producing homemade firearms without the use of a 3D printer requires a certain amount of mechanical knowledge as well as a few tools, to manipulate, chisel, file, drill, cut and mould the metal or plastic to the required shapes and sizes (Di Maio, 1999) (Hissa et al, 2003) (Koffler, 1970). While the amount of mechanical knowledge and ability varies from design to design, there is a minimum level of mechanical knowledge required, to produce even the most simplistic of designs (Holmes, 1996). This can be seen from the example of zip guns used in juvenile gang wars in New York in the 1950's, which required the use of a tools and limited skills in high school shop classes (Di Maio, 1999). On the other hand, homemade firearms produced by 3D printers from designs online, necessitate a much lower minimum level of mechanical knowledge and access to tools to produce, due to the process of additive manufacture (VICE, 2013). As this involves the printing of objects through layering of plastic or metal, all the components of the design are produced to the correct size and shape, allowing for designs to be made to a higher degree of accuracy than compared to traditional methods. Even though many designs require assembly after printing, all the parts printed are the correct size and shape which allows for easy assembly (VICE, 2013) (DNews, 2013). This ability to find a designs online and print those designs, mean, that a greater percentage of the general population will have the minimum skills necessary to access, produce and put together 3D printed homemade firearms, than compared to homemade firearms produced without a 3D printer.

Another notable difference linked to this concept of additive manufacture is the standardised nature of 3D printed firearms. Before the advent of 3D printers, homemade firearms had a very low level of standardisation (Singh, 2007) (Hissa et al, 2003). As often, homemade firearms were made using materials and resources available to the creator at the time (Di Maio, 1999). However, the increased use of 3D printers to print firearms could potentially result in standardization in quality of homemade firearms. The process of additive manufacture means that objects are produced to the same standard every time (Rimmer, 2012). The use of additive manufacture for the production of homemade firearms will mean that everyone printing the same design with the same or better printer, will be able to produce homemade firearms to the exact same standard. This is problematic as when more technically capable and structurally sound designs are available for download, this could potentially result in the increase in effectiveness and structural integrity of homemade firearms. While, current online designs suffer from the same structural integrity and effectiveness issues that can be seen with homemade firearms produced without a 3D printer, the continued improvements to these designs online show that 3D printed firearms have the potential to considerably raise the standard of homemade firearms.

Continued Development of 3D Printable Firearms

The majority of 3D printed plastic firearms that are currently accessible from websites and torrents are fairly simplistic and require more expensive printers to produce firearms that can withstand more than one firing, however, continued development of 3D printable firearm designs have greatly improved their effectiveness. As previously mentioned, this development of online designs is done in one of two ways. The first is individuals uploading their own individual design which could be completely original, or an amalgamation of other uploaded designs, while the second is modifying designs that have already been uploaded to websites like DEFCAD and Thingiverse (Business Insider Australia, 2013) (DEFCAD, 2013A) (DEFCAD, 2013C). The modification and improvement of existing designs is more popular with the 3D printing community and is referred to as 'modding' (Business Insider Australia, 2013) (Rollenhagenaug, 2013). It involves users posting their work in progress online. Other users will then print, test and modify the design, and repost the improved design. Through this process, designs are improved over time, refined and changed to become more effective and durable. This is true of most printable designs on these websites, including designs of 3D printable firearms (Business Insider Australia, 2013) (Rollenhagenaug, 2013). This modification of designs can be seen from the transformation from the original liberator designs that has one barrel, to the 'Derringer Pepperbox' design that is based on the liberator design but has six barrels rather than one (DEFCAD, 2013A) (DEFCAD, 2013C). The 'pepperbox' model is now into version three as the online community has continued to make improvements on this design (DEFCAD, 2013C). The development and production of original designs can also be seen in relation of 3D printable firearms; an example of one such original design is the first 3D printed rifle that successfully fired 14 rounds of .22 calibre rifle rounds. This design is substantially different from the original liberator design produced by Defense Distributed and substantially more durable (Rollenhagenaug, 2013). The current rate of development shows that these designs have considerable room for improvement. The modification and development of 3D printable firearm designs by the online community also show that this process can be substantially sped up for more highly demanded and popular designs (Business Insider Australia, 2013).

The storage of open source 3D printable firearm designs online has helped increase the rate of improvement and development. For open source 3D printable designs, the development and improvement of the same design can be done by many different users at the same time.

All of these users will print out the exact same design and are able to test and modify the same design (Pearce, et al, 2010). This enables an accelerated, self-directed, and sustainable development of that design (Pearce, et al, 2010). ‘Now, with affordable 3D printers on sale, widespread internet access and the open-source movement gaining followers, more people can use, study, copy and change a design for free and share the improvements online’(The Guardian, 2014). This accelerated, self-directed and sustained development also applies to designs of 3D printable firearms. On websites like DEFCAD.com, users can download and freely modify designs of a multitude of different firearms, these improved versions take the place of older versions of the same design and the process starts again. This process has enabled the rapid improvement of 3D printable firearms designs and will continue to do so with the continuing reducing price of 3D printers and access to the internet. Due to the storage of the modified and improved 3D printable firearm designs online and modification by the online community, the improved designs of 3D printable firearms have the potential to be more effective, reliable, accurate and easier to produce than historic homemade firearms. Improvements can be made by one person with the necessary expertise and these exact improvements can disseminated to the entire 3D printing community, through download and the process of additive manufacture.

The continued reduction in the price of 3D plastic capable printers may also speed this process up of modification and improvement in relation to all 3D printable designs. Current models of 3D printers are now as inexpensive as $199 and they are continuing to reduce in price (Murray, 2013). It has also been argued that as well as plastic capable 3D printers going down in price, eventually printers that can print in metal and other hybrid materials may also reduce in price enough to be considered to be a practical price for domestic households (Murray, 2013) (Rimmer, 2012). ‘3D printing is, like the computer in the 1970s, becoming available to the domestic enthusiast. Like the home computer, personal 3D printing has the potential to radically change aspects of the way in which we live; we can even envisage a society where home manufacturing of many items is the norm’ (Bradshaw, cited in Rimmer, 2012:19). The continuing reduction in the price of 3D printers, is likely to increase their use and many commentators claim in the near future the majority of home will contain a 3D printer (Birtchnell and Urry, 2013) (Rimmer, 2012).

Problems with Policing the Dissemination of 3D Printable Firearm Designs

While the policing of firearms has historically been physically based, 3D printed firearms and the storage of their design files on the internet has taken away from the physical style of policing. Before, the policing and regulation of firearms was based on limiting the number of suppliers and regulating who was able to access firearms. However, the advent of 3D printing has shifted this dynamic, through increasing the number of those that are capable of producing firearms to everyone with a capable 3D printer. This change will have a profound effect on how firearms will need to be policed and regulated, from the enforcement of these designs online to the security systems used to detect firearms. The problems of policing the internet are well known, however, these have not been explored in relation to 3D printable firearm designs. As these designs can be downloaded and uploaded at will, on websites enabling peer to peer downloads and user generated forums. The policing of 3D printable design files will need to be considered in relation to intellectual property theft or ‘cyberpiracy’ of music, films, games and software over the internet (Wall, 2001). One of the most obvious consequences of the new information and communications revolution is the increased communication capacity; however, as electronic transmission and reproduction of information has become so easy and common place, it has made the traditional view of copyright law increasingly irrelevant (Jewkes, 2012). One form of regulation and enforcement is the shutting down of websites that enable cyberpiracy. One well known case that highlights this is Napster, a free music downloading service that was forced to suspend its operation in 2001, when the Record Industry of America filed for copyright infringement. However, while Napster was successfully shut down, numerous peer-to-peer file-swapping services have emerged since Napster that continued to bypass copyright legislation. This includes websites like Pirate Bay, Isohunt and Kick Ass Torrents (Gil, 2014). While Pirate Bay was shut down by the Dutch court in May of 2012, a study done by Poort et al from the University of Amsterdam found instead of a reduction in illegal downloading, 'the percentage of downloaded films & series, games and books from illegal sources in the preceding six month had increased between May and November-December 2012, while the percentage downloading of music from illegal sources remained constant'. (2013:11). Other approaches that attempt to deal with cyberpiracy include legislative approaches both international and national, with The Council of Europe coming up with its Convention on Cybercrime, including in which is its national and international legislation to deal with cyberpiracy(Everett, 2009). This Convention is intended to act as a guideline for countries developing laws on the issues as well as a framework for international cooperation. Currently there are 46 states signed up to it including UK, USA and South Africa (Ibid). However, legislation, whether national or international, is not without its problems. Firstly, international and inter partnership working tends to be problematic due to slightly different legislation, procedure and domestic politics (Ibid). Secondly, legislative processes tend to move too slowly, taking years rather than the weeks or months that are required, due to the dynamic and ever changing nature of the online world in general and cyberpiracy in particular (Ibid). The aforementioned problems of internet policing and regulation in relation to 3D printed firearms and their designs has also been acknowledged by Defense Distributed founder Cody Wilson creator of the original Liberator design stating 'There is no way of purging the Internet of these files. It's just like the file-sharing conversation that played out over the last decade' (Cody Wilson, cited in Wagstaff, 2013)

In the United Kingdom, it is illegal to download, manufacture, purchase, sell or poses a 3D printed firearm, including its component parts without a firearms licence. However, the aforementioned problems with policing and regulating their designs online will most likely have a large impact on the enforceability and regulation of 3D printed firearm designs online (Poort et al, 2013). While 3D printers are currently not widely used, the continued reduction in price of 3D printers and the increasing availability of online design, mean that limiting the number of suppliers of firearms and regulating who is able to access printable firearm designs will become an ever more difficult task.

However, in the USA the situation is substantially different due to different legislation and less regulation. As mentioned in previous sections, most ammunition and component parts of firearms, excluding the lower receivers can be bought online without a firearms licence. As well at it being legal for individuals to make a firearm for his or her own person use, as long as it is not for sale and distribution (ATF, 2014). Meaning that, any US citizen with access to a 3D printer could potentially legally make 3D printed firearms as 3D printable designs of full firearms and lower receivers are easily accessible online. These factors mean that policing and regulating 3D printable design files online, will be of greater importance, as 3D printable lower receivers designs online undermine the current regulation system. An examples of this being the lower receiver of a firearm that has been used in a number of school shootings, the AR-15, designs of which are easily available online for direct download on website like Defcad.

Problems Posed on Current Regulation Systems by 3D printed Firearms

As previously mentioned 3D printed firearms created problems for the current regulatory systems in both the UK and the USA. In the UK, current laws state that 'The manufacture, purchase, sale and possession of 3D printed firearms, ammunition or their component parts is fully captured by the provisions in section 57(1) of the Firearms Act 1968' (Home Office, 2013:24). As 3D printed firearms are potentially lethal barrelled weapons, they are viewed as firearms by the law, with the Home Office stating 'the method of manufacture is not material to this consideration' (Home Office, 2013:24). However, while the production, purchase, sale and possession of 3D printed firearms are fully covered by the current regulation, 3D printed firearms do cause some regulatory problems. In the UK shotgun cartridges that don't exceed .36 inches in diameter do not require a firearms licence to purchase (Home Office, 2013). Meaning that if an individual had access to, or could develop a 3D printable firearm design that was capable of firing a standard shotgun cartridge, a 3D printed firearm could be printed and ammunition could be bought without going through any regulatory systems.

The 3D printings of firearms are also problematic for the regulation systems in the USA. The first regulatory problems that 3D printing has created, is the printing of component parts of firearms. Under the current regulation system, all other component parts of firearms, with the exception of the lower receiver can be bought online without going through the National Instant Criminal Background Check System. Meaning that firearms that are commercially produced to high standards, can be accessed without a criminal record check through the 3D printing of the only part that is considered a firearm, the lower receiver. In the USA it is also legal to produce a firearm at home as long as it is not for sale or distribution (ATF, 2014). This means that 3D printable firearms designs like the Liberator can be printed, assembled and fired legally, as the purchase of ammunition also doesn't require a firearms licence. 3D printable firearms have also created problems for The Undetectable Firearms Act 1988, while Congress renewed the ban of undetectable firearms for the next ten years, they didn't add any new restrictions on plastic firearms, such as making the required amount of metal difficult to remove (Roberts, 2013). This can be seen in the liberator design, as the legally required metal in the design can be removed quite easily (Roberts, 2013). If the legally required metal can be taken out and put back in designs of 3D printed firearms likes The Liberator, it makes the enforceability of the Undetectable Firearms Act extremely difficult as the metal can be removed just before passing through metal detectors.

While 3D printers have given individuals the ability to produce firearms, it would be asinine to assume that the majority of individuals that have access to 3D printers would attempt such a thing. As this can also be seen in relation to homemade firearms made without the use of a 3D printer, as some designs can be produced with just a piece of water pipe and cycle frame serving as the frame and a nail serving the function of the trigger, all of which can easily be accessed by the majority of the population in the UK and the USA (Singh, 2007). However, while the majority of 3D printer users will not use this technology in this way, a minority may. The potential abuse of this technology will lead to current regulation systems in both the UK and the USA requiring substantial reform to fully encapsulate and mitigate the problems posed by 3D printed firearms and the storage of their designs online.

Potential Criminal Uses of 3D Printed Firearms

While there have been no convictions for the criminal use of 3D printed firearms the standardised nature of 3D printed firearms, their continued development, problems with policing the dissemination of their designs and regulatory problems in both the UK and the USA will make this increasingly likely. Thus, postulations have been made in relation to some potential criminal uses of this technology and 3D printed firearms.

The first potential criminal use for 3D printed firearms would be the printing of unregulated firearms, for the purposes for criminal activity, without going through a regulatory system or acquiring a firearms licence. An example of this is the printing of the lower receiver of a AR-15. As the printing of the lower receiver of an AR-15 allows for the assembly of an entire semiautomatic firearm to be created without going through any regulatory systems in the USA. An example in the UK would be the 3D printing of a firearm that is capable of successfully firing a standard shotgun cartridge, as this would also negate current regulatory systems in the UK and allow individuals that wouldn't normally have access, access to potentially lethal firearms. As currently, standard shotgun cartridges can be purchased without a firearms licence. Worthy of note here is that the majority of 3D printed firearms are currently more expensive, less effective and harder to get hold of than non 3D printed illegitimate firearms. Thus, it is unlikely that individuals looking for illegitimate access to firearms would turn to 3D printable firearms currently (Reynolds, 2014). However, the continually reducing price of printers and increasing effectiveness of designs could mean that in the future 3D printed firearms are a logical alternative to historical illegitimate firearms.

Another potential criminal use of3D printers is the printing of illegitimate firearms that don't look like firearms, or are otherwise disguised. As previously mentioned, current firearm regulatory systems are negated through the printing of whole firearms or the printing of certain regulated parts. However, this situation is made even more complex when disguised firearms are taken into account. If designs of firearms that look similar to the traditional view of handguns can be created, printed and successfully test fired. It is easy to believe, that designs could also be created for fully functioning firearm that do not appear to resemble traditional firearms. These firearms could be disguised in objects like vases and would be extremely difficult to detect. While the same criticisms apply to current 3D printed firearm designs, the continued development of designs online show that this potential criminal use of this technology is not in the realms of science fiction.

The final postulated criminal use of this technology discussed is the sale and distribution of 3D printed firearms to individuals without access to a 3D printer. This could potentially be between individuals in the same country, as well as between individuals in different countries. This potential criminal use has been observed by Australia New South Wales police force on a website called Agora (Welch, 2014). Almost 50 lethal guns, from pistols to assault rifles, have been found on this website, including 3D printed firearms (Ibid). The liberator firearm designed by Defense Distributed was one of the firearms for sale on the website, with the seller advertising the plastic and easily disposable nature of the firearm (Ibid). This example found by New South Wales Police, shows that the potential criminal uses of 3D printers are being taken up by enterprising criminals eager to make money from the unintended consequences of 3D printers.

Summary, conclusions and postulations for the future

Summary

The aim of this research was to fully determine whether or not the concern regarding 3D printed firearms is justified and necessary, two countries with very different values in regards gun control were chosen to achieve this aim, namely the USA and the UK. Literary analysis was chosen to achieve this aim, as it allowed for the collection of large amount of literature and data from a variety of different perspectives, as well as the ability to perform cross cultural analysis.

The research has shown that while 3D printed firearms are in their infancy, they represent a serious problem for the future regulation of firearms while also presenting a multitude of new accessibility issues that differ notably to previously produced homemade firearms. 3D printed firearms have been shown to differ from traditionally produced homemade firearms in both minimum level of mechanical knowledge required and the level of standardisation in production quality (VICE, 2013) (DNews, 2013). The production of homemade firearms through the process of additive manufacture, allow different individuals through the download of an online design with the same of better printer to produce the same design to the same quality (Rimmer, 2012). Additive manufacture allows for the easy assembly of the chosen design, as all the different parts are made to the correct size and shape.

The continued development of 3D printable firearm designs has seen the original liberator design, improved, changed and reinvented. Some current designs online now claim to have semi-automatic fire functionality, with other designs advertising rifled barrels to improve accuracy (DEFCAD, 2013A) (Anthony, 2013) (DEFCAD, 2013C). As well as the diversification of designs online, the designs can also be said to have improved in reliability and consistency. The storage of 3D printable firearms online has also created new policing problems that historically have not been associated with homemade firearms. The design of 3D printed firearms and their download can now be considered in relation to intellectual property theft or 'cyberpiracy' of music, films, games and software over the internet (Wall, 2001). Policing of the internet is problematic and is fraught with lack of joined up inter-agency and international partnership working (Wall, 2001). The dissemination of 3D printable designs over the internet means that policing of 3D firearms is likely to become increasingly more difficult.

3D printed firearms also have been shown to create problems for the current regulation systems in the UK and the USA. The advent of 3D printable firearms and the accessibility and storage of their designs online, mean that both the UK's and the USA's firearm regulatory systems are in need of substantial reform to regulate the ownership of firearms once more.

Conclusions

Currently 3D printers are in use by a minority of hobbyists and enthusiast. However, the continuing reduction in price of 3D printers is allowing 3D printers to become more accessible to a greater proportion of the population in both the UK and the USA. It has been postulated by a number of different authors that this continued reduction in the cost of 3D printer will mean that 3D printers will likely be found in the majority of home in the near future (Birtchnell and Urry, 2013) (Murray, 2013) (Rimmer, 2012). As previously mentioned, it is illogical to assume that everyone with a 3D printer will produce 3D printed firearms; however, if nothing is done to modify legislation the increased use and availability of 3D printers will likely mean that it is only a matter of time before the first conviction of the criminal use of 3D printed firearm.

It has also been identified that 3D printers have the potential to radically improve the quality of homemade firearms, through increased standardisation due to additive manufacture and the continued improvement of accessible online designs. 3D printed firearm designs have increased in durability, accuracy and reliability since the development of the first 3D printed firearm, the Liberator. This development however has had further problems; the storage of these improved designs online means that any individual with access to a 3D printer and the internet also has access to these improved designs of 3D printable firearms. This group learning also means that improvements to designs can be made quicker as computer literate users have the ability to edit and improve designs at the same time (The Guardian, 2014) (Murray, 2013).

This research has also identified problems with current regulatory systems and with the online policing of 3D printable firearm designs. The current regulation systems in both the UK and the USA have been shown to be in need of revisiting, to fully embrace and deal with the new issues and problems associated with the production of 3D printed firearms and the storage of their designs online. This research also shows that the policing of 3D printable firearm designs online will be very problematic, as it can be considered in the same regard as the policing of copyright fraud. This is acknowledged by New South Wales Police Force, Police Commissioner who states in relation to the liberator design 'these particular weapons are almost impossible to stop being sent electronically, these files are out there and they are in wide circulation' (Andrew Scipione cited in Australia videos, 2013).

While, it can be acknowledged that currently 3D printed firearms don't pose much cause for concern currently. The continued development of their designs and the regulatory issues shown by this research, suggests that 3D printed firearms and their component parts will become an increasing cause for concern as 3D printing increases in adoption and accessibility.

Postulations for the Future

3D printed firearms are exceedingly likely to have an increasing effect on both the UK and the USA. The increases in the adoption and financial accessibility of 3D printers are likely to further increase the unintended consequences of this technology. It is likely to only be a matter of time before 3D printed firearms, become synonymous with black market weapons, as the costs of 3D printers go down, 3D printers become easier to use and the effectiveness of designs online improve.

3D scanners also have the potential to increase in use, alongside 3D printers. 3D scanners scan physical objects and create useable and sharable design files that can be uploaded to websites like Thingiverse.com (Makerbot, 2014). However, like 3D printers, this technology can also used in unintended ways. Similarly to 3D Printers, there are no controls to what objects can and cannot be scanned. This opens up the possibility of unintended items being scanned and converted into a design files. An unintended example of this would be the duplication and dissemination of existing commercial firearms by a 3D scanner. 3D scanners give individuals without knowledge of how to produce designs files, the ability to re-print designs and disseminate design files, further reducing the barriers of entry to this technology.

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